





# Environmental and social determinants of health

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Douglas Webb

# Prologue

In the “Era of Sustainable Development,” health is an essential input and the most valuable human development outcome. Achieving the best health outcomes involves tackling the environmental and social determinants of health that are the subject of this book.

Health is often mentioned in the outcome documents of the Rio+20 Conference and the new Sustainable Development Goals (SDG) established by the Member States and detailed in the report of the UN Secretary-General: *The Road to Dignity by 2030: Ending Poverty, Transforming All Lives and Protecting the Planet*. The new set of 17 goals includes a stand-alone goal for health—SDG 3: Ensure healthy lives and promote well-being for all at all ages—and addresses the environmental and social determinants of health in the other 16.

This book covers most of the health-related SDG themes and, it is hoped, will assist the public health community in creating the intersectoral synergies necessary for implementing the sustainable development goals in the decades to come.

The new UN Sustainable Development Agenda recognizes that environmental degradation has its roots in profound social, economic, and technological inequities that can and should be remedied. This means that the entire local and global framework of public policies, initiatives, and programs to promote public health must be expeditiously, critically, and realistically harmonized and modernized to move toward sustainable development with greater justice and solidarity.

This publication offers an independent perspective and does not necessarily express the agreements and resolutions of the Governing Bodies of the Pan American Health Organization (PAHO). In its 31 chapters, more than 100 authors and co-authors from different countries of the Region of the Americas voice their opinions, analyze situations, and offer proposals for strengthening and advancing decision-making capacity, public policies, intervention programs, and the necessary lines of applied research.

This English edition of *Environmental and Social Determinants of Health* expands on and updates the content of the earlier editions published in Spanish in 2010 and Portuguese in 2011. Our hope is that it will foster a general understanding and further the debate about the importance of mitigating the health damage caused by the most pressing environmental and social determinants associated directly or indirectly with health issues.

This publication represents PAHO’s continued commitment to more coherent management of the health determinants, grounded in a series of ethical principles and policies geared to promoting the health and well-being of all, especially the most vulnerable population groups.

*Dr. Carissa F. Etienne*  
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# Preface

## **Assembling the evidence on environmental and social determinants of health**

Early in Chapter 1 of this volume, by Akerman and colleagues, I find:

“What stage are we now entering, after the publication of the CSDH (Commission on Social Determinants of Health) report in August 2008? A continuation of the debate on the Commission’s proposals, with the consequent implementation of its recommendations in public policies and academic research? Or has its influence on public policy and academic research agendas already begun to wane?”

How could I not read on? I chaired the Commission (CSDH), worked hard with my colleagues for 3.5 years, produced a report, and what happened then? Is any one listening? This whole volume, starting with Chapter 1, tells me that people are listening. Actually starting with the Editors’ Introduction when they use the phrase ‘the causes of the causes.’ This phrase, borrowed from Geoffrey Rose, became one of our signature tunes for social determinants of health. We need to address the proximate causes of health inequities but we need to address the structural causes of inequities in the distribution of those causes.

I describe myself as an evidence-based optimist. Here, from Akerman and colleagues in Chapter 1 is evidence for my sunny state. After describing Brazil’s Commission on Social Determinants of Health, they continue:

“Chile and Argentina also have national commissions and Costa Rica’s is in the pipeline. Additionally, a number of intersectoral committees have been established in the Region. No analysis has been made of the results of the national commissions, but one could be considered as a future initiative.

“Indeed, there is life after the publication of the Report of the WHO Commission on Social Determinants of Health! The issue remains on the agenda.”

If one needed further evidence of that assertion, here are Pellegrini and Buss in Chapter 2:

“The CSDH revived this tradition of thought and action (going back to Virchow), kicking off a global SDH-based movement to tackle inequities in health. Among the several lines of action developed by the CSDH, three stand out:

- Joint work with country partners, including Brazil, to foster and support national health promotion policies through intervention on the SDH;
- Creation of knowledge networks made up of eminent institutions and scholars to collect, analyze, and disseminate existing knowledge on relevant subjects related to the SDH;
- Social mobilization around the subject of SDH through joint work with civil society organizations at the global level.”
- 

Many of the chapters that follow are testaments to these statements.

The editors make clear that they did not set out to produce a text book or a concise statement of PAHO policy. That said, there is so much here of interest to anyone wanting to learn about environmental and social determinants of health: cities, ecosystems, climate change, air pollution, energy, natural disasters, consumer protection, human rights, work, social protection, violence, traffic deaths, early child development and much more.

The ‘Environmental and Social’ of the title is key. There is a long tradition of environmental health. As chapter authors make clear the CSDH gave a major boost to social determinants of health. What is needed is to put the two together. This book provides many of the essential building blocks to do just that.

For example, the chapter on ecosystems by Rodrigo and Romero makes the case that the poor are especially susceptible to the effects of ecosystem disturbance:

- Their health is more precarious.
- They have less access to environmental services such as drinking water; and to material goods at the household level.
- They are less able to cope with disasters and other events.
- Their productivity and employment in activities that depend directly on the ecosystem is lower.

An abiding impression from this volume is the depth of expertise in the Region on all the topics covered. This positive impression can be beguiling. In their chapter on work Borja-Aburto and Sousa Santana review what is known from global research that can be applied to the Americas. They point out, however, that a small minority of the published literature actually comes from Latin America and the Caribbean. There is a great need to foster more research on these topics in the Region.

The richness of the material here makes clear that there is still a good deal of intellectual heavy lifting to be done. The newly agreed sustainable development goals will, one hopes, provide the momentum for a wider array of monitoring throughout the region to measure inequities in environmental and social determinants and in health outcomes. The new PAHO-commissioned review of health equity in the Americas will have as its starting point the substantial body of work contained in this volume. The Review’s aim will be to learn from activities in the Region and elsewhere and to formulate concrete policy recommendations to achieve health equity. There can be no more urgent, and rewarding, task.

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# Introduction

We are pleased to present the new English edition of *Environmental and Social Determinants of Health*, which complements earlier editions published in Spanish in 2010 and Portuguese in 2011.

There are many reasons for publishing this book, the primary one being to reiterate the importance of environmental health—in its physical, biological, and social dimensions—as an increasingly relevant component of health agendas in the Region of the Americas. A growing body of evidence indicates that good or ill health is determined at both the individual and population levels by a diverse, interactive, and complex gradient of environmental and social factors.

Environmental health has been evolving very dynamically in recent decades. New and ever-more complex social and technological challenges on a global scale are growing, even as more basic unresolved environmental problems at the local level, with substantial cumulative effects on human health. Meanwhile, innovations in knowledge, methodologies, measurement and analytical tools, and above all, technology, offer tremendous problem-solving potential that is growing day by day; this indicates that with the necessary political will, many environmental threats can be substantially mitigated, thus promoting human well-being. To achieve more sustainable development, when reformulating their public policies and intervention programs, most of the countries of the Region are introducing some of these innovations to one extent or the other. Despite this progress, however, only limited results have been achieved, mainly because of the inability of societies to reach the political consensus needed to significantly alter the “causes of the causes” of the profound inequities that adversely impact the health and wellbeing of large population sectors. We hope that readers of this book will find useful information that may contribute to this debate.

This English edition coincides with the target year (2015) for achieving the Millennium Development Goals (MDGs) established at the start of the 21st century. Some of the chapters in the Spanish and Portuguese editions addressed issues relevant to the discussion and implementation of activities aimed at meeting several of the MDGs and also examined some of the neglected areas and gaps. We also hope that the new English edition will contribute to the achievement of the recently agreed by all nations: “Agenda 2030 for Sustainable development and its Sustainable development Goals (SDGs)”, which represents a unique opportunity to achieve important advancements on health, through changes in the Environmental and Social Determinants of health.

In every chapter of this book, the authors propose lines of research that could yield new evidence to fill in the gaps in our understanding of several areas of environmental health and the social aspects of health. The book provides continuity for a pioneering proposal to strengthen environmental health in Latin America and the Caribbean that was initially presented in 1993 by the Pan American Center for Human Ecology and Health (ECO/PAHO), together with the U.S. Environmental Protection Agency (EPA) and the U.N. International Program on Chemical

Safety (IPCS). The purpose of this proposal was to encourage the development and implementation of research projects designed to increase the scientific information needed for sustaining and evaluating policies and programs to reduce and mitigate some of the harmful health impacts of exposure to environmental contaminants.

The reader will find that in each chapter, the authors address issues that may be broached in other chapters of the book, but with different interpretations or approaches, which do not necessarily coincide with WHO and PAHO's official documents or resolutions. As coordinators of the publishing process, after extensive discussions with the authors, we reached the conclusion that it was more valuable to preserve the plurality and diversity of opinions and interpretations—especially, differences of opinion on a given topic—rather than try to reconcile or homogenize their approaches and conclusions, in the hope that this would enrich the debate from different angles and perspectives.

We are proud that this book represents a broad spectrum of opinions and proposals, especially given the keen intellect and experience of each author. The authors have highly diverse profiles, professional backgrounds, and experience but at the same time complement one another. They constitute a stimulating mix of experts from the health sector and other sectors that deal with the environmental and social determinants of health. The views of academics are combined with input from the day-to-day activities of experienced government decision- and policy-makers. Several of the authors work in WHO collaborating centers. In short, this book offers a wide range of highly diverse contributions on critical issues in theory and practice associated with the environmental and social determinants of health.

This English edition has been enriched with six chapters on topics not included in the original Spanish edition of 2010. Its 31 chapters have been divided into three sections. The first covers major cross-cutting issues and the frame of reference for the environmental and social determinants of health, including the transition to sustainable development and environmental health governance in the Region of the Americas. The second covers developments in important technical areas in Latin America and the Caribbean, in particular the development of epidemiology and risk assessment; toxicology development; interactions between environment and the genome; the vulnerability of populations to environmental risks; social and environmental determinants of chronic diseases; the role of laboratories in environmental health; cities and health determinants; the degradation of ecosystems; the emergence and reemergence of diseases associated with environmental degradation; risk communication; the formulation of indicators; and consumer health protection. Finally, the third section includes chapters that offer more detailed analysis of specific environmental health issues related to energy use; water resources and basic sanitation; the importance of recreational waters; genetically modified crops and foods; the potential impact of nanotechnology and nanoparticles on health and the environment; sustainable agricultural systems; occupational risks; the buildup of industrial and hazardous waste; air, water, and soil pollution; and emerging issues such as violence, road safety, tobacco smoke, the environment as a facilitator of child development, and the impact of technological environmental emergencies and natural disasters.

Although the book covers a wide range of topics, it is by no means encyclopedic. We are aware, moreover, that knowledge and evidence are increasing at an ever more rapid pace and that some topics may not have been analyzed or updated in great detail. Nonetheless, we hope that its content will be of interest to policy- and decision-makers in the various sectors, programs working to address the environmental and social determinants of health, and those who study these issues.

We are especially grateful for the support and dedication of all the authors and coauthors, who wrote their respective chapters with great commitment and vision.

This book has been published thanks to the strong support of Dr. Carissa F. Etienne, Director of PAHO, Dr. Francisco Becerra, Assistant Director of PAHO, and Dr. María Neira, Director of the WHO Department of Public Health, Environmental and Social Determinants of Health, to whom we express our sincere gratitude.

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Editors

## New health agendas based on social determinants

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### ■ Introduction

Buss and Pellegrini Filho (1) provide a brief, three-stage overview of how health policies have considered or ignored the social determinants of health since the 1970s (1): the Alma-Ata conference of 1976 and its proposal of the primary health care strategy to achieve health for all by the year 2000, which once again put the issue of the social determinants of health in the spotlight (2); the 1980s and 1990s approach to health as a private good, shifting the focus more to individual medical care; and (3) the debate on the Millennium Development Goals in the 2000s and the commitment made by the countries through the United Nations to achieving predetermined goals, once again stressing the social determinants of health, an emphasis reaffirmed with the creation of the WHO Commission on Social Determinants of Health (CSDH) in 2005.

What stage are we now entering, after the publication of the CSDH report in August 2008? A continuation of the debate on the Commission's proposals, with the consequent implementation of its recommendations in public policies and academic research? Or has its influence on public policy and academic research agendas already begun to wane?

Our theory is that the health context (the need for health system reform) and the political context (greater regulation of the market and more social participation), both worldwide and in the Region of the Americas, favor an agenda more geared to action on the social determinants of health and economic inequities.

It is therefore necessary to ascertain whether the mobilization achieved during the three years of work by the WHO Commission on Social Determinants of Health has led to sustainable conditions (political will, financing, effective projects, assessments, research, impact analyses, etc.) to keep the issue alive and ensure its more lasting and effective presence in policy and research agendas.

If so, it is necessary to determine which strategies have helped keep the social determinants of health inequities on policy and research agendas and ensure that they are reflected in intervention projects. However, if keeping the issue on the agenda proves problematic, it will be necessary to propose strategies to keep it alive in policy-making and research.

This chapter includes: a) a brief overview of the debate on health and society; b) a consideration of the most recent revival of the issue with the creation of the WHO Commission on Social Determinants of Health; c) a conceptual examination of the social determinants of health; d) observation of signs of the social determinants of health in policy and research agendas after publication of the global report by the WHO Commission on Social Determinants of Health; e) recommendations for the sustainability of the agenda on the social determinants of health; and f) the outlook for the future.

## ■ Health and society: A brief overview of the social determinants of health

Medical sociology was first defined by Charles McIntire in 1894 (2). German pathologist Rudolf Virchow (1821-1902), considered the father of social medicine, also contributed to the pioneering work on the relationship between health and society, and between health and policy, when he made his famous statement:

“Medicine is a social science and politics is nothing more than medicine on a grand scale”(3,4). Following Virchow’s line of reasoning, Ramón Carrillo (1906-1956), Argentine neurobiologist, neurosurgeon, and Minister of Health under Juan Domingo Perón from 1946 to 1954, was a kindred Latin American spirit connecting the social context with health and asserting that, as causes of disease, microbes pale in comparison with the diseases caused by extreme poverty, sadness, anxiety, and the social misery of populations (<http://electroneubio.secyt.gov.ar/DrRamonCarrillo.htm>).

From these ideas and those of many other authors in the field of health sprang theories on public health in the Americas, derived from the economic, social, and political sciences, that have split into various currents and systems of thought and action in medicine and health (3).

Important among them are the pioneering studies on social determinants of the health-disease process conducted by Jaime Breilh and Edmundo Granda in Ecuador, Alsa Cristina Laurell in Mexico, and Cecília Donnangelo and Sérgio Arouca in Brazil in the 1980s, to cite but a few of the many that relied on social epidemiology, the social organization of health, and the relationships between health and work to reveal the linkages between health and disease outside the health service environment (5).

Until the 1970s, ideas about health were grounded on the premise that medicine was at the same level as other subsystems—economic, political, educational—and, in this context, the assumption was that society could be changed through any of these sectors.

That point of view was grounded in the theory of multiple causality in the health-disease process, whereby risk factors for illness and death are considered as potential aggressors against human “hosts”(6).

These ideas prompted authors such as Breilh in Ecuador and Laurell in Mexico to conduct major studies on the social determinants of health as a criticism of traditional epidemiology. The main themes of their research were social reproduction, lifestyle, determinants, social class, and/or epidemiological profile (7). Breilh (8) explains that in the late 1970s, the studies by various social medicine groups in Latin America led to the emergence of the notion of the social determinants of health, making the relationship between social structure and health visible, and adopting basic categories from the critical social sciences, such as “economic system,” “work,” and “social class,” which had been banished from contemporary public health models. The author points out that the public health models employed up to that point had focused on Leavell and Clark’s systemic triad and MacMahon’s multiple causality networks.

Influential works in Brazil were the thesis *O dilema preventivista* (The Preventivist Dilemma), by Sérgio Arouca, published in 1975, and the studies by Cecília Donnangelo, also published in the 1970s, which reformulated the categories used in health analysis. These authors introduced Marxist theory into their research, an element that became essential to the development of public health theory (9).

The social determinants theory seeks to explain the health-disease process by taking into account the way society is organized and social life is constructed. Social organization also has political, economic, and social determinants that intervene in the distribution of health and disease within and among societies (10). It is assumed that the concept of determinants should be understood and analyzed from the standpoint of how a society is organized —i.e., its economic and social structure, insofar as that dimension subordinates the relevant natural dimensions to the physical environment and the genetic and physiological make-up of individuals (11).

Nearly 25 years ago, as Ayres *et al.* recount (12), the AIDS epidemic raised new questions in the field of health determinants, exploring the concept of risk and introducing a new instrument for understanding this epidemic and intervening: analysis of vulnerability to HIV infection. The authors held that vulnerability is not the product of a series of merely individual factors, but factors that are primarily collective and contextual in nature, and of the available resources that lead to higher or lower susceptibility to the virus and the disease. Consequently, three dimensions should be considered for its analysis: individual, social, and programmatic.

This brief historical overview shows the dynamic nature of the subject from a conceptual, political, and ideological standpoint. However, one question seems to persist over time: how to effectively and permanently intervene in the influence of lifestyle on the living conditions and health of populations.

## ■ The social determinants of health: Contemporary revival of an important issue

The historical background provided above and the action of several countries (manifested in such documents as the 1974 Lalonde Report in Canada and the 1980 Black Report in the United Kingdom, which addressed the direct roots of unfair health inequalities) and some of the results of the WHO Macroeconomics and Health Commission certainly played a role in reviving the debate on the social determinants of health together with the proposal of the Commission on Social Determinants of Health.

In August 2008, the Commission on Social Determinants of Health ([http://www.who.int/social\\_determinants/thecommission/en/](http://www.who.int/social_determinants/thecommission/en/)), created by WHO in March 2005 (13), concluded its work of reviving the global debate on the social determinants of health with the publication of its global report, “Closing the gap in a generation: Health equity through action on the social determinants of health” ([http://whqlibdoc.who.int/publications/2008/9789241563703\\_eng.pdf](http://whqlibdoc.who.int/publications/2008/9789241563703_eng.pdf)), whose abstract was translated into the six official languages of WHO (14).

The message for the media at the time of its launch was loud and clear and made the headlines of the world’s major newspapers: “Social injustice is killing people on a grand scale.” Many claimed the report was “ideology,” to which Michael Marmot, Coordinator of the Commission on Social Determinants of Health, responded that it was ideology —ideology with evidence, since “health inequalities that could be avoided by reasonable means are unfair” (*Fair Society, Healthy Lives, Marmot Review, Strategic Review of Health Inequalities in England post-2010*, 2010, pg. 3, <http://www.instituteofhealthequity.org/projects/fair-society-healthy-lives-the-marmot-review>).

The Commission was formed with the mission of making a connection between knowledge and action to lay the scientific foundations and mobilize agencies in various sectors to develop policies aimed at reducing health inequities. Its objective was to give social relations and the factors that influence health and health systems a privileged place on political agendas. To do so, it capitalized on its capacity to exercise leadership and mobilize public interest through the presence of members from prestigious institutions in the health sector as well as in other sectors (15,16).

In the Region of the Americas, in July 2005, the Pan American Health Organization (PAHO) invited its member countries to develop an agenda to tackle the social determinants of health in the Region. On 13 March 2006, Brazil created the National Commission on Social Determinants of Health in response to this call (17).

Chile and Argentina also have national commissions and Costa Rica’s is in the pipeline. Additionally, a number of intersectoral committees have been established in the Region. No analysis has been made of the results of the national commissions, but one could be considered as a future initiative.

Countless initiatives have been launched in recent years by international organizations, countries, social movements, nongovernmental organizations, and academia to address this issue and keep it on the political and scientific agenda.

WHO has laid the operational and conceptual foundations for the work of the Commission on Social Determinants of Health and facilitated networking with the countries; promoted the creation of a national commission on social determinants of health in the countries; launched initiatives throughout the world to document intersectoral activities, lessons learned from public policies, and data analysis; fostered capacity building, research, and inequity measurement by means of observatories; promoted the development of a knowledge network for introducing the social determinants approach in public health programs; published articles and reports on promoting equity in health; influenced global reports on the issue of equity in health; and more (18).

With the advent of the Commission on Social Determinants of Health, many countries in the Americas made a commitment to exploring the issue, creating commissions or high-level groups to address the social determinants of health in public policies (19). Many of the Region's professionals and academics have collaborated with the nine knowledge networks set up by the Commission on Social Determinants of Health:

- Early Child Development
- Globalization
- Health Systems
- Measurement and Evidence
- Urbanization
- Employment Conditions
- Social Exclusion
- Priority Public Health Conditions
- Women and Gender Equity

These networks involving multiple countries conducted an exhaustive review of the concepts and evidence related to the social determinants issue and produced sound reports; full copies of these reports can be accessed at the WHO website.

PAHO, its collaborating centers, and the governments of Brazil and Chile held a regional meeting of consultation with civil society on the social determinants of health, which yielded the document of consensus "Charter of Brasilia" (<http://www.bvsde.paho.org/bvsacd/cd65/CartaBrasilia-eng.pdf>).

Educational action based on the social determinants of health approach was taken in conjunction with WHO, national governments, and academia to train the staff of international organizations, public policymakers, and public health instructors (see, for example, [http://www.actionsdh.org/Campus/WHO\\_-PAHO\\_SDH\\_e-course.aspx](http://www.actionsdh.org/Campus/WHO_-PAHO_SDH_e-course.aspx)).

Eleven PAHO Representative Offices in the countries included indicators related to the social determinants of health in their planning for the biennium 2008-2009 and committed human and financial resources to promote and defend the social determinants of health approach in the countries. However, it was noted that many of these frameworks would have to be redesigned, either because they were not specific or were not related to social determinants of health. More careful analysis of the new work plans for the biennium 2010-2011 would be necessary to learn how technical cooperation capacity had evolved in terms of the social determinants of health.

The 48th Directing Council of PAHO took up this issue and examined ways of integrating the social determinants of health approach into other PAHO agendas—for example, primary health care (<http://www1.paho.org/english/gov/cd/cd48-14-e.pdf?ua=1>).

In this context, in its biennial work plan 2008-2009, PAHO allocated resources to address the social determinants of health issue in the MERCOSUR area, in response to the priorities set by the member countries of that integration system. The issue was examined and commitments were made in Foz do Iguacu (October 2008), Buenos Aires (June 2008), and Asunción (July 2008), where the ministers signed a resolution promoting policies based on the social determinants of health approach.

The 62nd World Health Assembly, held in Geneva on 18-22 May 2009, ratified the Report of the Commission on Social Determinants of Health in the document "Closing the gap in a generation: Health equity through action on the social determinants of health" ([http://apps.who.int/gb/ebwha/pdf\\_files/WHA62-REC1/WHA62\\_REC1-en.pdf](http://apps.who.int/gb/ebwha/pdf_files/WHA62-REC1/WHA62_REC1-en.pdf)), which called on the international community to take a position on this issue, urging the Member States not to keep silent in the face of social and health inequities and requesting the Director-General of WHO to take steps to strengthen capacity within that organization to give sufficient priority to relevant tasks related to addressing the

social determinants of health. The resolution's call to this group of stakeholders gives the social determinants of health approach an important place on the international and domestic policy agendas as a mechanism for reducing social and health inequities throughout the world.

The question now arises as to whether all the recent efforts stemming from the call to action by the WHO Commission on Social Determinants of Health are sufficiently sustainable from a political and financial standpoint to keep the issue on the agenda, and if so, whether it can translate into public policies that are manifested through local intervention projects.

Many critics (20-22) claim that this entire movement was an academic exercise with no basis in reality, a reductionist interpretation of the social determinants of health based excessively on epidemiological data and weak from the standpoint of an analysis of the economic, social, and political contexts. We applaud this effort by WHO, especially to promote discussion of the social determinants of health in the international arena, but we share the conclusion that much of what was said must be translated into tangible efforts and experiences at the local level.

## ■ Question: At the end of the day, what are the “social determinants of health”?

Across the planet, vulnerable, socially disadvantaged people have less access to health resources and suffer and die earlier than those who enjoy a more privileged social position. Health disparities continue to grow, despite unprecedented wealth and global advances in technology. Most health problems can be attributed to the social conditions in which people live and work: these conditions are called the “social determinants of health” (23).

As already noted, recent years have seen growing interest in the relationships between population health, inequalities in living conditions, and the degree to which networks of linkages and connections have been developed among people and groups.

But, how should these inequalities be understood? According to Whitehead (24), what best defines these inequalities is the term *inequity*, or “differences that are unnecessary and avoidable, as well as excessive and unjust.”

Several studies note that once a country exceeds a particular economic growth threshold, an additional increase in wealth does not translate into major improvements in health conditions (25). This leads to the conclusion that the most important factor in explaining a country's general health situation is not its total wealth, but how that wealth is distributed. The assumption that the determinants of inequities are related to the ways in which a society is structured is the foundation for studies that propose models for exploring the relationships between how society is structured and the health status of its population, the purpose being to establish a hierarchy among the determinants, based on social, economic, and political factors and the mediators through which these factors affect the health status of the population (25).

The same authors add that by understanding this web of mediations we can explain, for example, why there is no consistent correlation between a society's macroindicators of wealth, such as the gross domestic product, and health indicators. Although the volume of wealth generated by a society is fundamental to improving living and health conditions, examining these mediations makes it possible to understand why some countries have a total or per capita gross domestic product that is much higher than that of others with far more satisfactory health indicators (27). From these mediation studies emerges the possibility of indicating the points where policy interventions can reduce health inequities.

Wilkinson and Marmot (26) looked for evidence in the relationships between the social determinants of health and the health conditions of populations and listed 10 social determinants of health: the social gradient, stress, early life, social exclusion, work, unemployment, social support, addiction, food, and transport. This work influenced the health policy of several countries, especially the United Kingdom (27).

Another classic study is that of Diderichsen, Evans, and Whitehead, published in 2001 (28), adapted from Diderichsen and Hallqvist's model, published in 1998, which notes that the social context facilitates social stratification, leading to differences in the social status of individuals, which determines their opportunities with respect to health (29).

The main contribution of this model is its analysis of points for policy action: “social context” refers to the delegation of social status, which implies social mechanisms for the distribution of power, wealth, and risks (i.e., the

social position of individuals); “social stratification,” which is different from social position, refers to exposure to risks; and “differential vulnerability” refers to differences in the consequences of an illness (1, 29).

The model points out the differences in exposure, vulnerability, and their consequences and shows where policies should be implemented to act on social stratification mechanisms (1). These authors explain that, in order to combat health inequities, intervention in social stratification mechanisms becomes of paramount importance, even though the responsibility for this intervention does not lie exclusively with the health sector.

Another study to explain the action of the social determinants of health is the model proposed by Dahlgren and Whitehead in 1991, (30) which is designed to demonstrate how the social determinants of health act in terms of the health inequities of social groups, distributing them at different levels depending on their scope.

This is a way of explaining how social inequalities in health occur as a consequence of the interplay among the different levels of conditions, from the individual level up to the level of communities affected by national health policies (29). This model includes four levels or layers: at the center of the figure are people, with their age, sex, and genetic factors —i.e., the personal characteristics that influence health. The innermost layer involves people’s lifestyles, including their behaviors. At this level, other determinants influence their attitudes and choices. At the next level, social and community networks influence personal patterns at the innermost level, for better or worse. At the next level of the figure are factors related to living and working conditions, the availability of food, and access to basic services. This level corresponds to cases in which socially disadvantaged people exhibit differences in exposure and vulnerability to health risks as a result of poor housing, exposure to more hazardous or stressful working conditions, and less access to services. Finally, at the outermost level, are the macrodeterminants: the prevailing economic, cultural, and environmental conditions in society that influence the overall process (29, 31).

Although this issue has been subject to a great deal of study, it still sparks debate and controversies.

Some people are critical of the expression “social determinants,” because they believe it implies the existence of a powerful social force that determines the action of social actors, causing them to lose their capacity for collective transformation and the search for identity (32).

For others, the expression “social determinants” as it relates to the health-disease process possesses potent explanatory power and offers strategic elements for the necessary social transformation: as they become factors, social determinants lose their dimension as sociohistorical processes (21, 33).

There also is a polemic surrounding the expressions “health determinants” and “determinants of health inequities.” For some people, the former is equivalent to the “risk factors” of classical epidemiology. When distinguishing the latter from the former, they associate it with a more transformative nature, believing it could facilitate an understanding of the unjust hierarchies of social structures, thus revealing the true “cause of the causes” of health inequities (34).

The debate is not over, but it is important to understand wealth and the polysemy of the “social determinants of health” concept. Adopting a common language would perhaps foster more coordinated political action.

Until we agree on a lingua franca, we must consider the “social determinants of health” concept in all its depth and breadth. Starting from this perspective, an understanding of the health-disease process will enable us to gain a broader, policy-oriented vision and show us the need for more coordinated and integrated public policies —between governments, social movements, and nongovernmental organizations – whose objective is a life worth living for all.

## ■ Observing signs of the social determinants of health in policy and research agendas since publication of the Report of the Commission on Social Determinants of Health

Revisiting the introduction to this chapter, where Buss and Pellegrini Filho (1) are cited as providing a brief three-stage overview of the way the social determinants of health have been considered or ignored in health policy-making since the 1970s, we would ask: “What stage is the issue of the social determinants of health now entering, since publication of the Report of the Commission on Social Determinants of Health in August 2008?”

Beyond Latin America, we can already detect signs of the entrenched nature of the debate and its propositions, with the consequent implementation of its recommendations in public policies and university agendas.

A first sign is *Fair Society, Healthy Lives, Marmot Review, Strategic Review of Health Inequalities in England post-2010*, published on 11 February 2010 and available at <http://www.instituteofhealthequity.org/projects/fair-society-healthy-lives-the-marmot-review/fair-society-healthy-lives-full-report>.

This analysis had four objectives: 1) identify the evidence most relevant to underpinning future policy and action to address health inequalities in England; 2) show how this evidence could be translated into practice; 3) advise on possible objectives and measures, building on the experience of the current Public Service Agreement target on infant mortality and life expectancy; and 4) publish a report of the Review's work that will contribute to the development of a post-2010 health inequalities policy.

Another sign was the Social Determinants of Global Population Health Conference, held 15-16 January 2010 in Cambridge, Massachusetts, USA, by the Harvard Center for Population and Development Studies, information about which can be found at <http://www.hsph.harvard.edu/population-development/events/past-events/#2010>. The conference's statement of objectives buttresses our hypothesis that the debate continues in the wake of the Report of the WHO Commission on Social Determinants of Health when it indicates that the objective of the conference is not to reinvent the work of the Commission but to take advantage of its recommendations. To this end, it attempted to formulate recommendations for concrete policy action, especially for the eight countries represented at the event (Brazil, China, India, Japan, Mexico, Uganda, the United Kingdom, and the United States). It also proposed keeping the issue on the research agenda, noting that the purpose of the event was to develop an applied research program to construct a database of evidence for policy development and lay the political foundations for keeping the issue on national policy agendas; this would be accomplished through a commitment by governments to take the lead and adopt a social determinants approach in national health policy.

More relevant still as a sign of the continuity of efforts to implement the recommendations of the Commission on Social Determinants of Health report was the call for the World Conference on Social Determinants of Health, which was held in Rio de Janeiro, Brazil, in 2011, as a demonstration of WHO's interest at that juncture. The Rio Declaration ([http://www.who.int/sdhconference/declaration/Rio\\_political\\_declaration.pdf](http://www.who.int/sdhconference/declaration/Rio_political_declaration.pdf)) was an effort by the countries to keep the issue on the international agenda. However, it did not meet the expectations of many segments of society, and other, parallel declarations with demands not addressed in the official declaration materialized. See, for example, "Protecting Right to Health through Action on the Social Determinants of Health. A Declaration by Public Interest Civil Society Organisations and Social Movements. Rio de Janeiro, Brazil (18 October 2011)," available at <http://www.phmovement.org/sites/www.phmovement.org/files/AlternativeCivilSocietyDeclaration-20Sep.pdf>.

This chapter proposes to see whether there are signs of practical application of the social determinants of health approach, mainly following publication of the Report of the WHO Commission on Social Determinants of Health (2008-2010), in 1) public policy agendas, 2) the development of applied research agendas to create a database for interventions, 3) ongoing education, and 4) local intervention projects based on the social determinants of health, or whether interest in the issue and its influence on public policy and academic research agendas has already begun to wane. To identify these signs, an exploratory online search was conducted in the Virtual Health Library (all sources), using the delimiters "Latin America" and "2005-2010" and the keywords "determinants AND health" (in Portuguese and Spanish) (35) in titles.

These indications (signs) consist of the existence (or absence) during the period in question of articles, theses, technical papers, educational resources, and local projects and initiatives on the analysis, implementation, or evaluation of initiatives based on the health determinants approach.

This study is exploratory and does not pretend to be exhaustive. We recognize its limitations, since it presents only evidence regarding the places and circles where interest in the issue of the social determinants of health and health inequities is observed in Latin America. This evidence, however, offers prospects for networking and more in-depth analysis of the topics with the actors encountered.

## ■ Social determinants of health in the Region of the Americas: Signs of life detected

Having established the search methodology (in the Virtual Health Library, using the words "determinants AND health" jointly in the title), the search in Portuguese yielded 29 hits (2005-2010), 11 of which (1) (six articles,

three theses, and two technical papers) (37) were devoted to analysis of the public policy agenda (6), the research agenda (1), and local projects (4). There were two studies on municipal management (Campo Bom, Rio Grande do Sul; Calgary, Canada; Imbituba and Garopaba, Santa Catarina), and the other nine, on academia (Rio de Janeiro, São Paulo, Bahia).

Worth noting are the authors' efforts to go beyond mere conceptualization of the social determinants of health and its doctrinaire aspect, seeking instead to better describe the use of the social determinants of health approach. Also important are Gonzalez's work (2009) on the use of this approach in the planning and decentralization of health administration; Buss and Pellegrini's (2008) cogent analysis of the role of other sectors involved in public policy-making to address the social determinants of health; Faenstein's epidemiological research (2008) to develop an agenda for tackling the social determinants of health linked with obesity, cancer, and mental health and to calculate the contextual variable through a study of residential areas; Dowbor (2008) and Aquino's (2006) demonstration of the aggregate capacity of the Family Health Program to intervene in the social determinants of health; and Rummel *et al.*'s (2005) conclusion about the need for continuous quantitative and qualitative monitoring of local activities (36).

The presence of almost 50% local experiences in our sample is a good sign (4,11) that reveals the effort to implement use of the social determinants of health approach in response to the criticism that the current wave of debate on this issue is nothing more than an academic exercise with no basis in reality. Here, however, it is necessary to look deeper to determine to what extent the slow but steady decline observed in social inequality in Brazil over the past nine years, with its significant impact on the Gini coefficient (from 0.567 in 1998 to 0.515 in 2008; IBGE/PNAD. See [http://g1.globo.com/Noticias/Economia\\_Negocios/0,,MUL1308447-9356,00DESIGUALDADE+CAI+NO+PAIS+EM+DEZ+ANOS+DIZ+IBGE.html](http://g1.globo.com/Noticias/Economia_Negocios/0,,MUL1308447-9356,00DESIGUALDADE+CAI+NO+PAIS+EM+DEZ+ANOS+DIZ+IBGE.html)) (in Portuguese only), is related to local initiatives promoted by national government policies to address the social determinants of health; such initiatives include the Bolsa Família family assistance program, the Family Health Program, and the program to increase access to education, and even more importantly, economic measures, such as the increase in the minimum wage, the loosening of credit, and more job creation stemming from economic growth (38).

The method proposed in the Gonçalves and Bógus study (39), which examines actions to address the social determinants of health in a local initiative in Campo Grande, is another positive sign that offers an opportunity for this in-depth analysis at the local level.

The search in Spanish yielded 50 hits (2005-2010), including 36 (12 articles, 1 editorial, 2 research reports, 17 technical papers, 4 educational resources) related to analyses of the public policy agenda (22), the research agenda (5), the continuing education agenda (8), and local projects (1).

Unlike the results of the search in Portuguese, it was found that the texts in Spanish included more technical papers from central governments (Chile, Colombia, Mexico, and Peru, for example). The material in Spanish includes only one documented local experience (40), in comparison with four in Portuguese, reflecting perhaps the higher degree of centralization of governments in the Spanish-speaking countries of the Americas. A clear sign from the Chilean documents is the explicit statement that the purpose of efforts to address the social determinants of health is to achieve equality in health. The technical papers in Spanish reflect PAHO publications and policies, and the important message that can be gleaned from these documents is the recommendation that action on the social determinants of health not be disassociated from other mandates, such as the Millennium Development Goals, health promotion, and "Healthy Municipios and Communities" (41). There are also suggestions on how to integrate the social determinants of health and the health services, an issue that often creates unnecessary friction between the health services and efforts to address the social determinants of health (42).

Also prominent are proposals for lines of research to develop conceptual and methodological guidelines for bringing measurement of the health status of populations closer to the social determinants of health approach (43). One important sign is seen in another work that calls on all those who advocate the social determinants of health approach not to forget to include environmental conditions in their analysis and intervention models, (44), and another is the participation of civil society, represented by a coalition of organizations (45). Yet another important sign detected in the analysis of the Spanish publications was the significant presence of open educational resources with several applied instruments on the social determinants of health and public policy-making, for example, the social determinants of health approach and the role of a public health observatory (46). These resources make it possible to develop continuing educational processes, an important factor for maintaining a social determinants of health agenda.

## ■ Constraints, recommendations, and outlook

The signs detected show that there is need, interest, knowledge, supply, and demand for the social determinants of health to remain on Latin America's policy, research, and education agendas. This is not to say that the approach has been given a green light; rather, a careful critical analysis of the material studied suggests a yellow light of attention or warning. Thus, recommendations must be extrapolated from the signs received. Some suggestions:

1. Countries could make equity in health an integral part of all policies and promote the use of instruments and indicators to quantify the impact on health and health equity.
2. National policies targeting the social determinants of health could be harmonized with local horizontal approaches.
3. Equity should be understood as the degree of success in the implementation of the social determinants of health approach and not just the quantitative result of a reduction in deficiencies related to a mere intervention in the determining variables.
4. The participation of social movements should occupy center stage in advocacy, in the formulation, implementation, and assessment of public policies, and in research agendas based on the social determinants of health approach.
5. Teaching institutions could share their research agendas more with municipal administrators, seeking technology transfer methods for practical application of the social determinants of health approach in management.
6. In analyses of intersectoral action, a more accurate determination of each sector's role in addressing the social determinants of health is needed.
7. Associating the social determinants of health with specific epidemiological research topics could encourage interdisciplinary research.
8. Systematic documentation of local activities that affect the social determinants of health could enhance the power of the approach to explain the effects of strictly economic measures.
9. Local action to tackle the social determinants of health could be preceded by ongoing qualitative and quantitative monitoring.
10. Demonstrating that mass public health care policies can affect the social determinants of health could lead to better targeting of investments.
11. It is essential that models for analysis and intervention in the social determinants of health put the variables of environmental justice and climate change on an equal footing.
12. Providing open online educational resources is a good way to democratize teaching and learning about the social determinants of health.
13. The Pan American Health Organization needs to resume its role as coordinator and facilitator in merging parallel agendas with the social determinants of health approach to prevent the fragmentation of activities.

At the end of the lectures he gives around the world in his crusade to promote action on the social determinants of health, Michael Marmot—English epidemiologist and Coordinator of the WHO Commission on Social Determinants of Health from 2005 to 2008—always says that this sectoral effort to promote equity in health needs to become an authentic global movement spearheaded by the United Nations; in other words, a movement that will prompt deliberate efforts that move hearts, minds, governments, and social movements to step into the public policy arena and fight the unequal and unfair distribution of resources, services, and power among groups and countries noted in the Report of the Commission on Social Determinants of Health. This would be a **first goal** following the Commission's report: organize initiatives to spark this global movement.

Such a movement will certainly not be led by individuals working on their own but by organizations that can keep the issue alive and dynamic. An example from Brazil illustrates this **second goal**: the creation of the Center for Studies, Policies, and Information on Social Determinants of Health (CEPI-DSS) at the Oswaldo Cruz Foundation (FIOCRUZ), with the general objective of supporting government and civil society activities to promote equity in health through the production and dissemination of knowledge and information, the training of personnel, and the

monitoring and evaluation of sectoral and intersectoral policies and programs that act on the social determinants of health.

A **third goal** would be to treat information as a public good easily accessible to everyone who needs it. Constructing the social determinants of health portal of the Virtual Health Library (BIREME) in three languages (Portuguese, Spanish, and English) would be an expression of this ethical imperative (<http://bvdsdss.icict.fiocruz.br/php/level.php?lang=en&component=34>).

A **fourth goal** related to the portal would be to assess, monitor, and broadly disseminate to different audiences the various types of data and information on equity and inequity collected and analyzed by observatories, in order to influence public policies that promote equity and the democratization of opportunities.

A **fifth goal** would be to systematically document coordinated intersectoral interventions in emerging local or regional situations where harm is detected in a specific sector due to consequences that affect services, but where the sector does not have the operating capacity or ability to resolve the situations. Furthermore, to prevent environmental injustice, conflicts over land ownership, or city planning interventions that could have permanent negative repercussions for the affected group, projects should be subject to some precautionary and control mechanism prior to approval.

An illustrative example of this was the action taken by a municipal health administrator in a city in the ABC region of Greater São Paulo. This administrator and his team observed that a new road project in his area divided a community in two, in addition to erecting temporary housing for men, primarily young bachelors. This situation affected the community in several ways. The health services noted a significant jump in adolescent pregnancies, as well as an increase in the incidence of sexually transmitted diseases.

There is no doubt that the health services have the responsibility for dealing with such problems and mitigating their effects. However, some social and health consequences cannot be addressed or even fully anticipated by the health services, for example, the harmful effects of splitting the community in two with the construction of the road project. Another interinstitutional mechanism should have been created to handle this problem, which had permanent consequences for local residents.

The unanticipated effects of infrastructure projects or other public policies lead to a **sixth goal**, which is pressure and advocacy by ombudsman's offices and the Public Ministry through a health equity impact report modeled after the "Report on the Environmental Impact of Infrastructure Projects."

Last but not least is the **seventh goal**, taken from the article by Galvão et al. (47), whose title announces that the environmental and social determinants of health agendas should be interlinked:

*Climate change is a common concern for every sector of society and interventions addressing public health and climate change can strengthen inter-sectoral collaboration, which is needed to tackle such a complex issue. The social determinants of health agenda calls for strong cooperation and collaboration between all actors within society and reinforces the social pillar of climate change. In order to highlight the links between these pillars, we conclude by reiterating the messages in the CSDH report, namely:*

- *Firstly, we need to ensure that economic and social policy responses to climate changes and other environmental degradation take into account health equity.*
- *Secondly, there is widespread recognition of the disruption and depletion of the natural environmental system, climate change included. It is not a technical discussion between environmental experts, and should concern large portions of people affected by their consequences.*
- *Thirdly, underpinning the call for global human justice, the inescapable evidence of climate change and environmental degradation have set clear limits to a future based on the status quo and are promoting and increasing global willingness to do things differently.*
- *Fourthly, international agencies and national governments building on the Intergovernmental Panel on climate change (IPCC) recommendations, consider the health impact of agriculture, transport, fuel, buildings, industries and waste strategies concerned with adaptation to and mitigation of climate change.*
- *Fifthly, much more analysis of the relationship between social determinants of health, environmental change and health inequities is needed to inform policy and practice.*

*Last but not least, as all authors on social policies have stressed the agenda for climate change should not be seen as one more silo in the social determinant of health framework but a bridge to be connected to the other agendas in an articulated and integrated manner to reinforce the claims for social justice and health as a human right.*

According to *Health in the Americas* the environment is where life happens, where needs are met, and where the appropriation and use of resources are concretized. It protects and provides conditions for good health, and shapes and is shaped by human action in a dynamic relationship. The same socioeconomic driving forces that define social classes, organize the industrial and agricultural production, delineate trading norms and rules, and demarcate the possession and distribution of goods and services in the society are the ones who define how human beings interact with different environmental ecosystems. The environmental determinants of health are complex, and not necessarily country based. Binding conventions and international agreements, as well pressures of the market posed by the Global economy can greatly influence the environmental component of the country's burden of disease.

Canada, for example, keeps asbestos mining active despite the fact there is no internal market for asbestos in the country anymore, being the totality of the production meant to less controlled markets of developing countries. Asbestos is a powerful carcinogenic and there are safer and affordable alternatives in the market. Because of its high economic interests, as asbestos still mobilizes large resources in the world, Canada has opposed to all types of banning or restrictions of asbestos in international forums on chemical safety in the past years, which could greatly benefit primary prevention of cancer worldwide by decreasing the population entering "at risk". Mining workers in Canada may accept the risk of being exposed to the toxic mineral fibers due to lack of other job opportunities, and based on the idea they know how to protect themselves, have access to protective equipment, and to good quality of health care. All of this is most certainly missing for workers and populations in less developed countries, where they may be powerless to influence national policies, and at higher risk of exposure and disease.

The same could be said on the water scarcity in Peru due to the disappearance of ancient glaciers, a consequence of Global warming, which increases risks of water-borne diseases and, of human insecurity due to increase in conflicts between farmers (great consumers of scarce water) in the mountains and the people in the cities. Other example is the Westernization of China's culture that has enormously increased the demand for beef, boosting areas for cattle grazing in Brazil, including in vulnerable areas of the Amazon Region, increasing carbon emissions that affect global climate, with consequences for human health locally and worldwide.

Within a country's socioeconomic context, inequities can also determine who are more prone to be exposed to environmental risks. Air pollution, for instance, is not equally distributed in space, and low socioeconomic position has been associated to increased risk of effect of air pollution exposure. However, typical monitoring networks are not dense enough to characterize neighbourhood differences in the cities. A recent study in Florida, USA (Stuart, Mudhasakhul & Sriwatanapongse, 2009) used a qualitative ecological approach to show inequalities, using a inequity index that quantifies the potential inequities in the proximity of point sources of air pollution, and to air quality monitoring sites. Blacks, Hispanics, and people living in poverty were found to live disproportionately near sources of air pollution and away from air quality monitoring sites, characterizing environmental injustice.

Another aspect that could be highlighted is that the increase in the prevalence of non communicable diseases worldwide and specifically in the Americas cannot be halted without interventions on the environmental determinants. Clean and safe neighbourhoods with plenty access to playgrounds and social life, a great variety in the availability of quality controlled food and housing, healthy workplaces etc., could greatly contribute to reduce risks of premature death and disability, in addition to the traditional approach of improving health care, and health promotion based exclusively on personal choices.

Escalating human pressure on the environment causes environmental changes and ecosystem impairment, which in turn, results in human health impacts. Global environmental changes include desertification, water scarcity, loss of ecosystems and loss of biodiversity, among others. These phenomena have their own drivers; however, climate change is acting as an additional driver impacting these in a negative way. In addition, environmental changes have a direct effect on human well-being and health, by changing the distribution of infectious diseases, nutritional status and patterns of human settlement (WHO, 2005). (EN <http://www.who.int/globalchange/ecosystems/ecosys.pdf>).

**Source:** Chapter 3, *Health in the Americas*, 2012

## ■ Conclusion

Indeed, there is life after the publication of the Report of the WHO Commission on Social Determinants of Health! The issue remains on the agenda.

Important signs buttress this assertion. However, the guarantee of this longevity must be consolidated in a concrete demonstration that this life —or rather, the adoption of the social determinants of health approach— can improve other lives. This will be an ongoing challenge.

The signs detected do not fully answer many of the questions raised throughout this chapter, but point the way in the recommendations.

In any case, we believe that this life could also be hanging by a thread without leadership; knowledge; good-quality, transparent, and easily accessible public information; resources; systematic and analytical documentation; evaluations of existing activities; and new projects that improve people's lives.

In the words of Dr. Carissa F. Etienne, Director of the Pan American Health Organization:

*Preparations for the 8th Global Conference on Health Promotion are now well underway. The main theme of the conference is 'Health in All Policies' – a public-policy approach across sectors. **Health in All Policies addresses health effects across agriculture, education, environmental, housing, transportation, fiscal, and other policies. It seeks to improve health and at the same time contribute to the well-being and wealth of communities through structures, mechanisms, and action planned and managed primarily by sectors other than health.** In other words, Health in All Policies is not confined to the health sector and the public health community but is a complementary strategy aimed at improving a population's health, with health determinants as the bridge between policies and health outcomes. **Health in All Policies reminds us that we must continue our efforts to improve health in partnership with other sectors by identifying mutual interests that can serve both health and other policy aims and impacts.***

***Universal health coverage is a case in point. Universal health coverage represents the spirit of Alma-Ata in 21st century terms. It opens up a new opportunity to put people at the center of development, taking the social and environmental determinants of health into account. This requires multisectoral collaboration.** Engagement with ministries and institutions responsible for fiscal, monetary, and education policy is essential to ensure adequate funding for health, raised in ways that minimize financial barriers, to allow the appropriate types of health workers to be trained. Collaboration with the ministries of labor and social security to ensure that social protection becomes universal and is not limited to the formal sector is, in fact, a requirement of the UN's Social Protection Floor Initiative. Strong political leadership and commitment is important to make such collaboration work, and universal health coverage has the potential to increase economic growth, improve educational opportunities, reduce impoverishment and inequalities, and foster social cohesion.*

*The outcome of the United Nations Conference on Sustainable Development has further emphasized the relationship between universal health coverage and the social, environmental, economic, and security dimensions of the sustainable development framework. **Universal health coverage is one of the enablers of sustainable development and offers a way of sustaining gains and protecting investments in the current set of health-related post-Millennium Development Goals.***

*Debates about the post-Millennium Development Goal targets are also well underway. **Formal UN discussions have now begun. Universal health coverage and its contribution to sustainable development must be recognized and incorporated into post-2015 development goals and targets. This will enable countries to move rapidly towards it and preserve the gains that many have already made. It will also require commitment at the highest level, as well as innovative partnerships that entail agreements on shared higher goals across sectors.***

*As we approach the 2015-mark, we are hopeful that there will be a global agreement to work towards universal health coverage as a fundamental public health goal that puts equity at the very center. **Achieving health equity on a global scale will require not only the acknowledgement that health is determined by factors that lie outside the health sector, but also the commitment of resources from government, the private sector, academia, and civil society.** Recognition of the interdependence of all sectors in a community, region, and country is necessary for improving health, along with acknowledgment that a participatory approach that includes the communities that are most marginalized is needed for success in reducing health inequities. Policy coordination is necessary to address the various social determinants of health by integrating health in all policies, whether education-, environment-, employment-, or transportation-focused. Global strategies to achieve health equity can mirror those strategies in local communities by building social, political, and economic power in communities where resources are scarce and where health inequities are concentrated.*

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# The social determinants of health movement in Brazil

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## ■ Introduction

The importance of the social determinants of health (SDH) and the need to address the inequities in health they generate<sup>1</sup> (1) gained new momentum with the creation of the World Health Organization (WHO) Commission on Social Determinants of Health (CSDH) in March 2005. In fact, it has long been known that the distribution of health and disease in the population is not random but, rather, due to the socioeconomic stratification of population groups. In the mid-19th century, authors such as Villermé (1782-1863) in France and Chadwick (1800-1890) and Engels (1820-1895) in England observed a clear association between high mortality rates and poverty, although their opinions about the causes of this association, and especially its solutions, differed (2).

Also at this time, Virchow (1821-1902) stated that “Medicine is a social science and politics is nothing else but medicine on a large scale.” According to this author, one of the main functions of public health was to study the living conditions of the various social groups and determine the effect of these conditions on health. In order to fulfill its great task, medicine should intervene in political and social life, identify the obstacles that prevent normal functioning of vital processes, and remove them (3).

Throughout the 20th century, great strides were made in the study of these relations, particularly those between living and working conditions and health status. Research efforts currently focus on the ways in which the SDH generate health inequities among social groups (4). Latin American social epidemiology contributed significantly to the study of the social determination of health and disease in the countries of the Region (5).

By recognizing that health is a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity, the definition of health adopted in the 1948 WHO Constitution recognizes the importance of the social determinants of health. This approach was subsequently reiterated in the 1978 Declaration of Alma-Ata, adopted at the International Conference on Primary Health Care, which states that “The existing gross inequality in the health status of the people particularly between developed and developing countries as well as within countries is politically, socially and economically unacceptable.” The five International Conferences on Health Promotion held between 1986 and 1997—particularly the first one, which gave rise to the Ottawa Charter—emphasized the importance of acting on the SDH as a means of promoting health. By recognizing peace, shelter, education, food, income, a stable ecosystem, social justice, and equity as essential requirements for the health of the people, the Ottawa Charter identified the following as key conditions for health promotion: building healthy public policies, creating supportive environments, strengthening community actions, developing personal skills, and reorienting the health services (6).

The CSDH revived this tradition of thought and action, kicking off a global SDH-based movement to tackle inequities in health. Among the several lines of action developed by the CSDH, three stand out:

- Joint work with country partners, including Brazil, to foster and support national health promotion policies through intervention on the SDH;
- Creation of knowledge networks made up of eminent institutions and scholars to collect, analyze, and disseminate existing knowledge on relevant subjects related to the SDH;<sup>2</sup>
- Social mobilization around the subject of SDH through joint work with civil society organizations at the global level.

The CSDH final report, titled *Closing the gap in a generation*, was published in September 2008 and is available online at [http://www.who.int/social\\_determinants/final\\_report/en/index.html](http://www.who.int/social_determinants/final_report/en/index.html). The report highlights three key strategies to tackle health inequities:

- improve daily living conditions;
- tackle the inequitable distribution of power, money, and resources;
- measure and understand the problem and assess the impact of action.

Brazil entered the global SDH movement set in motion by WHO early and decisively, establishing a National Commission on the Social Determinants of Health (CNDSS) only one year after the creation of the CSDH, in March 2006. The CNDSS was established by Presidential Decree to serve a two-year term. This early engagement of Brazil is consistent with a longstanding tradition of commitment by public health professionals, researchers, and other sectors of society at large to the improvement of the health situation of the Brazilian people. Indeed, since the early 20th century, Brazilian public health professionals have devoted their efforts to improving knowledge about the relationships between socioeconomic determinants and health and to developing concrete actions based on this knowledge, with a view to improving health and living conditions. Inspired by this tradition, various sectors of society became part of a health sector reform movement that contributed decisively to recognition by the 1988 Constitution of health as the right of every citizen and the duty of the State and to the establishment of the Unified Health System (UHS), founded on the principles of equity, solidarity, and universality.

The creation of the National Commission on Social Determinants of Health was part of the health sector reform process. Composed of prominent leaders of the social, cultural, scientific, and business sectors, its diverse membership reflects the recognition that health is a public good constructed through the collective involvement of all sectors of Brazilian society (7).

During its two years in operation, the Commission carried out a series of activities related to the generation of information and knowledge about SDH and the review of SDH-related policies and interventions, as well as mass media activities. The objective of the latter was to promote greater societal awareness of the importance of health inequities and the possibility of fighting these inequities by acting on the SDH, in the understanding that these determinants are a product of human action and therefore can and should be modified by human action (8). In other words, the CNDSS emphasizes the influence of the social determinants in creating health inequities, while simultaneously recognizing that this determining relationship should not be viewed fatalistically, as the health situation of an individual or group is not inevitably predetermined by social position. Conversely, this determining relationship provides ample room for individual decisions or choices, just as these choices are subject to objective limitations (9).

The final report of the Commission, *As causas sociais das iniquidades em saúde no Brasil* (“The social causes of health inequities in Brazil”) (10), is a product of this work. Written by the CNDSS technical secretariat and submitted for public comment before publication, the Report includes a review of the major economic and social changes in the country in recent decades, as well as an analysis of progress made and challenges remaining for the health situation of the Brazilian people, with particular emphasis on the challenges posed by health inequities. This work was made easier by the availability of comprehensive, reliable information systems, as well as by the quantity and quality of the nation’s scientific output. Based on this situation analysis and a review of ongoing interventions targeting the SDH, the Commission makes a series of public policy recommendations for the promotion of health and well-being that affect the social determinants at all levels —i.e., interventions that affect the economic, social, and cultural macrostructure, living and working conditions, and individual risk patterns.

The key conclusions of the CNDSS report are presented below, along with some updated data, both on health situation analysis grounded in the SDH approach and, especially, on recommendations for policies and interventions for tackling health inequities. Some ongoing initiatives inspired by the work of the CNDSS are then described.

## ■ The CNDSS Report

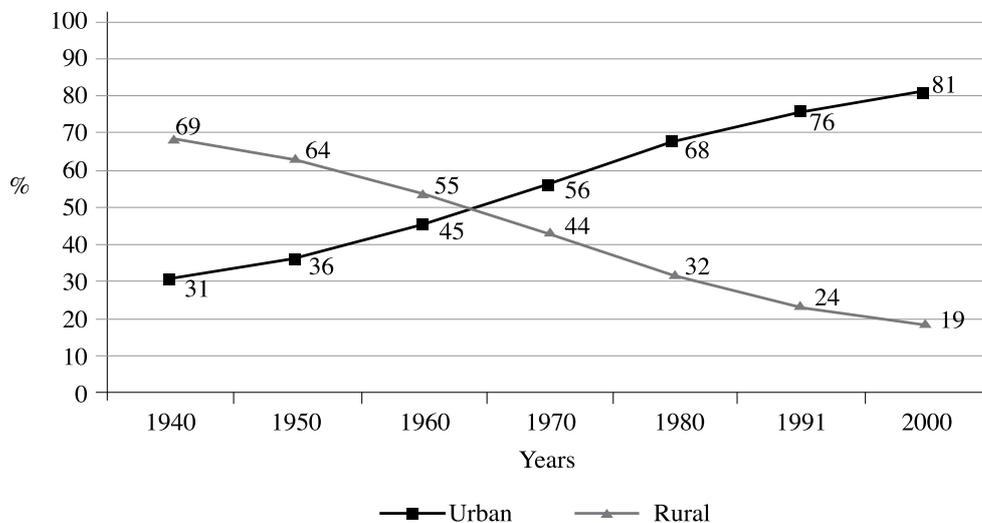
### The health situation and its determinants

The Report begins by highlighting the major economic, social, and demographic changes that have taken place in Brazil, particularly in the past four decades, with a significant impact on the living and working conditions of the population and, consequently, its health situation. The 1960 census revealed that 55% of the workforce (therefore, a majority) was active in the primary sector, while the remaining 45% worked in the secondary and tertiary sectors. By the 2000 census, only 19% of the population worked in rural areas, whereas 60% were employed in the services sector and 21% in industry. Clearly, this rapid redistribution of the economically active population from the agricultural sector to the industrial and services sectors entailed extraordinarily rapid urbanization. In 1960, the majority of Brazil's population (55%) lived in rural areas, while in 2000, 81% lived in urban areas. The 2010 census, the official results of which were scheduled to be available in 2012, is likely to indicate the continuity of these trends.

This rapid increase in the proportion of the population living in urban areas, compounded by growth of the population itself, which numbered roughly 70 million in 1960 and close to 150 million in 2000 (190 million by 2010), created an enormous demand for services and urban infrastructure and led to sweeping cultural and environmental changes in a political context marked during most of this period by a dictatorship that repressed the emergence of new forms of organization and social participation that would have been consistent with these transformations.

These past decades have also been marked by major economic changes. Per capita GDP rose to US\$5,750 in 2006, up from US\$2,060 in 1960 (constant values, with 2006 as reference). However, these extraordinary gains in wealth and the modernization of the economy were not accompanied by a corresponding improvement in income distribution. Despite undeniable progress (the Gini coefficient declined to 0.515 in 2008, from 0.64 in 1991), income distribution in Brazil is still one of the most unequal in the world. The 2009 UNDP Report (<http://hdrstats.undp.org/en/indicators/161.html>) notes that Latin America is the world's most unequal continent. Of the 15 countries where the difference between rich and poor is greatest, 10 are in Latin America. As a rule, the Gini coefficients of the Region are 18% higher than those of sub-Saharan Africa, 36% higher than those of East Asian nations, and 65% higher than those of the wealthiest countries. Within this context of inequality, according to the UNDP, only Haiti and Bolivia fare worse than Brazil among the nations of Latin America. Furthermore, according to this report, despite being among the world's eight largest economies, Brazil ranks 75th out of 182 countries on the Human Development Index (HDI).

**Figure 2-1.** Resident population (%) by housing situation, Brazil, 1940-2000



Source: Brazilian Institute of Geography and Statistics (IBGE).

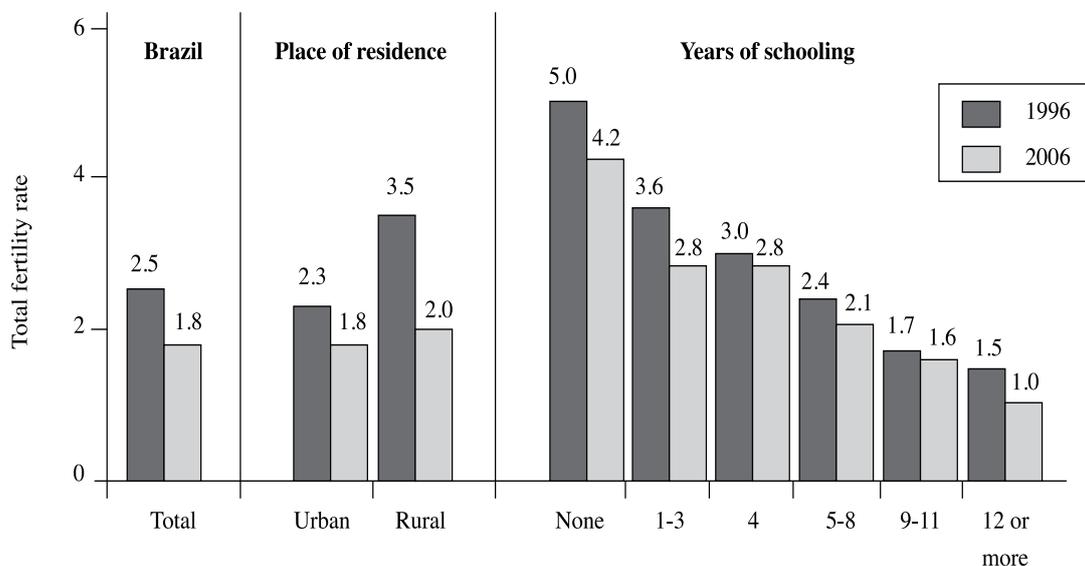
Rapid industrialization and urbanization have led to significant changes in population fertility patterns. The fertility rate fell from 6.3 children per woman of childbearing age in 1960 to 2.3 in 2000 and 1.8 in 2006, according to the most recent National Demographic and Health Survey. However, as has been the case with other “transitions,” such as the epidemiological transition and the nutrition transition, the demographic transition in Brazil is also incomplete and beset by inequalities in terms of economic and social variables. The average fertility rate of 1.8 actually conceals major differences by educational attainment, with stratified fertility rates of 4.2 for women without a formal education versus 1.0 for those with 12 or more years of schooling. This decrease in fertility and the increase in life expectancy have wrought a major change in the age structure of the population, with a rapid increase in the proportion of older adults—a situation that calls for the development of public policies to address this phenomenon, whose speed is unparalleled in the world experience.

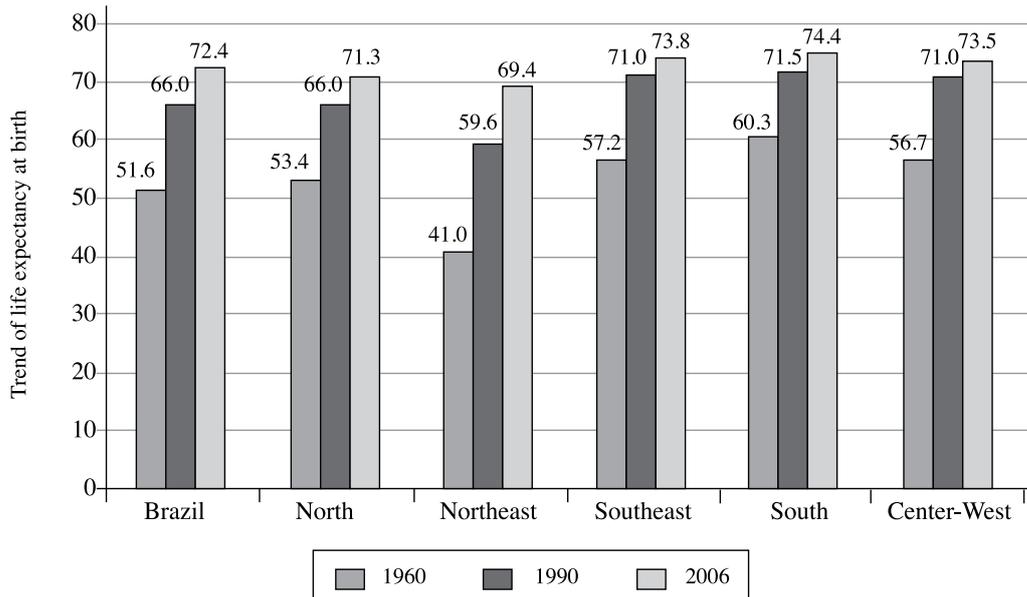
In recent decades, major progress has also been made in terms of social development. In 1960, 40% of the Brazilian population aged 15 and older was illiterate; by 2006 that rate had fallen to 10.4%, although with substantial differences between regions and income groups. In the South region, the illiteracy rate was 5.7% in 2006, versus 20.8% in the Northeast. In families earning less than half of one minimum wage per capita, the illiteracy rate was 17.9%, versus only 1.3% in families earning more than two minimum wages per capita.

These significant advances and contrasts in the country’s economic and social development in recent decades are also observed in the health situation. In 1960, life expectancy at birth was 51.6 years for the country as a whole, 40 years in the Northeast region, and 60 years in the South; that is, someone born in the Northeast had a life expectancy 20 years shorter than someone born in the South region. In 2006, overall life expectancy was 72.4 years; life expectancy at birth had risen to 69.5 years in the Northeast and 74.5 years in the South, showing improvement across all regions, with a downward trend in inequality, visible in the shrinking of the gap between the Northeast and South regions from 20 years to 5.

Another important example is infant mortality. In 1985, diarrhea was responsible for 17.3% of all deaths in children in the first year of life, with figures ranging from 30.1% in the Northeast to 11.8% in the Southeast. Twenty years later, in 2005, this rate had declined markedly to 4.2% in the country as a whole. Although the decline in the Northeast has been greater than that observed nationwide (from 30.1% to 5.1%), the difference between Northeast and Southeast—where this rate declined to 1.8%—has remained or increased slightly. In 1985, nearly half of all deaths in children in the first year of life in the Northeast had an ill-defined cause (45.5%), while this rate was 6% in the Southeast and the national average was 23%. A mere 20 years later, in 2005, the national average had fallen to 6.9%, and the Southeast average, to 3.9%; the Northeast region accounted for the steepest decline, to 9.7%, denoting major improvement in the access to and quality of health care in this period.

**Figure 2-2.** Total fertility rates by sociodemographic characteristics: PNDS, 1996 and 2006



**Figure 2-3.** Life expectancy at birth, Brazil and its regions, 1960-2006

Source: IBGE and Simões.

Despite this undeniable progress, however, major inequities in access, utilization, and quality of the health services persist, depending on social position. A prime example is the use of mammography for breast cancer screening. As Figure 2-4 shows, there is a clear gradient in access to this screening modality depending on educational attainment, used as a proxy for socioeconomic stratum. In the health supplement of PNAD 2003, the percentage of women aged 25 and older who had undergone mammography at least once ranged from 24.5% for women with less than 1 year of formal education to 68.1% for those with 15 or more years of schooling. In the health supplement of PNAD 2008, these rates ranged from 38.1% to 70.7%, indicating a downward trend for disparities in access.

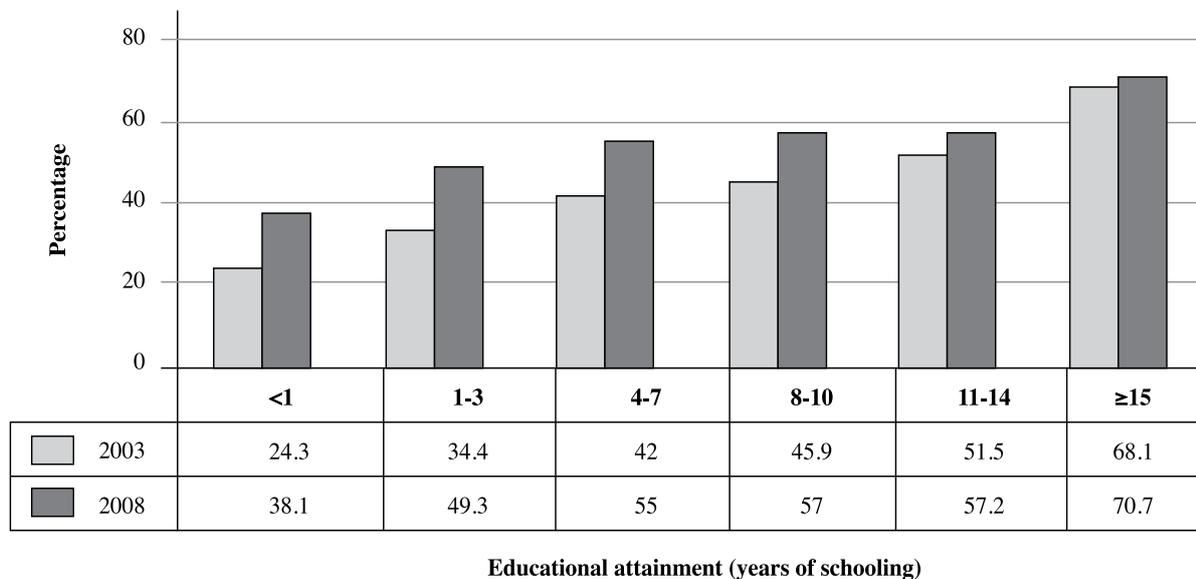
**Figure 2-4.** Women aged  $\geq 25$  years with access to mammography, stratified by education, 2003 and 2008

Table 2-1, constructed with data from the 2008 PNAD supplement (available at <http://tabnet.datasus.gov.br/cgi/dh.exe?pnad2008/pnad.def>), shows major differences in self-perception of one's health status as a function of educational attainment. The percentage of individuals who considered themselves to be in poor health ranged from 36.3% among those with less than 1 year of formal education to 11.9% among those with  $\geq 15$  years, with a clear corresponding gradient for every 3 additional years of schooling. The percentage who reported seeing a physician in the past 12 months also shows a gradient, but in the opposite direction than expected, if self-perception of poor health is considered an indicator of the need for medical attention. However, the differences observed in access to a physician were significantly less than those observed in self-perception of poor health. Access to a dental appointment showed a steep gradient; notably, 31.3% of individuals with three years of formal education or less had never been to the dentist.

The CNDSS report revealed other major inequities in mortality, morbidity, nutritional status, and health service utilization as a function of socioeconomic variables such as income, education, and place of residence. It also revealed major inequities in such health determinants as basic sanitation, housing conditions, labor and employment, access to information, and individual behavior.

**Table 2-1.** Selected results of the 2008 PNAD health supplement regarding health status and access to health services

	<i>Educational attainment (years of schooling)</i>					
	<1	1–3	4–7	8–10	11–14	$\geq 15$
% report poor health	36.3	28.8	26.4	20	14.9	11.9
% consulted a physician last year	67.1	63.3	63.5	64	70.5	80
% never been to dentist	20.2	11.1	5	2.6	0.8	0.1

## Policies designed to tackle health inequities through a social determinants of health approach

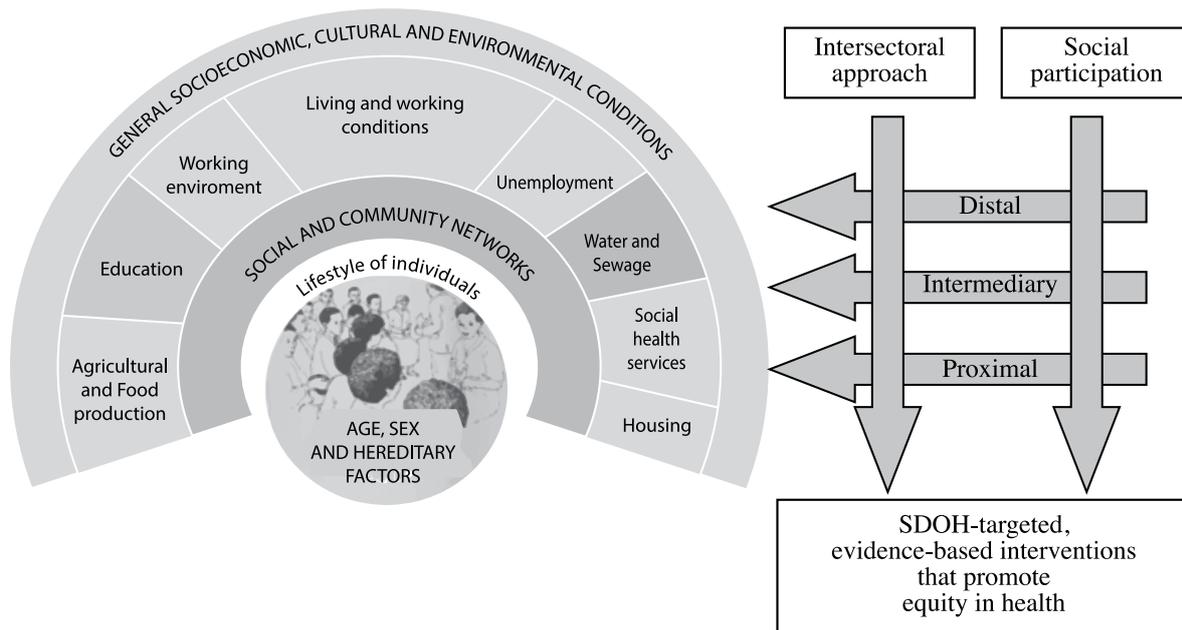
To address the aforementioned challenges, CNDSS put together a series of policy and strategy recommendations, particularly to tackle inequities in health. It initially examined federal government initiatives designed to act on the SDH by reviewing federal public spending on social programs from 2004 to 2006, as recorded in the Integrated Financial Administration System of the Federal Government (SIAFI). During this period, more than 390 government programs and 4,000 initiatives that could be classified as acting on the SDH were implemented annually.

The Report selected 86 activities implemented by 16 federal agencies, reaching more than 11.2 million families, for a total expenditure of R\$45.2 billion. These selected actions were associated with improvements in health and living conditions and reductions in social inequalities, and were geared to vulnerable populations. They included the following areas: agriculture, nutrition, environment/housing, education/sports and culture, noncontributory social protection, work and productive inclusion, prevention and control of violence, and promotion of rights.

Despite this tremendous effort, some problems are still evident. The majority of investments were highly concentrated in a few organizations, and there was evidence of discontinuity between programs and little coordination among them. Monitoring and evaluation systems were not uniform and, despite sharing similar objectives, some programs were completely disconnected from one another, suggesting redundancy and inefficiency. Despite a multitude of programs and activities, there was no organized agenda designed to explicitly address the issue of health inequities, nor were any goals set explicitly for this objective.

The CNDSS report attempted to eliminate these issues by recommending SDH-targeted actions to promote health and combat inequities covered in the various layers of the Dahlgren and Whitehead model (11)—i.e., that act upon the proximal determinants (those related to individual behavior), the intermediary determinants (those related to living and working conditions), and the distal determinants (those related to the economic, social, and cultural macrostructure). Whatever the level on which they act, these interventions should be firmly supported by three pillars: intersectoral coordination, scientific evidence and information, and social participation. They should therefore be based on coordinated action by the various sectors and spheres of public administration, the involvement of broad segments of society, and solid information and scientific evidence.

Schematically:



[Model core: "Age, sex, and hereditary factors"]

## ■ Intersectoral coordination

The sector-based organization of the modern State offers a series of advantages stemming from the division of labor but also presents some drawbacks, such as the fragmentation of activities and the difficulty addressing complex issues that require the intervention of different State entities.

Recognizing that a sector's health outcomes are determined by the action taken in other sectors is not exclusive to the health sector, as the majority of sectors (including economic and productive ones), display a certain impotence due to their inability to control all the variables they believe they should control.

For this reason, adopting the SDH perspective should not imply that health is the dependent variable of all other sectors and that these sectors should therefore be persuaded to work on behalf of health. In fact, the health sector should simultaneously be considered both determined and determinant, which calls for the adoption of strategic mechanisms for negotiation among sectors for their mutual benefit. These mechanisms should seek to connect not only sectors, but also the different spheres (federal, state, and municipal) and branches (executive, legislative, and judiciary) of government, with the common objective of sustainable human development that permits equality of opportunity and creates the conditions for the effective exercise of citizens' rights.

To institutionalize a sustainable process for coordinating intersectoral activities to tackle the SDH, CNDSS recommended the creation of an agency within the Office of the President's Chief of Staff tasked with monitoring and evaluating the SDH-related programs and policies developed by federal government agencies. The Ministry of Health would serve as the Technical or Executive Secretariat of this agency through a National Secretariat with a leadership role and the technical and political capacity to promote and take action both inside and outside the health sector. Such an institutional arrangement would be replicated in the state and municipal spheres to boost the efficiency of SDH-related intersectoral policies at these levels of government. To strengthen the capacity for formulating and managing intersectoral public policies that affect SDH, the CNDSS recommended the development of wide-ranging processes for training managers and staff at the various levels of government and sectors of civil society involved in these actions.

## ■ Information and scientific evidence

Defining effective policies and programs to tackle health inequities requires reliable, easily accessible information and knowledge to understand how the social determinants act to create health inequities and to determine which areas the interventions should target to fight them.

Although Brazil has a wealth of nationwide information systems that cover the different types and levels of SDH, these systems were not designed to shed light on inequities associated with the socioeconomic stratification of population groups, permit an analysis of the trends in these inequities, or determine priority points for interventions and impact analysis. The country also lacks intermediary entities, such as observatories, at the interface between information production and the decision-making process to systematically and continuously conduct and disseminate analyses of inequities and their determinants to support the evidence-based definition and implementation of health policies and actions.

There are barriers and challenges to the use of scientific knowledge as a basis for decision-making on policies for tackling health inequities, namely:

- The relatively limited number of evaluations of SDH-targeted interventions. To prepare its report, the CNDSS was able to rely on a wealth of domestic scientific output on the relationships between SDH and health outcomes, but no such wealth of information is available in terms of the evaluation of interventions.<sup>3</sup>
- The research agenda in general is defined exclusively by researchers themselves, with little or no participation by the other actors involved in the decision-making process.
- The relationships between the knowledge production and utilization processes are jeopardized by institutional, linguistic, and cultural barriers, as well as differences in values among actors who play a role in the two processes.
- The research findings in this field are not prescriptive; they merely point to a range of potential interventions that will then be selected through a complex process involving criteria of a political nature.
- The transfer of successful experiences is hindered by the diversity of situations and substantial dependency on the context in which the activities are carried out.
- The decision process in public policy-making is complex and involves different actors, interests, and criteria.

To overcome these constraints, significant changes must be made in the way research agendas and priorities are established, in the institutional loci where research activities are carried out, in the criteria for validating knowledge, and, especially, in the modes of knowledge transfer/dissemination/utilization. Agendas defined in terms of problem solving, with mechanisms that permit the participation of both researchers and knowledge users; institutional arrangements that establish collaborative networks between different types of institutions for further development of the research process; knowledge validation processes involving peers and non-peers, in which both scientific merit and social relevance are the main criteria; and knowledge dissemination modalities that are not limited to scholarly journals, but allow knowledge to reach the various actors in the decision-making process are some of the possible necessary changes (12).

As mentioned above, the decision process for public policy-making, particularly when it comes to tackling inequities, involves a range of actors. Therefore, the search for greater utilization of information and knowledge in this process entails making such information more widely accessible to the actors involved in the process and not just policymakers. Reducing inequities in access to knowledge and information should in itself contribute to reducing inequities in health, since information-related inequities are a major determinant of health inequities, as they hinder the capacity for individual and collective action by members of a society to effect structural, behavioral, and policy change (13).

**The CNDSS Report addressed this issue and made a series of recommendations for the production of scientific evidence to further the development of SDH-related policies. These recommendations include:**

- Regular support for SDH studies and research projects, selected on the basis of established criteria. CNDSS, together with DECIT/MS and CNPq, supported 21 research projects on different aspects of the SDH, using varied perspectives and methodological approaches. At the initiative of the Center for Studies, Policies, and Information on Social Determinants of Health (CEPI-DSS), the scientific articles that emerged from these projects were published in a special issue of *Cadernos de Saúde Pública* in the first semester of 2011. These included articles on early child development and SDH; inequities in mortality and access to health services in various Brazilian cities; the importance of social capital and social support in perinatal care and other services; inequities among the elderly population; violence and social inequities; and inequities and the Millennium Development Goals in Brazilian municipalities.
- The creation of networks for information exchange and collaboration between researchers and administrators, with a view to greater interaction between them, monitoring of project implementation, and discussion of the policy implications of their results.
- Definition of a set of indicators for systematically monitoring health inequities and assessing the impact of intersectoral action on these inequities.

## Social participation

Social participation has both intrinsic value, as a duty and right of populations to take part in the decisions that affect them, and the instrumental value of ensuring the necessary political support to allow for the redistribution of power and resources, thus enabling action on health inequities through SDH-targeted interventions. In fact, these interventions depend on extensive social mobilization to raise awareness among the different sectors of the population about the gravity of the problem of health inequities—and the urgent need to address them.

In Brazil, as in other Latin American countries that experienced similar situations, civil society organizations (including nongovernmental organizations—NGOs) played an important role in the resistance to dictatorial regimes and became symbols of the democratic struggle and citizens' rights. After the restoration of democratic rule, these organizations engaged in direct participatory democratic activities and diversified their roles, dealing both with matters of general interest, such as the environment and human rights, and matters of interest to specific groups, in addition to operating as service providers. Their activities have contributed to the expression of citizenship, particularly by historically underrepresented minorities, who are becoming new political actors in the broadest sense of the word.

These forms of direct social participation cannot be considered a panacea, however, since (as experience has shown) they can also be coopted, manipulated, and bureaucratized or made to advance only corporate interests. Their relations with the State may involve a series of double-edged distortions. While the State can undermine civil society, making it a mere appendix of the government through dependence on resources and cooption of leadership, relations with civil society can deform the government's ability to represent the public interest, fragmenting public policies to meet the demands of pressure groups.

Distortions can also exist in relations with the different forms of representative democracy, to the extent that certain civil society sectors proclaim themselves organized society, when they actually represent the legitimate interests of certain social groups but not those of society as a whole or even of all the segments that they claim to represent, which, in fact, are often even unaware of their existence (14).

Social participation plays a key role in strengthening what many authors call "social capital." The importance of this factor to development is increasingly recognized in the literature. Social capital consists of the degree of confidence among social actors in civic behavioral standards and associative capacity within a given society. In a society with a high degree of social capital, high levels of confidence in interpersonal relations, strong associative capacity, heightened civic awareness, and positive ethical values prevail. Social capital makes other forms of capital, such as human and financial capital, more productive.

Many studies show that, the greater the social capital, the greater the long-term economic growth, the lower the levels of violence and crime, the stronger the forms of democratic representation, the greater the investment in human and capital, and the greater the level of citizen participation and pressure for efficient, effective services (15).

A number of studies also show that the waste of social capital is an important mechanism through which income inequality negatively impacts the health situation. Major income inequities reduce social cohesion and lead to lower political participation. Countries and states with greater income inequities exhibit low levels of social cohesion and political participation and are those that invest the least in human capital, which affects the health of their populations (16).

To promote social participation in the formulation and implementation of SDH-related policies, the CNDSS Report recommended:

- Strengthening participatory administrative mechanisms by training members of civil society to participate in different bodies in the social sector and greater integration of such bodies at the local level;
- Broadly disseminating knowledge and information on SDH to the different segments of society, using language and technologies suited to the culture, values, and interests of these segments.

## ■ Select ongoing initiatives

### Center for Studies, Policies, and Information on Social Determinants of Health (CEPI-DSS)

The Oswaldo Cruz Foundation served as the headquarters of CNDSS and was responsible for publishing its Report. In an attempt to address some of the recommendations contained in this report, Fiocruz, through the National School of Public Health (*Escola Nacional de Saúde Pública Sérgio Arouca*, ENSP), created the Center for Studies, Policies, and Information on Social Determinants of Health (CEPI-DSS). ENSP has extensive experience in setting up research centers in a variety of fields, which facilitates greater integration of faculty and investigators across its various departments, increasing institutional capacity to address complex subjects requiring an interdisciplinary approach.

The general purpose of CEPI-DSS is to support government and civil society activities aimed at promoting equity in health through the production and dissemination of knowledge and information, the training of personnel, and the monitoring and evaluation of sectoral and intersectoral policies and programs that act on SDH.

Its lines of action are:

- To maintain the Observatory on Health Inequities, launched in 2012 to monitor inequities in health and analyze ongoing policies and programs to address them, with a view to supporting the design, implementation, and reorientation of sectoral and intersectoral public policies that promote equity in health. The Observatory seeks to follow the definition of Gattini (17), who conceived of such entities as “a policy-oriented virtual-based national center aimed at performing systematic and ongoing observation on relevant issues about population health and health systems, in support of effective and evidence-based health policy, planning, decision-making and action in public health and health systems. The ultimate goal is to contribute to the preservation and improvement of health of the population, including the reduction of inequalities.” The Observatory operated by CEPI-DSS monitors 70 indicators related to SDH, the health situation, and health care, from 2000 to the present. Data are stratified by socioeconomic variables and disaggregated at the country, macroregion, and metropolitan levels. The Observatory can be accessed through Portal DSS at <http://dssbr.org>.
- To develop in-person and virtual training on SDH for administrators, public health professionals, and other areas of the social sector operating in the various spheres of government, as well as civil society representatives in venues for participatory management.
- To support the implementation of studies and research to produce knowledge and information on SDH that can contribute to the definition and implementation of policies and programs to tackle health inequities.
- To establish networks for collaboration among researchers, administrators, and other potential users of the knowledge generated.
- To develop processes for disseminating knowledge and information on SDH to government sectors, academia, professionals, and the general public. This line of action includes the SDH Portal (Portal DSS,

<http://dssbr.org>), which contains article abstracts, interviews, news, opinion pieces, and experiences of interest to the field of SDH, and the Virtual Health Library on SDH (<http://bvssdss.icict.fiocruz.br>), which currently contains nearly 100,000 articles.

To conduct a more in-depth analysis of the health situation of each macroregion in the country and current policies to tackle inequities in health in these macroregions, with a view to strengthening these policies, CEPI-DSS is organizing Regional Conferences on SDH in conjunction with CONASS, CONASEMS, the MoH, and PAHO. The first conference was scheduled for September 2013 in the Northeast region and was expected to include representatives from the three branches of government, civil society, and experts. To mobilize interest among the various participating actors and promote discussion of the Conference topics, the Portal DSS Nordeste website (<http://dssbr.org/site/nordeste>) was launched in February 2013.

## Participation of Brazil in international initiatives related to SDH

### MERCOSUR and UNASUR

The CSDH Report highlights the need for a sustainable, global movement to link the efforts of governments, business, civil society organizations, and international organizations to reduce the wide gaps in the social and health situation among and within countries. The global and/or regional nature of many of the SDH warrants a search for new institutional arrangements to increase the effectiveness of international action on these factors and for greater coordination of international development cooperation (18). In the Region of the Americas, both the Union of South American Nations (UNASUR) and the Southern Common Market (MERCOSUR) have sought to engage with this global SDH-based movement through a series of initiatives in which Brazil has been a key player.

In 2009, MERCOSUR created an Intergovernmental Commission on Social Determinants of Health, whose responsibilities include:

- The preparation of regional strategies that incorporate the social and health dimensions to reduce poverty and promote sustainable development.
- The reorientation of research in the field of SDH, promoting studies of economic and social processes for the improvement of health.
- The development of instruments for measuring inequities.
- The sharing of experiences related to SDH.

At its first meeting, held in September 2009 in Montevideo, the Commission approved a Work Plan (which remains in effect) with the following objectives:

- To increase awareness of health inequities and their determinants among different population groups. To meet this objective, countries are developing a consensus-based set of basic social and health indicators for the monitoring and comparative analysis of inequities.
- To exchange information on policies, programs, or actions geared to the SDH. Based on a shared guideline, a database of experiences in fighting inequity through action on SDH is available through the MERCOSUR Portal by the second semester of 2013.
- To develop competencies and strengthen institutional capacity to act on SDH. In coordination with the UNASUR Working Group for Human Resources Development and the South American Institute of Governance in Health (ISAGS), training activities for administrators responsible for designing and implementing social policies in different sectors and spheres of public administration are expected to take place.

UNASUR established the Working Group on Health Promotion and Action on Social Determinants, which first convened in Caracas, Venezuela, in January 2010. The group's mandate was to strengthen health promotion and action on the social determinants of health in order to reduce inequities in each member state through infor-

mation generation, intersectoral coordination, and community participation in the development, implementation, and monitoring of public health policies. The Work Plan approved by the Coordinating Committee of the South American Health Council includes:

- Establishing basic indicators for health equity, setting criteria for the evaluation of policies to reduce inequities, and developing monitoring mechanisms.
- Developing methodologies and strategies for intersectoral coordination and social participation.
- Developing mass communication mechanisms that ensure access to information on health promotion and SDH by different segments of society.
- Developing research protocols for multicenter projects on topics of common interest related to equity in health and action on SDH.

Recognizing the need to strengthen country capacity in the Region for public policy-making and implementation in this area, the UNASUR Working Group on Health Promotion and Action on Social Determinants drafted proposals for training activities to be carried out through the South American Institute of Governance in Health (ISAGS).

ISAGS was created by the UNASUR South American Council of Health in 2010 with the primary role of strengthening national capacity for the planning, implementation, and management of health policies and systems. Its planned activities include:

- brief and lengthy seminars and courses, both virtual and in person, on topics in management, leadership, and governance in health;
- development of applied research and studies to address the demands of the Region;
- guidance for developing national or regional plans, programs, and standards;
- production, management, and dissemination of knowledge related to regional health priorities.

ISAGS conducts its activities largely through networks for collaboration with regional institutions. Its physical facilities were donated by the Brazilian government and are located in Rio de Janeiro, Brazil, and its implementation was promoted by the FIOCRUZ Center for International Relations in Health (CRIS). CRIS is an agency of the FIOCRUZ board, established in 2009 to coordinate and foster international cooperation and exchange in health, administer agreements and conventions, attract international resources for health, and represent FIOCRUZ at international forums and organizations.

### **World Conference on Social Determinants of Health**

After discussing the CSDH Report, the 62nd World Health Assembly (WHA), held in May 2009, adopted Resolution 62.14, which, among other measures, requested the Director-General of WHO to convene a global event to discuss renewed plans for addressing the alarming trends of health inequities through addressing the SDH. During the 63rd WHA, the Brazilian government volunteered to host this event, the World Conference on Social Determinants of Health (WCSDH), which was held in October 2011 in Rio de Janeiro.

The Conference aimed:

- to identify the basic principles, methods and strategies for developing SDH-targeted interventions to reduce health inequities;
- to strengthen political commitment by member states to develop and implement such interventions;
- to share experiences on how to address SDH;
- to propose new arrangements and strategies for international action on health and development with an SDH-based approach.

The presence of official representatives of more than 120 of the 194 WHO member states, as well as representatives of civil society organizations and experts from the world over, reveals the keen interest of the international community in the issue of the SDH. In the Rio Political Declaration (19), signed by all 120 governments represen-

ted, the countries recognized that health inequities are unacceptable, and they committed to fighting them through SDH-targeted actions. In addition to the Declaration, the Conference produced a discussion paper, “Closing the gap: Policy into practice on social determinants of health,” (20) which summarizes the available knowledge about SDH-targeted interventions and constitutes an important guideline for the definition of national policies and programs.

The international environment is highly favorable for implementing the WCS DH recommendations. In May 2012, the World Health Assembly adopted WHA Resolution 65.8, which ratifies the commitments made during the conference as set forth in the Rio Political Declaration. In addition, the resolution urges WHO, international organizations, and other global stakeholders to assist countries in meeting these commitments and requests that WHO provide yearly updates on the implementation of this resolution.

“The Future We Want” (21), a document adopted during the United Nations Conference on Sustainable Development, held in Rio de Janeiro in June 2012, and endorsed by a UN General Assembly Resolution in September 2012, includes health with an SDH-based approach among the pillars of sustainable development. Definition of the global post-2015 development agenda is under way, and the SDH should have a key place in the selection of the health and sustainable development goals to be included in this agenda (22).

To conclude, we would do well to heed the warning of Whitehead and Dahlgren (23), who noted that “health for all” strategies are often twisted into “health for some” strategies when the determinants of health inequities are not taken into account. Global initiatives, coupled with institutional and professional capacities and the SDH-targeted efforts that have been undertaken in Brazil, seem to indicate an awareness of the importance of these determinants, creating a favorable scenario for implementation of effective policies and actions at the global and national levels for the reduction of inequities in health.

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## ■ Notes

- 1 Health inequities are defined as inequalities in health between groups of people which are not only systemic and relevant, but also avoidable, unjust, and unnecessary.
- 2 The final reports are available at [http://www.who.int/social\\_determinants/themes/en/](http://www.who.int/social_determinants/themes/en/).
- 3 The bibliography of this Report, which consists of approximately 400 references, is recorded on a CDROM provided with the hard copy edition of the Report (published by FIOCRUZ) and is also available online at <http://search.bvsalud.org/dss/?where=DSS>.

# The transition to sustainable development and human sovereignty: Situation and outlook in the region of the Americas

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From the early 16th century onwards, the colonization of the Americas was a conflict-ridden process of domination characterized by skirmishes, battles, and wars between the native peoples of this continent and the colonizers. While the Conquest shook the very foundations of the north-American civilizations the worst consequence, apart from the bloody conflagration that is war, was the imposition of an economic model based on the plundering of natural resources and the enslavement and extermination of many indigenous peoples, as well as the brutal importation of slave labor, mainly from Africa.

As Eduardo Galeano argues in *The Open Veins of Latin America (1)*, this economic model led to major population displacement and the break-up of communal agricultural units, which indirectly destroyed the traditional collective farming systems. Subjugated by the colonizers, indigenous peoples were expelled from or neglected their lands, and many were forced into slave labor in the mines. The lust for gold and silver was the driving force behind the Conquest, while agricultural activities such as sugarcane growing (introduced from the Canary Islands) and logging also helped fuel the exploitative colonizing effort. Colonial plantations, subordinated to external demand and in many cases financed from abroad, led directly to the emergence of today's large landed estates (*latifundios*). One of the factors that is holding back Latin America's economic development, it is also at the root of the marginalization and poverty in the Region. This economic model has survived for hundreds of years. The global consolidation of capitalism in the 19th century heralded a new phase of international domination, first led by Britain, and then, after the Second World War, the United States, which, as a superpower, imposed new forms of imperialist domination.

In the Americas, this process led to widespread inequities and deep social, economic, and cultural divisions. It also produced a plethora of political regimes, ranging from capitalist to socialist, and to conflicting regional interests that today are reflected in every aspect of the daily lives of the people in this region.

## ■ Latin America's crisis of destiny

In recent decades, three regions of the world have vied for global superiority: North America, Europe, and East Asia. The first region is under the direct control of a megastate—the United States. The second is moving toward unification and the formation of a continental megastate—the European Union. The third region boasts at least two megastates—China and Japan—both of which have significant influence in a region whose economic success is partly due to dynamic integration.

Three other regions have failed to define regional projects or build political structures capable of implementing them: the Middle East, Africa, and South America. The first is under military occupation. The second is crippled by high levels of poverty and serious internal conflicts.

Among the peripheral regions, South America is best positioned to create its own integration project. Our countries share similar aspirations of sovereignty, development, and justice; our peoples can build a common identity; and our economies are complementary. In a world increasingly threatened by shortages, we possess abundant natural resources, that will be increasingly sought after, including energy and biological resources. We have a favorable balance of population, territory, and resources, meaning that we can easily be self-sufficient in terms of food and energy. Furthermore, we have access to two vast oceans.

Building continental unity has been a recurrent dream throughout our history. This dream featured powerfully in the lives and work of our foremost intellectuals, soldiers, and statesmen, such as Venezuela's Simón Bolívar, Cuba's José Martí, Peru's José Carlos Mariátegui, Argentina's Ernesto Guevara, Brazil's Darcy Ribeiro, and so on.

Three major obstacles have stood in the way of achieving unity among our nations:

- a) For most of our history, our economies have depended on exporting raw materials linked to and directly controlled by foreign capital. The transportation infrastructure in many of our countries was built to connect production areas directly with the ports, from which the products were shipped to Europe or the United States. Industrial goods flowed in the opposite direction. The local elites who dominated this system had more in common with foreign interests than with their own societies.
- b) At the heart of the continent there was an empty economic and demographic space: the vast Amazon region and its extensive periphery, with its virtually insurmountable distances and scattered extraction activities.
- c) Our societies gradually took shape over the centuries and eventually produced a variety of populations in the different countries. The "new peoples" predominated, for example, in Argentina, Brazil, Chile, Colombia, and Venezuela. These were a mix of native peoples from the region and others from Europe, Africa, and even Asia, who together made up a workforce in the service of European capitalism. Meanwhile, Bolivia, Ecuador, Paraguay, and Peru remained the strongholds of the heirs to the pre-Columbian civilizations, and their peoples are now reasserting their identity. Certain other countries have "mestizo" populations, among them Mexico, where strong pre-Columbian and European cultures intermingle.

Notwithstanding the above, the stage is now set for clearing the path to greater regional unity and the construction of a regional project:

- a) The developmentalist efforts of the 20th century led to more industrialized economies, enhanced technical capacities, more robust domestic markets, and an incipient network of infrastructure for internal connections (although further on, we shall see that this development also left us weaknesses that must be overcome).
- b) The role for the Amazon region has changed. In the 21st century, the Amazon should form the hub of a new joint cooperation and development project to ensure our peoples' control of strategic resources, such as fresh water, biodiversity, energy sources, and minerals, and to advance in the field of biotechnology.
- c) Our peoples still need to confront our greatest challenge: to control the processes that will determine the course of our own future history. With the European invasion, the heirs to the pre-Columbian civilizations lost control of their own destiny. The new peoples formed after the invasion never had this control. European modernism, which has survived even during the phase of U.S. hegemony, considers all the peoples of South America to be passive peoples, none of them capable of taking ownership of its own history. Remedying this situation is what justifies and sustains our long-held dream of continental unity.

The first bold steps in this direction could be an ambitious joint project for the Amazon region: the integration of the continental energy grid and the creation of an accounting currency to regulate intraregional trade and escape U.S. dollar dependency. We will have to begin by overcoming various constraints, such as those we have inherited from the developmentalist efforts that forced us into peripheral modernization without bringing us any nearer to the center of the global system, for several reasons.

The international system, ushered in at the dawn of the modern age, was highly polarized between a relatively small central core and a large number of peripheral countries. With the exception of the core countries, rapid development basically took place in regions with plentiful, valuable natural resources (agricultural, mineral, etc.). Once these resources were exhausted or no longer needed, the producing areas went into decline and resumed their peripheral status.

This core/periphery model underwent partial change in the 20th century. Some countries on the periphery experienced remarkable economic growth that was based not on the exploitation of abundant natural resources, but on intensive industrialization. While growth cycles (which transformed local production systems in certain countries) were fostered by different regimes, exhibited different characteristics, goals, and values, and benefited different social classes, they nevertheless had one feature in common: they took advantage of supra-market coordination mechanisms to accelerate industrialization and its associated modernization processes.

The successive disputes for hegemony at the center of the system, which were a major feature of the period described by Hobsbawm as the “Short Twentieth Century (1914-1991)” (2), created favorable conditions for implementing projects in some traditionally peripheral spaces.

In the sphere of international economic relations, the countries that benefit most are those that succeed in controlling a greater part of the surplus produced in the totality of the system. In order to become a leading player, a country needs to structure its economy around activities that generate a differentiated gain that is above (preferably, far above) the average. Such positions are, by definition, excluding (otherwise, the gain achieved would not be differentiated). The international economic system is therefore structurally asymmetrical.

Since activities that ensure a differentiated gain can change over time, achieving and maintaining a leading position does not depend on controlling specific sectors, technologies, or goods—all of which can change rapidly and undermine the gain. These activities require remaining at the forefront of technology development and innovation—i.e., possessing a permanent capacity to create productive combinations, processes, or products. The nucleus of the international system consists of shared spaces for knowledge creation, where the dynamics of innovation are most heavily concentrated. These spaces achieve controlling positions precisely because they nurture and re-create ideas, thereby yielding greater benefits for the international division of labor. At the other extreme, dependency is also dynamically regenerated.

We have succeeded in gradually internalizing the productive activities that once sustained the core countries’ leading role, but a major problem remains: such activities lose their differentiated status precisely when the “modernizing periphery” has managed to absorb them. Renewed competition from the core country innovators undermines the importance and profitability of the activities on the periphery. These are eventually relegated to second place by the core economies, which resume their privileged positions by updating the most effective productive combinations. As a result, inequality returns to the periphery.

A logical impossibility prevents leveling strategies, such as those used by the South American countries during their developmentalist cycles, from changing our countries’ positions within the system. It is impossible for a country to emerge from its peripheral status through the extensive exploitation of natural resources, or by copying products and technologies (and their associated lifestyles) that have already matured in the core countries. Backward economies are faced with a dual challenge: to selectively internalize technical and cultural elements of the current paradigm while simultaneously creating the conditions that will quickly enable them to break the cycle of dependency and shift toward a new paradigm. This approach is not restricted to the technical and economic spheres but also involves the sphere of social relations. Ending dependency is therefore closely linked to the more general question of transitioning toward a new type of society. Incapable of rising to this challenge in the past, the South American developmentalist effort manifested its inherent structural weaknesses and was easily extinguished with the arrival of a new international order in the late 20th century.

The globalized order affects societies in significantly different ways. The core countries are affected in the economic, technical, and policy-making areas (including policy-making with military repercussions), which are closely intertwined, due to the close ties between big business and powerful national governments. In the remaining countries, these areas are not integrated due to the geographic dispersal of production chains across the globe, a phenomenon stemming from decisions made by major corporations with zero commitment to weaker states and societies, where they establish subsidiaries. The negative effects of this globalized economic structure become more evident in times of crisis, as they heavily undermine the power of weaker countries and societies to respond.

During the 1980s (the “lost decade”), per capita income in the Latin American and Caribbean countries fell by an average of 0.7% per year. In 1990, the average per capita income for the Region was some \$3,300, or almost 10%

less than in 1980 (\$3,500). However, the economic recovery that began in the 1990s led to an increase in per capita income, which reached \$6,780 by 2008 (3).

Between 2000 and 2006, the GDP of the countries of the Americas varied substantially from one subregion to another: the Central American Isthmus (\$5,687), the Andean area (US\$5,300), the Latin Caribbean (\$6,528), and the non-Latin Caribbean (\$7,410) had lower GDP levels than the average for the Region as a whole (\$8,771), while the Southern Cone countries (\$10,042) and North America (\$37,085) were above the average.

South America experienced significant disruptions in the 1990s: *a*) nation states became weak and demoralized and ceased to be promoters of development and social organization, becoming hostages to the financial system; *b*) the productive base and natural resources sectors were abruptly denationalized, and external agents returned to make the key decisions and determine how our countries should be inserted into the international economy; *c*) in the Region's most developed countries, privatization, often accompanied by the break-up and denationalization of enterprises, destroyed the incipient endogenous clusters that generated development; and *d*) the superpower retained its military presence in the heart of the Region.

The growth of global capitalism was based on three processes imbued with a deep destructive capacity, with potentially fatal effects on health and the environment: *a*) the reshaping of the productive apparatus based on the new technology (4) to accelerate production, while directly fostering the creation of unhealthy systems; *b*) the (sometimes fraudulent) plundering of vital resources and public goods (5), including energy, land, and water resources, radio frequencies, public services, etc.; and *c*) fundamentalist strategies aimed at creating monopolies in the global market.

In the case of Ecuador, for example, structural adjustments were imposed through a gradual legislative reform that began in the late 1980s and early 1990s, despite social protests and the downfall of several neoliberal presidents. The indirect result was a setback in health (6). The year 1990 marked the beginning of a period characterized by the adoption of neoliberal policies that triggered a series of deregulations and measures that favored monopolies, facilitated the privatization of state enterprises, afforded excessive protection to foreign investment, flexibilized the labor market, and promoted, without public consultation, irresponsible mining while undermining social rights.

The structural adjustment in Ecuador, as in other Latin American countries, involved a series of decrees that directly impacted environmental, social, and health rights. Decree 2224, for example, is illustrative; this measure introduced new public practices in the water sector, including the privatization of water resource management. Also worth mentioning is the signing of agreements that led to the introduction of the World Bank's so-called "country assistance strategies," under the pretext of improving the quality, coverage, and efficiency of services. These strategies were in effect a Trojan horse aimed at the privatization of various public services and, using a number of specific programs as a smokescreen, caused the State to lose sovereign control of, for example, its health budget.

There is no doubt Latin America's agricultural sector was the main victim of the social and environmental degradation and the crisis caused by reduced access to essential inputs. Although industry has always dominated agriculture, Latin American societies are marked by the uneven and combined development of two systems of agroindustrial capital accumulation, linked and unlinked (7), that impact small farmers in different ways. In linked agricultural systems, the agricultural sector produces cheap food for the workforce and domestic market and supplies the poor with a minimum degree of purchasing power to ensure the consumption of the goods produced and a return on capital. In the unlinked neoliberal system, neoliberal agroindustries tend to neglect this basic function of agriculture to focus the sector more on the production of high-quality goods for the luxury and external markets. In recent decades, this much more socially and environmentally aggressive system has expanded, with the multinational food and biotechnology companies playing a major role.

Small and medium peasant-farming economies are at a disadvantage whatever the system in place. The growth of the neoliberal system has aggravated the agribusiness crisis, causing rapid decline and decapitalization among small- and medium-scale farmers, sealing the fate of food sovereignty, increasing the vulnerability and dependency of our countries, which are unable to compete with North American subsidized agriculture, and, worst of all, triggering enormous environmental disruption.

The development process described above reveals an absence of sustainability, understood as a transformative paradigm that prescribes a series of conditions that enable socioecological systems to lay the foundations for, and sustain, not just any type of life but one that is full, worthwhile, happy, and healthy.

## Transformation or hegemony: The “sustainability” and “sustainment” discourses

From the standpoint of human rights and nature, sustainability must be considered the nonnegotiable basis of any social system or development model. Unfortunately, these concepts have given rise to much ambiguity and confusion, especially with regard to the indiscriminate use of the terms *sustainability* and *sustainment*. Hopefully, the following paragraphs will clarify the differences between the implied meanings of these words, which are at the heart of the debate on development models and have deep sociopolitical implications.

The idea of “sustainable” is part of the “sustainment” paradigm. The root of both words is the verb “to sustain,” which clearly relates to the idea of supporting and maintaining. On the other hand, the word “sustainable” forms part of the paradigm of sustainability, which is concerned with the idea of sustaining or laying foundations.

This apparently pointless distinction must be clarified, since there is a need to distinguish between two radically different concepts about socioenvironmental rights and development. The “sustainment” paradigm is imperceptibly linked to the idea of maintaining the social model, but altering certain “maladjusted” parameters to enable the current social system to continue. In contrast, the “sustainability” paradigm leans in the direction of a quest for deep social and philosophical change, not only for sustainable development, but also for the creation of sustainable societies.

Meanwhile, “sustainment” (continued operation) is a one-dimensional concept that refers basically to time and is concerned, as Carlos Abaleron (8) explains, with the simple satisfaction of needs as conventionally defined by the hegemonic system.

There are various interpretations of sustainability as a multidimensional process from which certain key arguments can be extracted. The conventional approach to this problem emerges from the concept of sustainability popularized by the 1987 Brundtland Commission (9). Originally titled *Our Common Future*, the Commission’s report emphasized the responsibility of humanity to meet “the needs of the present without compromising the possibilities of future generations to meet their own needs” and defined sustainable development as a process of change in which the exploitation of resources, the direction of investments, and the orientation of technological and institutional change are all in harmony, thereby increasing current and future potential to meet the needs and aspirations of human beings. This means that the development of the human being must occur in a way that is compatible with the ecological processes that sustain the functioning of the biosphere.

Other voices have called for a more in-depth approach to sustainability, since, although it is important to analyze the transgenerational satisfaction of basic needs and the biocapacity of a particular territory (i.e., its biological productivity), real sustainability involves other elements. In this respect, there is a need to broaden the content of sustainable processes by addressing the actual components of sustainability, which are: social, cultural, political, generational, and environmental equity; comprehensiveness (something that seeks to integrate all facets of development and is not simply concerned with sector-specific factors); sovereignty (as the basis for a self-sufficient life); interculturalism (to overcome discriminatory and impoverishing unilateral and Eurocentric viewpoints); the balance between the past, present, and future, not only to guarantee and satisfy the needs of future generations, as suggested by the *Brundtland Report*, but also to advance the reconstruction of the “needs system”; and, finally, the adaptation of development to spatial and environmental conditions.

Other authors have considered the opportunities for ecological, social, economic, and political action. The ecological dimension involves the need to preserve and maximize the diversity and complexity of ecosystems: their productivity, natural cycles, biodiversity—all of them conditions linked to the physical and cultural survival of human beings. The social dimension relates to the achievement of equitable access to environmental goods in both inter- and intra-generational terms, between genders, and between cultures. Meanwhile, the economic dimension concerns the need to rethink economies according to material and nonmaterial needs, understood not only as needs but as potentialities, and their impact on the sustainable functioning of ecosystems. The political dimension refers to moving beyond the anthropocentric notion of management and promoting the direct participation of people and groups in decision-making, in determining their collective future, and in managing environmental goods through decentralized, democratic government structures. This implies the need to give a new meaning to politics and to mainstream new practices based upon direct participation and leadership by the people, looking for alternative ways forward that necessarily arise from horizontal relationships, which are the opposite of centralized, vertical power structures (10).

One of the key criticisms of the hegemonic approach is its assumption that a society can be sustainable without actually being so. A society, for example, can sustain minimum survival conditions within certain time limits and at

the same time be concentrating and excluding, discriminating, uncultural, wasteful, and, therefore, unsustainable. A society can, up to a certain point, supply and import certain goods to meet its population's basic survival needs (e.g., food) and call it "sustainment" or "food security," but this does not mean that sustainable foundations have been laid for ensuring food security in its territory (11).

Some authors, including Martinez-Alier (12), have attempted to formulate pertinent and progressive concepts of sustainment from a multidimensional point of view, focusing on the proposition of an ecological economy that, at least theoretically, considers economic production and the economy itself from a socio-metabolic standpoint, with conceptual links between the social and natural sciences and history.

In 2001, the Canadian International Development Research Center (IDRC) proposed an alternative to the neoliberal model, called the "Integrated Human Ecosystem" (IHE), aimed at constructing a new ideology focused on the social question (13).

After exploring this range of approaches to the concept of sustainable development, we can make a critical assessment of the propositions based upon three guiding concepts, as posited by Klaus Frey: the first sees the market as a development-regulating force (the liberal economic approach); the second involves approaches that consider the State and its regulatory and planning institutions essential tools for ensuring that the common good prevails in the development process (the ecological-technocratic approach to planning); and the third involves concepts that focus on the need to promote extensive political mobilization and greater participation by populations and civil society organizations in the quest for a sustainable development model (the democratic participation political approach).

Although the international community has unanimously embraced the concept of sustainable development, it is nevertheless difficult to verify its supposed commitment to defending the environment and future generations from its current actions and measures. There is a basic lack of research to support sustainability and development theories at the political-administrative level.

The failure to include intangible common goods in development policies is not confined to the question of how best to manage natural resources, or how to improve the workings of market forces. In modern societies, this problem affects all activities and decisions made in the social, economic, political and administrative spheres. Notwithstanding the important issue of analytical capacity and the limitations of scientific knowledge, the challenge of sustainable development is above all a political problem that involves the exercise of power while ensuring that the issues of political-administrative institutions, participation, and the political process are firmly on the agenda (14).

The market approach of economic liberalism confers power on the market's "self-regulating forces," and presupposes that the pressure exerted by competition, economic growth, and prosperity will automatically lead to the rational use of natural resources, technological advances, and new consumer needs compatible with the demands of the environment (14).

While this approach focuses on the market (the economic dimension), the second approach, the so-called ecological-technocratic planning approach, highlights the ecological dimension—i.e., the compatibility between economic development and the preservation of natural resources, since it presupposes that there is no justification for assuming a predominantly positive correlation between economic growth, poverty, and ecological sustainability. This approach contains two separate propositions: one emphasizes the strengthening of State technology (the "Stable State Society"), and the other, ecodevelopment, which seeks to harmonize different interests to ensure that the social, cultural, and spatial dimensions, as well as economic and ecological considerations, are addressed. This involves the concept of "other development," based on participatory political planning.

The third approach, the democratic political participation approach, addresses society-supported sustainability and considers that, with the diversification of the networks for negotiation now being forged among the different actors in societies and among States, the present-day State is gradually losing its capacity for unilateral hierarchical leadership. These increasingly dense networks intensify the pressure on current political-administrative systems at all levels of government. Environmental problems clearly indicate that environmental policies set out to achieve much but end up accomplishing very little (15,14). The theories of participatory, deliberative democracy and communitarianism increasingly reveal growing disillusion with the transformative potential of the State. They represent the search for an alternative to the free market as the only mechanism for societal decision-making on pathways to development, as well as the hope that civil society can become the key player in the sustainable development of contemporary society. In short, this approach highlights the need for public participation in environmental policy-making, which is essential for ensuring a substantial change in current public policies.

Unlike the ecocentric approaches focused on nature and its protection, the democratic political participation approach makes people and society the center of attention and reflection. This approach can therefore be considered a “sociological approach to sustainable development” (16,14). Furthermore, it represents a struggle to achieve respect for, and a guarantee of, the basic rights of the more socially fragile sectors and the creation of a public sphere in which questions of ecology and nature, as well as socioenvironmental problems, can be discussed and resolved.

We believe that it is necessary to improve emancipatory learning to enable us first to rethink the needs and inalienable rights that should be respected by production, and then to construct the rules and monitoring tools essential for knowing and enforcing the sustainable limits of all human activity with implications for life as a whole.

All approaches to the issue of sustainability must consider the need to identify environmental, ecological, social, economic, cultural, and spatial vulnerabilities.

History bequeathed to the American hemisphere a range of inequities, vulnerabilities, and immense suffering. This has been true especially in South America, Central America, and the Caribbean, where indiscriminate urban growth and polluting industries have fostered all kinds of exclusion, leading to higher crime rates; threats to ecosystems and biodiversity; soil, air, and water pollution; and greater vulnerability of the Region to climate change.

The concept of vulnerability is normally defined as a situation in which three components are present: exposure to risks, inability to react to risks, and difficulty adapting to the situations caused by risks (17).

In recent years, the term “social vulnerability” has often been used by academics and government bodies in Latin America. The concept of vulnerability has been especially emphasized by international agencies such as the United Nations, the World Bank, and the Inter-American Development Bank. The visibility of studies on social vulnerability is due in part to dissatisfaction with the conventional approaches to poverty and the ways it is calculated, based exclusively on income levels and fixed measurements such as the poverty line. The concept of social vulnerability, which considers insecurity, exposure to risk, and the problems caused by economic events or changes, provides a broader view of the living conditions of the poorest social groups, while taking into account the resources and strategies of families compelled to deal with the fallout from the risks to which they are exposed (18-20).

It is worth mentioning the important contribution made by Kovarick (21), who, in his writings on socioeconomic vulnerability, put forward an innovative proposal to compare civil vulnerabilities in different countries.

A further line of research on vulnerability, based primarily on a geographic approach, can be found in the various studies on natural hazards and risk assessment. Under this approach, vulnerability can be understood as the interaction between the risks posed by the characteristics of a particular place and the degree of exposure of the population living there (22). Studies with this approach (mainly on engineering aspects) have been conducted in local spaces and territories (23,24).

The viability of the recommended approaches for tackling these problems rests on considering the concept of vulnerability and its determinants: *a*) population vulnerability—that is, the existence of vulnerable groups (based on social, political, and economic status; ethnicity; gender; disability; age; etc.) resulting from different types and degrees of social exclusion; and *b*) institutional vulnerability, related to the way particular societies function vis-à-vis public policies, decision-making processes, and the performance of institutions under the existing structural conditions or pressures that can foster or exacerbate risk situations and events. In order to address vulnerabilities in the poorest countries and regions of the Hemisphere where populations are significantly exposed to risk, it is important to have an organized State and the participation of the epistemic communities and all organized civil society sectors. It is for this reason that essential knowledge is being produced and transferred to address the entire range of problems, especially those of transnational origin that require specific environmental, political, and economic knowledge at the international, regional, and national levels, as well as the participation of different populations and cultures (25).

Important work has been done in this respect by Puerto and Freitas (26) and Puerto and Fernandes (27), who approach vulnerability as a transdisciplinary concept that brings together various irreducible aspects of risk that occur in socially vulnerable contexts.

In recent years, vulnerability has become a core theme for the scientific communities working on environmental change and sustainability, among them the International Human Dimensions Program on Global Environmental Change (IHDP); the International Geosphere-Biosphere Program (IGBP); the Intergovernmental Panel on Climate Change (IPCC); and the United Nations Program on the Environment (UNEP). One issue that is frequently raised is the vulnerability of water resources in relation to drinking water, lack of sanitation, and water-borne diseases. Poor populations generally have no access to adequate basic sanitation (water supply and sewerage systems) and are

often forced to live in areas where water is subject to high levels of pollution. Around 1.1 billion people in developing countries today have inadequate access to water, while 2.6 billion people lack basic sanitation (28).

Social and environmental vulnerability studies often have different approaches. While the literature on social vulnerability focuses on individuals, families, or social groups, geographic studies on risks and natural disasters explore environmental vulnerability from a territorial standpoint (regions and ecosystems), as well as considering local spaces and territories (23,24).

It follows that the differences between these two types of vulnerability studies, in terms of their scope and the object of analysis, must be considered when addressing the two dimensions of socioenvironmental vulnerability: the social and the environmental (29,30).

The multiple interactions between the current range of socioeconomic, behavioral, and environmental factors can cause highly complex problems, particularly in the areas of environmental sustainability and human sovereignty. Thus, studies on these topics require a much broader approach.

This new approach is needed because continuing use of conventional scientific reductionism will result in a failure to understand and formulate strategies for preventing and controlling socioenvironmental risks. Funtowicz and Ravetz (31) claim that an approach must be based on knowledge of three types of uncertainties: technical uncertainties related to the accuracy of data and analysis; methodological uncertainties arising from the unreliability of data and include more complex and important aspects of information, such as values and reliability; and epistemologic uncertainties related to the gaps in scientific knowledge (31).

We must also tackle the concept of vulnerability addressed in the field of philosophy, and more specifically, the concept that is emerging in bioethics. Drawing on interpretations of Foucault's power models, there is a need for research on human beings based on the notion of "bare life," considering bioethics a tool for protecting vulnerable people while at the same time addressing the actual problem of vulnerability (32,33).

These formulations are reflected in the economic, social, environmental, and cultural situation of the peoples of Latin America and the Caribbean, as well as that of excluded groups in North America.

The Latin American and the Caribbean region is the most highly urbanized region in the world. Some 77% of its population lives in cities, and the rate of urbanization is increasing. Between 1987 and 2005, the overall rate of urbanization increased from 69% to 77% in an estimated population of 560 million. This varies from country to country. In Argentina, Puerto Rico, and Uruguay, for example, over 90% of the population lives in urban areas. The regional megacities (Mexico City, São Paulo, and Buenos Aires) have populations of around 20 million, 18 million, and 13 million, respectively (34).

Urban growth generates a greater need for transportation, whose poor condition in the Region implies greater pollution and a higher risk of accidents. Traffic accidents cause an estimated 130,000 deaths and 1.2 million injuries annually in the Americas, leaving 1 in 10 accident victims with some form of disability. Traffic accidents are more frequent in the poorer countries of the Region due to poor vehicle maintenance, the large number of road users (pedestrians, cyclists, and motorcyclists), low levels of road safety education, and inadequate regulation (35).

Rapid indiscriminate urbanization and industrialization also contribute to higher levels of air pollution due to the increased use of fossil fuels (especially diesel oil) and to emissions of carbon dioxide, particulate matter, and other toxic substances that directly impact the health of biomes. Short- and long-term exposure to these pollutants is associated with increased mortality and morbidity from respiratory and cardiovascular diseases. Worldwide, an estimated 800,000 premature deaths are caused annually by cardiovascular and respiratory disease, lung cancer, and respiratory infections (the latter in children under 5) specifically related to exposure to particulate matter (35).

These emissions also contribute to global climate change. According to the IPCC, the earth's temperature rose during the 20th century by 0.2-0.6°C, causing sea levels to rise between 10 and 20 cm. IPCC forecasting models predict an even worse scenario, with global warming increasing by 1.4-5.8°C by 2100, causing widespread negative global impacts. Four countries in the Americas are among the world's highest producers of carbon dioxide emissions: Brazil, Canada, Mexico, and the United States (35). A further major problem caused by global warming is that of "climate migrants." According to the report of the United Nations Climate Change Conference, held in Bonn (Germany) in June 2009, by 2050 at least 200 million people will be displaced as a result of climate change, and, in the worst-case scenario, this number could rise to 700 million, according to the Brazilian newspaper *O Globo* (11 June 2009).

Increased urbanization due to the concentration of wealth has exacerbated urban poverty. In Latin America and the Caribbean, 39% of urban families live below the poverty line, with 54% of them living in extreme poverty (35).

In 2006, some 205 million inhabitants of Latin America and the Caribbean were living in poverty and 79 million in extreme poverty, mainly in the central and southern parts of the continent. This average figure, although substantial, masks the way in which actual poverty is distributed (see Figure 3-1).

Poverty and extreme poverty are directly linked to the nutritional status of the population. According to FAO, the percentage of people in Latin America and the Caribbean who do not consume the minimum daily calorie requirement ranges from 2% in Argentina, Barbados, and Cuba to 47% in Haiti. This situation is generally reflected in the low weight-for-age levels among children under 5 (35).

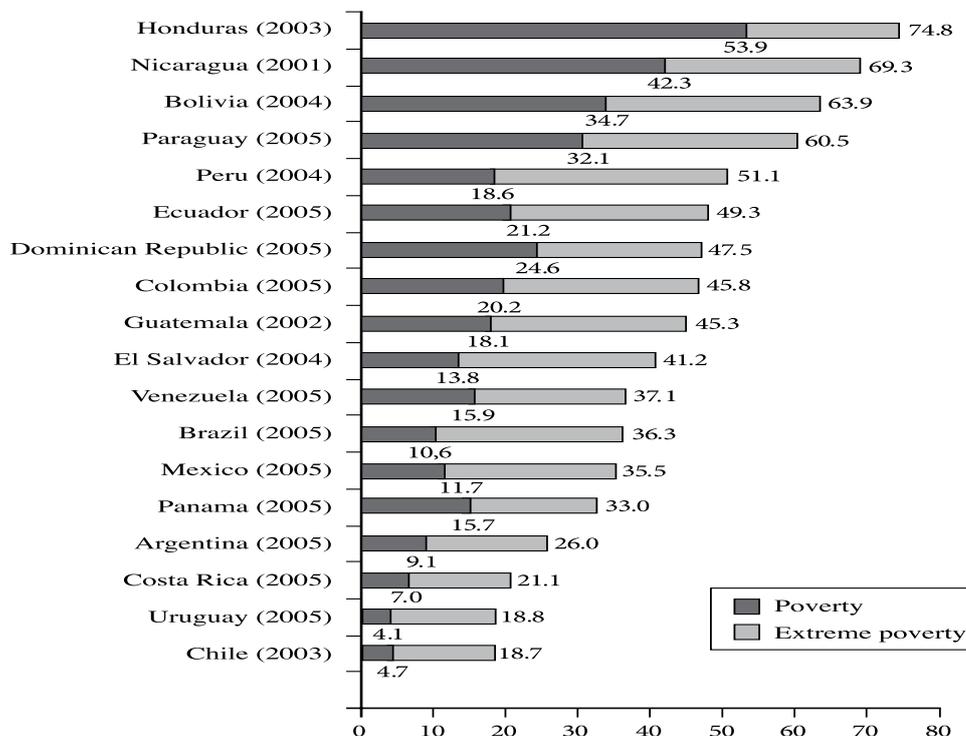
As for education, despite rapidly rising enrollments at the basic education level (up from 86.2% in 1990 to 91.5% in 2004), unequal access to schooling by the most vulnerable groups and the persistent disparities within countries are still the main challenges. An ECLAC study shows that in 2002, at least one in every four adolescents aged 15-19 from the 20% poorest population group failed to finish primary school. That same study reveals that children in rural areas have fewer opportunities to finish their basic schooling than children living in urban areas. Furthermore, there are considerable differences between children from the indigenous and nonindigenous population who finish their basic education. This is particularly true in Bolivia, Brazil, Ecuador, Guatemala, Nicaragua, Panama, and Paraguay (35).

Given these circumstances, it is not surprising that violence and crime continue to rise in the Region, which currently has one of the highest homicide and kidnapping rates in the world (Figure 3-2). Over the past 10 years, an estimated 110,000-120,000 homicides and 55,000-58,000 suicides have occurred in Latin America. Juvenile delinquency and crime involving gangs that specialize in kidnapping, human trafficking, and gun and drug smuggling remain a major concern (36).

This is especially the case in Central America, where violent deaths have risen in nearly every country and now account for 100 deaths per 100,000 population (except for Costa Rica). Surveys show that in most of Central America, over 20% of the population has fallen victim to crime (36).

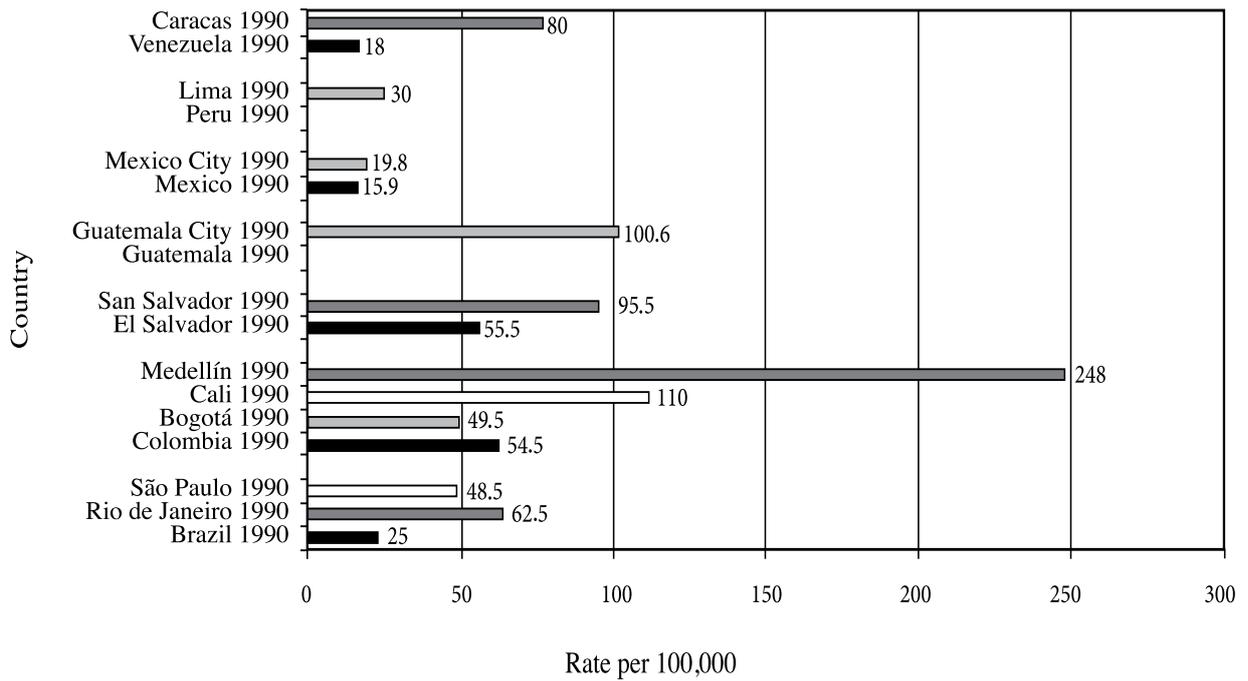
In addition to the suffering it causes, violence also has a profoundly negative impact on development and entails high costs for society as a whole. At the macroeconomic level, external and internal investment has declined to the detriment of long-term growth prospects. Meanwhile, at the microeconomic level, violence discourages many people from investing time and money in education, while others turn to crime (Figure 3-3).

**Figure 3-1** Poverty and extreme poverty in Latin America and the Caribbean (PAHO/WHO, 2007)



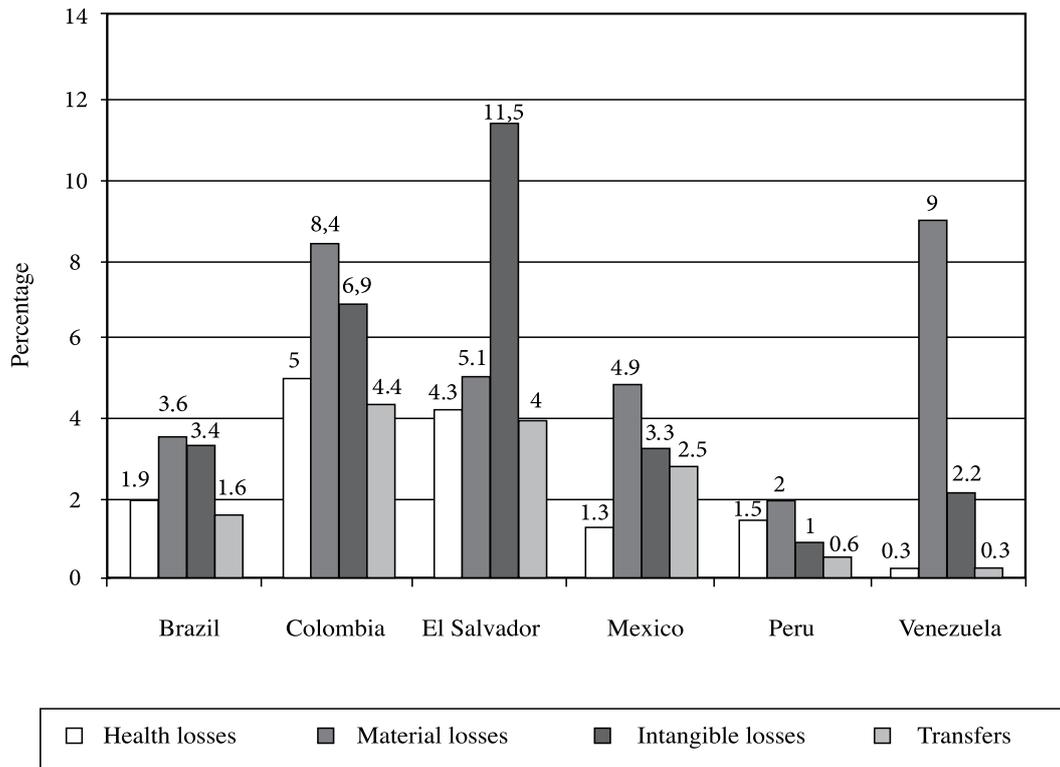
Source: Based on ECLAC (2006), *Social Panorama of Latin America 2006*. (Statistical Annex).

**Figure 3-2 Urban violence in Latin America: Homicide rate per 100,000 population**



Source: (37)

**Figure 3-3. The Economic cost of violence in Latin America (as a percentage of GDP in 1997)**



Source: (8)

In addition to environmental degradation and inequality in the poor outskirts of the cities, where living conditions and access to clean water and basic sanitation leave much to be desired, people in these places are also exposed to very high levels of chemical and biological pollution caused by the dumping of improperly treated or eliminated industrial and domestic waste that seeps into the aquifers.

These conditions are getting worse in countries such as Haiti, where the percentage of the population with access to safe drinking water declined from 60% in 1990 to 58% in 2004 (35).

Access to safe drinking water is a serious problem both for current generations and for future development. Throughout the 20th century, water consumption kept pace with population growth. Four out of 10 people in the world now live in areas where water is scarce. If the current situation persists, by 2025 an estimated two thirds of the world's population will live in countries with serious water supply problems (35).

Deforestation from excessive logging and the expansion of crop- and grazing land is reducing global vegetation coverage, limiting its genetic diversity, and causing erosion and desertification. Between 1999 and 2000, 4.28 million ha of vegetation were lost, 240,000 ha of which were in North America (except Canada), 340,000 in Central America, and 3 million in South America (35).

Biodiversity is also being threatened due to the conversion of forests to grazing land or crop production or to urban infrastructure, all of which contributes to the loss or fragmentation of natural habitats.

This context of deforestation, reduced biodiversity, water shortages, and droughts is generally related to sociopolitical disasters, such as armed conflict and forced migration, which exacerbate soil degradation, erosion, and desertification. The resulting loss of arable land contributes significantly to one of the greatest threats to human security in many regions: food security.

These factors have a serious impact on the burden of morbidity and mortality and the health status of entire populations. In 85 of the 102 most common diseases throughout the world, environmental risk factors are contributory factors to the burden of morbidity (39). The specific percentage of diseases attributable to environmental causes varies widely, depending on different conditions. An estimated 24% of disability-adjusted life years (DALYs) and 23% of all deaths are due to environmental factors. Among children up to the age of 14, the proportion of deaths attributable to environmental causes is as high as 36%. Disaggregation of the respective data reveals the differences between regions and points to the greater vulnerability of the world's poorer regions (40).

Rigotto and Augusto's (41) analysis of socioenvironmental inequities in Brazil resulting from the current globalized development model explores the link between health, the environment, and development, showing that the paradox between Brazil's natural and human potentialities and its levels of poverty are a reflection of environmental injustice and the violation of human rights. A better understanding of this situation can create opportunities for poor populations to aspire to a better life.

For more details about the current situation of the Americas and the effects of various environmental conditions on health, see the material in the list of references (34,36,42).

It is clear that areas of environmental degradation are often those marked by persistent poverty and social deprivation. This suggests that environmental vulnerability is a key factor in the spatial distribution of poverty and social deprivation in major cities. We can argue that the social and spatial environmental dimension of poverty can be analyzed by exploring the issue of vulnerability in terms of the spatial interplay between social and environmental problems. Furthermore, areas of substantial environmental vulnerability display socioeconomic conditions that are significantly worse than those in areas with lower levels of environmental vulnerability, highlighting the existence of critical areas with a large concentration of social and environmental risks and problems (43-47).

## The key point: Growing economic concentration and falling standards of living

The collective activities of human beings on Earth involve a process of artificialization (48). Human activities revolve around a system of social reproduction involving different ways of relating to nature that cause and sustain changes in natural reproduction systems and their elements (49). However, since there is intense synergy between nature and human social reproduction, it is impossible to separate the human side from the natural side, and it is unrealistic to attempt to draw a precise line between natural and social processes—between the processes of a human being as a living thing in nature and the natural ecosystems that form part of a society's existence. This fascinating dialectic, described in revolutionary science and philosophy since the 19th century, forms part of the ancestral knowledge of our peoples and helps us to formulate a comprehensive definition of "ecosystem."

We can first consider the idea of a system that reflects the interplay between nature and ecology, since together they constitute a complex, multidimensional, and regulated set of linked, interdependent processes. However, this system is intersected by social relations, since the relations between human beings and nature are not purely natural or biological but social—that is, economic, cultural, and political—and create a guiding logic that determines the forms of life in human societies, how social-natural spaces are constructed, and how patterns or modes of behavior are structured for human life in these spaces.

In the light of the above arguments, we propose a concept of “ecosystem” that involves an interconnected and coherent socioecological grouping characterized by landscape, biodiversity, temperature, rainfall, flora, fauna, and different levels and forms of artificialization—elements that, when artificialized, are transformed into socioecological processes.

In reality, ecosystems are *socioecosystems*, since they are punctuated by social relations that determine: the equitable or inequitable logic of human processes and artificialization; the construction and segregation of the socioecological spaces involved; the sustainment or loss of biomass and biodiversity; the construction of social patterns of exposure and vulnerability to the ecosystems associated with economic production or consumption; and, finally, the types of impacts on life itself.

At the root of this problem is the emergence of market societies that have undermined the collective meaning of social reproduction by shifting from production for meeting material and spiritual needs, to frenetic productivity focused on the accumulation of wealth. We have therefore moved from producing use-values considered goods to the production of merchandise and profit. Two historical processes emerge from this productivity logic that have devastating implications for human rights and nature: the accumulation and concentration of economic wealth as the center of all social activities, including those related to artificialization, and the consolidation of an anthropocentric approach to development, relegating to second place the importance of constructing a collective life in harmony with nature and grounded in an emancipatory culture and spirituality.

## ■ Final considerations

Massive economic growth over the past three decades has unleashed on the world a set of strategies and mechanisms designed to impose an extreme productivity culture on humanity. Widely regarded as the basis of development, this culture has little to do with the everyday aspects of life.

Major corporations have used their power and combined hegemonic strategies of persuasion to impose their domination by speeding up economic and political mechanisms that are taking up the space for life and bringing the biosphere to the edge of a catastrophe of hitherto unimaginable proportions.

Seen from the South (and from the standpoint of its victims in North America), the Wall Street disaster provides the most visible evidence of a financial *tsunami*. It is, above all, a clear warning to social movements and responsible academic communities around the world that it is not primarily a question of fighting the profound iniquities of market societies and the dramatic setbacks in universal rights caused by the private concentration of capital. Rather, it is an opportunity to react globally against the mechanisms of dispossession, wealth concentration, and the gathering pace of unhealthful productive systems based on the destruction of life as we know it and which present no real prospects for their future reproduction.

In other words, what is at stake is nothing less than the ability of our planet to sustain life in the coming years. This is not just a dilemma for our survival as a species. It raises the fundamental question of whether it will be physically possible to enjoy a good life at some point in the future.

The big challenge in the fight for health and the environment and the promotion of responsible academic research in the coming decades will be (i) understanding the deep-seated interdependence among social, health, and environmental achievements and (ii) relating the urgent need for social-health-environmental justice to the tough environmental issues that human beings face at the local and national levels. These interlinked questions have been endlessly discussed by people of varied ideological leanings, but they have frequently avoided exploring the substantive elements of the problem. Hence, the need to submit the pivotal concepts of *sustainable development theory* (or what others mistakenly call “sustainable development”) to rigorous critical scrutiny and careful epistemological analysis. This should not only detect diametrically opposing viewpoints but serve to clarify the strategic interests of those from opposite sides of the social system who seek to drive practices and concepts in totally different direc-

tions. Concepts such as “sustainability” could therefore end up being transformed into instruments of hegemony and “business as usual,” rather than into tools for emancipatory social and scientific action.

Under these circumstances, especially when various Latin American countries are now poised for change, there is a pressing need for social movements to modernize their agendas. The same holds true for academic and intellectual groups whose work involves defending life and justice.

At the beginning of the 21st century, we are witnesses to a nascent backlash in South America. While Venezuela spectacularly regained possession of its main source of wealth (oil), the most interesting example is perhaps that of Bolivia, given its special position: it is not only at the geographic center of the South American continent, but is also the principal meeting point for two large human groups, the “new” and the native peoples that make up the region’s population today, which is why the country has always been threatened with disintegration.

The emergence of a government that truly represents Bolivia’s majority indigenous population, with an agenda to reform the country and preserve national unity, is a new development with broad implications: a reformed, democratic, and united Bolivia shows that the unity of the peoples of South America is not only possible but necessary.

The effects of the international crisis on South America are still not clear. The drop in the prices of agricultural products, basic manufactured goods, and oil is reviving old balance-of-payments problems and making it harder for the countries of the region to secure external financing. This situation can be addressed by making passive adjustments (i.e., simply adapting to the new, less-favorable conditions), or active adjustments, using the crisis to promote genuine structural changes and open new pathways to growth. There are examples of both approaches: Brazil responded actively to the 1929 crisis by launching an important cycle of industrialization, and passively to the 1981 external debt crisis, which ushered in a long period of stagnation.

The decisions that South America makes in response to the crises will strengthen one of the two options open to it: either it will decide to join the area that is under the direct control of the U.S. megastate (with the future prospect of the region being formally declared a “dollar zone”), or it will become an autonomous regional cooperation and development area, the embryo of a South American federation. At the beginning of the 21st century, we are now at a crossroads in our history. The creation of UNASUR (the Union of South American Nations) could well lead the way to the second option, as can be deduced from the general objectives set forth in this organization’s Constitutive Treaty in 2008 (50):

The objective of the South American Union of Nations is to build, in a participatory and consensual manner, integration and union among its peoples in the cultural, social, economic and political fields, prioritizing political dialogue, social policies, education, energy, infrastructure, financing and the environment, among others, with a view to eliminating socioeconomic inequality, in order to achieve social inclusion and participation of civil society, to strengthen democracy and reduce asymmetries within the framework of strengthening the sovereignty and independence of the States.

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# Environmental health governance in Latin America and the Caribbean

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## ■ Introduction

In this chapter we focus on the current state of environmental health governance, particularly in the countries of Latin America and the Caribbean (LAC). We outline some of the demographic, economic, social, and other determinants involved, and consider the question of the burden of disease attributable to environmental risk factors.

We explore some of the basic concepts related to governance and its interaction with human rights, environmental justice, and human security, and examine the links between environmental health and global public goods. We also consider some of the issues arising from the growing number and complexity of international environmental treaties and agreements.

We describe the arduous task of developing a system of governance for health and the environment associated with global sustainable development. We also emphasize the growing importance of global environmental changes as the new drivers of environmental health agendas.

Finally, we discuss some of the key lessons learned, and the challenges that are still facing the Latin American and Caribbean region.

## ■ Environmental health in Latin America and the Caribbean

Latin America and the Caribbean has a substantial debt stock in environmental terms, especially with regard to environmental health. While some of the Region's countries have improved their national health services, most of them have found it impossible to introduce robust intersectoral health reforms due to their persistent sector-specific approach to public policies, concepts, and action plans. Although there have been notable improvements in the doctrines, methods, and metrics related to environmental health and the social determinants of health, the health services in much of the Region remain predominantly assistentialist, wedded to narrowly-focussed conventional prevention and promotion programs, despite the growing evidence that environmental and social factors are largely responsible for a significant burden of death and disease (1).

According to projections, the world's population will rise to some 9.1 billion by the mid-21st century (2). If this trend continues, the population of Latin America and the Caribbean will reach an estimated 751 million by 2050, equivalent to 8.3% of the global population (3).

The Americas are already the world's most urbanized region. In 2010, 82.1% of North America's population and 79.4% of that of Latin America and the Caribbean lived in urban areas. Recent data show that although urban growth in Latin America and the Caribbean began to slow between 2005 and 2010, it is predicted that by 2025 nine of the world's 30 largest cities will be in the Americas: São Paulo, Mexico City, New York, Buenos Aires, Los Angeles, Rio de Janeiro, Bogotá, Lima and Chicago (4).

This unparalleled population growth will continue to put pressure on the natural environment. As the global economy absorbs a greater number of people, the demand for energy, food, water, wood, fibers, and all types of consumer goods promoted by insatiable corporate expectations, will affect the resilience of the different ecosystems irreparably. A recent study claims that 15 of the 24 global ecosystems (60%) are being degraded or used in an unsustainable way (5). Meanwhile, the net benefits for human well-being and economic development have been highly asymmetrical. While select minorities have reaped huge profits from this process, the great majority have not benefited at all. Indeed, many people have been impoverished as a result. The real costs and losses caused by these social and environmental injustices are only now coming to light (6).

According to ECLAC, the Latin American and Caribbean economy grew by 2.1% per year between 1950 and 2009 (7). The 2008-2009 financial crisis significantly undermined the international financial system, threatening the economic and social stability of all the countries of the Region. Although between 2010 and 2012 the global economy showed signs of recovery, due especially to the stronger performance of the emerging countries, their pathway towards sustainable economic growth has not escaped the turmoil experienced by the major global economic players (8,9). Despite the recent upturn of the United States economy, new imbalances are hitting the European and Asian economies hard and curbing the prospects of several Latin American and Caribbean countries (10).

In Latin America and the Caribbean, the crisis of the late 1990s was preceded by 4 years of sustained per capita GDP growth, averaging some 4.4% per annum. In 2009, most countries of the Region saw their rates of economic growth and per capita income fall as a result of the crisis. The following year, however, growth resumed, with per capita GDP rising by 4.8% and producing the lowest levels of poverty (31.4%) and extreme poverty (12.3%) of the past 20 years. Notwithstanding this more optimistic scenario, at the end of 2011 the Region still had 177 million inhabitants in poverty, of whom 70 million were in absolute poverty. During the same period, 15% of the population of the United States and 11% of Canada's were living below the poverty line (11,12).

Faced by the economic crisis, most countries of the Region introduced counter-cyclical measures in 2008-2010 to mitigate the effects of the crisis, mainly by introducing conditional cash transfer programs and by protecting and expanding public social expenditure, which accounted for up to 3% of GDP in 2010 (13).

Although between 1980 and 2010 the Region's Human Development Index rose from 0.573 to 0.704, this was still lower than that of the OECD countries in 1980 (0.754). By 2010, the Region's HDI was nearer 0.717, defined by UNDP as a "high development" threshold. These figures however mask substantial differences of equity between and within the countries, whose sustainable development agendas continue to be dominated by ambivalent realities (14). On the one hand, structural rigidities persist that reinforce the intergenerational reproduction of historical inequities leading to social stratification. This restricts access to decent jobs, quality education, healthy housing conditions, health services similar to those enjoyed by the rest of the population, and to a range of other facilities, and weakens the prospects of a more equitable distribution of wealth and power. On the other hand, there has been some progress in recent years resulting from higher occupational earnings (13) and the impact of redistributive income policies (15,16) channeled through progressive and sustained conditional cash transfer programs to the most vulnerable sectors. This has occurred in a context of growing democratization and decentralization (17), alongside technological advances and better access to basic education by the most socially disadvantaged population groups (18), thus providing opportunities for establishing less unjust societies. In Latin America and the Caribbean, an estimated 60 million people emerged from poverty in 2010, denoting a change of unprecedented magnitude (13).

According to ECLAC, Latin America and the Caribbean was the world's most inequitable region in 2009, with an average Gini coefficient of 0.52 in the 18 countries analyzed (higher than that of Sub-Saharan Africa (0.44) and East Asia and the Pacific (0.41) (19). Other studies however revealed that, in terms of income distribution, the Region's Gini coefficient fell from 0.56 in 2003 to 0.48 in 2008. This shift, probably due to the changes implemented in the countries with the largest economies (Brazil and Mexico), as well as in the other 11 countries studied, occurred at a time when other developing regions were experiencing growing income inequality (20,21,22).

In every society the inequalities and asymmetries of power associated with income distribution widen the gap between citizens and institutions, and between citizens and political parties (23). Despite the economic crises that have periodically afflicted Latin America and the Caribbean (especially the crisis of 2009), the opinion polls con-

ducted that year by *Latinobarómetro* showed that the level of popular support for democracies in the countries of the Region exceeded that of 2006, when the Region's economic growth was at its highest for the decade (24).

The countries of the Region are evolving in general towards less fragile democracies, seeking to build new constitutional frameworks and more transparent, participatory electoral processes, with freedoms increasingly recognized as a civil right. While further disruption cannot be discounted, two apparently opposing yet not incompatible processes are underway. First, the growing decentralization and empowerment of communities is laying the foundations for plural, participatory democracies. Second, the countries are becoming increasingly involved in the globalization process. These two processes impact on how power is redistributed and real citizenship is built. Together with economic advances, these developments are helping the countries of Latin America and the Caribbean to aspire to higher levels of autonomy and self-confidence. Major problems such as violent crime, drug trafficking, and endemic corruption are however placing at risk some of the progress that has been achieved to date.

The use of social networks is rapidly expanding, transformed by the IT revolution that is fueling new perceptions, expectations, and demands in every sphere of life. Different sectors of the community increasingly use the networks to organize protests, to support multifarious causes, and, importantly, to voice their views on a wide range of topics such as the economy, the environment, education, and health (25).

In Latin America and the Caribbean, upward mobility and the steady growth of the middle classes are paving the way for the emergence of new markets for goods and services, including health and education. At the same time, aspirations and political preferences are changing. In some countries of the Region, political parties and other traditional institutions are losing the credibility and trust of the societies that they represent (26).

Globalization is leading to the emergence of new correlations of forces that represent different pragmatic and ideological interests. In this rapidly changing world, the countries of the Region have been increasingly proactive in expanding and safeguarding their presence in a range of commercial and political groupings. Each country has broadened its horizons by joining various alliances, partnerships, and groupings, that come together as the result of geographic proximity or for commercial, cultural, or political reasons. The countries are, for example, increasingly prominent in global strategic forums such as the Organisation for Economic Cooperation and Development (OECD), the Group of 20, the Asia-Pacific Economic Cooperation Forum (APEC), and the BRICS group (Brazil, Russia, India, China, and South Africa). Meanwhile, they remain members of the longstanding pan-regional bodies, as well as playing a role in newer organizations such as the Bolivarian Alliance for the Peoples of Our America (ALBA), the Union of South American Nations (UNASUR), and the Community of Latin American and Caribbean States (CELAC) (27).

The local, national, regional, or global environmental and environmental health agendas are still tied to historical, political, demographic, and socioeconomic realities, and it is only in this context that the proposals for better governance can be understood. Between 2008 and 2010, for example, the proportion of people who claimed that climate change affected the well-being and development of their home country increased from 84% to 88%, while the proportion of those who prioritized economic over environmental issues fell from 37% to 17% (28).

One of the best examples of interdependence in a globalized world is perhaps represented by the current efforts to develop governance for the environmental and environmental health agendas, where external decisions can have a major impact on those made internally, and which inevitably affect the traditional concepts of sovereignty. External decisions, often influenced by foreign interests controlled by small elites, can negatively affect large population sectors that are far removed from the dominant centers of economic power. For some authors, such as Paul and Anne Ehrlich, our civilization is currently facing a profound crisis (29).

## The Burden of Disease Attributable to Environmental Causes

WHO estimated in 2006 that some 24% of disability-adjusted years of healthy life lost (DALY) and 23% of premature deaths worldwide were caused by exposure to avoidable environmental risks (30), with one third of the deaths being those of children under five years old. In the Americas, the estimated burden of disease from preventable environmental causes (17%) (31) significantly undermined health services, financial stability, economic growth, and governance in the broadest sense (32).

In late 2012, the findings of the Global Burden of Disease Study 2010 (GBD 2010) (33), were issued. This study analyzed 67 risk factors (8 of them from environmental causes, including tobacco smoke, unimproved water sources, unimproved sanitation, dust pollution, indoor air pollution, atmospheric ozone pollution, lead poisoning, and exposure to radon gas in homes) in 21 regions of the world (6 of them in the Americas). The methodology was based on estimating and comparing the DALY caused by 291 different pathologies reported in 1990 and 2010.

This study only considered a part of the burden of disease and death that affects population groups in varying degrees of severity, since it was impossible to broaden the scope of the survey due to methodological constraints, incomplete data or lack of evidence. The data collected was nevertheless invaluable for further developing policies and intervention programs.

As well as exploring the environmental risks, the GBD 2010 warned of the carcinogenic risk of occupational exposure to the following: asbestos, arsenic, benzene, beryllium, cadmium, chromium, diesel soot particles, exposure to second-hand tobacco smoke, formaldehydes, nickel, polycyclic aromatic hydrocarbons, silica and sulfuric acid. Other occupational risks included occupational exposure to asthmagenic substances, gases, steam and smoke, noise and work-related injuries (33).

The main findings of this study suggest that, between 1990 and 2010, the contribution of the various risk factors to the regional and global burden of disease and injuries changed substantially: from risk factors that cause mainly communicable diseases in children to those associated with non-communicable diseases in adults (33).

The study revealed, for example, the growing burden of disease attributable to primary and secondary exposure to tobacco smoke and to general indoor and outdoor air pollution. The level of the burden of disease caused by airborne particulate matter was substantially higher than that estimated in the previous risk analysis. While in 2000 outdoor air pollution represented 0.4% of the DALY, this rose to 3.1% in 2010, for a number of reasons. First, more recent epidemiological studies produced new evidence on the link between airborne pollution and diseases such as ischemic cardiopathy and stroke that were excluded in the previous analysis. Second, the scope of the study was expanded. In the previous study, the air quality measurements were restricted to the large and medium-sized cities, whereas new data was obtained from high-resolution satellites that allowed exposure and burden levels to be quantified in both rural and urban environments. Third, the previous analyses of airborne pollution did not include the additional risks above a concentration of 50  $\mu\text{g}/\text{m}^3$  for PM<sub>2.5</sub> that were highlighted in later epidemiological studies. The same study attributes 250,000 premature deaths per year in the Americas to airborne pollution (33).

In 2010, unimproved water and sanitation caused 0.9% of the DALY compared with 2.1% in 1990. This significant reduction resulted mainly from the lower number of deaths caused by diarrheal diseases (33). It is worth noting that between 1992 and 2012, access to improved water sources in Latin America and the Caribbean expanded from 86% to 92%, although access to improved sanitation rose only marginally from 70% to 78% (34). The failure to meet the sanitation targets established in MDG 7 has serious negative repercussions for health, especially in rural areas. Furthermore, it is noteworthy that adequate and reliable data on the quality of drinking water are not always available.<sup>34</sup> The GBD 2010 admits that the real burden arising from low quality water and poor sanitation may be underestimated, and stresses the need for more precise epidemiological data to evaluate the impact of low-quality water compared with better quality water, as well as to compare residential piped water with that obtained from publicly accessible improved water sources. The study also points to the role of personal hygiene as a contributory factor (33). The findings of the GBD 2010 however contrast with the results of different studies carried out in the Americas that show that the lack of clean drinking water and proper sanitation are unequivocally and directly related to intestinal infections (35,36,37,38,39,40).

The exposure of large populations in the Region to chemical pollutants is a health hazard that has been insufficiently recognized or studied. While the world's population grew by 1.85 times between 1970 and 2010 (from some 3.7 billion to approximately 6.9 billion) (41), the production and use of chemical products increased 10 times (42). In Latin America and the Caribbean, the value of chemicals produced between 1999 and 2009 rose from US\$127,500,000 to US\$260,500,000 (43). In recent years, efforts to improve risk evaluation methods have contributed to reducing exposure to certain chemical pollutants. Major efforts nevertheless still need to be made to curb the use of pesticides and persistent organic pollutants, whose impacts on health have yet to be explored in an appropriate and timely fashion (44). Chemical pollutants are a particular hazard for high-risk groups such as young children, who are more vulnerable due to their bodyweight, metabolism and the immaturity of their tissues and respiratory organ systems (45).

## Governance: Some conceptual bases

The terms *governability* and *governance* are of relatively recent use in the developing world, and there is often confusion about their use, relevance and scope (46).

“Governability” is generally more associated with the idea of political stability, involving concepts such as the absence of violence, the existence of a legitimate constitutional regime, and the ability of a regime to prevent situations that could endanger the continuity of the political system. We can briefly define governability as “*the capacity*

of a political regime to anticipate and manage social change, within an institutional framework, in accordance with the strategic objectives of the State.” The level of governability reflects the ability of a State or government to effectively manage risks that are capable of destabilizing it. Governability also requires the representatives of the State to engage and negotiate with other political stakeholders. Governability does not necessarily require a democratic basis; a government or regime might well be authoritarian. Governability has more to do with political efficacy than with the quality of a regime (47).

There are many different definitions of “governance,” but all allude to a new way of governing (48), where the State ceases to have a monopoly on knowledge and economic and institutional resources. This involves a somewhat paradoxical situation: on the one hand, the growing *interdependence* of groups in a society concerned with internal matters, but which also have to deal externally with a wide range of countries due to globalization; on the other hand, the increasing complexity of the processes and decisions that reflect the plurality and *fragmentation* of the various actors. These new realities herald the transformation of power structures, with the State seeking to adapt to the new challenges of the 21st century. While these new forms of governance do not signal the end of the State, whose role will continue to be essential for plotting courses of action and forming coalitions, the main emphasis will shift to citizens who are already starting to play a more active role in pursuit of strong, deliberative, and proactive democracy (49).

For the purposes of this chapter we have adopted the definition of governance proposed by the Commission on Global Governance in 1995: “*Governance is the sum of many ways individuals and institutions, public and private, manage their common affairs. It is a continuing process through which conflicting or diverse interests may be accommodated and co-operative action taken. It includes formal institutions and regimes empowered to enforce compliance, as well as informal arrangements that people and institutions either have agreed to or perceive to be in their interests*” (50).

Governance differs from the hierarchical control model. Governance narrows the gap between public and private interests through the interplay between autonomous actors, and uses communication networks to obtain access to information and knowledge, to define and prioritize problems, and to make and implement decisions. Governance does not depend on the filter of a relatively homogeneous and centralizing political-administrative elite, but adopts ways to coordinate and delegate powers at various decentralized points of contact that are increasingly concerned with citizens’ rights. It implies bringing together interests at all levels, both horizontally and vertically, and harmonizing local internal and global external concerns in established geographic and population spaces, as well as reconciling the interests of the present generation with those of future generations. Governance is one of the mechanisms without which truly sustainable development cannot take place.

Governance cannot be instituted by decree. It is the sum total of the intentions of stakeholders, whose behavior can be inspired or inhibited with coercive or voluntary incentives or penalties.

Governance is exercised in practice during the formulation, implementation, and oversight of public policies. According to Oszlak and O’Donnell (51), there is no single definition of the term *public policies*. Any definition partly depends on the conceptual differences involving, for example, the scope of public policies, or the action or inaction of a government faced by problems or demands. Policies can be based on explicit or implicit decisions. In the present context, and for the purposes of this chapter, we understand public policies as “*a set of actions that manifest a given format of intervention by the State in a matter requiring the attention, interest and mobilization of other stakeholders in society.*” While public policies can occasionally be voluntary, they are generally backed by rules to ensure compliance. Ideally, they are based on the interpretation of a supposed reality prior to an analysis of their social significance, time-related importance, technical complexity, the resources required for their implementation, and the existence or not of relevant precedents. If these basic elements are considered, the resulting analysis will eventually influence societies and the lives of their individual members.

The conceptual debate on the future interplay between the environment and development is based on three different approaches. The first is wholly *anthropocentric*, and considers human well-being as paramount. This approach, while not detracting from the importance of preserving the ecosystems, considers that technological innovation, together with market forces, will help us to survive as a species and to achieve new levels of wealth and prosperity. The second approach is *egocentric*, and is therefore diametrically opposed to the first. It is based upon conserving the ecosystems in a pristine state as the only way to maintain life, including that of the human species. Furthermore, this approach argues that well-being depends by and large on reducing consumption levels within the limits of ecological resilience and on reducing structural inequities. Finally, the third approach falls midway between these two alternatives. This argues that human well-being depends upon fostering careful, intelligent, and flexible exploitation of natural resources while maintaining a balance between the available resources and

human needs. This *conciliatory* approach is being tested empirically, with mixed results. Its success will depend on our ability to calibrate, in the metaphorical sense, at least two compasses. The first involves investing in good science to minimize uncertainties; the second is to ensure that public policies are founded on ethical principles to reduce historical social and environmental inequities. Setting both compasses to steer our way forward should help us to develop roadmaps that can lead to genuinely sustainable development. Dynamic and proactive governance would contribute substantially to building the difficult and complex consensus needed at the local, regional, and global levels. In this context, the slogan launched by WHO during the 1992 Rio Earth Summit is especially appropriate: “*Think globally, act locally*” (52).

Governance as an institutional system increasingly depends on networks to enable different interlocutors with different complex dialogue and consensus-building approaches, to come together. Ideological and ethical debates often create tensions, especially in view of the asymmetries of the various players regarding their own perceived power and varied knowledge and practices, where the fine lines between the public and the private are frequently blurred. The State’s role in these circumstances is essential for reaching the necessary levels of consensus (53).

The emerging sociocultural movements have changed societies’ models of organization and production, redefining collective action and creating demands for equity and justice, both symbolically and in practice. The theory of collective action affirms that the social capital accruing from networks of reciprocity, voluntary cooperation, and commitment, contributes to building stronger communities. The new social movements can therefore be seen as part of a process of cognitive interface between power and discourse involving individuals, groups, and organizations that come together in segmented and multifaceted structures to reconstruct shared, communal spaces on a permanent and dynamic basis (54).

The new forms of protest involve strategies based on different networking tools to mobilize people to criticize perceived weaknesses, failings, abuses, etc. The various strategies can be independent or coordinated with other social movements. The ecology movements, for example, through shared voluntary cooperation networks, thrive in this new climate of protest, and have had some success in bringing about reforms.

With the rapid growth of communication technologies it is now clear, contrary to original expectations, that the Internet can promote citizenship in circumstances where it was previously nonexistent. Recent events show how a society can be quickly mobilized through use of the new tools that engender and strengthen participation by a wide range of players, and provide a dynamic interface between, for example, different levels and sectors of government, between governments and their citizens, or between citizens themselves, by empowering communities, groups, and social movements. These new forms of communication are the key to disseminating and legitimizing demands for more freedom and democracy, environmental and human rights protection, and other causes (55).

While the demands of a broad spectrum of social movements (environmentalist, feminist, sexual diversity, human rights, etc.) are increasingly articulated, both globally and nationally, as the result of the remarkable progress made in terms of the availability of and access to the new communication technologies, a significant digital divide nevertheless remains that affects the more disadvantaged sectors of society in particular.

New public-private partnerships are emerging every day between institutions able to initiate and strengthen new models of governance. For example, many firms are anxious to acquire “green” certifications for their products, obtaining ISO 14 000 approval or complying with a range of codes of conduct (56). Although firms’ motives are strongly influenced by commercial imperatives, their initiatives, generically described as Non-state Market Driven (NSMD) (57), are nevertheless moving in the right direction. The same applies to the Coalition for Environmentally Responsible Economies (58) (CERES), which promotes “green” investments. Meanwhile, the United Nations is promoting a Global Pact involving a group of firms committed to aligning their operations and strategies with the 10 principles espoused by the UN in the areas of human rights, employment, the environment, and the fight against corruption, with a view to seeking new business opportunities that contribute to expanding markets and trade to benefit economies and societies nationally, regionally, and globally (59).

Certain projects linked to the “green economy” initiative can potentially contribute to curbing the greenhouse gas emissions produced by different manufacturing sectors, in an effort to improve environmental quality and global public health (60). The implementation of this initiative has stimulated widespread debate on key issues such as technology transfer and national sovereignty over resources (61).

## Environmental health governance

The 2000 World Health Report defined health governance as “*the participation of all actors, institutions and resources whose primary purpose is to improve health in ways that seek to ensure a more equitable distribution of wealth across populations*” (62,63).

PAHO accepts the concept of the steering role in health as “*constituting the exercise of public health policy responsibilities and competencies, which cannot be delegated, within the framework of relations between government and society in a modern State. It is the government’s responsibility, exercised by the National Health Authority*” (64).

Leadership and governance are closely linked, with both exhibiting the fundamental elements of leadership and management (including the ability to guide the health sector and mobilize the various stakeholders in support of national health policies), regulation (the design and the application of regulatory frameworks to promote and protect health), the harmonization of health services delivery (the ability to coordinate the different groups of suppliers and users in order to expand health care equitably and efficiently), and intersectoral functions.

The main challenge is to coordinate supply and demand in a highly complex environment where actors from many different sectors need to come together to ensure the level of health care that we wish the entire population to enjoy.

According to WHO (1993), environmental health comprises “*those aspects of human health, including quality of life, that are determined by physical, chemical, biological, social, and psychosocial factors in the environment. It also refers to the theory and practice of assessing, correcting, controlling, and preventing those factors in the environment that can potentially affect adversely the health of present and future generations*” (65).”

Environmental health aims to protect present and future generations. It is therefore in line with the concept of sustainable development espoused in the Brundtland Report, which defines it as “*satisfying the needs of the current generation without compromising the capacity of the future generations to meet their own needs*” (66). The linkages between environmental health and sustainable development are complementary and mutually beneficial.

For the purpose of this chapter we define environmental health governance as “*the processes and the means adopted by a society to promote joint action to prevent and reduce health risks associated with environmental imbalances in both the present and future generations, and to contribute in this way to inclusive and sustainable development.*”

Environmental health governance is essentially intersectoral, involving the full participation of government entities, and a large number of different bodies representing the academic and productive sectors, and civil society. This complex process is not spared from the conflicts and contradictions arising from the different priorities, interests and methodological approaches of the stakeholders. The main functions of good environmental health governance at national and subnational levels can be described as follows:

1. Intersectoral policy formulation to ensure that risk prevention, health promotion, and environmental protection are linked to social and economic development.
2. Formulation of sector-wide regulations and legal instruments that link risk prevention, health promotion and environmental protection with social and economic development.
3. Intersectoral promotion of behaviors, attitudes, and practices to benefit health, the environment, and social and economic development.
4. Setting priorities based on intersectoral diagnoses that consider human health, the environment, and social and economic development.
5. Participatory planning, programming, and financing of the intersectoral management of health, the environment, and social and economic development.
6. Implementation of intersectoral plans, programs, and actions, including the allocation of resources for risk prevention, health promotion, and environmental protection, consistent with social and economic development.
7. Monitoring, evaluation, and verification of the outcomes of the intersectoral plans, programs, and actions concerned with health, the environment and social and economic development.

To ensure good environmental health governance in practice, appropriate functional spaces are needed to foster participation and cooperation among the different stakeholders. These spaces may be national-level interministerial committees, mixed executive/legislative commissions, commissions representing different levels of government, intergovernmental committees involving the academic and productive sectors, civil society and social movements, and other relevant groupings such as those now emerging from social networking activities.

## Human rights and environmental justice

There is a clear interrelationship between effective environmental protection, health, and human rights. These links have been acknowledged since the Universal Declaration of Human Rights of 1948, and have assumed even greater importance since the two global human rights conferences of Tehran (1968) and Vienna (1993) (67).

“Human rights” have been acknowledged as such by three successive generations. The first generation, based on the bourgeois revolutions of the 17th and 18th centuries, placed particular value on *freedom*. The second resulted from the social democratic movements that highlighted the importance of *equality*, while the third emerged from the sufferings of humanity during the Second World War and from the post-war decolonization period, and exalted the value of *fraternity*. The right to a balanced environment is a third-generation “fraternal” right. It is vital to consolidate the genuine exercise of human rights by ensuring that this right is also fully respected (68).

Environmental protection is clearly linked to protection of the individual and of vulnerable social groups. Human rights cannot be exercised in the absence of a healthy environment in which well-being and development thrives for the benefit of all. This right was enshrined in the Declaration of the United Nations Conference on the Human Environment (Stockholm, Sweden, 1972), which declared, in Principle 1, that “*Man has the fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being, and he bears a solemn responsibility to protect and improve the environment for present and future generations. In this respect, policies promoting or perpetuating apartheid, racial segregation, discrimination, colonial and other forms of oppression and foreign domination stand condemned and must be eliminated*” (69).

The second meeting of the Group of Legal Consultants of the United Nations Environment Program, held in Geneva, Switzerland, in March 1991, highlighted the importance of recognizing the right to a healthy environment and to development as a human right closely associated with living conditions, poverty eradication, demographic pressures, education, nutrition, housing, urbanization, and health (70). The Rio Conference in 1992 also signaled the importance of the close relationship between the environment, health, development, and human rights, a proposal that is now enshrined in the Declaration of Rio (71).

The environment, human rights and public health are inseparable. It is impossible to consider one separately from the others. At the same time, we cannot avoid linking all three topics to that of environmental justice, understood as “*a set of principles and practices that ensure that no social group, whether ethnic, racial, class or gender, can shoulder a disproportionate burden of the negative environmental consequences of economic operations, political decisions and federal, state, or local problems or of the absence or omission of such policies*” (72).

The social networks advocate that “*environmental justice*” is a benchmark for achieving happiness and solidarity. Linking environmentalism with social justice has become an important example of how to resist the impacts of global capitalism that demands increasing freedom to decide when and where to invest in the most diverse regions of the globe. These decisions are increasingly contested, with varying degrees of success, by social and environmentalist movements, leading to discussions and negotiations that were unheard of in the past. Environmental problems cannot be resolved unless the views of the civil society directly affected are considered.

The whole concept of environmental justice is consistent with the building of a new environmental rationality. This means fully understanding the entire range of environmental problems and formulating effective decisions to achieve an environmentally secure State, in contrast to the patrimonial (patron-client) security espoused by the failed liberal model of the State. One positive step taken in this direction was the launching in 2010 by the Federal University of Ceará (Brazil) of the first map of environmental injustice and health in Brazil (73).

## Human security

In 2005, the UN Secretary-General presented a five-year progress report to the UN General Assembly on the implementation of the Millennium Declaration of 2000. This report addressed three key concepts associated with security and human rights. First, the “Freedom from Want” called on every developing country to adopt a comprehensive national strategy to achieve the Millennium Development Goals by 2015, and on every developed country to support these strategies by increasing development and debt relief expenditure. The second, “Freedom from Fear,” asked all states to agree on a new security consensus by establishing a Peacebuilding Commission. The third concept, the “Freedom to Live in Dignity,” encouraged states to strengthen the rule of law, human rights and democracy in concrete ways, and especially to embrace the principle of the “Responsibility to Protect” as a basis for collective action against genocide, ethnic cleansing and crimes against humanity. Finally, member countries were requested to contribute to a United Nations Democracy Fund (74).

Human security involves safeguarding vital freedoms, such as protecting vulnerable people, building on their strengths and encouraging their aspirations. It also involves creating an enabling environment for providing the basic means of survival, dignity and sustainable livelihoods (75).

The threats to people's security, particularly referring to the most vulnerable groups, include poverty, the spread of disease, destruction of the environment, lack of access to water, and failure to find permanent jobs (76).

Human security encompasses equitable access to education, work and health, total respect for human rights, and the prevention of crime and violence. In this respect, the greatest challenge for national states at present is to guarantee the safety of their populations in an increasingly globalized world, where most of the risk determinants such as organized crime, environmental degradation, financial crises, terrorism and pandemics, are exogenous.

It follows that the concept of human security has little to do with the traditional model of national security based exclusively upon State-centered, territorial-patrimonial principles. It now places the human species at the center of the discourse and calls for collective, multidimensional, universal and preventive action, in contrast to the former approach based on defense of property and individual wealth.

Human security from a multidimensional standpoint includes components such as economic security, food security, health security, environmental security, personal security, and community and political security. The human being is seen in terms of his complex social, cultural, economic and political status, with security being an essential part of his existence. The concept also includes people having the right to a decent life, participating in community life, with their material and non-material needs met, with full access to political representation, with their human rights respected, and with the prospect of living lives that are relevant both locally and globally. From this standpoint, human security is indivisible and non-excludable. Human security, with its positive externalities, is a global public good par excellence (77).

While the State and international organizations responsible for global governance cannot forego their roles as guarantors of human security, the active and committed participation of the nongovernmental social sector and private enterprises is also required. Meanwhile, States must retain their sovereign right to define courses of action within the institutional context of the multilateral organizations.

## Global public goods

The classical definition of a public good is "*one consumed by the members of a community, country, or geographical area in such a way that its consumption or use by an individual or a group in a country or region does not reduce the consumption or use of another*" (78). Public goods are freely accessible, indivisible and non-excludable and in this sense have global reach (79).

This does not mean that anything can be termed a global public good. There are "pure global public goods," such as the guarantee of a relatively stable climate or infectious diseases control. Universal vaccination is a good example of this. There is also a wide range of topics that could be only partially defined as global public goods, such as health services that by nature are limited in scope.

Different categories of global public goods can involve different combinations of actions and forms of financing (international, national, public or private). Given that the consumption of public goods involves positive externalities for a society, it is naturally incumbent on the State to manage the public funds needed for their production and supply.

It is essential to note that the concept of "*common heritage*" applies to the environment, meaning that all countries and peoples have a role to play in preserving the air or the oceans. This common heritage must, by definition, be managed multilaterally, since its benefits can be enjoyed by all.

A World Bank study suggests that global public goods can be financed by employing various strategies, including the following: (80) (i) to consider the long-term sustainability of global public goods and their positive cost-benefits by requiring countries and their citizens to adopt common incentives by using globally applicable standards, treaties, and regulatory mechanisms, and (ii) to establish synergies and coordination among the national and international development actors. This involves inter alia providing more assistance to poorer countries by transferring international public and private funds to supplement their limited financial resources, to scale up their local development efforts, and to help them benefit from global public goods.

The same study suggests that "international institutions are much weaker than domestic ones. There is no world government with the authority to supply public goods directly, financed by taxing the global citizenry, or indirectly, for example, by telling individual countries how much of the public good they must supply. Nor is there an international institution capable of enforcing an agreement among countries to supply public goods. In the horizontal world of international governance, there can be no third-party enforcement. While states do enter into agreements and treaties to supply transnational public goods, such agreements must be self-enforcing. Self-enforcement is a problem because the provision of public goods is vulnerable to free-riding behavior" (80).

Another challenge facing international governance in terms of global public goods is to decide how a more efficient institutional and regulatory architecture should be constructed. This involves taking collective global action through the existing coordination mechanisms to create a consensus on the promotion of goods of public interest. Instruments such as the Montreal Protocol are successful examples, while other agreements such as the Kyoto Protocol and the commitments made to the United Nations Commission on Sustainable Development reveal non- or only partial compliance with the obligations mandated by the organs of international governance (81).

While the global governance topic is closely linked to the production and supply of global public goods, the mechanisms of global authority remain weak and the establishment of a genuinely global society is still out of reach.

In the absence of a world government, the promotion of global public goods still rests with the joint global efforts of national governments, social organizations, and private enterprises in areas where the international agencies should be playing a vital role. There is a need for a far-reaching reform to improve the procedures and dynamic of these bodies, especially those of the United Nations and its specialized bodies.

Global public goods are today a priority topic for academic research and are on the agenda of the international organizations, since the markets and the emergence of different global issues are driving thought and action towards viable alternatives for alleviating poverty and improving the deteriorating environment. Both can have serious repercussions for health and human security. In the national and international context, a political-institutional framework is required to promote joint action by the political and social agents to ensure the correct production and management of public goods, and to guide globalization along a path of equitable development. Market forces and the efforts of separate states cannot *per se* guarantee either the proper operation of the global economy or rational environmental management. We need therefore to strengthen collective international action and consensus-building between all the relevant public, social, and private stakeholders.

There is also an urgent need to scale up the role of international cooperation, especially as regards development financing. Only by improving coordination between international organizations, national governments, NGOs, the private sector and the non-State public sector, can global public goods be more effectively promoted at the local, regional, and global levels, and the foundations laid for sustainable globalization. Better coordination would make it easier to design new public policy tools in the environmental health area (82).

Global public goods are interdependent. Their impact is not restricted to current populations: future generations will also be affected. Since future generations will inherit a legacy of accumulated knowledge on natural resources, global goods are clearly of intergenerational importance.

Insufficiently regulated and failed financial markets have caused collateral damage to entire communities. The costs of failure have been shouldered not only by the direct beneficiaries of the financial markets but also by entirely innocent communities. Industries that produce high pollution levels are an example. Pollution problems can be dealt with either by bilateral negotiation between the perpetrators and the victims or by community intervention (local institutions, nonprofit organizations, governments, supranational authorities, etc.). Joint action to produce and preserve public goods, by introducing regulations or establishing funds to indemnify the victims, is entirely possible.

In short, global public goods can be described as goods that are produced, consumed, preserved, and promoted nationally and internationally, and whose external benefits can have repercussions at the regional, hemispheric, or global level.

## Agreements and International Environmental Treaties

The first attempts to introduce international governance of the main environmental problems in the Americas were made in the late 19th century, when yellow fever, plague, and cholera epidemics ravaged several countries of the Hemisphere. In the 1870s, yellow fever spread rapidly in Brazil, Paraguay, Uruguay, and Argentina, causing in Buenos Aires alone over 15,000 deaths. The epidemics reached the United States along the shipping routes, and a major outbreak of yellow fever in the Mississippi River Valley in 1878 caused over 100,000 cases and 20,000 deaths. It was clearly impossible to combat the epidemics without internationally-agreed actions. The Fifth International Sanitary Conference, in Washington, D.C., in 1881, ruled that it was necessary “*to institute an international reporting system on the real health situation in the ports and places...*” This led to the introduction of effective sanitation and hygiene measures to control and prevent recurrences. In an unprecedented spirit of inter-American cooperation, the Second International Conference of the American States (Mexico City, 1901) recommended that a convention of representatives of the health services of all the American republics should be convened. In late 1902, the First International Sanitary Convention of the American Republics duly assembled in Washington, marking the

foundation of the International Sanitary Bureau and heralding the Pan American Sanitary Conferences that have taken place uninterrupted ever since (83).

One of the most significant documents in terms of health governance was the Pan American Sanitary Code, adopted during the Seventh Pan American Sanitary Conference, held in Havana, Cuba, in 1924, and amended in 1952 (84). This code was one of the main precursors of the International Health Regulations (IHR) that were adopted globally in 1969. The Code was the first multilateral initiative to prepare an effective framework for preventing the international spread of disease, and especially to monitor, report, and control six communicable diseases: cholera, plague, yellow fever, smallpox, recurrent fever, and typhus. The IHR was amended in 1973 to incorporate additional measures on cholera, and again in 1981 to include measures for action on smallpox, eventually eradicated after an unprecedented international effort. After a thorough review of the IHR, the World Health Assembly in 2005 adopted new regulations for “*preventing, protecting against, controlling and providing a public health response to the international spread of disease in ways that are commensurate with and restricted to public health risks, and which avoid unnecessary interference with international traffic and trade*” (85).<sup>2</sup>

The term *public health emergency of international concern* is not limited in the IHR to the emergence and international reporting of specific diseases but includes all the threats to public health, including environmental disasters or those caused by acts of bioterrorism that require a coordinated global response (85).

The new IHR, effective from 15 June 2007, stipulated that by the year 2012 the countries would develop, strengthen, and maintain basic capacities to detect, evaluate, and intervene to take international action to address important public health events, including those linked to the environment. It also specified the obligations that all the branches of WHO (headquarters, regional and country offices) needed to comply with. However, the countries have requested a possible extension (being negotiated) of this deadline from 2012 to 2016 (86).

Environment-related multilateral diplomacy has a long history. The first treaties were adopted in Europe in the 1870s (80). The number has since grown dramatically, highlighting the global importance of environmental topics. According to the Database on Agreements and International Environmental Treaties of the University of Oregon (United States), 1,591 bilateral agreements, some 1,173 multilateral agreements, and 247 accords of a legal nature had been registered by January 31, 2013 (87). A survey in 2003 by Ronald B. Mitchell, an expert on the topic, showed that multilateral agreements since the 1960s have tended to focus increasingly on topics of global interest (88). The present multiplicity of legal instruments is a further indication of the vast complexity of environment-related topics and interests.

The growing number of multilateral and bilateral actors and the proliferation of initiatives have led to the shelving or dismantling of potentially interrelated projects, to wasted human and economic public resources, and to unfocussed goals, especially when joint decisions are handed down from the international to the national and local spheres with no precise guidelines. It follows that international law plays an increasingly important role in coping with the difficult political inter- and intragovernmental issues involved (88).

Many of the Region’s countries are signatories to the multiple agreements, conventions and international treaties designed to preserve the environment. Many of these voluntary or mandatory instruments also concern human health, but the health sector has been very slow to implement them.

### The binding nature of international norms

Just as a State’s constitution regulates and distributes the exercise of power nationally, a treaty created by an international organization, approved by its Founding States and fully accepted by its newer members, establishes the functions, institutional dynamics, and norms for its operation. When a State seeks membership of an international organization it is primarily exercising sovereignty when eventually agreeing to be a Member. That State is then responsible for exercising, jointly and reciprocally, with the other Member States, some function that it previously exercised as an individual State. In short, that State chooses to exercise a function together with others in defense of its own national interests on the understanding that this can be done better jointly than individually (89).

In the health area, as in the environmental area, the interdependence between states is readily apparent. There can be no doubt that the fight against epidemics, or the preservation of ecosystems that cross national borders, can only be effective when problems are tackled jointly. However, if a Member State of an international organization insists on applying its own rules to a problem of common concern the chances of success will be more limited. Given the growing flows of people and goods, and the obvious transnational nature of the environment, excessive tolerance or rigor shown by an individual state can have serious impacts on the control of an epidemic or disease, or on the environment as a whole.

## Integration of international norms in national legal frameworks

Integrating international norms into domestic law is complex. Since the Latin American countries adhere to the theory of legal dualism, treaties, agreements, and international norms are only applied after they have been incorporated into domestic law. Dualism relates to how the national parliaments function: *If the Executive Branch were to directly produce rules in international forums without the Legislative Branch being able to control the process of their preparation, this process would escape from parliamentary control. The Parliaments would be faced with a limited capacity to prepare laws for the country. The Executive Branch is thus forced to act in harmony with the Legislative Branch (89).*

The use of legal dualism means that international treaties and agreements become part of national law once they have been approved by Parliament and are subsequently ratified by the Executive Branch.

This process also applies to international treaties and agreements on environmental preservation and health and, once ratified, they have the force of law at the national level, with the exception of clauses on which governments have specifically entered caveats when signing a treaty or agreement.

There are certain situations which do not require a country to incorporate international norms into domestic law according to the prevailing legal dualism arrangement. For example, a country does not need to incorporate “simplified form agreements” that involve simply executing obligations that have been adopted in a previously incorporated agreement. This also applies to the legislative processes of international organizations. When Member States confer certain normative competencies on an international organization (i.e., authority to draft a norm), the rights arising from such authorization derive from the founding charter of that organization. It follows that the charter, duly incorporated into the legal frameworks of Member States, acts as a kind of “normative umbrella” that embraces the new norms derived from the exercise of functions by the respective international organization. A norm from an international source may therefore be applied immediately without the need for a formal domestic legal instrument (89).

## Building global health and environmental governance: Complex pathway

During the last 50 years successive UN Secretary-Generals and the UN specialized agencies have convened many international conferences and events with the primary aim of exploring and discussing a range of topics directly and indirectly related to sustainable development and its sectoral interfaces, including health and the environment. The conclusions and recommendations produced by these global conferences have significantly influenced the national and international agendas on these topics.

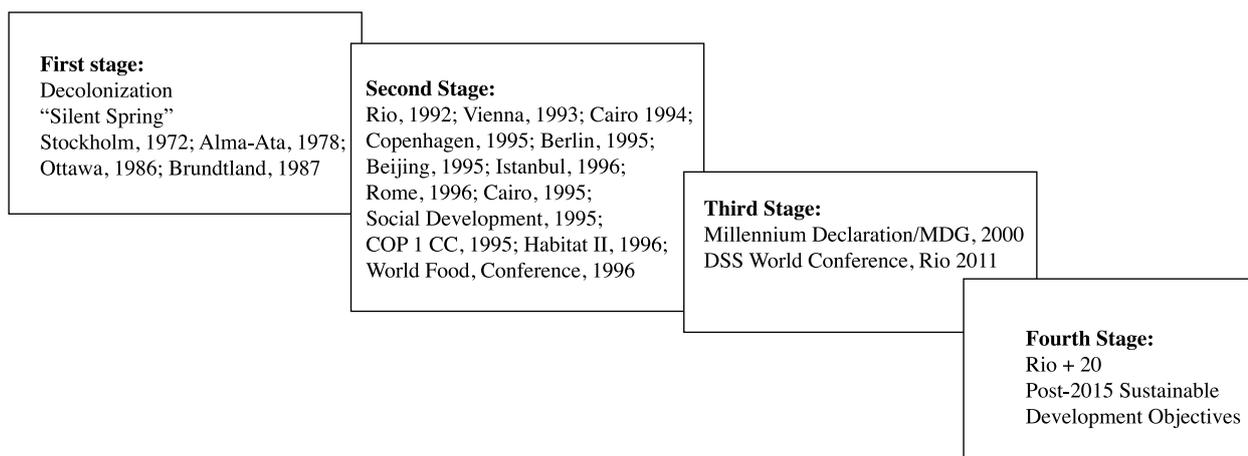
We have already highlighted “information” as a public good derived from the contributions of many different actors, and whose benefits are of interest and use to all humanity. In this respect, the informative conclusions and recommendations emerging from major international conferences on health and the environment (and on other topics) have contributed substantially to mainstreaming public policies of national and international interest. Moreover, the widespread adoption of numerous international treaties and agreements has been crucial for strengthening health and environmental preservation as international public goods.

The major global conferences can be grouped in four nonsequential and overlapping stages, as follows.

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**Figure 4-1.** International conferences organized by the United Nations System on health, the environment, and sustainable development

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The **first stage** began in the mid-20th-century when a number of mainly African and Asian countries emerged from colonial rule to reclaim their territorial rights, including the use of their natural resources. The so-called Third World countries began attempts to accelerate their economic growth programs, often using the natural environment in an irrational manner. This exacerbated the differences of opinion between the industrialized North and the impoverished South regarding the scope and targets of environmental preservation.

Rachel Carson’s censure, in her environmental science book *Silent Spring* (1962), of the indiscriminate use of DDT and its impact on living beings, helped raise the profile of environmental issues (90).

The major events that took place between 1972 and 1987 were of special importance due both to the topics addressed and their subsequent impacts: the Conference on Human Environment, in Stockholm, Sweden (1972)(91); the Conference on Primary Health Care, in Alma-Ata, USSR (1975); (92) and the Conference on Health Promotion, in Ottawa, Canada (1983) (93). These were followed by *Our Common Future*, a report drafted in 1987 by the World Commission on Environment and Development (66), which brought the “first stage” to a close.

The Stockholm Conference, attended by representatives of 113 countries, 19 intergovernmental agencies, and over 400 nongovernmental organizations, was a watershed in the area of environmental (including health) governance (91). Notwithstanding the many differences among the delegates, initial agreement was reached on some agenda items. These are enshrined in the Declaration of Stockholm (94) as 24 principles intended to establish new ethical guidelines for human behavior concerning the preservation of the environment.

Principle 1 establishes that “*man has the fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being, and he bears a solemn responsibility to protect and improve the environment for present and future generations.*”

Principle 21 establishes that “*States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.*”

Principle 22, emphasizes that “*States shall cooperate to develop further the international law regarding liability and compensation for the victims of pollution and other environmental damage caused by activities within the jurisdiction or control of such States to areas beyond their jurisdiction.*”

The general thrust of the Declaration of Stockholm is that “*Man is both creature and moulder of his environment, which gives him physical sustenance and affords him the opportunity for intellectual, moral, social and spiritual growth,*” and that “*Both aspects of man’s environment, the natural and the man-made, are essential to his well-being and to the enjoyment of basic human rights and the right to life itself.*”

A further key result of the Stockholm Conference was the launching of a Plan of Action containing 109 recommendations on environmental policies. These recommendations highlight two important considerations: that environmental problems are often closely linked and require a comprehensive approach, and that the environment and development are two mutually reinforcing faces of the same coin (95).

The Stockholm Conference left an important legacy, relaunching diplomacy and international jurisprudence as fundamental pillars for improving the governance of environmental agendas nationally and globally, in broad frameworks that encompass the protection of human health, well-being, and quality of life. The Conference was also important for stimulating decision-making on new political, social, and financial ways of initiating and consolidating different forms of thinking and acting with regard to environmental issues, and for fully recognizing their possible negative effects on human well-being and health.

This Conference signaled the start of ambitious academic research and technical development programs that, within a relatively short time, revolutionized information and knowledge on the behavior of natural or constructed ecosystems. The resulting data provided a benchmark for formulating, implementing, and evaluating public policies on the complex interrelationships between the environment, economic growth, development, and human well-being.

After the Stockholm Conference a large number of major environmentalist movements began to come together and strengthen at the local and international level. Governments in the Americas, for example, set about creating new and incipient environmental management divisions in accordance with the Stockholm recommendations. It is noteworthy that prior to the Stockholm Conference the health sector in most Latin American and Caribbean countries had an overall normative mandate for basic sanitation and sometimes had to assume sanitation-related operational functions.

Strongly influenced by the Stockholm Conference, some countries in the Region, such as Mexico (96), decided to broaden the mandates of their Health Ministries to cope with the new challenges posed by pollution and the deterioration of ecosystems.

At the international level, the Stockholm Conference was a determining factor in the creation of the United Nations Environment Program (PNUMA) (97), and laid the foundations for the International Program on Chemical Safety, (IPCS) (98). Meanwhile, almost all the multilateral agencies began to view the environment as a new area of concern. In the international health sphere, the Pan American Health Organization Governing Bodies, for example, established the Pan American Center for Human Ecology and Health (ECO) in 1974 (99).

The International Conference on Primary Health Care (PHC), held in Alma-Ata (capital of Kazakhstan) in 1978 (91), highlighted the need for urgent action by all governments, all health and development workers, and the world community to protect and promote the health of all people (*Health for All by 2000*).

The Alma-Ata Conference reaffirmed the principle that health is a human right and that the global quest for attainable maximum levels of health required the participation of social and economic sectors in addition to that of health, particularly the sectors concerned with agriculture, livestock, food, industry, education, housing, public works, communications, etc.

Alma-Ata emphasized the importance of PHC promotion, prevention, treatment, and rehabilitation, and other key topics such as access to clean drinking water and sanitation.

The somewhat idealistic goal of “Health for All by 2000” was not attained since the complexities of healthcare delivery within a predetermined timespan made it impossible to comply with such a short deadline. A more realistic slogan was subsequently coined for relaunching the PHC strategy: “Health for All.”

The implementation of PHC globally has varied significantly from one country to another due to the different ways in which health and health care have evolved in each country, and to countries’ different political and social systems. In recent years, many countries in the Americas have begun to reinterpret and modernize their approach to PHC with a view to meeting the health and environmental health challenges of the 21st century. This renewal process owes much to the Declaration of Alma-Ata (1978), and to the lessons learned and experiences gained over the last 30 years (100).

The First International Conference on Health Promotion was held in 1986, in Ottawa, Canada, partly in response to the new concept of public health inspired by the Alma-Ata Declaration (*Health for All by 2000*) (92). The Ottawa Charter draws attention to the multisectoral and nonexcludable responsibility of the health sector, emphasizing that health and well-being depend on a set of prerequisites, including peace, access to food, education, income, shelter, ecosystem stability, sustainable natural resources, social justice and equity, all in turn dependent on public policies that promote community action, the development of life skills, and the reorientation of health services.

During the past 20 years six further international conferences on health promotion have taken place (Adelaide, Australia, 1988; Sundsvall, Sweden, 1991; Jakarta, Indonesia, 1997; Mexico, 2000; Bangkok, Thailand, 2005; and Nairobi, Kenya, 2009) (101).

The Eighth International Conference on Health Promotion, in Helsinki, Finland, in June 2013, focussed on “Health in All Policies,” on the implementation of the recommendations of the WHO Commission on the Social Determinants of Health, and on reviewing the emerging proposals for a renewed PHC.

The Helsinki Statement on “Health in All Policies” reaffirmed that *“the enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition. We recognize that governments have a responsibility for the health of their people and that equity in health is an expression of social justice.. We know that good health enhances quality of life, increases capacity for learning, strengthens families and communities and improves workforce productivity. Likewise, action aimed at promoting equity significantly contributes to health, poverty reduction, social inclusion and security”* (102).

The 154th Session of the Executive Committee of PAHO, in June 2014, produced the *Plan of Action on Health in All Policies*. This was submitted to the 53rd Directing Council of PAHO and approved in September 2014 (103).

In 1987, the World Commission on the Environment and Development, known subsequently as the “Brundtland Commission” (in honor of Dr. Gro Harlem Brundtland), presented its report entitled *Our Common Future* (66). This report confirmed the conceptual bases for sustainable development (*“development that meets the needs of the present without compromising the ability of future generations to meet their own needs”*), emphasizing two fundamental concepts: first, that of “needs” that correspond to every human being and, second, *“limitations imposed by technology and social organization on the environment’s ability to meet both present and future needs.”* It is noteworthy that the Brundtland Report’s definition of sustainable development focussed on environmental protection, careful husbandry, and consumption of nonrenewable natural resources. The latter definition was revisited during the Rio Conference in 1992, which reaffirmed that the three pillars of sustainable development were economic development, social justice, and environmental protection.

During this first stage, other important events directly affected governance of the environmental agendas and their relationship with the health sector. An example is the disaster at Bhopal (India) in 1984, where many people were killed or injured by methyl isocyanate that escaped from a Union Carbide plant (104). In the same year, in San Juanico, a neighborhood on the outskirts of Mexico City, gas tanks exploded leaving many dead and injured (105). Later in the same decade there were other episodes, such the explosion at the Chernobyl (Ukraine) nuclear power plant in 1986 that caused international alarm when radioactivity was detected in various Northern and Central European countries (106). An oil tanker called the Exxon Valdez spilled some 10.8 million gallons of crude oil into the sea off the coast of Alaska, devastating local wildlife (107).

At the Vienna Conference in 1985, the discovery of the ozone hole in Antarctica and its possible consequences for public health (especially skin cancer) gave rise to the Vienna Convention for the Protection of the Ozone Layer, and subsequently to the Montreal Protocol in 1987 (108).

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989) required the countries affected by the transboundary transportation of hazardous waste to give their prior informed consent (109).

Against this background, the **second stage** of conferences convened by the United Nations began with the preparations for the largest and most ambitious conference on the environment and development ever held. The city of Rio de Janeiro, Brazil, was selected to host this major event. Preceded by intensive negotiations involving broad groups of stakeholders and practitioners from governments, civil society, and the private and academic sectors, the United Nations Conference on Environment and Development (the “Earth Summit”) opened on 5 June 1992, attended by the representatives of 178 countries, including 118 Heads of State and Government, 8,000 delegates, 3,000 observers from some 1,400 NGOs, 9,000 journalists, and 15,000-20,000 visitors (110).

While the agenda of the Stockholm Conference had mainly addressed specific topics, such as air, water, and soil pollution, the Earth Summit had a more strategic dimension, dealing with broader topics of global importance and scope, such as the preservation of biodiversity and ecosystems. In parallel with the Earth Summit, scientists from academic and research bodies (e.g., the International Council for Science (ICSU), the Scientific Committee on Environment Problems (SCOPE), the International Union for the Conservation of Nature (IUCN) presented important reports on topics such as potential ozone layer degradation by chlorofluorocarbons (CFC). They also disseminated the first reports on major environmental changes, highlighting the pivotal role of the UNEP environmental databases, especially the INFOTERRA information system, the Global Environmental Monitoring System (GEMS) (111), and other joint initiatives by international bodies such as the International Registration of Potentially Toxic Chemical Products (IRPTC)(112) that resulted from collaboration between WHO, UNEP, and the International Labor Organization (ILO), with support provided by national organizations such as the Environmental Protection Agency of the United States of America (EPA).

Although the North-South debate was resurrected at the Stockholm Conference and the Rio Earth Summit, the latter proved to be a timely opportunity for launching a set of global, regional, and local policies that would hopefully lead to genuine sustainable development. The Declaration of Rio emphasized in the first of its 27 principles that “*Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature*” (113). Subsequently, the United Nations Framework Convention on Climate Change (CMNUCC)(114) and the Convention on Biological Diversity (CBD) were launched in the same positive spirit (115).

The Rio Conference also launched “Agenda 21,” a non-binding document with 40 chapters containing 115 programs and goals, and identifying the governmental, civil society, academic, and international agency stakeholders to be responsible for their implementation. Agenda 21 consisted of four major sections: (i) economic and social development; (ii) the conservation and management of resources for development; (iii) the strengthening of major groups; and (iv) the procurement and management of the resources required for the implementation of the Agenda (116). The Agenda however contained no binding timetables or specific goals, and the definitions and operational indicators referring to the different topics were framed in terms that allowed each country to interpret them as they wished. These drawbacks reduced the opportunities for monitoring and systematically evaluating compliance with the Agenda 21 proposals.

Section I, Chapter 6 of Agenda 21 (the social and economic dimensions) refers specifically to the promotion and protection of human health, focussed on: a) meeting primary health care needs, especially in rural areas; b) the fight against communicable diseases; c) the protection of vulnerable groups; d) the resolution of urban health problems; and e) the reduction of risks to health arising from pollution and other environmental hazards.

This chapter emphasized that health ultimately depends on the capacity to manage the interplay between the physical, spiritual, biological, economic, and social environments, as well as the need to focus on ensuring adequate water supplies and sanitation services, safe food and appropriate nutrition.

Given the complexity of the causal relationships that affect human health, many other related topics with possible implications for health are analyzed in other sections of Agenda 21, in addition to the subjects addressed in Chapter 6 (117,118).

Everything indicated that the Rio Conference would herald a new era of North-South cooperation, with the participation of all actors: governmental, civil society, and the productive and academic sectors. A new more promising era seemed to be dawning, but after the delegates had returned home the traditional inertia displayed by the dominant interests once again took over the agendas, and the promised results fell short of expectations. Most observers and environmental experts considered that the optimism generated by the Earth Summit was undermined by the failure of most of the developed countries to reach the agreed target to commit 0.7% of their GDP to official development assistance for expanding a consumption-based economic model to stimulate the flows of all types of goods, including environmental goods (110).

More tangible outcomes of the Earth Summit included, however, the United Nations Convention to Combat Desertification (UNCCD), launched in 1994 (119).

The United Nations Framework Convention on Climate Change (UNFCCC) was opened for signature during the Rio Conference and became effective in 1994. The Kyoto Protocol to this Convention urged developed nations to reduce greenhouse gas emissions (GHG) between the years 2008 and 2012 by at least 5% from the 1990 levels (120). The Convention defines climate change as “*a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods*” (121).

The Parties to the Convention are required to submit national reports (“national communications”) on implementation. While some of the Parties and the Intergovernmental Group of Experts on Climate Change (IPCC) have studied climate change at great length, especially its impact on human health and well-being, not all national communications have addressed the latter in detail.

In 2008 and 2009, the World Health Assembly expressed concern at the IPCC’s findings that showed the negative effects of global warming on some aspects of human health, especially in developing countries, small developing island states, and in vulnerable local communities with minimum capacity to prepare and adapt to the changes. The IPCC also argued that the exposure to future extreme climatic events could affect the health of millions of people, by increasing malnutrition, mortality, disease and injuries, diarrheal and cardiorespiratory diseases, and changes in the patterns of vector-borne infections (122,123).

In the Americas, the Directing Council of PAHO approved in 2011 the Strategy and Plan of Action on Climate Change and Health, urging the Member States to strengthen their capacities to assess the impacts of climate change on health and to implement appropriate mitigation measures (124).

A total of 19 Conferences of the Parties (COP) were held (125), but the negotiations, although heading in the right direction, proceeded at a slow pace. Despite the evident gap between progress on the scientific front and political agreements, the COPs nevertheless gave rise to optimism. For example, during the COP 17 in Durban, South Africa, in 2011, all the countries agreed to produce in 2015 a clear definition of what needed to be done, and by when, and to proactively assign the responsibilities for taking this forward to all the sectors involved (126).

The scientific community continues to discuss new possible scenarios that address climate change in a more comprehensive and analytical way in order to dispel uncertainty and anticipate the possible implications for socioeconomic development, as well as to be able to respond better to these risks and their residual impacts (127).

PAHO and WHO continue their efforts in the COP, and have collaborated continuously and closely on topics related to climate change in the Americas and the rest of the world, with a view to raising awareness on the repercussions of climate change for health, evaluating country-specific risks, and strengthening health systems to guarantee adequate protection from climate-related risks and to promote the profile of public health in climate change decision-making in other sectors.

In 1998, the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (the Rotterdam Convention) was signed (128), and in 2000, within the framework of the Convention on Biological Diversity, the Cartagena Protocol on Biosafety was signed, aimed at regulating the trade in genetically modified organisms (GMO) (described in the protocol as “living modified organisms”), including the prior consent procedures required for their safe transfer, handling, and use (129).

The Stockholm Convention on Persistent Organic Pollutants was adopted in 2001 aimed at regulating, banning or eliminating the production and use of certain persistent organic pollutants (POP), restricting or regulating others, and eliminating or reducing the emissions produced by a third group. Exposure to these pollutants can cause adverse repercussions for health such as cancer, immunological defects, and hormonal changes (130).

During the 1990s, various major global conferences took place, of which the most important were: the World Conference on Human Rights, in Vienna, Austria (1993); (131) the International Conference on Population and Development, in Cairo, Egypt (1994); (132) the World Summit for Social Development, in Copenhagen, Denmark (1995); (133) the First Conference of the Parties to the United Nations Framework Convention on Climate Change, in Berlin, Germany (1995); (134) the Fourth World Conference on Women, in Beijing, China (1995); (135) the Second United Nations Conference on Human Settlements (Habitat II), in Istanbul, Turkey (1996); (136) and the World Food Summit, in Rome, Italy (1996) (137).

The World Summit on Sustainable Development was held in Johannesburg, South Africa, in 2002. This event, attended by over 100 Heads of State and Government and representatives from the governmental and private sectors, was marked by a degree of skepticism in view of the inadequate preparatory arrangements, and the results were considered “tepid,” with several industrialized countries refusing to accept concrete targets (138). The Summit however acknowledged the need to find a better basis for the global governance of environmental topics by providing opportunities for more active participation by all the stakeholders (139).

The various political declarations and documents generated before, during, and after these conferences created an enabling environment, and revealed the need to consolidate efforts to achieve more integrated and sustainable development.

These efforts were to be taken forward during the important **third stage** that is expected to last until around 2015. The first most significant event was the Millennium Declaration (140), followed by the World Conference on the Social Determinants of Health, held in Rio de Janeiro, Brazil, in 2011, which proved to be an important milestone for health (141).

The 189 UN Member States committed themselves to redoubling efforts to eradicate global poverty by establishing the Millennium Development Goals (MDG), to be met by 2015, taking 1990 as the base year. This initiative includes 8 goals, 18 targets, and 48 indicators. Although not all the MDGs are concerned with health, MDGs 4, 5, and 6 address the topic specifically, while MDG 7 deals with environmental sustainability (142).

During the 57th World Health Assembly in 2004, WHO Director-General Dr. Lee Jong-wook announced the creation of a new commission to gather evidence on the social and environmental causes of health inequities and ways to overcome them, and to provide guidance on the topic for all WHO programs (143). This materialized in the Commission on the Social Determinants of Health, whose purpose was to draft evidence-based recommendations for policies and interventions on social determinants aimed at improving health and reducing health inequities. The

Commission decided to include the environmental component as part of the social determinants agenda, since the environment is continuously modified, especially by human interventions.

The Commission dedicated three years to meeting this goal (144). Its final report, issued in 2008, entitled “Closing the gap in a generation: health equity through action on the social determinants of health,” emphasized that “reducing health inequalities is an ethical imperative...social injustice is killing people on a grand scale,” and that “the high burden of illness responsible for appalling premature loss of life arises in large part because of the conditions in which people are born, grow, live, work, and age” (145).

In 2009, the 62nd World Health Assembly requested the WHO Director-General to convene a global meeting between representatives of member states with a view to discussing new plans for dealing with the alarming trends in health inequities. The result was the World Conference on the Social Determinants of Health held in Rio de Janeiro, Brazil, in 2011. The final Political Declaration stated that “We understand that health equity is a shared responsibility and requires the engagement of all sectors of government, of all segments of society, and of all members of the international community, in an ‘all for equity’ and ‘health for all’ global action” (146).

The Declaration also highlighted the need to take “resolute action on social determinants of health across all sectors and at all levels” in order to “improve living conditions and fight against the inequitable distribution of power, money and resources,” as well as to take action to “measure the magnitude of the problem, analyze it, and evaluate the effects of the interventions” (145).

Although the above does not explicitly mention the environmental determinants of health, it implied that all the sectors of government and society should commit to the “Health for All” principles.

The **fourth stage** began with the United Nations Conference on Sustainable Development, held in Rio de Janeiro in June 2012, known as “Rio+20” (147). Rio+20 has subsequently evolved into a process of ongoing negotiation aimed at defining the new post-2015 sustainable development objectives.

At the Rio Conference, 193 national delegations and some 100 Heads of State and Government signed the document entitled “*The Future We Want For All*” and reaffirmed that poverty eradication was the main challenge to sustainable development. Discussion also centered on the need for production and consumption to follow “green economy” principles, for reversing the negative effects of global environmental change, and for strengthening democracy and governance at all levels.

The parallel “People’s Summit” attracted some 50,000 people to 3,000 events organized by civil society and environmentalist movements. Although some of the conclusions did not accord with those of the main conference, they served to draw attention to different viewpoints and expectations regarding the ways to achieve sustainable development (148).

The “green economy” concept attracted much debate. In this respect, the document —“*The Future We Want For All*—” argues that a green economy within a context of sustainable development and poverty eradication is one of the key instruments for achieving sustainable development. While this instrument involves taking different approaches to policy formulation, it is not however bound by a set of rigid rules. The document emphasizes that a green economy should contribute to poverty eradication and sustained economic growth by increasing social inclusion, improving human well-being, and creating worthwhile employment opportunities, while ensuring the healthy functioning of global ecosystems (148). For the Rio+20 participants, particularly those representing environmentalist movements, the “green economy” simply represented new frontiers for global capitalism to exploit. Others criticized the failure to address more robustly the environmental, social, and economic aspects of development, claiming that traditional economic interests continue to prevail.

Although substantive debates took place on the importance of strengthening governments at all levels, the necessary consensuses were not achieved for implementing new governance schemes to ensure global sustainable development.

Rio+20’s “zero draft” of the outcome document initially disregarded health topics. However, Brazil and several other countries remedied this by ensuring that the final conference document (“*The Future We Want For All*”)(149) included health and population topics (in paragraphs 138 to 146) (150), emphasizing that health is a prerequisite, a result, and an indicator of the social, environmental, and economic aspects of sustainable development, which would be impossible to achieve without reducing the high burden of morbidity caused by communicable and non-communicable diseases. It was vital to address the social and environmental determinants of health in order to create inclusive, equitable, economically productive, and healthy societies.

The importance of equitable universal health coverage was also acknowledged as important for promoting health, social cohesion, and sustainable human and economic development. This included: preventing and controlling communicable diseases such as HIV, AIDS, malaria, tuberculosis, influenza, and poliomyelitis; focussing

more on the growing emergence of communicable diseases as one of the main obstacles impeding sustainable development in the present century; the right and access to medical drugs for all; the need to comply with international commitments on sexual and reproductive health; the need to reduce maternal and child mortality; the need to improve the health of women, youth, and children; and the need to promote universal access to modern, secure, effective, accessible, and acceptable family planning methods (149).

The document also reiterated the commitment to systematically study the demographic trends and predictions in national, rural and urban policies and strategies, and the challenge presented by migrations. It also committed to reducing, inter alia, air and water pollution and that caused by chemical products (149).

Although the health topics included in the document confirmed the need to take action on and resolve traditional and emerging problems, it also addressed other intersectoral topics such as the health impacts of urban growth, manufacturing plants, energy production, and lack of food security (151).

The document *The Future We Want For All* (152) was prepared by the United Nations Working Group (some 60 different agencies including WHO) responsible for the post-2015 development agenda. This document outlines a scheme (Figure 4-2) for sustainable development, based on three interrelated principles: human rights, equality, and sustainability, with sustainable development based on inclusive economic development, environmental sustainability, inclusive social development, peace, and security. The enabling factors include universal access to good quality health services and the importance of other intersectoral activities that imply an impact on future health levels.

**Figure 4-2.** The UN integrated framework for realizing “The Future We Want For All” (United Nations Post-2015 Sustainable Development Agenda)



As with Agenda 21 in 1992, the official document approved 20 years later, *The Future We Want For All*, similarly lacks goals and indicators. It was proposed that these gaps would be tackled subsequently in the negotiations on the new post-2015 Sustainable Development Goals (SDGs).

The **fourth stage** highlights the need to define the SDGs based on two strategic lines of action: (i) to urge all the countries to continue their efforts to achieve the MDGs as initially formulated (153), and (ii) to take forward

all the consultation and negotiation processes required for defining the new post-2015 SDGs with a time horizon of 2030 (154,155).

The Americas have made substantial progress towards fulfilling the Millennium Development Goals. While virtually all the MDGs relate to health in one way or another, three of them (4, 5, and 6) are of specific health interest, and three others (1, 7, and 8) propose targets that relate closely to health. This reflects the broad consensus on the importance of health as both an input and a product of sustainable development. It also demonstrates that the health of different groups of society is a key indicator of the performance of different countries. Although child mortality has been significantly reduced in Latin America and the Caribbean, the available data reveals that not all the countries will comply with MDG 42 to “*reduce mortality among children under five years of age by two thirds.*” A major challenge is the high rate of neonatal mortality faced by the most vulnerable populations (27).

Meanwhile, the incidence of malaria and tuberculosis has been reduced well before the target date, and there has been significant progress on reducing the spread of HIV/AIDS through the better access to treatment (MDG 6). The Region has also advanced significantly in complying with the goals on clean drinking water (MDG 7)(156), although the data available on basic sanitation indicates that this target will not be reached by the proposed date, especially in the rural areas.

Despite significant progress on reproductive health in the region (MDG 5), the available figures show that the target of reducing maternal mortality by 75% will not yet be achieved (27,157,158,159).

Since the launching of the MDGs, governments, civil society, and the academic and private sectors, as well as international agencies, have gained valuable experience on the implementation of programs designed to meet the three main health-related MDG targets: (160,161) (i) knowledge on the prevention and reduction of specific problems that have traditionally been associated with a higher burden of death and disease caused by infections, especially among children; (ii) the availability of precise targets and indicators and relatively simple and uniform methods for measuring progress and shortcomings; and (iii) the mobilization of extraordinary financial and technical cooperation resources focussed on the most needy countries.

A consultation meeting convened by ECLAC in Bogotá, Colombia, in March 2013 (162) revealed a series of structural deficiencies in the Region’s performance on the MDGs, including:

- The lack of interface between economic growth, environmental protection, and health, especially in key sectors such as energy and mining.
- Gender, ethnic, and territorial inequalities persist despite progress on poverty reduction, and make Latin America and the Caribbean one of the most unequal regions of the world.
- Productivity increases are not accompanied by the creation of worthwhile employment, higher added value activities, or full access to workers’ basic rights.
- Low educational standards continue to restrict employment opportunities.
- Limited environmental and disaster protection.
- The State needs to do more than oversee public finances and keep inflation in check. In the long term, the State needs to overhaul the tax structure and improve collection to enable it to play a full and active role in promoting sustainable development.
- A universal social protection system is needed to replace social policies based on assistentialism, in order to reduce the vulnerability of the population and break the cycle of social exclusion and inequality.
- The health area is still highly fragmented and segmented, and many challenges remain, including the need to lay the foundations for unrestricted universal access to good quality health.

Overcoming the above constraints will require greater emphasis on shared responsibility between sectors and on the need to include health-related topics in all the public policy agendas. This major task will involve better coordination between the health sector and other sectors, especially the education, employment, and environment sectors, while coping with cultural differences and promoting proactive commitment by all citizens.

The United Nations organization, and especially its Secretary-General, played a strategic role in the second phase of the fourth stage. The Secretary-General established three working groups: (i) the UN Working Group for the Post-2015 Development Agenda, consisting of 60 different agencies including WHO (163); (ii) the High-Level Panel of Eminent Persons, co-chaired by the Prime Minister of the United Kingdom and the Presidents of Liberia and Indonesia; (164) and (iii) the Sustainable Development Solutions Network (165), aimed at obtaining the views on sustainable development of the academic sector, civil society, and the productive sector. The United Nations

General Assembly also established the Open Working Group on Sustainable Development Goals, with 30 country members under the co-presidency of the Permanent Representatives of Hungary and Kenya. Sixteen countries in the Americas are represented in seven of these working groups (166).

An inter-agency technical support team (TST) was also established to support the Open Working Group, under the aegis of the UN System Task Team. The TST, comprising over 40 UN bodies, is co-chaired by DESA and UNDP. The TST will provide technical support, including analytical inputs, background material, and expert panelists. An information platform will share UN system knowledge with the OWG (167).

There have also been efforts to ensure the widest, and most inclusive, consultations nationally, regionally and globally. Eleven Thematic Consultations have taken place (168), including the High Level Dialogue on Health in the Post-2015 Development Agenda, held in Botswana in March 2013, supported by WHO and UNICEF. The key messages from this “Global Conversation” were as follows (169):

- To maximize health at all stages of life.
- To ensure that the future SDG agenda focuses on the specific health targets related to the unfinished agenda.
- To address the growing burden of non-communicable diseases as an additional specific health goal, with emphasis on prevention.
- To include universal health coverage as a right. This implies working on the social determinants as well as on the prevention, care, and control of disease.
- A post-2015 world should be more inclusive, transparent, and accountable. There are emerging governance models that offer opportunities for greater citizen participation and intersectoral action.
- Modern interconnectivity can catalyze change and provide an enabling environment for achieving the goals. Strengthening countries’ health information systems is essential for successfully implementing a post-2015 agenda.
- More attention needs to be paid to global and national governance structures and institutional capacities, and the health architecture needs to adapt to the 21st century and the post-2015 goals.

The Health Assembly and the Directing Council of PAHO have included in their respective agendas a progress analysis on MDG compliance, stating that the topics directly and indirectly related to health should be treated as core questions in the definition of the post-2015 SDG: *“Acknowledging that universal health coverage implies that all people have access without discrimination to nationally determined sets of the needed promotive, preventive, curative, palliative and rehabilitative essential health services and essential, safe, affordable, effective and quality medicines, while ensuring that the use of these services does not expose the users to financial hardship, with a special emphasis on the poor, vulnerable and marginalized segments of the population... policies and actions in sectors other than health have a significant impact on health outcomes and vice-versa, hence the need to identify synergies between policy objectives in the health and other sectors through a whole-of-government, whole-of-society and Health in All Policies approach to the post-2015 development agenda”* (170).

The report submitted by the three groups convened by the UN Secretary-General (the High-level Panel of Eminent Persons (171), the United Nations Sustainable Development Solutions Network (UNSDSN) (172,173), and the United Nations Working Group on the Post-2015 Development Agenda) (174) was submitted to the United Nations Open Working Group on Sustainable Development Goals for scrutiny and eventual incorporation in the Group’s final report (175). Presented in mid-2014, this report contains 17 goals and 169 targets. It was ratified by the UN General Assembly in December 2014 and included in the United Nations Secretary-General’s Synthesis Report entitled *The Road to Dignity by 2030: Ending Poverty, Transforming All Lives and Protecting the Planet* (176).

The proposed 17 SDG goals are as follows :

- Goal 1. End poverty in all its forms everywhere
- Goal 2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture
- Goal 3. Ensure healthy lives and promote well-being for all at all ages
- Goal 4. Ensure inclusive and equitable quality education and promote life-long learning opportunities for all
- Goal 5. Achieve gender equality and empower all women and girls
- Goal 6. Ensure the availability and sustainable management of water and sanitation for all

- Goal 7. Ensure access to affordable, reliable, sustainable, and modern energy for all
- Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
- Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
- Goal 10. Reduce inequality within and among countries
- Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable
- Goal 12. Ensure sustainable consumption and production patterns
- Goal 13. Take urgent action to combat climate change and its impacts
- Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
- Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
- Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
- Goal 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

## Health and the sustainable development goals for 2030

Among the 17 SDGs, the third synthesizes the health-related topics in the following nine specific targets (174):

- 3.1. by 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births.
- 3.2. by 2030, end the preventable deaths of newborns and under-five children.
- 3.3. by 2030, end the epidemics of AIDS, tuberculosis, malaria, and neglected tropical diseases and combat hepatitis, water-borne diseases, and other communicable diseases.
- 3.4. by 2030, reduce by one-third pre-mature mortality from non-communicable diseases (NCDs) through prevention and treatment, and promote mental health and wellbeing.
- 3.5. strengthen prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol.
- 3.6. by 2020, halve global deaths and injuries from road traffic accidents.
- 3.7. by 2030, ensure universal access to sexual and reproductive health care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programs.
- 3.8. achieve universal health coverage (UHC), including financial risk protection, access to quality essential health care services, and access to safe, effective, quality, and affordable essential medicines and vaccines for all.
- 3.9. by 2030 substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination.

SDG 3 also highlighted the need for the following:

- 3.a. to strengthen implementation of the Framework Convention on Tobacco Control in all countries as appropriate.
- 3.b. to support research and the development of vaccines and medicines for the communicable and non-communicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration which affirms the right of developing countries to use to the full the provisions in the TRIPS agreement regarding flexibilities to protect public health and, in particular, provide access to medicines for all.
- 3.c. to increase substantially health financing and the recruitment, development and training and retention of the health workforce in developing countries, especially in LDCs and SIDS.
- 3.d. to strengthen the capacity of all countries, particularly developing countries, for early warning, risk reduction, and management of national and global health risks.

Various international forums have acknowledged that health is simultaneously an input, a product, and an indicator of sustainable development (149). It was therefore no coincidence that when the Millennium Declaration

was launched, three of the eight MDGs targeted priority health topics. While this close relationship between health and development is still a major concern, the health topics discussed during the negotiating process for the 17 SDGs focussed on their third goal, which covered the targets of several unconcluded MDGs, especially those concerning the reduction of maternal mortality, avoidable deaths of children under five years old, as well as the urgent need to reduce the burden of disease and death caused by AIDS, malaria, tuberculosis, and other tropical pathologies. Meanwhile, other emerging health problems relating to non-communicable chronic diseases, mental health, road safety, addictions and reproductive health were included in other proposed targets. The eighth target refers, for example, to the need to achieve universal healthcare services coverage, and the ninth emphasizes the need to reduce deaths and diseases caused by environmental factors.

The first seven targets recall the fragmented history of the efforts and vertical interventions on certain pathologies or population groups, and emphasize the strategic requirement to continue to support specialized organizations and funds such as UNAIDS, and the Global Fund to Fight AIDS, Tuberculosis, and Malaria, and to pay less attention to more comprehensive strategies such as universal health services coverage and the reduction of disease and death from environmental causes. Although it is important to reduce the burden of death and disease from avoidable causes, the continued dissipation of efforts and resources can reduce the efficiency and effectiveness of the actions carried out, as well as further complicating the already difficult governability of the health systems at all levels.

Regardless of the architecture of the proposed goals, the health-related targets, given their interface with the biological, social, economic, political and environmental areas, can only be achieved if substantial progress is made on the 17 goals.

The recent Ebola crisis in Africa is a good example of the growing difficulty to provide a timely and coherent response to a serious emerging health problem whose origin and spread was due to a combination of multiple environmental, economic, and demographic factors, as well as to the weaknesses of the local health services. In addition to the high mortality rates caused by the worst Ebola epidemic ever, the high costs and collateral damage have significantly transformed the social, economic and political stability of the affected countries (177). From the international standpoint, this crisis was seen as a serious threat to global peace and security, to the extent that the UN Security Council was called upon to formulate a response that was ultimately beyond the scope of the world health system. As a result, the United Nations Mission for Ebola Emergency Response (UNMEER) was established in September 2014 (178).

The outcomes of the debates programmed to take place on different dates and in different forums will continue to nurture decision-making on the new SDGs and their progress indicators before September 2015. The discussions so far indicate that while the MDGs focused on poverty reduction, especially on the most vulnerable countries and populations, the proposed SDGs are more targeted to equity. This means that the task of implementing them will vary from country to country. Each country will be able to select the goals and targets that it considers most important in terms of its own historical, political, and social circumstances, and will be able to choose its own ways to measure, evaluate, and commit to them. This approach will inevitably have major implications for governance at local, regional, and global levels (179, 180, 181).

At the regional level, ECLAC, UNDP, and the World Bank, with the support of the governments participating in the UN Open Working Group on Sustainable Development Goals, will continue to be the agencies responsible for guiding the consultation and dialogue process for building the necessary consensus prior to the adoption of the post-2015 SDGs by the United Nations General Assembly in September 2015.

## ■ Milestones in environmental health governance in Latin America and the Caribbean

### Summits of the Americas

The Declaration of Principles of the First Summit of Heads of State and Government of the Americas, issued in December 1994 in Miami, contained four priority action topics. One of them was “*to guarantee sustainable development and conserve our environment for future generations.*” The same Declaration called on the OAS and the Inter-American Development Bank (IDB) to provide assistance to help countries meet, with PAHO and ECLAC support, the commitments enshrined in the Declaration.

One of the positive results of the Summit was, for example, the launching of the program “*Elimination of lead in gasoline in Latin America and the Caribbean*” in 1995 by the World Bank, supported by PAHO and various other technical cooperation agencies. By 2006, the sale of leaded gasoline, which can harm children’s neurobehavioral development, had been phased out in all the countries of the Region (182).

### Conferences of environment ministers

UNEP’s Regional Bureau for Latin America and the Caribbean (UNEP/ROLAC) has facilitated regular inter-governmental consultations with the leading environmental authorities of the Region over recent decades. A key outcome of these efforts was the Forum of Environment Ministers of the Region, which has become the main political gathering on environmental topics in the Region (183).

UNEP/ROLAC, acting as the Forum Secretariat, has played an important role in organizing meetings, preparing supporting documents, and especially, developing partnerships between governments of the Region in order to narrow the gaps between the regional and global environmental agendas. Other regional agencies have also participated in these forums, while the Interinstitutional Technical Committee (UNEP, UNDP, ECLAC, Inter-American Development Bank, and World Bank) has been a useful channel for international cooperation activities in the environmental area in the region. However, the interministerial forums have failed to regularly address topics that specifically highlight the close relationship between the environment and health. This has impacted negatively on the formulation of policies, programs and strategies on environmental health topics.

PAHO, UNEP/ROLAC, ECLAC, UNDP, OAS, IDB, and the World Bank, play a major role in providing opportunities for dialogue. They have also occasionally been asked by the countries to assume Secretariat functions to facilitate the environmental health governance processes in the Region. All the agencies maintain good contact with their respective national counterparts, either institutionally or on an individual level, with a view to assisting the different regional, subregional, or national agendas designed to monitor adherence to the commitments agreed in global forums, to comply with the mandates of various government bodies, to support regional environmental health initiatives, and to respond to the specific priority requirements of one or various countries.

### Meetings of Health Ministers of the Americas on environmental topics

The Meeting of Ministers of Health and Environment of Americas that took place in Washington, D.C., in 1995, with PAHO support, adopted the Pan American Charter on Health and Environment in Sustainable Human Development (184).

This Charter sets forth the principles of a strategic policy approach and establishes common priorities and shared responsibilities for all the countries of the Region. It also proposes measures to benefit health and the environment in a framework of sustainable development, in view of the threats arising from poverty. PAHO assumed the responsibility for the Technical Secretariat and for providing technical assistance to countries to help them develop national health and environmental plans.

The national plans have gradually combined with subregional strategies. For example, at the Special Meeting of the Central American Health Sector (RESSCA XII), Central American health ministers and social security directors called upon the environment ministers and the heads of the water supply campaigns to draft a Central American Regional Action Plan: *Environmental health in Central America: a future vision in the framework of integration* (185).

The work done on these topics by the countries, supported by PAHO and UNEP, culminated in the III Summit of the Americas held in Quebec, Canada, in April 2001, which called upon the United Nations Environment Programme (UNEP) and PAHO “to support the convening of a regional meeting between Ministers responsible for the Environment and Health to take stock of progress achieved, to identify priority areas for renewed emphasis and cooperative initiatives, and to explore ways of moving forward in the Americas and globally, with a view to contributing to the 2002 World Summit on Sustainable Development, recognizing the links between the environment and human health” (186).

The First Meeting of Ministers of Health and Environment of the Americas was held in March 2002 in Ottawa, Canada (187), chaired by Environment Canada and Health Canada. The purpose of this meeting was to: a) build bridges between the health and environment sectors to address common topics; b) strengthen the countries’ capacities to address health and environmental issues effectively; c) establish follow-up mechanisms on health and environmental problems in the Americas; and d) contribute to the upcoming World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa.

One of the main results of this meeting was the GEO Health (188) project aimed at strengthening existing programs and strategies by scaling up national scientific capacities for preparing comprehensive environmental and health assessments, “acknowledging that these are the key to decision-making and consensus-building on regional and national actions.”

In response to this initiative, the United Nations Environment Program (UNEP), and the Pan American Health Organization (PAHO), in collaboration with Brazil’s Oswaldo Cruz Foundation (FIOCRUZ), agreed to work together to ensure that GEO Health became a viable and reliable alternative for carrying out comprehensive assessments of environmental and health problems in Latin America and the Caribbean. GEO Health provided a new opportunity for increasing the output of dependable scientific information based on a sharing arrangement with communities, and to guide decision-makers to implement short- and long-term sustainable policies for the comprehensive solution of problems related to health and the environment (187).

The Second Meeting of Ministers of Health and the Environment of the Americas took place in Mar del Plata, Argentina, in June 2005 (189). On that occasion the ministers decided that regional cooperation should focus on three priority areas: (i) water and solid waste management; (ii) safe management of chemical substances in line with the commitments made in the Stockholm, Rotterdam, and Basel Conventions; and (iii) the environmental health of young children, focussed especially on the threats of emerging and reemerging diseases. The ministers requested PAHO, UNEP/ROLAC, and OAS support to enable the countries to comply with these priorities.

As part of its mandate, the OAS agreed to provide support to water and solid waste management, while UNEP/ROLAC took on chemical substances management and PAHO agreed to continue to deal with environmental health affecting children, having already issued its *Atlas of Children’s Health and Environment in the Americas* in 2004 (190). The Commission for Environmental Cooperation (CEC) published its report *Children’s Health and the Environment in North America: A First Report on Indicators and Measures* (191). In January 2006.

While the meetings of health and environment ministers provided opportunities for deepening political dialogue at the national, subregional, and regional levels, the results to date have been incipient and piecemeal and call for further action (192).

### Central American Conferences on Ecology and Health (ECOSAL I, II, and III)

The First Central American Conference on Ecology and Health (ECOSAL I) was held in El Salvador in September 1992, attended by the Ministers of Health, Environment, and Natural Resources, the Directors of the National Environment Commissions of the Central American countries, and the Director of PAHO. This conference, convened as part of the RESSCA annual meetings program, reflected some of the debates that had taken place two months previously at the Earth Summit in Rio, particularly with regard to better water and sanitation coverage, chemical safety, workers’ health, and the interdependence of sustainable development and health. The *Declaration on Ecology and Health of Central America* contained the main conclusions of this conference. The incipient Central American Integration System (SICA) provided support for ECOSAL I through its Central American Commission for Environment and Development (CCAD) (193).

ECOSAL II was held in September 1993 in Tegucigalpa, Honduras. All the Central American countries held national preparatory meetings to identify priorities for devising a Central American Plan of Action in Ecology and Health (PACES) up to the year 2000. Once this plan had been approved, efforts were made to identify possible external donors (194). ECOSAL III, held in Managua, Nicaragua, in September 1994, was devoted to assessing the progress made on the targets approved in PACES a year earlier (195).

In the light of these developments within ECOSAL, the Central American presidents signed in 1994 the Alliance for Sustainable Development (196), and inaugurated the Project on Environment and Health in the Central American Isthmus (MASICA) (197). This subregional health and environmental development program forms part of the Health Initiative for Central America (ISCA), supported by PAHO and with financial assistance provided by Nordic bilateral agencies, especially the Norwegian Agency for Development Cooperation (NORAD), the Swedish International Development Agency (ASDI), and the Danish International Development Agency (DANIDA).

One of the key outcomes of ECOSAL and MASICA was PAHO’s *Project on Occupational and Environmental Aspects of the Exposure to Pesticides in the Central American Isthmus* (PLAGSALUD) (198). This was carried out between 1994 and 2003 by the seven countries of the subregion, with technical support and follow-up financing provided by DANIDA.

A subproject supported by MASICA, *Conservation of the Water Resources and Monitoring of Water Quality* (PROAGUA) (199), focussed on the rural areas, with a view to improving institutional capacities to conserve and

improve the quality and quantity of water resources, and to strengthen national and regional plans and programs for monitoring and controlling drinking water quality.

As a result of PROAGUA, both water quality and the institutional aspects of the water services improved, resulting in the reduced incidence of diarrheal diseases in the seven Central American countries.

In June 2004, the Central American Ministers of Agriculture, Environment, and Health met in Guatemala under the auspices of SICA (200) to analyze strategies for the comprehensive management of water resources, for tackling nutrition and food security, and for preparing a regulatory framework on live and modified organisms and biosafety in the subregion. The ministers met again in Panama in 2006 (201), and added avian flu and subregional agro-environmental intersectoral strategies to the agenda. In April 2008, in Panama, the ministers approved the Regional Strategy on Agro-environmental and Health Strategy in Central America, with emphasis on hydrobiological and environmental change (202).

## Pan American Center for Human Ecology and Health

The Pan American Center for Human Ecology and Health (ECO), created in 1974 by a resolution of the PAHO Governing Bodies (98), is a regional technical center of PAHO headquartered in Mexico. With the Pan American Center for Sanitary Engineering and Environmental Services (CEPIS) (203), ECO forms part of PAHO's Environmental Health Division. The Center commenced operations in 1980, occupying facilities (until 1997) provided by the Mexican Government.

ECO was founded in response to the needs arising from exposure to growing environmental pollution and its possible repercussions for human health. In their quest during several decades for economic and social growth, the Latin American and Caribbean countries had rapidly developed their industrial and other sectors, paying scant attention to the potentially harmful impacts of pollution on health and the environment. In due course the countries requested the assistance of PAHO to develop new approaches, methodologies, and specialized resources to alleviate health and environmental hazards.

During its 17 years of activity, ECO's main priority was to assess the risks associated with exposure to chemical substances, pesticides poisoning (due to poor handling), air pollution, and scrap metal. The Center produced 656 publications (204) for global distribution, and participated actively in the development of many human resources training programs throughout the Region. ECO pioneered the organization and promotion of electronic data networks that were later to form part of PAHO's Virtual Health Library (VHL).

Apart from the catalytic role of international organizations, it is also worth noting the role of civil society groupings over the years. One example is the Inter-American Association of Sanitary and Environmental Engineering (AIDIS) (205), established in 1948 with PAHO support, as a nonprofit technical/scientific civil society. Since its foundation, AIDIS has collaborated closely with PAHO and is an observer at the meetings of the Governing Bodies.

## ■ Subregional processes

### Southern Common Market

The Southern Common Market (MERCOSUR) was created on 26 March 1991 by the Treaty of Asunción (206) as a customs union comprising the Argentine Republic, the Federative Republic of Brazil, the Republic of Paraguay, and the Eastern Republic of Uruguay. Venezuela signed the Protocol of Adhesion on 4 July 2006, but was not formally admitted to the organization until 2012 due to non-ratification of the protocol by the Paraguayan Congress. Bolivia's full membership of MERCOSUR has been under negotiation since June 2011 (207). MERCOSUR's founding charter states that *"The States Parties of MERCOSUR share a commonality of values that is based on democratic, pluralist, defense of fundamental freedoms, human rights, environmental protection and sustainable development, including the commitment to the consolidation of democracy, legal certainty, the fight against poverty and social and economic development with equity."*

MERCOSUR addresses health in two main forums: first, the meeting of the Ministers of Health of MERCOSUR and Associated States, established in 1995, and second, the No. 11 Working Subgroup (SGT 11), created in 1996 with the aim of harmonizing the various different laws to eliminate the obstacles to trade in the subregion, and to coordinate actions between the member states on health care, goods, services, raw materials, and health products

and epidemiological and health surveillance, with a view to promoting and protecting the health and lives of the populations by providing comprehensive and good quality health care, thus contributing to the integration process.

The Meeting of MERCOSUR Environment Ministers, created by the Common Market Council in 2003 (Decree. N° 19/03), is the main political forum for coordinating environmental policies (208). Technical topics are the responsibility of a special environmental working group (SGTE 6), created in 1995, whose legal framework was established in the Treaty of Asunción (209), in the following terms: “*environmental conservation should be one of the means for achieving the expansion of its markets, accelerating the processes of economic development of the States Parties with social justice, in a context of free trade and consolidation of the customs union, considering the basic directives of environmental policy approved in GMC No. 10/94 and the principles of sustainable development arising from the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992.*” SGT 6 focuses on the following thematic areas: sustainable management of natural resources; quality of life and environmental planning; environmental policy tools; and environmentally sustainable production activities.

## The Andean Community

Since 1998, the Andean Health Agency/Hipólito Unanue Agreement (ORAS/CONHU) has served as the Andean Integration System’s institution for coordinating, supporting, and promoting, individually or collectively, the efforts and actions of the member countries to improve the health of the Andean populations (210), prioritizing cooperation mechanisms to develop systems and subregional methodologies under the Comprehensive Plan for Social Development (PIDS) that governs actions in the following thematic areas: socio-occupational integration; education and culture; health; rural development; food security; the environment; and social development in frontier areas.

## The South American Community of Nations

The South American Community of Nations was founded at the meeting of presidents of the region in Cuzco, Peru, in December 2004 (the Cuzco and Ayacucho Declarations). This Community, known since 2007 as the Union of South American Nations (UNASUR), reflects the growing links between political leaders in the region in recent years. Its members are the Federative Republic of Brazil, the Plurinational State of Bolivia, the Eastern Republic of Uruguay, the Cooperative Republic of Guyana, the Bolivarian Republic of Venezuela, and the Republics of Chile, Colombia, Ecuador, Paraguay, Peru, and Suriname (211).

The UNASUR Summit Conference, held in Brasilia on 30 September 2005, produced an Agenda of Priority Projects, a Plan of Action, and Declarations on the *Convergence of Integration Processes in South America and Integration in the Infrastructure Area*, giving priority to: political dialogue; physical and energy integration; the environment; South American financial mechanisms; asymmetries; telecommunications; and the promotion of cohesion, inclusion, and social justice (212).

The South American Health Council was created at the Special Meeting of UNASUR Heads of State and Government on 16 December 2008 in Salvador, Brazil, with the goal of creating mechanisms to forge integration in health topics through other regional integration bodies and to promote policies and coordinate cooperation activities between the member countries. The South American Health Council was established in Santiago, Chile, on 21 April 2009 (213).

## The South American Institute of Governance in Health (ISAGS)

The ISAGS was created by the UNASUR Council of Heads of State and Government in Cuenca, Ecuador, in April 2010. This is a public intergovernmental institution whose main goal is to promote critical thinking and knowledge management, and to generate innovation in health policies and governance in order to provide South American Health Ministries with the best available practices and evidence-based information on health management. ISAGS’s three basic functions are to produce and manage knowledge, promote leadership, and provide technical support. ISAGS is also concerned with developing leadership for managing health systems, services, organizations, and programs and for providing technical support to government health sector institutions (214).

The Institute’s Three-Year Plan 2012-2015 emerged from a set of priorities contained in the South American Health Council’s 5-Year Plan 2010-2015, including the following: 1) the Health Surveillance in South America Network; 2) the development of universal health systems; 3) universal access to drugs; 4) health promotion and ac-

tion on health determinants; and 5) the development and management of health-sector human resources, priority targets, and products (213).

### The Amazon Cooperation Treaty Organization

The Amazon Cooperation Treaty (ACT) was signed in 1978 by Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname, and Venezuela, to promote joint activities aimed at the shared and harmonious development of the Amazon Basin, including environmental protection and the rational utilization of the Amazon Region's natural resources. The eight nations subsequently established the Amazon Cooperation Treaty Organization (ACTO) in 1998 with a view to strengthening and implementing the Treaty's goals. ACTO's Permanent Secretariat has been located in Brasilia since December 2002 (215).

ACTO considers that the Amazon Region, with some of the world's richest natural resources, is of major strategic importance for the future development of its member countries and that of other countries in the region, and that this unique asset needs to be preserved and promoted in accordance with sustainable development principles.

ACTO's Strategic Plan of 2004-2012 (216) (now replaced by the Amazon Cooperation Strategic Agenda) covered a wide range of environmental topics and commitments relating to the recommendations and commitments arising from the pertinent multilateral legal instruments, including the Convention on Biological Diversity, the Convention on International Trade in Endangered Species of Wild Fauna and Flora, the Convention on the Protection of the World Cultural and Natural Heritage, the United Nations Framework Convention on Climate Change, the United Nations Convention to Combat Desertification, and the Ramsar Convention on Wetlands. The Strategic Plan also embraced specific health and environmental health programs, since the region had undergone profound changes in its epidemiological, demographic, educational, and employment profiles due to economic growth and industrialization, migration, growing urbanization, the emergence of new economic activities, and changing agricultural models.

### The North American Free Trade Agreement (NAFTA)

The North American Free Trade Agreement (NAFTA) (217), establishing a free trade area between between the United States, Canada and Mexico, became effective on 1 January 1994.

Since 1994, Canada, the United States of America, and Mexico have collaborated on North American environmental protection topics in accordance with the North American Agreement on Environmental Cooperation (NAAEC) (218). This Agreement entered into force simultaneously with the NAFTA, to ensure that economic growth and trade liberalization in North America were accompanied by effective cooperation and continuous improvement in the area of environmental preservation in all three countries.

The Commission for Environmental Cooperation (CEC), an international body within NAAEC, aims to: a) respond to environmental concerns in the three countries; b) contribute to preventing possible environmental and trade conflicts; and c) promote effective compliance with environmental legislation. The CEC consists of the Council, the Secretariat, and the Joint Public Advisory Committee. One of its most ambitious projects has been the elimination of DDT from malaria control activities. This project eventually expanded beyond Mexico's borders to include, with PAHO and UNEP/FMAM support, the Central American countries (219).

### The Caribbean Community

The Caribbean Community (CARICOM) was founded in July 1973 by the Treaty of Chaguaramas, signed by Barbados, Guyana, Jamaica, and Trinidad and Tobago. Antigua, Belize, Dominica, Grenada, Montserrat, Saint Kitts and Nevis, Saint Lucia, and Saint Vincent and the Grenadines acceded to the Treaty in May 1974, thus forming what is known today as the Caribbean Community, a successor to the British West Indies Federation (a grouping from 1958 to 1962 of the old British Caribbean colonies), and the Caribbean Free Trade Association (CARIFTA) (220).

The Council for Human and Social Development (COHSOD) was created during the CARICOM Conference of Ministers of Health in 1984. Composed of ministers appointed by the Member States, the Council aims inter alia to promote health improvements, including developing effective and accessible health services for all, and addressing topics relating to the environment, sustainable development, and environmental health (221).

The Caribbean Environmental Health Institute (CEHI) was established in 1980 by the CARICOM Ministers of Health to tackle in an organized manner the health concerns of the English-speaking Caribbean population. The main objectives of CEHI are to provide technical and advisory services to its members in all areas of environmental

management, including water supplies, liquid waste and sewage disposal, solid waste management, water management, coastal zone management including beach pollution, air pollution, occupational health, vector control, agricultural pollution and pesticide control, disaster prevention and preparedness, natural resource conservation, environmental institutional development, and the socio-economic aspects of environmental management (222).

### The Community of Latin American and Caribbean States (CELAC)

The Community of Latin American and Caribbean States (CELAC) (223), a regional integration and political bloc consisting of 33 states, was formed at the Unity Summit, which encompassed the 21st Summit of the Rio Group and the 2nd Latin American and Caribbean Summit on Integration and Development (CALC) at Playa del Carmen, Quintana Roo, Mexico, in February 2010. As a successor of the Rio Group and CALC, CELAC is a regional bloc that aims to “*strengthen the political, social and cultural integration of the region, stimulate its independent and sustainable economic growth, and advance the well-being and quality of life of all of its people on a basis of democracy, equity and broader social justice.*”

CELAC espouses the following principles and common values: respect for international law; sovereign equality of the States; the non-use or threat of force; democracy; respect for human rights; respect for the environmental, economic, and social pillars of sustainable development; international cooperation for sustainable development; and unity and integration of the States of Latin America and the Caribbean based upon a permanent dialogue to promote regional peace and security based on solidarity, social inclusion, equity, equal opportunities, complementarity, flexibility, voluntary participation, plurality, and diversity.

### The Bolivarian Alliance for the Peoples of Our America (ALBA)

The Bolivarian Alliance for the Peoples of Our America (ALBA) was created at the Third Summit of Heads of State and Government of the Association of Caribbean States, held in Margarita Island, Venezuela, in December 2001, as an alternative to the Free Trade Area of the Americas. ALBA is an intergovernmental organization based on the “One Nation” idea of the social, political, and economic integration of the countries of Latin America and the Caribbean to face present and future challenges jointly. The member countries of the Alliance are Venezuela, Bolivia, Cuba, Dominica, Ecuador, Honduras, Grenada, Nicaragua, Saint Kitts and Nevis, Saint Lucia, Antigua and Barbuda, and Saint Vincent and the Grenadines (224).

ALBA’s action agenda includes the environment, climate change, and health (225).

### The Central American Integration System (SICA)

The Central American Integration System (SICA) was formed on 13 December 1991 as the result of an amendment (the Tegucigalpa Protocol) to the Charter of the Organization of Central American States (ODECA) signed in Panama on 12 December 1962. It began operating officially on 1 February 1993 (226).

The members of SICA are El Salvador, Guatemala, Honduras, Nicaragua, Costa Rica, Panama, Belize and the Dominican Republic. Mexico, Chile, Brazil, Argentina, Peru, and the United States of America are regional observers, while the Republic of China (Taiwan), Spain, Germany, Italy, Japan, Australia, South Korea, France, and the Holy See are extra-regional observers. SICA’s General Secretariat is in El Salvador.

The Council of Ministers of Health of Central America (COMISCA) and the Central American Commission for Environment and Development (CCAD) form part of SICA.

The COMISCA is the political entity of the Central American Integration System that provides direction for the regional health sector by identifying, addressing and resolving regional health problems and taking joint action through the *Meso-american Public Health Plan and Agenda* and other forums and meetings that guarantee the Central American population’s right to health (227).

CCAD was established during the Summit of Central American Presidents held in San Isidro de Coronado, Costa Rica, in December 1989. It is the regional body responsible for coordinating and facilitating environmental protection efforts through the optimum and rational use of resources, and controlling pollution. Its main goals are to: a) strengthen national bodies and improve standardization; b) strengthen regional governance by harmonizing national legislations; c) distribute information; d) determine priority areas of action; and e) promote participatory, democratic, and decentralized environmental management (228).

## Environmental health governance in the Americas

Debate on environmental health governance in the international sphere tends to be highly conceptual, and is often restricted to issues of global interest, with little impact at the country level. While the debates have been enriched by the accumulation of empirical and theoretical knowledge, strengthening environmental health governance at the operating level has not been given priority in the political and economic agendas of most developing countries.

In the Americas, environmental health governance is characterized by two different approaches. The first approach is incipient and sectoral, mainly confined to the actions carried out by the health and environmental authorities. These actions tend to proceed along parallel but non-converging lines and are generally centralized at the national level. Dialogue with other sectors and nongovernmental actors is intermittent. The actions are only coordinated with other stakeholders in acute situations or in response to immediate social demands. The second approach is based on models that are typified by the redundant presence of multiple agencies from different public and independent private entities engaged at the central, state, provincial or local levels. Although their objectives may coincide, these substantial numbers of people from the academic, productive and social sectors are involved in running programs and taking actions governed by different mandates and interests. This scenario leads to complex and sometimes contradictory situations, often fraught with conflicts that are difficult to resolve.

Although there are incipient environmental health governance models in several Latin American and Caribbean countries, the trend is towards the increasingly complex models shared at national and subnational levels, but the academic, social, and productive sectors are still underrepresented.

Certain countries in the Region have created decentralized regulatory agencies for comprehensively monitoring environmental and other health hazards. One example is Mexico's Federal Commission for Protection against Sanitary Risks (COFEPRIS), created in 2001 (229).

In 2009, Brazil organized its First National Environmental Health Conference, an interesting and unique experience in the Region. Convened at the behest of the President of the Republic, the Conference aimed to engage all sectors of society in developing public environmental health policies. The debates, conclusions, and recommendations of the Conference drew heavily on the output of various state and municipal meetings that preceded the main event. Over 60,000 people in some 1,500 municipalities were involved in this unprecedented opportunity for dialogue and debate that effectively expanded the universe of social and political actors committed to environmental health in Brazil's urban and rural areas, and who were ready to help reduce socioenvironmental vulnerability and promote more sustainable development. This Conference had a major impact on the National Health Conferences, whose conclusions and recommendations play a major role in national environmental health policy-making (230).

Mindful of the complexities, the multiple stakeholders involved in different environmental agendas, and the need to strengthen their governance, various Latin American and Caribbean countries have established national environmental commissions to facilitate the harmonization of diverse interests between different levels of government, the productive sector, and civil society. The Foreign Ministries of several countries have also created special environment divisions to expand their technical competencies in development and environmental issues as a prelude to assuming a more substantive role in the diplomatic and governance aspects of the international environmental agendas.

The national environmental commissions generally enjoy independent legal status and their own budgets, and operate as decentralized public agencies. Their key functions are: to submit environmental policy proposals to the President of the Republic or the Environment Minister or Secretary; to analyze and report on the implementation and enforcement of environmental regulations; to oversee the environmental impact assessment system; to manage the drafting of environmental quality standards; to set pollutant emissions limits; to provide environmental advice and analysis and to coordinate and communicate information on environmental matters.

## Lessons learned

1. In most Latin American and Caribbean countries environmental health governance is still incipient. There are significant communication deficiencies between the various sectors and actors, and coordinated action is still rudimentary. The gap between theory and practice remains a challenge.
2. Despite all the meetings, agreements, and national and international negotiations on environmental health and sustainable development, the available evidence shows that environmental degradation continues, with a significant impact on public health, especially in the less developed countries. This sug-

- gests that, despite all the international efforts, national governments are failing to implement the many agreements as broadly or as quickly as required.
3. The health hazards associated with environmental imbalances include the longstanding problems caused by the lack of basic sanitation or from exposure to pollutants from, inter alia, industrial processes, energy generation, agriculture, extraction of raw materials, and uncontrolled urban growth. These hazards are compounded by emerging problems that affect the world as a whole. The cumulative effect of these risks affects different population groups unevenly. While many Latin American and Caribbean countries can now better diagnose the main environmental health problems, their actions to mitigate and correct these problems remain inadequate, fragmented, and short of what is required. Their programs tend to be more reactive than proactive, and more remedial than preventive. Many health ministries have failed to give priority to the environmental and social determinants of health. There is also a chronic shortage of human, technological, and financial resources.
  4. At the global and regional levels, the influence of the actors involved in the complex web of environmental and health agendas continues to be highly uneven, and only limited progress is being made toward more balanced and inclusive governance. Economic interests predominate over social interests.
  5. The globalization process and the current model of economic growth are incompatible with sustainable development. Free market policies overrule alternative proposals based on solidarity, social justice, and moral values. While the “Green Agenda” and social protection initiatives present potential opportunities to head in new directions, these are not free from uncertainty and conflict. They risk becoming the new frontiers of investment and economic growth while failing to provide real solutions to social and environmental problems.
  6. Although several developed countries have always given precedence to bilateral over multilateral agendas, the negotiations to define and establish the new Post-2015 Sustainable Development Goals up to 2030, afford an opportunity for more inclusive and democratic participation in a more optimistic climate.

## Challenges

The developing and emerging countries, home to some 80% of the global population, will in the future account for an increasingly high proportion of global economic activity. These populations are adversely affected by growing environmental degradation that, together with the loss of ecosystem resilience, will have negative direct and indirect repercussions for human health. This somber outlook has contributed to a growing awareness that the preservation of a balanced environment and the value of health are legitimate social demands. While the solutions depend on implementing appropriate public policies, they are unlikely to be beneficial without enhanced commitment at all levels of government, the academic and productive sectors, and civil society. The individual citizen must learn to be an “active subject,” helping to drive and ensure the success of public policies. This presupposes, especially in Latin America and the Caribbean, that a set of key challenges and questions for future environmental health governance will need to be addressed:

- It is essential for the countries to combine their social, economic, and environmental agendas in a more forward-looking, coherent, and sustainable manner.
- The health sector must take greater responsibility for, and play a more leading role in, matters related to the prevention and alleviation of health hazards linked to environmental imbalances.
- The countries must implement the supranational solutions required for addressing more effectively and productively the most critical global environmental problems that affect health, well-being and sustainable development.
- The international organizations should coordinate more effectively their mandates and programs directed to different population groups.
- The necessary action plans must be based on minimum action criteria to achieve effective solutions, and to avoid problems accumulating that make it impossible to take appropriate corrective measures to protect the health and well-being of populations according to their levels of vulnerability.
- At the international level, a better and fairer North-South distribution of responsibilities and costs is needed.

- Countries need to have access to environmentally appropriate technologies, and to ensure that human and financial resources are invested in a responsible and sustainable manner based on the best available evidence.
- The Post-2015 Sustainable Development Goals (especially the targets and indicators) need to be clear and measurable. They must also be supported by the governments, the bilateral and multilateral technical and financial cooperation agencies and broad sectors of society to ensure that national and international resources are allocated in ways that will produce better results in an increasingly complex and competitive world.

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# Beyond risk assessment and environmental epidemiology: New challenges in the Americas

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## ■ Introduction

This chapter broadly presents an overview of current methods recommended for use in environmental health and linking health to the sustainable development agenda. It focuses on the diagnostic and assessment part of the business, in the sense that most solutions to such problems are to be found in spheres of human activity mostly outside the public health sector, such as energy use regulation, transport policies, regulation of pesticide use, or building codes. Consequently, methodologies for promoting the actual reduction of contaminants and risks and the maintenance or rehabilitation of ecosystems that support life on Earth are only partially addressed in this chapter, which stresses the importance of rigorous methods and issues recommendations for strengthening their use in the Region.

## ■ State-of-the-art methods: An illustrative review

### Methods in environmental health

#### Priority diseases with strong environmental links

There is no shortage of lists of diseases with some or even strong environmental links, as can be assessed through systematic literature reviews. Several infectious or toxicity-related diseases transmitted by air, water, or

food were identified several centuries ago, and preventative or protective measures to address outbreaks and the spread of related diseases are embedded in laws and regulations, as well as religious prescriptions, in most countries around the world. When our drinking water and food quality control systems work well, we can often forget about the existence of such threats, but this is not the case when such systems do not exist or perform poorly. The same holds true for air quality, be it outdoor or indoor or in the workplace. Several chronic diseases are either caused, promoted, or exacerbated by the poor quality of the environment. It is therefore important to include an environmental component in chronic diseases surveillance when scientific knowledge warrants it.

Political recognition of the importance of such problems in the Latin American and Caribbean region was reiterated at the First Meeting of Health and Environment Ministers of the Americas, held in Ottawa in 2002 (1). This process is presented in greater detail in Chapter 3. It is, however, important to recall the environmental health priorities that were identified through this process. Priorities for the Americas in 2002 were: a) Integrated management of water resources, including water contamination and basic sanitation; b) Air quality; c) Health implications of natural and manmade disasters; d) Sound management of chemicals; e) Potential health impacts of climate variability and change, particularly with respect to small island developing states; f) Workers' health, including the detrimental impact of HIV/AIDS on productivity; g) Food security and safety; and h) Ethics of sustainable development from a health and environment perspective.

Another interesting approach to identifying priority diseases for the Americas makes use of environmental burden of disease (BOD) analysis (2), which looks at environmental health determinants and aims at preventing disease through healthier environments. The country profiles contain selected information from global surveys on a few key risks and offer rough estimates of population health impacts, facilitating priority-setting and the selection of relevant health-creating investments. The data used comes from the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, the World Health Survey on indoor air quality, various World Bank and WHO/PAHO sources and estimates of outdoor air quality, and other sources (2). Malaria-related data is also available. While these estimates may be somewhat outdated, they remain the best ones available and offer plenty of opportunities for action. The typical country file is presented in Box 5-1 along with a reading guide. The Global Burden of Disease Study 2010 shows that in Latin America, smoking, including second-hand smoke, is among the five leading risk factors for global disease burden.<sup>2</sup>

Such estimates are based on the epidemiological concept of the etiological fraction of a given disease attributable to preventable risks, usually expressed in DALYs, or disability adjusted life years and deaths. The method relies heavily on academic research most often done in developed countries with its expert interpretation applied to quite different countries (3). It nonetheless provides rough estimates of the potential for prevention once applied to a specific country. At the present time, 20 publications are available in: the Environmental burden of disease series (4). The Latin American and Caribbean region compares relatively well to other regions of the world in terms of environmental BOD (based on 2004 data), with the exception of a cluster of eight countries in the Region: Bolivia, Ecuador, Guatemala, Guyana, Peru, Haiti, Honduras, and Nicaragua (depending on the criteria used for priority-setting), where child and adult mortality rates are high. These countries could benefit from more intensive preventative interventions (5), especially for diarrheal diseases linked with water, hygiene, and sanitation; respiratory diseases related to the use of highly polluting indoor cooking fuels; and lead exposure. Moreover, BOD studies considering other contaminants, such as pesticides, could identify other priority countries.



**BOX 5-1 A SAMPLE COUNTRY PROFILE WITH READING GUIDE**

**Country profiles - reading guide**

Population	186,4 millions
GNI/capita	8.230 US\$
% urbanization	84%
% people living in cities greater than 100,000 habitants	45%
Population below the poverty line (national)	22% (1998)
Population below the poverty line (international, <\$1/day)	8% (2003)
Under age 5 mortality rate	34/1,000 live born
Life expectancy	70 years

**Environmental burden of disease for selected risk factors, per year**

Risk factor	Exposure	Deaths year	AVAD/1.000 cap/year
Water, sanitation and hygiene (diarrhea only)	Improved water: 90%	15,000	3,6
	Improved sanitation: 75%		
Indoor air	SFU% households: 13%	4,100	0,6
Outdoor air	Mean urban PM 10: 35 ug/m <sup>3</sup>	12,900	0,6
Main malaria vectors	<i>A. darlingi</i> , <i>A. nuneztovari</i> , <i>A. triannulatus</i>		
Main other vectors	<i>Lutzomyia intermedia</i> , <i>L. wellcomei</i> , <i>L. pessoai</i> , <i>Culex quinquefasciatus</i> , <i>Triatoma infestans</i>		

Yearly burden attributable to three risk factors

**Environmental burden of disease (preliminary), per year**

Estimate based on regional exposure and national health statistics 2004

Deaths (World - lowest: 13, highest: 289)  
% of total burden

37  
233.000  
18%

Deaths preventable through the environment each year

**Environmental burden by disease category [DALYs/1000 capita], per year**

Disease group	World's lowest country rate	Country rate	World's higher rate country
Diarrhea	0,2	3,9	114
Respiratory infections	0,1	2,1	56
Malaria	0,0	0,2	32
Other vector-borne diseases	0,0	0,9	4,2
Lung cancer	0,0	0,4	2,5
Other cancers	0,5	1,8	4,0
Neuropsychiatric disorders	1,4	3,3	4,4
Cardiovascular disease	1,3	3,6	13
COPD	0,0	1,2	4,7
Asthma	0,3	1,8	2,4
Musculoskeletal diseases	0,5	0,8	0,5
Road traffic injuries		2,7	0
Other unintentional injuries		4,4	19
Intentional injuries		3,0	7

Indicates how much of a country's burden is preventable through healthier environments (i.e. for inter-country comparison)

Indicates how the preventable environmental burden of disease is spread across disease groups in the country (i.e. for intra-country comparison)

Indicates how the preventable environmental burden of disease compares with other countries (i.e. for inter-country comparison)

**Other indicators**

Use of leaded gasoline	No
Overcrowding	N/A
Malnutrition (% stunting)	14% (1996)

Some limitations are inherent to methodologies used to build BOD estimates. Limitations and quality problems with initial data (mortality, morbidity, classification, underreporting in certain categories, exposure, etc.) remain paramount. Comparability of BOD estimates between countries is heavily dependent on comparability of data quality on environmental exposures or health impacts. Those estimates are also sensitive to social values built into the DALY metric (6) or other similar metrics such as health-adjusted life years (HALYs) or quality-adjusted life years (QALYs). For a useful comparison and discussion of these measures, the weighting system applied by different groups, their impact on the metric and underlying (often hidden) ethical decisions, see Gold *et al.* (7). The use of a 95% confidence interval in the presentation of data is intended as a reminder of these inherent limitations. Nonetheless, such summary measures of population health remain useful for their intended purpose of offering the possibility of more rational allocation of resources for health- and environment-related investments.

## Hazard/exposure measurements

A variety of methods can be used to evaluate both hazards and exposure to hazards. A hazard can be defined as a situation that has the potential to cause harm or damage, without necessarily leading to either. The risk is a measure of vulnerability (exposure) to a potential hazard. While hazard assessments tend to focus on individual hazards, risk assessments take both hazards and exposure into account and can be applied to individual, cumulative, and/or synergistic agents or events.

The assessment of risk associated with exposure to chemicals and other noxious agents can be measured through direct and indirect means, or through a combination of the two approaches. Both epidemiological and toxicological methods are relevant. Direct approaches focus on estimating the incidence and/or probability of health effects that are attributable to one or more environmental agents on the basis of direct measures of an individual's exposure to the agent(s). They require information about actual or past exposures for which there are adequate data to estimate real exposure levels as well as the health effects attributable to the exposure. Direct or body burden assessment includes measuring the concentration of a toxic substance (or one of its metabolites) in blood, fat, bone, muscle, urine, exhaled air, or hair samples. In this case, a link between the direct measurement and the degree of actual or past contaminant exposure is needed. Quasi-direct approaches include the analysis of contaminants in air, food, or water. Such studies have shown that in Latin America, an estimated 100 million people breathe air that does not meet minimum quality and safety standards, and this estimate does not include those exposed to indoor air pollution and other small-scale sources (8,9).

An indirect approach to exposure measurement relies on various processes to estimate the incidence or probability of the appearance of effects that are anticipated to occur (or to have occurred) in humans exposed to a noxious agent or agents. Risk assessment studies are fundamental to this approach (see next section below). A combination of the two methods is often used to estimate the direct exposure of an individual to a contaminant and the anticipated effects of indirect exposures, or vice versa. This approach is particularly useful when there are limited data regarding exposure or the potential health effects are being directly measured in the study population (i.e., incidence of tumors, asthma).

Environmental hazards are often analyzed using spatial data collected from environmental (e.g., geological, atmospheric) surveys. At the macro-level, information can be collected via remote sensing techniques, although at higher resolutions, field data are required. Exposure measurements build on the direct and indirect methods listed above. In addition, in these cases potential impacts on the social and environmental determinants of health can be as relevant to the analysis as the effects of the hazard on an individual.

Technical hazards (e.g., industry, transport) are of particular concern in both developing and developed countries. In the Latin American and Caribbean region, PAHO (10) cautions that “[l]ittle has been done in terms of regulation and prevention and the health sector is poorly prepared to face a large-scale chemical, radiological or other technical disaster. The risk will most probably increase in tandem with economic development and the globalization of trade.”

## Risk assessment

Although risk assessment can be applied to many contexts such as microbiological, radiological, or traumatic risks, we focus here on toxicological risk assessment, as it remains central to everyday life in our modern chemical society.

The U.S. National Academy of Sciences paradigm for toxicological risk assessment (TRA) includes four components, namely 1) hazard identification, 2) dose-response assessment, 3) exposure assessment and, 4) risk characterization (11). In the first step, the situation and the chemical that represents a public health concern are identified (e.g., lead in drinking water, residues of a given pesticide in food). Once the hazard is identified, further work is conducted to determine, based on an exhaustive literature review, the kind of toxicity that the chemical under study might trigger, as well as the biological mechanisms involved.

In doing so, it must be determined whether a carcinogenic or noncarcinogenic effect is associated with the chemical, in which organ this effect is likely to occur (“target organ”), the toxic moiety responsible for the effect (parent compound or metabolite), and the first adverse effect or its known precursor in a biological cascade that occurs in the most sensitive species as the tested dose increases (“critical effect”). Also, particular attention should be paid to the weight-of-evidence of data related to the relevance of the various routes of exposure to the toxic effect. Indeed, this can lead, for example, to identifying a product as “likely carcinogenic by the oral route but not by the inhalation route” (12). Obviously, such a classification would have direct implications for the overall risk assessment, depending on the exposure route involved in the human situation analyzed. It would also be important in the case of exposures that may occur through multiple routes—for example, with the domestic use of water through showering (dermal and inhalation) and bathing (dermal) (13,14).

For the dose-response assessment, human data are preferred if available, but this is rarely the case due to ethical considerations. As a result, animal studies are generally used. A “critical study” is a study involving the most sensitive species relevant to humans, based on the appearance of an “adverse” health effect at the lowest administered dose among the tested species sharing similar mechanisms of toxicity with humans. For instance, animal data on tumors mediated through a mechanism dependent on a protein that is not synthesized in humans would not be considered relevant. In the critical study, a point of departure (POD) for the dose-response assessment is established. Preferably, the highest-tested dose not associated with a statistically significant increase in the incidence of a critical effect (no observed adverse effect level, NOAEL) is retained. Alternatively, the lowest-tested dose associated with such an increase (lowest observed adverse effect level, LOAEL) can be chosen. Since the values of the NOAEL or the LOAEL consist each of single points on the dose-response curve and depend on the experimental specifications, a benchmark dose (BMD) is often sought to account for the entire dose-response curve. The BMD consists of the 95% lowest confidence interval of the dose associated with a given increase (5-10 %) in the incidence of the adverse effect (15).

An important consideration in this second step is whether the critical effect is carcinogenic or not. For a noncarcinogenic effect (e.g., teratogenic, developmental, neurotoxic), the basic assumption is that the dose-response curve exhibits a threshold of dose under which no effect occurs. Conversely, the assumption of carcinogenic effect is that no such threshold exists and that a single molecule can trigger cancer, at least in the case of genotoxic chemicals (e.g., mutagens that interact directly with DNA). However, a threshold approach is often considered for carcinogens exhibiting a nonmutagenic (epigenetic) mode of action (e.g., hormonal-mediated cellular growth factors), while for nonthreshold carcinogens, a “slope factor,” expressed in terms of “excess cancer risk per unit of exposure,” is used (16). For threshold effects, the chronic oral reference dose (RfD, in mg/kg/day) or inhalation reference concentration (RfC, in mg/m<sup>3</sup>) is calculated from the POD, divided by several factors to compensate for the uncertainty generated by the use of data derived from a context that differs from that of the exposure of human populations. A tenfold uncertainty factor is traditionally attributed to each one of these extrapolations (for a potential total factor of up to 100,000, although a factor exceeding 3,000 would indicate that not enough data are available to determine an Rfd or an RfC (15), as follows (17):

- i) the animal-to-human extrapolation, assuming the human is more sensitive;
- ii) the “healthy human adult” to the “sensitive subpopulation” extrapolation;
- iii) the LOAEL-to-NOAEL extrapolation;
- iv) the subchronic to chronic extrapolation;
- v) a potentially incomplete database.

The relevant toxicological information on numerous chemicals can be found in several databases (see hyperlinks in the list at the end of the chapter) (18-21). The RfD, RfC, and slope factors are used to pose a judgment on the population’s exposure calculated in the third step of the TRA. The latter consists of using several assumptions to estimate the intake of the chemical of concern from the different media of the environment (e.g., water, air, soil) and through different routes of exposure. Several databases can be consulted to obtain the values relevant to the

different exposure variables (22-24). This comparison represents the fourth and final step of the TRA, namely the risk characterization. For threshold effect, the exposure of each subgroup of the population (neonates, children, the elderly, pregnant women, adults, etc.) is divided by the RfD or RfC to generate a risk quotient (RQ). A RQ less than or equal to 1 indicates that the chemical and situation under study does not pose a significant risk to the subgroup studied. This risk can be calculated for both chronic and nonchronic exposures using reference values determined for the appropriate duration. For nonthreshold carcinogenic effects, cancer risk is estimated by multiplying the slope factor by the population's lifetime average daily exposure.

RfD, RfC, and cancer slope factors may be used to determine environmental guidelines for chemicals in drinking water (25,26) and indoor air (27). Default assumptions, such as the amount of water or air absorbed per day and average body weight, are used in doing so. In the case of a carcinogenic substance, determination of the guideline is based on a dose associated with a cancer risk considered negligible—e.g., 1 extra case of cancer per 1 million population following lifetime exposure (28). Ambient air quality guidelines as well as occupational limits are also determined to regulate chemical exposures of human populations, although using slightly different approaches (29,30).

Among the current TRA improvements, stochastic approaches such as Monte Carlo simulations are increasingly being used to evaluate the population's variability in exposures to chemicals. Such approaches have proven valuable in several cases, including the comparison of toxicological to infectious risk in vector-control interventions (31), interpreting population biomonitoring data on drinking water contaminants (32), and estimating population cancer risk from dichloromethane (33). Efforts are also being made to replace default uncertainty factors by science-based factors (34). Refining the exposure and dose-response assessment based on internal dosimetry instead of external exposure is also an issue. In this regard, physiologically-based pharmacokinetic (pbpk) models are powerful tools for performing species-to-species, route-to-route, and high dose-to-low dose extrapolations (35,36).

Empirical models can also be used to determine biological reference values (37), which in turn can be used to evaluate the risk when biological monitoring data in blood, hair, or urine are available (38,39). In this regard, Gosselin *et al.* (40) evaluated the risk of methylmercury exposure for Amazonian populations, based on a toxicokinetic model and hair measurements, while Grandjean *et al.* (41) assessed the health risk of organophosphate pesticide exposure in Ecuadorian children, based on their excretion of metabolites in urine and subsequent comparison with the levels expected to be encountered following an exposure to the RfD. Risk assessment can also be based on epidemiologic data, such as the link studied by Monge *et al.* (42) between parental occupational exposure to pesticides and childhood leukemia in Costa Rica. The mounting results of such studies have led some public health professionals to establish regional initiatives to reduce a population's exposure to toxicants, such as COPEH-TLAC (43). In pursuing their objectives, such initiatives have extensively referred to EcoHealth approaches to human health (44).

Some caution must be exercised when interpreting epidemiologic data with respect to causality. While epidemiology makes it possible to describe many associations involving various diseases and potential risk factors, it often has difficulty establishing a causal link. This is particularly true for observational epidemiology (compared to clinical trials). One example is the time it has taken for cigarettes to be recognized as a causal factor in the increased incidence of lung cancer: cigarettes were recognized as an etiological factor for lung cancer only in the 1960s, whereas the suspicion of such a link arose during the 1940s. There are two main steps in interpreting the results of an etiological investigation: a significance assessment based on the statistical analysis of the results of the investigation, and a causal assessment, which often makes use of results from outside the investigation (45).

### **Significance assessment**

An etiological investigation is used to test the existence of an association between exposure and a disease. The significance assessment involves arriving at a conclusion, based on the statistical analysis, about whether to reject the absence-of-association hypothesis or not. This conclusion can only be established with sufficient credibility following a properly conducted statistical analysis. This, of course, not only means that the appropriate tests were used but that the potential confounding factors were considered, and that the risks of error were controlled. This last point is perhaps too often disregarded despite its importance. Its discussion differs, depending on whether the result is significant or not.

In the case of a nonsignificant result, the power of the investigation must be questioned. If the power is sufficient, the investigation provides useful scientific knowledge. Even if it does not allow the absence-of-association hypothesis to be accepted, it allows for the conclusion that the strength of the association between exposure and

the disease (measured by the relative risk, for example) is below a certain value. If the power is too weak, we can restrict ourselves only to the weak observation that the quality of the instrument used to test for the existence of an association between exposure and the disease was not good, such that the conclusion addresses the inadequacies of the investigation as a tool, rather than the essence of the problem.

In the case of a significant result, the risk of error  $\alpha$  must be properly controlled, meaning that we did not put ourselves in the position of concluding about the existence of an association with a risk of error above the 5% (or less) required. This question arises in most epidemiological investigations, because we most often have to test several associations in the same investigation. We must then consider that risk  $\alpha$  is only really controlled for in the question or questions of primary interest, as defined *a priori* in the protocol. For the other associations that must be studied, either because the data suggested it, or because the exploration of secondary potential relationships was planned, we must consider that risk  $\alpha$  is poorly controlled and that the results yielded must be confirmed by further study.

### ***Causality assessment***

The question of causality arises when there is a significant result. This means knowing whether the association found between an exposure and a disease corresponds to a cause-and-effect relationship. This question has been the subject of many philosophical debates, and we do not intend to discuss these different trends of thought. Readers interested in the discussion of these aspects applied to epidemiology can refer to the excellent collection of texts assembled by Rothman (1988). However, we should mention that even with the best interpretation criteria, it is always possible to arrive at a wrong conclusion about the results of one or more studies—for example, by rejecting a causal association when there actually is one.

Knowing that a causal conclusion cannot be reached from a single observational investigation, the factors that compel such a conclusion and those that contradict it must be examined. The main causal criteria are discussed briefly below. Several authors have proposed criteria for facilitating the interpretation of the results of one or more epidemiological studies. The best-known criteria are those of Hill, dating back to 1965. These criteria can be used only after eliminating important biases as a possible explanation of the significant results observed. These criteria are the following:

- *Strength of association*: The strength of association is measured by the relative risk (RR). The higher the RR, the stronger the association. The association is generally considered weak if the RR is below 1.5, and strong if it is above 3. As an example, in the case of the tobacco-lung cancer association, the association is considered particularly strong with an RR of approximately 10. The relative risk associated with secondary smoke (smoke inhaled by nonsmokers) is generally below 1.5 and therefore considered weak. The stronger the association, the lower the probability that the observed RR can be explained by residual confounding and, therefore, the greater the likelihood that the association is causal. That being said, it must be remembered that if the association is truly causal, a low RR cannot be disregarded. It may in fact be responsible for a large proportion of cases in the population (if the exposure is frequent or the incidence of the disease is high in unexposed individuals).
- *Constancy*: The more frequently the association is observed in several studies conducted in different countries and, if possible, with different tools, the more the association will seem credible. In fact, there is little likelihood that the same errors can appear again in a similar way in different contexts and with different research tools. However, we also need to recognize that, conversely, the presence of contributing factors (factors involved in the causal mechanism) in some populations can modify the observed relationship, and therefore cause the RR to vary.
- *Specificity*: A relationship will be specific when the same cause always produces the same effect. In fact, as already mentioned by Hill, this criterion is an interesting factor when it is present, but its absence certainly does not allow causality to be ruled out. In fact, most environmental exposures (acting most often systemically) will lead to different health problems. Lead or arsenic poisoning is a good example.
- *Temporality*: Exposure must always be present prior to the appearance of the disease. We add that the exposure must be present during the disease's potential induction period, namely the period preceding the latency period. In other words, since a cancer diagnosis is expected to be preceded by a latency period of several years (varying with the type of cancer), recent exposure occurring in the months preceding the diagnosis will not likely be responsible for the appearance of this cancer. However, the recent

exposure can be an indicator of past habits, and if a factor acts in the progression of a cancer, it may act in the final months of its evolution.

- *Dose-response* (called biological gradient by Hill): This is the most important criterion in toxicology for determining a substance's toxic nature and establishing safe exposure levels. Generally, the effect must gradually increase with the exposure dose, but this is not always the case. The U curve describing the effect of alcohol consumption on cardiovascular diseases is a good example of this. Furthermore, considering the difficulties encountered in retrospective studies for measuring prior exposure, the dose-response curve observed in epidemiology can be very weak or nonexistent due to errors in the classification of exposed subjects.
- *Biological plausibility*: This is always an important criterion for assessing the causal nature of an association. Can plausible biological explanations explain the observed result? Unfortunately, the interpretation of this concept varies with the author, leading to confusion. In practice, if the studied substance produces the same or a similar effect in animals, biological plausibility is established. When only cellular studies are positive (*in vitro* or *in vivo* tests), conclusions about this criterion are more difficult.
- *Consistency*: Consistency refers to the compatibility of the observation with the knowledge acquired or observations already made on the same subject. It is therefore a broader concept than that of biological plausibility. For example, it can involve the consistency of the results of ecological studies with etiological studies, or even the consistency of the results observed in a residential environment and a work environment.
- *Experimental proof*: This is proof by human experimentation. It mainly involves the experimental proof of the disappearance of the effect when the exposure disappears. In fact, experimental proof in humans is difficult to establish, but it is sometimes used for brief exposure and acute effects (allergy).
- *Analogy*: This is the general concept that the toxic properties of a substance or an agent can be deduced from knowledge about the toxicity of other agents or substances in the same family. While this general concept is interesting *a priori*, in practice it sometimes fails (PAHs or PCBs, for example).

Use of these criteria has been the subject of numerous debates; it is certainly not a panacea likely to solve all the difficult cases of interpretation of epidemiological associations. In particular, these criteria cannot make up for mediocre studies conducted on a given subject (if only ecological studies are available, for example). Furthermore, none of these criteria is essential, except, obviously, the criterion of temporality, for stating an association as causal. However, the criteria of constancy, dose-response, and biological plausibility are often determinants for affirming a causal link. These criteria are frequently used in environmental epidemiology for assessing the nature of an association.

## Laboratory methods and quality control

The reliability and credibility of scientific studies whose conclusions are based on analyses of biological specimens or specimens of another nature rely, in large part, on the application of quality systems that ensure the technical integrity of the analyses. To achieve this objective, ISO standard accreditation, such as ISO/IEC 17025: General Requirements for the Competence of Testing and Calibration Laboratories ([www.iso.org](http://www.iso.org)), constitutes official recognition of a laboratory's ability to manage and conduct analyses.

In an accredited laboratory, the competency of personnel involved in the analytical process is ensured by a systematic training program with a specific evaluation of the effectiveness of the training activities put in place. The environmental conditions of the premises used to conduct the analyses are monitored in such a way as to ensure that analyses are performed properly. The equipment is used by authorized personnel only and is subjected to calibration and performance checks before conducting any analyses. Similarly, all software involved in the operation of equipment and used to produce analytical results is protected and monitored to prevent any incident that would invalidate the integrity of the analytical results.

Detailed instructions describe the procedures for collecting, transporting, and storing specimens on which analyses will be conducted. If applicable, national and international regulations are applied, such as the Transport of Dangerous Substances Regulation (TDSR) and the Canada Post Guide section on packaging potentially infectious materials.

The analytical methods are validated according to rigorous criteria, such as those described in ISO/IEC 17025 and CAN-P-1629 ([www.scc.ca](http://www.scc.ca)). The following elements are studied: the limit of detection, limit of quantification, limit of linearity, recovery, reproducibility, ruggedness, sensitivity, accuracy, and the evaluation of the matrix effect. Before implementation, the performance of the method is undertaken through the analysis of certified reference materials or the analysis of proficiency testing materials from recognized external quality assurance programs. Results are sometimes also compared with those from other competent laboratories. Finally, uncertainty is determined according to regulations described in the Guide to Quality in Analytical Chemistry, Eurachem ([www.eurachem.org/](http://www.eurachem.org/)), and the Guide to the Expression of Uncertainty in Measurement GUM ([www.iso.org](http://www.iso.org)). All information regarding the validation of analytical methods is systematically collated to ensure a history of the validation. Any modification made to an analytical method is also validated. Once validated, the analytical methods are recorded according to developed criteria, for example ISO/IEC 17025.

The monitoring of analyses conducted is ensured by the implementation of internal quality controls that must respect recognized standards such as those set by Westgard ([www.westgard.com](http://www.westgard.com)). In addition, the ISO/IEC 17025 standard requires that accredited laboratories participate in external quality assessment schemes (EQAS) recognized in the field of analysis. ISO provides laboratories with a list of accredited suppliers (<http://palcan.scc.ca>). One of these, the *Centre de toxicologie du Québec* (<http://www.inspq.qc.ca/ctq>), offers programs that allow participating laboratories to verify the accuracy of their analytical results and thus find a bias in analytical methods. For example, the Interlaboratory Comparison Program for Metals in Biological Matrices also provides information (see <http://www.inspq.qc.ca/ctq/paqe/pcimmb>) on the accuracy and precision of various analytical methods. With regard to the AMAP (46) Ring Test for Persistent Organic Pollutants in Human Serum (<http://www.inspq.qc.ca/ctq/paqe/amap>), it also seeks to verify that analytical results produced by participating laboratories are comparable. This information is vital in the case of large-scale international studies, since it helps determine the presence of a significant bias in results produced by the different international laboratories participating in these studies.

Low performance observed in both internal quality control and EQAS is documented. When a problem is identified and a solution found, if applicable, samples are re-analyzed and the results corrected. Clients are notified of the measures implemented to ensure the reliability of the analytical results transmitted.

To ensure the quality of the analysis, each element described above is monitored to identify any variations and find their causes, correct the situation, and verify the effectiveness of the corrective measures put in place. Systematic verification of customer satisfaction is carried out periodically, and improvements are made based on the suggestions. In addition, an accredited laboratory periodically performs internal audits of its processes, procedures, and methods of analysis as well as a review of quality management systems to ensure the compliance of its operations. These two activities make it possible to verify operational effectiveness and compliance and make the appropriate improvements to provide customers with high-quality service. Lastly, an external audit by a recognized accrediting organization, such as the *Bureau de normalisation du Québec* ([www.bnq/](http://www.bnq/)) or the Standards Council of Canada ([www.scc.ca/](http://www.scc.ca/)), confirms the maintenance of high-quality standards by the accredited laboratory.

## Outbreaks and cluster analysis/investigation/surveillance

Environmental epidemiology can provide information for decision-making and resource allocation through quantitative estimates of the risk reduction to be gained by controlling exposure to environmental hazards. Since 2005, the 193 WHO Member States have been required by the International Health Regulations (HRI) to develop, strengthen, and maintain minimum national core public health capacities, to be implemented by June 2012.<sup>3</sup> These core capacities include surveillance and the capacity to detect health events above expected levels (for instance, exposure to chemicals in a large-scale fire) and report all available information immediately to the appropriate level of health care response. The prerequisite is a strong and competent workforce of epidemiologists. There is (unfortunately) no shortcut to mastering the epidemiological tools needed for outbreak and cluster detection and investigation. Countries need strong public health systems that provide data for active surveillance of infectious diseases and poisonings as their priority, along with periodic analysis of chronic diseases and environmental exposures for cluster detection as part of their routine.

Epidemiology and surveillance training in Latin America and the Caribbean are supported by PAHO and national governments in several ways, and the development of an epidemiology portal is one such initiative of interest (47), although environmental health-related topics and overall active maintenance and marketing are lacking. Both the dynamic 2007 Society for Environmental Epidemiology (ISEE) convention in Mexico and the very

successful 2008 World Congress of Epidemiology in Porto Alegre, Brazil, were firsts for Latin American epidemiology, demonstrating the strength and relevance of epidemiology in the Region. Environmental health lagged behind, however, representing less than 1% of total communications. That being said, public health epidemiologists from national and international organizations assert that a pressing need to boost capacity for disease surveillance remains (48), especially for chronic diseases, given the current epidemiological transition from acute to chronic diseases. Unfortunately, the recommendations of these gatherings do not yet include environmental or ecosystem variables of interest for surveillance applied to noncommunicable diseases. Use of a broader conceptual framework would support the inclusion of those environmental and ecosystem influences on health status. This would help prioritize the surveillance and control of globalization side effects such as tobacco marketing, increased air pollution with trade liberalization, increased overland transport of goods, rising grain prices due to exports for ethanol production, and occupational hazards related to the relocation of toxic jobs (49).

Several online tools are available to support training, among them the Virtual Resource Center of the Public Health Initiative developed recently by the WHO Regional Office for South-East Asia and the CDC (50). The topics covered include biostatistics and epidemiology, health information systems/surveillance, outbreak investigation and response, epidemiological investigations, human subject protection, scientific communication, program management, and disease-specific epidemiology. A recent and similar program developed by PAHO is called the Virtual Campus for Public Health (see <http://www.campusvirtualsp.org/>) and is geared to management and basic public health concepts and sciences, although only one course with specific relevance to environmental health is offered in pharmacoepidemiology. Such training tools are much needed, as only 12 schools of public health outside the United States and Canada offer training in the Region (47).

Finally, knowledge about the linkages between exposure to contaminants, other environmental or ecosystem health determinants, and their impact on health status and well-being is scant throughout the world, with the exception of Europe (see [http://www.enhis.org/object\\_class/enhis\\_Environment\\_and\\_health\\_issues.html](http://www.enhis.org/object_class/enhis_Environment_and_health_issues.html)) and the United States (see <http://www.cdc.gov/nceh/tracking/>). Canada has also recently joined the movement (see Box 5-2); some accomplishments from Quebec are also presented in Chapter 26.



### **BOX 5-2 ENVIRONMENTAL HEALTH SURVEILLANCE IN CANADA**

by Marie-Eve Dufresne, Adam Probert, and Jacinthe Séguin, Health Canada

The Government of Canada is responsible for ensuring and improving the health of Canadians in partnership with provincial and territorial governments. Part of this shared responsibility involves the surveillance of illnesses and diseases including those associated with environmental risk factors. The Public Health Agency of Canada, Statistics Canada and the Canadian Institute for Health Information (CIHI), are each involved in complementary aspects of health surveillance, including direct collection of data from Canadians, aggregation of local administrative data, and reporting on the state of population health. Health Canada, plays an additional role in assessing and reducing health risks posed by environmental factors as well as communicating information to protect Canadians from avoidable risks from environmental exposures.

However, health outcome tracking alone is not sufficient to support the development of public health policies and programs and to respond to the increasing demand for information from the public and decision-makers. The complex relationship between health and environmental risks requires a comprehensive and systematic collection of information on environmental hazards, human exposures, and health effects. Advances are being made with respect to the collection, analysis, interpretation, and communication of environmental health information in Canada. This case

example provides an overview of the responsibilities and activities relating to health surveillance and environmental monitoring (including biomonitoring) data and information at the national level. It highlights several initiatives currently underway that intend to advance the understanding of the effects of environmental hazards on health and assess the effectiveness of risk reduction measures.

#### **Environmental Monitoring**

With respect to monitoring of environmental hazards, there are several systems generating data useful for the management of environmental health issues. Air quality is a prominent concern and air quality monitoring stations located across Canada are managed by provinces, municipalities, territories, and Environment Canada. Almost all stations collecting ground-level ozone and PM<sub>2.5</sub> data are organized under the National Air Pollution Surveillance (NAPS) program, a cooperative arrangement among the federal government, provinces, and territories that has existed since 1970. Data from the NAPS has contributed to the measurement of the effectiveness of air pollution control strategies, identification of urban air quality trends, and warning of emerging air pollution issues. It is also being used in the development of the Air Quality Health Index (AQHI), which takes into account the risk to health caused

by exposure to a combination of several air pollutants and current weather conditions. The AQHI is used as a public information tool to protect the health of citizens on a daily basis from the negative effects of air pollution.

In addition, the federal government also reports on water quality and greenhouse gas emissions through the Canadian Environmental Sustainability Indicators initiative. These indicators are developed in partnership between Environment Canada, Health Canada, and Statistics Canada and the information provided in these indicators comes from federal, provincial, and territorial governments, who all share responsibilities for environmental management in Canada. Other monitoring systems in place (e.g., National Pollutants Release Inventory, weather and UV-B monitoring) also play an important role in identifying and managing environmental health risks.

### Public Health Surveillance

Whereas distinct environmental monitoring or health surveillance systems have been developed and refined over decades, the development of environmental health surveillance systems is a much more recent domain of activity, with the quality and completeness of the information varying according to individual hazard or exposure. There is a strong interest in strengthening the environmental health dimensions of current major health surveillance systems and many pieces of a national network/system exist to provide a foundation on which to build. However, information regarding environmental hazards, exposures, and the health outcomes associated with those hazards and exposures is not currently available in one centralized system. Current efforts in Canada are focussed on generating new data on exposures and health effects separately to demonstrate the distribution and trends in environmental health that would enable federal, provincial, and territorial governments to make comparisons with other countries and evaluate the effectiveness of control actions.

### Biomonitoring Initiatives

Chemicals monitoring and surveillance is an emerging area for the Government of Canada and significant advances have been realized in recent years with the launch of a few initiatives that will track levels of environmental contaminants in Canadians over time. Biomonitoring data will be released in the coming years from two major initiatives covering different segments of the population and several biomonitoring components of specific programs.

The first nation-wide initiative to collect nationally representative data on human levels of environmental chemicals is the Canadian Health Measures Survey, a partnership between Health Canada and Statistics Canada. The survey will collect blood and urine samples to test for environment markers among a representative sample of 5,000 Canadians. These environmental markers include various heavy metals, pesticides, and other chemicals and their by-products. A national health measures and biomonitoring survey of First Nations and Inuit peoples to complement the CHMS is currently planned.

A second initiative, Maternal-Infant Research on Environmental Chemicals, will provide national-level biomonitoring data for pregnant women that will be

available for use in risk assessments and the management of environmental chemicals. Data from this survey will provide a baseline for existing exposures and allow comparisons of data with other countries and identification of emerging trends.

Additional biomonitoring initiatives are being conducted as part of other environmental programs such as the Canadian Northern Contaminants Program established in 1991 and the National First Nations Environmental Contaminants Program.

### National Surveys

Statistics Canada has developed several national surveys on factors influencing health. Some of these surveys track, for example, how Canadians behave to protect themselves from different risks, including environmental health risks. To gather information on health determinants, health status, and health system utilization, Health Canada, Statistics Canada, and CIHI joined their efforts to develop the Canadian Community Health Survey.

Statistics Canada also conducts longitudinal surveys such as the National Population Health Survey. This survey is designed to enhance the understanding of the processes affecting health and it collects cross-sectional as well as longitudinal data. It measures the health status of Canadians and adds to the existing body of knowledge about the determinants of health. Other longitudinal surveys include the National Longitudinal Survey of Children, which is the first Canada-wide survey of children that started in 1994. This survey collects information from different fields including health. Statistics Canada also collaborates on the Canadian Longitudinal Survey of Aging, a national longitudinal survey of adult development and aging that was launched in 2008.

### Environmental Health Indicators

The development and use of various types of indicators has become widespread in many domains, including those of health and the environment. In Canada, both environmental monitoring and health surveillance data exist; however, those sources are rarely integrated to directly track the impact of the former on the latter. There is room to improve how we analyze the information we currently collect and better communicate what we know about environmental health nationally.

Health Canada is currently working towards the development of a comprehensive suite of indicators integrating health and environmental data. The purpose of this project is to provide a standard model of environmental health information that will, over time, demonstrate demographic, geographic, and temporal trends in environmental risks to the health of Canadians. This will be done by developing a series of environmental health indicator profiles using currently available data, and in parallel, recommending areas for future data collection or aggregation. One of the main challenges in this task is the integration of data from a wide range of sources and the sound analysis and monitoring of the identified relationships between hazards, exposures, and health effects.

## Conclusion

A pan-Canadian initiative has established that health surveillance is a core function in public health. The responsibility for planning, implementing, and maintaining surveillance systems in Canada is shared among several levels of government and can only be accomplished through partnerships with a diverse array of stakeholders including federal, provincial, territorial, and municipal governments,

universities and research institutions, and non-government organizations. Environmental health is a broad field and associated responsibilities with regards to surveillance or monitoring of hazards, exposures, or health effects vary across the levels of government, depending on the type of activities performed and the issues of concern in a region.

## ■ Methods in sustainable development

A focus on sustainable development emphasizes the contributions of a variety of sectors to mitigating the adverse effects of hazards, improving resource management, and informing policies and investments to improve human health and well-being. This section reviews methods related to trends in ecosystem services, sustainability reporting, and disaster preparedness.

### Trends in ecosystem services

Ecosystem services are defined in the Millennium Ecosystem Assessment (MEA) as “the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits.”(51). Trends in ecosystem services are determined not only through remote-sensing and survey data and environmental models, but also socioecological information collected from a variety of monitoring programs. Indicator programs provide information about changes in services over time, as well as changes in pressures, status, impacts, and responses of the systems in question.

The MEA is a synthesis of a number of international initiatives that track changes in ecosystem services. The Global Environmental Outlook (GEO) (52) program includes a series of indicators that are now part of the UNEP Year Book series (formerly the GEO Year Book Series). The World Resources Institute supports a searchable database, Earth Trends, containing information about Latin American and Caribbean trends in a variety of topics, including agriculture, biodiversity, economics, and human health. In addition to greenhouse gas emissions, the recent synthesis report of the Intergovernmental Panel on Climate Change highlights ecological trend data showing changes in the climate of the eastern Amazonian region, as well as the risk of significant losses of biodiversity throughout the tropics (53). The IPCC Water Synthesis highlights the exposure of Latin American countries to extremes of flood and drought, as well as the threat of changing distributions of infectious disease (i.e., malaria, dengue). In the small island states, concerns about water quantity and quality are particularly significant (54).

The Global International Waters Assessment focused on identifying changes in ecosystem services and has a specific focus on the ecological status and causes of environmental problems in 66 water areas in the world, including freshwater, coastal, and marine areas (55). Regional assessment reports in the Latin American and Caribbean region include the Caribbean Sea, the Caribbean Islands, the Patagonian Shelf, the Brazil Current and Northeast Brazil Shelf, the Amazon, the Humboldt Current, and the Eastern Equatorial Pacific. This assessment went beyond empirical data analysis and used an iterative method for the regional assessments. It involved four main steps: scaling, scoping, causal chain analysis, and policy option analysis. This method was chosen to evaluate the root causes of key concerns (freshwater shortage, pollution, habitat and community modification, unsustainable resource exploitation, and global change) and identify pathways of concern and possible responses.

Identifying trends in ecosystem services depends on good-quality data. With regard to the Latin American and Caribbean air quality data, Cifuentes *et al.* (9) found that locating, accessing, and compiling such data is a significant challenge. With few exceptions, the data are not readily available, and their quality is known only by a few local experts (when they exist, the data are current, and researchers are allowed to use them). In addition, given in part the expense of launching, operating, and maintaining regular air monitoring networks, the data are rarely continuous and may be available only briefly. Moreover, they are often not comparable. All of these factors make

identifying air quality trends very difficult. The UN is currently conducting a Global Assessment of Environmental Statistics (56) aimed at assessing current national programs as well as the factors impeding the collection, compilation, and dissemination of relevant information. The first phase of the study engaged a range of Latin American participants (including Bahamas, Bolivia, Brazil, Dominica, Guatemala, Peru, and Uruguay) and found considerable interest among the respondents in expanding their use of environmental statistics (for example, for water and energy use and emission data). A comprehensive summary of the first stage of this analysis, focused on the Latin American and Caribbean region, was recently published by ECLAC (57). The study identified significant progress in institutionalizing environmental statistics in national organizations, while also pointing to insufficient human and financial resources and the availability and quality of data as key factors impeding progress in this area.

Global and regional interest in trends in ecosystem services is linked not only to ongoing interest in knowing about the state of the natural resources on which human populations depend, but to the implementation of the concept of payments for environmental and ecosystem services (PES) as a means of protecting the public goods that come from good stewardship over private resources. Costa Rica became a pioneer of PES programs in the Latin American and Caribbean region with its 1997 introduction of a country-wide payments program (*Pago por Servicios Ambientales*, PSA). The program targets four forest-related services: greenhouse gas mitigation, hydrological services, scenic value, and biodiversity. The program's contracts have evolved over time and currently include timber plantations, forest conservation, agroforestry, natural regeneration, watershed conservation, biodiversity, and carbon sequestration. The program is funded primarily by the government but also receives funding from service users, international agencies, and NGOs (58). In the Latin American and Caribbean region, PES programs are currently operating, for example, in Costa Rica, Colombia, Ecuador, Honduras, Mexico, and Nicaragua (59,60). The Latin American and Caribbean programs are wide-ranging and include the full spectrum of PES activities, including the purchase of land. The Organization of American States (OAS) maintains a database of PES programs that includes over 350 entries. A variety of regional and national programs emphasize both the protection and restoration of environmental services and the potential contribution of PES to meeting poverty-reduction goals in the Region. This has led to a variety of innovative programs while also highlighting the challenges of creating targeted programs geared to meeting multiple objectives. Wide-ranging poverty-reduction programs linked to PES payments struggle with the place-based nature of some of the services rendered. This is less of a factor for PES related to greenhouse gas emission-reduction efforts but becomes more significant for programs related to biodiversity and water quantity and quality. The ability to target payments to "poor" populations is also difficult where services are tied to land ownership. In these cases, third-party organizations, such as NGOs, may be involved in the PES system (59).

## Sustainability reporting

Among the methods developed to implement the concept of "sustainable development," sustainability-reporting programs are the object of growing attention. Reporting programs include both performance and process indicators for a variety of topics.

### *Performance*

The Global Reporting Initiative (GRI) (61) is a multistakeholder network that develops, supports, and maintains an internationally accepted framework for sustainable development reporting based on the principles of transparency, accountability, reporting, and sustainability. The reporting initiative includes indicators related to economic, environmental, human rights, labor, product responsibility, and social issues. It is an iterative process that can be entered into by any institution and includes a variety of self-declared application levels of varying methodological sophistication. The GRI provides a variety of information services, including specialized guidance for some sectors (i.e., food processing, airports, mining, and metals). The GRI is currently refining its reporting framework to better include community impacts, gender considerations, and supply-chain considerations. The GRI Sustainability Reporting Guidelines complement the UN Global Compact ([www.unglobalcompact.org](http://www.unglobalcompact.org)), a strategic policy initiative targeting business, particularly where the guidelines are used to enhance the Compact's Communication on Progress requirement. The Compact focuses on 10 human rights, labor, environment, and anticorruption principles and currently includes over 5,100 corporate participants and stakeholders from over 130 countries. The GRI protocol can also be used to help organizations operationalize their commitment to the Earth Charter. In Latin

America, organizations such as *Unimed Brazil* (Brazil), *Fundacion Casa de la Paz* (Chile), *Emgesa* (Colombia), *Procesador nacional de alimentos* (Pronaca, Ecuador), *Pemex* (Mexico), *Red de la energia del Perú* (Peru), and *Banesco Banco Universal* (Venezuela) are involved in the GRI program.

### **Process**

Sustainability reporting in the environmental sector is also linked to a variety of management-based and sustainability reporting approaches. Environmental management systems are a key element of this approach. Incentives for implementing a management system include regulatory and supply-chain pressures, competitive advantage, and the potential identification of cost savings (i.e., energy, materials, waste disposal). The two leading approaches are the International Standard Organization's (ISO) 14001 (environmental management) (62) standards and the European Commission's EcoManagement and Audit Scheme (EMAS) (63). The ISO 14001 standard emphasizes the development of clear management systems within a given company or plant. Critics argue that this ISO 14001 certification can be obtained through the completion of the required process steps without any particular shift in environmental emphasis or production/waste streams. In reality, the dialogue generated within a participating operation tends to lead to some incremental improvements, although they may be modest.

The EMAS program complements the ISO 14001 standard in that both are internationally accepted management-based instruments designed to improve the environmental performance of companies. The two programs are applicable to a wide range of industries and require third-party certification. The main distinction between EMAS and ISO 14001 is the former's emphasis on the release of a public environmental statement and environmental performance data in addition to the design and implementation of an environmental management system. This key difference places an additional onus on the participating companies to be accountable for their commitments. Both the Caribbean Initiative for Sustainable Development (ILAC) and ECLAC track the number of ISO 14001 certifications in the Region as an indicator of sustainable development. The ISO itself does not certify organizations, although it regularly tracks the number of certifications issued globally. In 2007, Central and (mostly) South American countries accounted for 2.8% of the world total of ISO 14001:2004 certifications (of 154,572 certifications), while Africa/West Africa accounted for 3.6%; North America, 4.7%; Europe, 42.1%; and the Far East, 46.2% of the world total (64).

Sustainability reporting systems that take economic, environmental, and social impacts into account include accounting frameworks such as full-cost accounting, the natural capital approach, and triple bottom line accounting. In the field of environmental economics, the UN Statistics Division is developing a System of integrated Environmental and Economic Accounting (SEEA) guidelines. The UNSEEA program focuses on methodological developments in the field of environmental-economic accounting, as well as on the promotion, coordination, and standardization of methods and practices.

Full-cost accounting internalizes nonmarket values by including a wide range of costs (i.e., environmental and social, direct, indirect, and hidden) in order to better reflect the actual cost of production to the institution and society at large. The natural capital approach is closely linked to the environmental services methods discussed above. It is defined as "a means for identifying and quantifying the natural environment and associated ecosystem services leading to better decision-making for managing, preserving, and restoring natural environments (65)." The World Bank adapted this approach to its proposed indicators for Millennium Development Goal (MDG) #7 on environmental management (World Bank, 2006—for other proposed indicators for the Latin American and Caribbean region (66). The triple bottom line (TBL) accounting/reporting framework is another attempt to consider not only economic viability, but also social well-being and environmental protection (67). The audit is guided by a range of both internal and external principles and policies. The units of analysis may vary across the fields, thus avoiding the need to quantify "unquantifiable" values. The difficulties inherent in quantifying nonmarket costs pose a significant challenge to the majority of these accounting techniques, as well as a range of ontological and epistemological challenges. Nonetheless, these approaches are gaining significant momentum in the field of corporate social responsibility. UNEP's Finance Initiative program includes an active Latin American chapter interested in finance and sustainability, with its most recent publication focused specifically on Argentina (68).

## Disaster preparedness

The UN and WHO define a disaster as “a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources.” There is a continuum of the “disaster cycle” that begins with prevention and preparedness and moves on to response and recovery. In the Latin American and Caribbean region, the number and severity of natural hazards, and regional vulnerability are increasing, due in part to unplanned urbanization, demographic growth in risk-prone areas, and insufficient environmental management (69), not to mention climate change. The number of people affected by natural disasters in the Americas is summarized in Table 5-1 (70). Natural disasters include biological, climatological, geophysical, hydrological, and meteorological disasters. The data are contained in the WHO Collaborating Centre for Research on the Epidemiology of Disasters’ (CRED) Emergency Events Database (EM-DAT).

**Table 5-1.** Total number of people affected by natural disasters by region, 2000-2012

<i>Year/Region</i>	<i>2000</i>	<i>2001</i>	<i>2002</i>	<i>2003</i>	<i>2004</i>	<i>2005</i>	<i>2006</i>
Caribbean	1,875	5,914,948	428,109	278,328	1,051,611	2,658,587	46,948
Central America	158,180	2,636,393	863,363	300,028	173,643	3,668,033	296,536
North America	89,138	206,356	175,822	277,532	5,101,821	855,904	87,437
South America	715,145	2,115,200	1,138,142	2,442,639	2,918,414	1,054,719	1,117,820
<i>Year/Region</i>	<i>2007</i>	<i>2008</i>	<i>2009</i>	<i>2010</i>	<i>2011</i>	<i>2012</i>	
Caribbean	641,118	817,042	30,541	4,460,053	75,688	664,660	
Central America	2,161,539	1,354,180	3,170,902	2,237,222	4,751,984	1,908,471	
North America	668,618	13,393,618	11,526	12,471	440,418	94,651	
South America	5,645,651	4,426,900	2,789,991	7,325,849	3,716,803	2,169,654	

**Source:** EM-DAT: The OFDA/CRED International Disaster Database, [www.emdat.be](http://www.emdat.be), *Université Catholique de Louvain*, Brussels, Belgium.

In the United States, Hurricane Katrina in 2005, Hurricane Sandy in 2012, and the BP oil spill in the Gulf of Mexico in 2010 are good examples of catastrophic events. The greatest impact of the BP oil spill was on marine species,<sup>4</sup> but the impact on human public health caused by exposure to toxic chemicals was also highly reported.<sup>5</sup> In the case of the two hurricanes, the adequacy of the government disaster responses was quite different between 2005 and 2012. Indeed, during Hurricane Sandy many lessons learned from Katrina were successfully applied.

As indicated by Tierney (71), “Catastrophes differ from disasters in important respects: scale and severity of impacts; deaths, injuries and economic losses; and the extent to which catastrophes destroy or cripple disaster response systems and critical infrastructure and civil society institutions that are necessary for disaster response” (p. 3). While few would argue the catastrophic nature of Katrina, the city of New Orleans has also become a symbol of inadequate disaster preparedness and response, as well as a reference case highlighting social and environmental inequity and injustice in the country. There are many lessons that can be learned from the U.S. experience, among them the need for i) community participation in the development of disaster plans (including evacuation plans) that specifically address the constraints facing economically, physically, socially, and age-vulnerable populations; ii) support for environmental and technical mechanisms that reduce threats to human populations, including mitigative investments in the environment (i.e., mangrove forests), improved land use planning and engineering designs (i.e., that reflect land subsidence and sea-level rise) as well as ongoing review and reappraisal mechanisms to keep up with changing social, technical, and environmental conditions (including climate change); iii) professional, flexible, and responsive governance arrangements that effectively collaborate with a diverse array of civil society organizations (i.e., nonprofit organizations, religious institutions, volunteers); and, iv) investments in post-disaster planning and recovery that lay the foundation for more resilient communities (71,72).

Prevention is key, but despite national-level pledges to prioritize risk prevention, reduction, and preparedness and prevention and mitigation efforts, investments in prevention have been marginalized by *ex post* strategies and the expectation of external assistance (10,69,71,73). In much of the Latin American and Caribbean region, post-disaster analyses inevitably highlight health infrastructure that is not disaster-resistant, failed water and sanitation infrastructure, and poor (or nonexistent) land use planning and settlements on marginal or flood-prone lands (73). In New Orleans, flood protection measures (such as the building of new levees, drainage pumps, and canals) instituted after Hurricane Betsy in 1965 may well have increased the vulnerability of large segments of the population in 2008 by creating new “protected” land for development (72). To address such challenges, the IDB’s 2007 Disaster Risk Management Policy is increasingly geared to supporting proactive actions, including structural and nonstructural measures.

There is consensus in the literature about the need to link disaster preparedness to larger strategies for sustainable development, and for national governments—and especially the health community—to become more engaged in this work. Reform of the humanitarian sector is needed to better engage national governments (particularly those such as Argentina, Brazil, Chile, Cuba, Mexico, and Venezuela, which are developing their own programs) (10) in order to build their capacity to offer disaster-related assistance and respond to emergencies. Cuban experience and investments in disaster preparedness are particularly noteworthy (74). This need for capacity building and the creation of open and transparent governance systems for managing external funds is particularly urgent in light of emerging threats such as pandemic influenza and climate change (10). The 2005 Hyogo Framework for Action and the International Strategy for Disaster Reduction represent possible entry points for national-level action in this area, as do several of the Millennium Development Goals. PAHO’s 2008-2012 Strategic Plan specifically includes an emphasis on a secure and disaster resilient health sector in the Americas, complementing a WHO strategic focus on the same area. The OAS’s Program for Natural Hazard Risk Reduction emphasizes both international policy support as well as enhancing community-level resilience.

Disaster-preparedness methods are generally considered either top-down and coordinated by the international humanitarian community or bottom-up and engaged with affected communities locally. There is consensus in the literature that both approaches are needed. De Sherbinin *et al.* (75) built on the findings of complexity science, which also inform the ecological services field, to examine the vulnerability of large urban areas, including Mexico City, to bundles of stressors that ultimately affect the adaptive capacity of an area. The need for multilevel, adaptive, and integrated planning approaches, as well as robust and adaptive planning programs, has led PAHO to begin developing a number of disaster preparedness methodologies and technical guidelines for the Latin American and Caribbean region. Overly prescriptive international programs, such as minimum standards for humanitarian assistance (i.e., the SPHERE guidelines), are in some cases inappropriate, particularly where the minimum standard (i.e., for potable water) exceeds that which was available locally before the disaster (10). Disaster preparedness is linked to overall inequality in the Region, which has the potential to lead to increased post-disaster violence (10); vulnerability to natural hazards is strongly linked to poverty (76). The Regional Disaster Information Centre for Latin America and the Caribbean (*Centro Regional de Información sobre Desastres América Latina y Caribe*) is a focal point for regionally-specific information. The Inter-American Network for Disaster Mitigation of the OAS is another key regional institution.

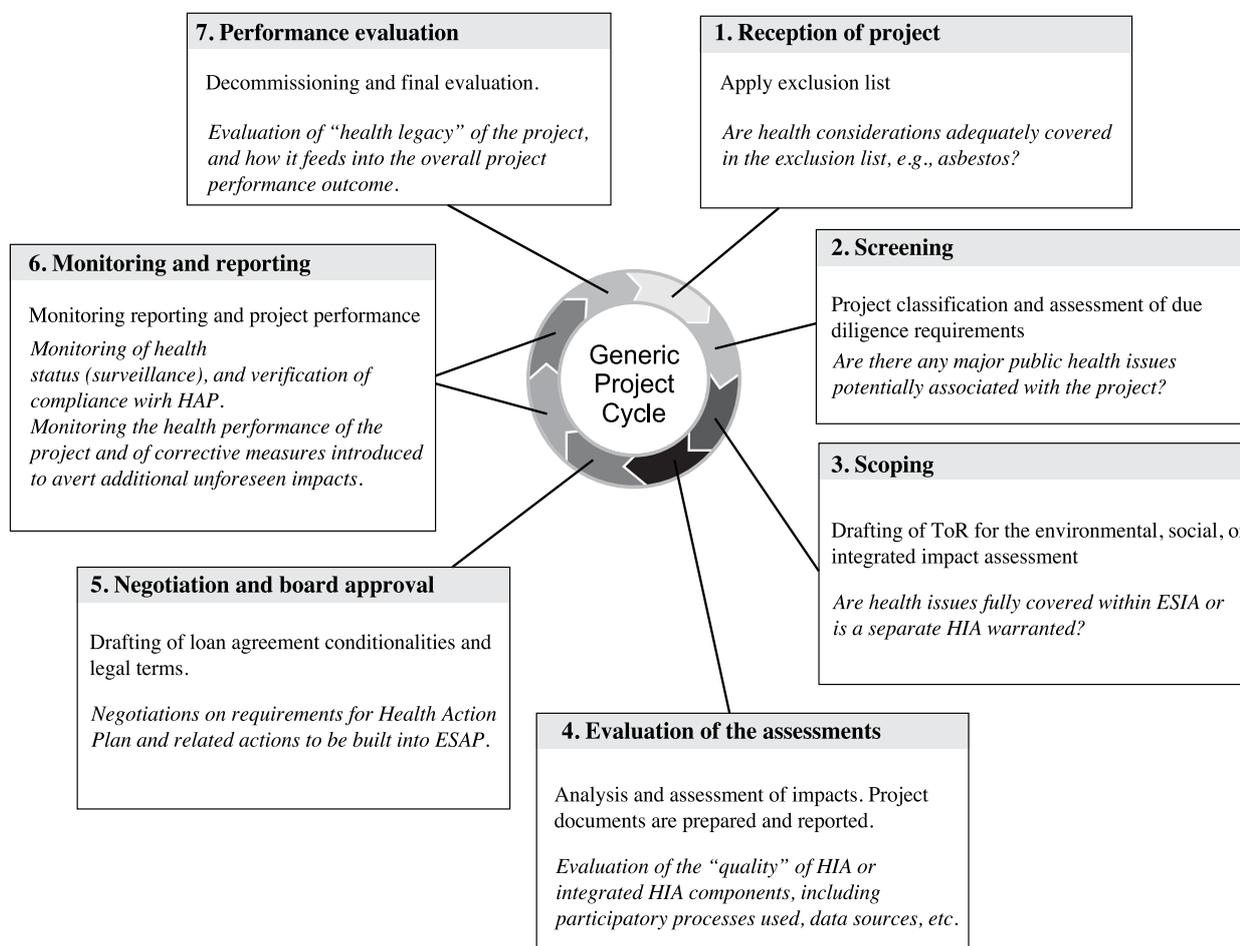
## ■ Integrative methods

### Health Impact Assessment

Health Impact Assessment (HIA) aims to identify, mitigate, and/or enhance the impacts of non-health-sector policies on public health. It can be particularly useful in identifying the underrecognized or unexpected impacts of non-health policies (77). A variety of frameworks have been developed to guide the development and implementation of HIA studies. Kemm (78) classifies them as either broad or tight, with the former characterized as holistic, sociological, and qualitative, and the latter limited, epidemiological, and quantitative. The quantification of risks tends to be more associated with HIAs that are focused on toxicological risks (such as toxic substances), and less commonly, may include a consideration of years of potential life lost (YPLL) and quality-adjusted life years (QALY) (79). A common focus is on the reduction of health inequalities. Community engagement may or may not be an element of the HIA process and is more likely in localized assessments. Early versions of HIA emphasized hazard

and risk assessments and were grounded in the biomedical model of health. More recent approaches tend to emphasize a social-ecological systems approach and the broader determinants of health (79) already used in Canada in the late 1990s (80). HIAs tend to share a staged approach involving screening, scoping, profiling, and appraisal (involving, for example, risk assessment, communication, and management). The final stages include monitoring and evaluation of the impact of the HIA on its target programs or policies (36, 79) (Figure 5-1). HIAs are limited by uncertainties around potential linkages to health, as well as limited data resources and the need for intersectoral interest and cooperation.

**Figure 5-1.** Links between Health Impact Assessment and the Project Cycle (adapted from World Health Organization, WHO Report on the Global Tobacco Epidemic, 2008-The MPOWER package. Available at: <http://www.who.int/tobacco/mpower/en/index.html>)



(ESAP = Environmental Surveillance Assessment Program)

In Latin America, HIA is not widely applied, although some nationally and externally funded projects (i.e., supported by a development bank, such as the IDB) may require an "impact assessment"—a category that includes one or more environmental, social, sustainability, and poverty impact assessments (such as environment and social impact assessments) (36). Cuba has recently implemented an interesting national HIA system (see Box 5-3). The latest WHO draft framework for HIAs in the development lending field includes screening, scoping, evaluation based in part on public engagement processes, and the development of a health action plan before implementation of a new project. The health action plan may specifically include targeted social investments in the affected com-

munities and should clearly distinguish between issues for which the implementing agency may be liable and those that are voluntary efforts to improve community health outcomes. Follow-up measures, including monitoring, reporting, and evaluation, are fundamental to the overall success of the HIA (36). The explicit incorporation of health into international agencies' environmental impact assessment (EIA) programs would be relevant, given the preponderance of projects that have both direct (i.e., water and sanitation programs) and indirect (i.e., hydroelectric projects, neighborhood revitalization programs) impacts on human health and well-being and on the social and environmental determinants of health.



### **BOX 5-3. CUBA'S SYSTEM OF HEALTH IMPACT ASSESSMENT**

by Maricel García Melián, Manuel Romero Placeres and Mariano Bonet Gorbea (National Institute of Hygiene, Epidemiology, and Microbiology of Cuba)

Cuba's creation of the Ministry of Science, Technology, and Environment (CITMA) in 1995 led to a rapid improvement in environmental protection. CITMA is responsible for the environmental licensing of development projects, which is issued in order to exercise due control over applying current environmental legislation and contains the authorization allowing these projects to proceed. There are cases in which it is necessary to perform an environmental impact assessment (EIA).

The EIA is a procedure that seeks to avoid or mitigate undesirable environmental effects brought about by plans, programs, and projects for works or activities. It does this through a prior estimate of the changes these would have on the environment and, as appropriate, may deny the license necessary to proceed or may approve it under certain conditions. Consultations with other agencies, as well as local authorities and the population, are part of the EIA process.<sup>i</sup> These agencies include the Ministry of Public Health (MINSAP), through its national and provincial sections, which evaluate the adverse health effects of the proposed works or activities.

In 2003, the National Institute of Hygiene, Epidemiology, and Microbiology (INHEM) developed a methodology to improve the health impact assessment within the framework of the EIA process, taking into account the specific characteristics of Cuba.<sup>ii</sup> The methodology was analyzed in a workshop involving environmental health specialists from the entire country and the University of British Columbia of Canada, and its text was improved and subsequently published in the form of a manual.<sup>iii</sup> The methodology thus developed is based on a qualitative assessment of risks and comprises the four stages briefly described below.

#### **Identification of the dangers to health**

This stage makes it possible to select those activities that may be most dangerous to health. Specifically, dangers caused by biological, chemical, physical, and psychosocial agents are considered. The manual presents the principal characteristics of investment projects that are dangerous to human health.

For each project activity, the associated dangerous environmental agents are identified, and the necessary information on their adverse effects on human health is obtained. Taking into account the qualitative assessment of the severity of the deterioration in health and duration of the effect, the non-carcinogenic adverse effects were then assigned a score between 1 and 5. From these 144

adverse effects were classified. Cancer was assigned a score of 5, in the case of human carcinogens classified as such by the International Agency for Research on Cancer (IARC). Carcinogen agents classified as probable were assigned the value of 4, and potential carcinogenic agents a value of 3.

If several agents of a single type associated with an activity were identified, those that presented the greatest danger to health, in terms of the severity of the effects, were selected. Furthermore, if a dangerous environmental agent had more than one effect, the most serious reasonably anticipated effect was selected.

#### **Identification of the potential impact on health status determinants**

This stage goes on to identify the determinants that will be directly or indirectly impacted, caused by the project's most dangerous activities. The principal determinants of health status that may be impacted by project activities are: air quality, water quality, food, housing and its environs, soil quality, and work environment, as well as the social context.

In order to define the importance of the impacts, they are classified according to five characteristics, and each characteristic is given one point. The total of these points falls between 0 and 5, and the importance is classified as follows: between 0 and 1) no importance, 2) minor importance, 3) moderate importance, 4) important, and 5) very important.

#### **Identification of vulnerable population groups**

This stage identifies population groups that may be affected by changes in health status determinants. Considering the number of people who may potentially be exposed to the impacts, each impact is given a score between 1 and 5.

#### **Assessment of the acceptability of the impacts**

The total score as far as danger, importance of the impact, and the exposed population are concerned, constitutes the total risk, which can have a score between 3 and 15. Depending on the total score, the risk is classified as follows: low ( $\leq 6$ ), moderate (7-9), high (10-12), and very high (13-15). Only low-risk impacts will be considered acceptable. Preventive measures or mitigation should be considered for the remaining impacts, which should be presented by the investor and analyzed by the health authorities. For impacts classified as of very high risk to health, presentation of a proposal for program monitoring should be considered

indispensable. The manual presents a non-exhaustive list of environmental health indicators, which can be used.

The manual was distributed to the Cuban Provincial Centers of Hygiene, Epidemiology, and Microbiology, in order to serve as a tool for health authorities in the EIA process, which contributes to the improvement of this activity. From the teaching standpoint, it has been incorporated into the Environmental Health Masters Degree program of INHEM, and into the Environmental Health course of study for the university degree program in Health Technology.

It is important to point out that the technical rigor of the EIA process in Cuba has increased. For example, in 2005 of the 291 environmental licenses requested, 78.7% were approved, while in 2006 of the 400 requested, 65% were granted.<sup>iv</sup> The provisions issued by MINSAP in the context of the EIA are respected by the institutions responsible for the process, as well as by investors, and take into account that the objectives of the Environment Law include human

health care, elevation of the quality of life, and improvement of the environment in general.

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## Indices of inequality resource consumption

The most used and well-known measure of global inequality in income distribution is the Gini index, which is of ongoing interest in the Latin American and Caribbean region (81). A Gini index of 0 indicates perfect equality, while an index of 100 indicates perfect inequality. The UNDP Human Development Reports (HDR) include Gini index tables. In the 2013 HDR,<sup>6</sup> Sweden and Norway had the lowest index numbers (25.0 and 25.8, respectively), indicating a more equal distribution of wealth. Comoros had the highest (64.3), indicating a severely lopsided distribution. In the Latin American and Caribbean region, Nicaragua had the lowest index (40.5), while Haiti had the highest (59.2). Argentina, Venezuela, Uruguay, and Jamaica were between 44 and 46, while the majority of the Latin American and Caribbean countries included in the report were in the 50s. The index is most useful for tracking changes in a country over time, since due to differences in data collection methods, the index numbers are not strictly comparable. Another index, the Atkinson inequality index, is now used to measure inequality in the Human Development Index (HDI) components; it puts more weight on the lower end of the distribution within and across groups, better accounting for child mortality, illiteracy, and income poverty than the Gini coefficient.<sup>7</sup>

Inequity in health is generally defined as disparity in health that is avoidable, unnecessary, and unjust (82). A more specific definition provided by Braveman (83), highlights social justice issues as well as the areas where public policies could make a difference:

*A health disparity/inequality is a particular type of difference in health or in the most important influences on health that could potentially be shaped by policies; it is a difference in which disadvantaged social groups (such as the poor, racial/ethnic minorities, women, or other groups that have persistently experienced social disadvantage or discrimination) systematically experience worse health or greater health risks than more advantaged groups.*

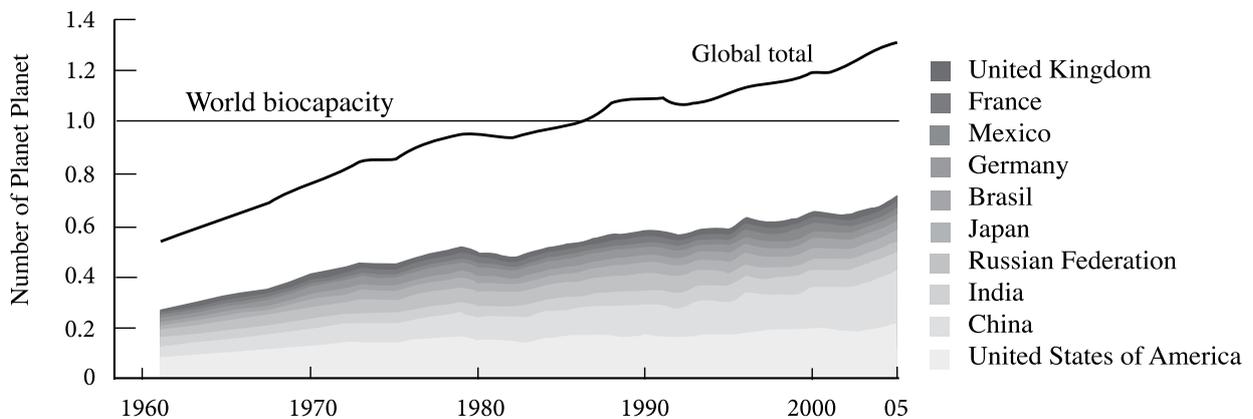
Inequity in health is a significant issue in the Latin American and Caribbean region. Hotez *et al.* (84) note, for example, that the Region's poorest people, including selected indigenous populations and people of African descent, are disproportionately affected by the so-called "neglected tropical diseases" (such as trichuriasis, ascariasis, hookworm, and leprosy). Progress toward the first Millennium Development Goal—to eradicate extreme hunger and poverty - is limited. UNEP (70) reported that, even prior to the current economic crisis, only five countries had succeeded in achieving major poverty reductions since 1990 and that the others had made little or no progress toward this goal.

The WHO World Health Report 2000 included an index of health equality focused on child survival. In the U.S., an Index of Dissimilarity (ID) focuses on the differences between various kinds of groups (including racial/ethnic and socioeconomic groups). In Colombia, researchers have created a new Inequity-in-Health Index (IHI) based on several of the indicators being used to track progress toward the Millennium Development Goals (85). In this model, indebtedness, income, and corruption levels were also considered relevant. The Human Development and Human Poverty Indices both measure national achievements (or the lack thereof) in three dimensions of human development: a long and healthy life, knowledge, and a decent standard of living. The Human Poverty Index highlights the poverty of choice and opportunity that confronts millions of people around the world and negatively

affects their development. Other UN-supported indices of inequality include the Gender-Related Development Index and the Gender Empowerment Measure.

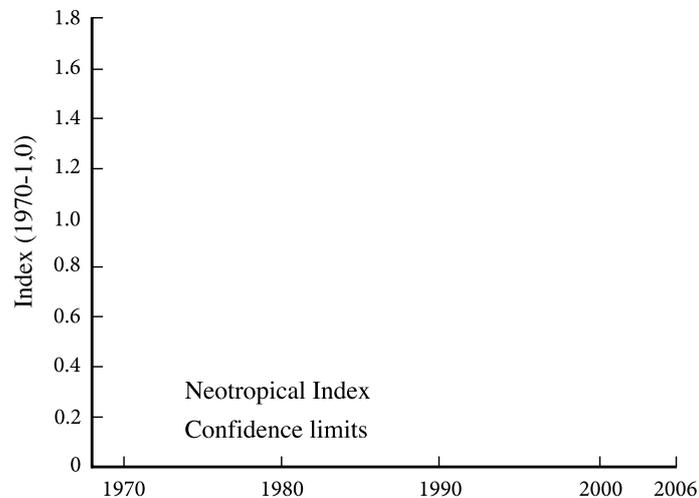
In addition to indices of health and well-being such as the one developed by Vemuri and Costanza (86), there are many well-established indices of resource use. These include indices that measure ecological system changes, as well as those that focus on alternatives to economic indicators. The Ecological Footprint is a measurement of human demand on the Earth's ecosystems. It represents how much biologically productive land and water (including marine) resources are needed to support a human population in a given lifestyle (87). According to the World Wildlife Fund (WWF) report from 2008, the United Arab Emirates and the United States of America have the highest ecological footprints (9.5 and 9.4, respectively), with Uruguay ranking highest of the Latin American and Caribbean countries (5.5) and Malawi, Afghanistan, and Haiti (0.5) lowest. These numbers change over time as countries' land use, energy, development, and consumption patterns change (Figure 5-2); however, they do not really incorporate health concerns or data in their calculation. Both the Ecological Footprint and the Living Planet Index are used by the WWF to communicate a sense of humanity's impact on the Earth. The Living Planet Index focuses on biodiversity to reflect the health of the planet's ecosystems. The Latin American and Caribbean region is considered a neotropical region, and the index is summarized in Figure 5-3. The index tracks 202 populations of 144 neotropical species.

**Figure 5-2.** Changes in the Ecological Footprint of selected countries over time (1961-2005)



*Source:* World Wildlife Fund for Nature, Living Planet Report 2008, WWF International, Gland, Switzerland, 2008.

**Figure 5-3** Neotropical Living Planet Index. The neotropical zone covers the majority of the Latin American and the Caribbean region. The index highlights a dramatic decline in the region's biodiversity over the past 25 years.



*Source:* World Wildlife Fund (WWF), 2008.

The Genuine Progress Indicator builds on the concepts of the earlier (1989) Index of Sustainable Welfare and is considered an alternative to the gross domestic product (GDP) in that it uses the same set of personal consumption data that informs the GDP but distinguishes between transactions that enhance human well-being and those that do not.

In Europe, a suite of four indicators is being used to monitor EU progress on its Resource Strategy. These include the Ecological Footprint (EF), Environmentally-weighted Material Consumption, Human Appropriation of Net Primary Production, and Land and Ecosystem Accounts (88).

## Mapping and Internet-based technologies

Worldwide, organizations invest billions of dollars annually to acquire data about the land and its occupation, resources, inhabitants, and uses. In the same way, practitioners in environmental health have developed several information systems, most of them now using GIS (geographic information systems) and Web-mapping technology to support their different activities. Combining public health and GIS has led to the organization of several symposia over the past 15 years, as well as scientific publications. Many projects have reached a high level of maturity. After an initial investment in the approach in the late 1990s, PAHO has maintained its infrastructure and offers a basic noninteractive atlas. This is also the case for most countries that offer such a web-mapping service in the region.

U.S. government agencies, which are required by law to publicly disseminate government information, are large producers of web-mapping applications. The Web Interactive Cancer Mortality Maps application (<http://www3.cancer.gov/atlasplus/index.html>), developed by the National Cancer Institute (NCI) and the National Institutes of Health (NIH), is a good example and presents the geographic patterns and temporal tendencies of cancer mortality rates (for more than 40 cancer sites) during the period 1950 to 2004. For its part, the CDC Injury Center's Interactive Mapping System application (<http://www.cdc.gov/ncipc/maps/>) provides access to the geographic distribution of mortality rates by injuries in the United States. These systems probably represent the best widely available web-mapping tools in public health nowadays.

However, these systems have been developed with geospatial technologies of a “transactional” nature, which do not benefit from the advances offered by the most recent decision-support technologies offered in the field of “business intelligence” (BI). BI technologies are not built to manage data transactions, but rather, to support complex analysis and knowledge discovery. BI relies mostly on a different data structure, called hypercube, and encompasses technologies such as dashboards, OLAP (on-line analytical processing), data mining, datamarts, and data warehousing. Using BI technology has become common practice in several organizations, since these technologies have been commercially available for over a decade. However, it is only within the past few years that commercial software has appeared to enable users to bridge BI and geospatial technologies. In spite of university-based research and development going back to the mid-1990s, only recently have integrated solutions been placed on the market by small innovative companies and major software providers (89). These new technologies make possible more efficient (i.e., faster, easier) performance of tasks that are very difficult and time-consuming with typical GIS and web-mapping technologies, namely the production of summarized information, aggregate data, trend analysis, spatial-temporal comparisons, interactive exploration of data, geographic knowledge discovery, etc. Such technologies are not meant to replace GIS and web-mapping applications, but rather, to add new capabilities for the analysis of data stored in current systems and provide a better return on investment.

Maps naturally help in the knowledge discovery process. Within a context of spatial data, maps do more than make data visible; they become active tools in supporting the user's thought process. Maps can display information that would not be visible using tabular data, especially for phenomena whose spatial distribution does not follow pre-established boundaries (e.g., administrative boundaries). Several studies in the cognitive sciences have demonstrated the superiority of images over numbers and words in stimulating understanding and memory (90-92), resulting in a better knowledge-discovery process (brain more alert, better visual rhythm, and better general perception). The full potential of maps remains untapped, as explained in detail and with several examples in Proulx *et al.* (89).

## National assessments by topic

Several international agreements signed by countries in the Region require regular reporting to comply with United Nations requirements. Treaties such as the United Nations Framework Convention on Climate Change (better known as the Kyoto Protocol), or the Montreal Protocol on Substances that Deplete the Ozone Layer have detailed and agreed-upon methods of measuring either greenhouse gases or ozone-depleting substances. Curiously enough, nothing of the sort exists for health reporting in international treaties as they apply to persistent organic chemicals, or the health effects of the pollutants these treaties are trying to reduce.

The best approach for adequate national reporting on priority contaminants, diseases, or environmental threats of public health significance remains to be determined. In several instances where contaminants need to be measured in environmental or human matrices, laboratory quality control will be critical to determining reliable risk levels. For cross-cutting and long-term topics such as climate change, where adaptation decisions will affect populations for decades, several organizations strongly recommend some form of real public participation in the assessment and decision-making process (93). Such public approaches also make it harder to control and hide critical information still withheld in both developed and developing countries.

Some international standards do exist for a few assessments, though. One such recent recommendation is the publication *Guidance on the Global Monitoring Plan for Persistent Organic Pollutants* (94), which offers sampling and sample preparation methodologies for maternal milk and plasma to be followed in national reporting, as well as interlaboratory comparison and cooperation issues to be addressed.

## ■ Environmental health, sustainable development, and risk assessment in the Region

### Commitment to data collection (health and non health sectors)

The deficiencies of systematic data collection in the Latin American and Caribbean region, particularly at the national and subnational level, are a key impediment to better understanding the links between environment, health, and sustainable development in the Region. In addition, the absence of regional and national policy frameworks for addressing sustainable development is a key concern. Despite the progress being made in many areas, the majority of Latin American and Caribbean countries lack programs to collect and integrate environmental statistics at the national level (57). In addition, there is little effective integration of the large number of smaller datasets that do exist in the country, resulting in lost opportunities for effective reporting that could help drive policy change in the Region. Where national data collection does exist and/or methodologies to estimate trends have been developed, the nature of these programs is such that the data collected tend not to be well-suited to informing regional comparisons and/or contributing to regional compilations (66,95).

In the health sector, several regional programs for epidemiological surveillance are focused on improving the collection and analysis of regionally comparative statistical data. These include regional hubs of World Health Organization programs, such as DengueNet (global surveillance network for dengue), Global SalmSurv (salmonella surveillance), and other global programs such as PulseNet (foodborne disease [FBD] surveillance and molecular biology). Burden of disease (BOD) studies (such as the Caribbean Epidemiology Centre's current program of BOD studies related to FBD in St. Lucia, Grenada, Trinidad and Tobago, and Jamaica) are also helping fill knowledge gaps. In addition, the Region supports other initiatives such as the Americas' Network for Chronic Disease Surveillance (AMNET) and the Mega Country Health Promotion Network, and has developed regional information systems, such as SIRVETA (*el sistema de información para la vigilancia de las enfermedades transmitidas por los alimentos*) and the Central American Diabetes Initiative (CAMDI).

In the environmental management field, data collection, information resources, and university curricula are heavily skewed toward water resource management issues, to the detriment of regional capacity to tackle other widespread and chronic issues, such as air pollution, coastal zone management, and deforestation (66). The reemergence of yellow fever and malaria outbreaks in Jamaica and the Bahamas points to the need for constant vigilance and investments in epidemiological and environmental surveillance and reporting systems (10), as well as the need for capacity building in a wide range of environmental and public health disciplines.

One of the challenges of relying on international organizations for indicator data collection is that the global methodologies may not be comparable with regional statistics. For example, ECLAC's water and sanitation data are not comparable with those compiled by the WHO/UNICEF Joint Monitoring Programme for water and sanitation, due to differences in both the methodologies and definitions used (96).

## Data analysis, including spatiotemporal

There is a small but active community in the Latin American and Caribbean region focused on geographic information systems (GIS), remote sensing, and data management issues. For example, the Global Spatial Data Infrastructure program publishes a regional newsletter containing information about a wide range of geospatial programs. Some projects, such as the proposed Spatial Data Infrastructure of the Bolivarian Alternative for Latin America and Caribbean (ALBA) (*Infraestructura de Datos Espaciales del ALBA* [IDEALBA]), have a strong social focus to their activities. Others, such as GeoSUR (*La red geoespacial de América del Sur*), focus more on the technical aspects of this issue. To date, the application of geospatial data to address environmental and health issues appears to be project-based, although many of the baseline datasets collected (such as those pertaining to land use, hydrological boundaries, and nearshore marine systems) are relevant to a number of environment and health issues, such as vector-borne or extreme weather event health impact surveillance.

In the health sector, the WHO GeoNetwork program supports public health mapping and the development of GIS systems. The Global Environmental Outlook (GEO) analysis of Mexico City included the development of a "geotext" system designed to be used in spatial analyses to provide policymakers and the public with clearer messages and enhanced information resources (97). A recent addition from the U.S. Global Change Research Program is called MATCH, for Metadata Access Tool for Climate and Health (<http://match.globalchange.gov/geoportall/catalog/main/home.page>). This clearinghouse of publicly available metadata and sources of monitoring and surveillance datasets is an online tool for both researchers and public health specialists.

While remote sensing has helped create some regional and subregional datasets, the lack of both accessible technology and the technical capacity to collect primary data has led to an overreliance on secondary data resources related to specific environmental health issues in the Region (98). In addition, the serious issues associated with rapid urbanization in the Region have also served to concentrate environmental surveillance programs at this level. Air quality monitoring, for example, is almost entirely concentrated in urban areas (66). This concentration is a reflection of the seriousness of the issue in urban areas; however, the lack of national surveillance programs may impede the development of regional solutions and underestimate air quality concerns in suburban, rural, and remote regions, as well as the emissions from other sources, among them the transboundary transport of suspended particles from forest fires or desert dust storms, which are both predicted to increase with climate change.

## Dissemination

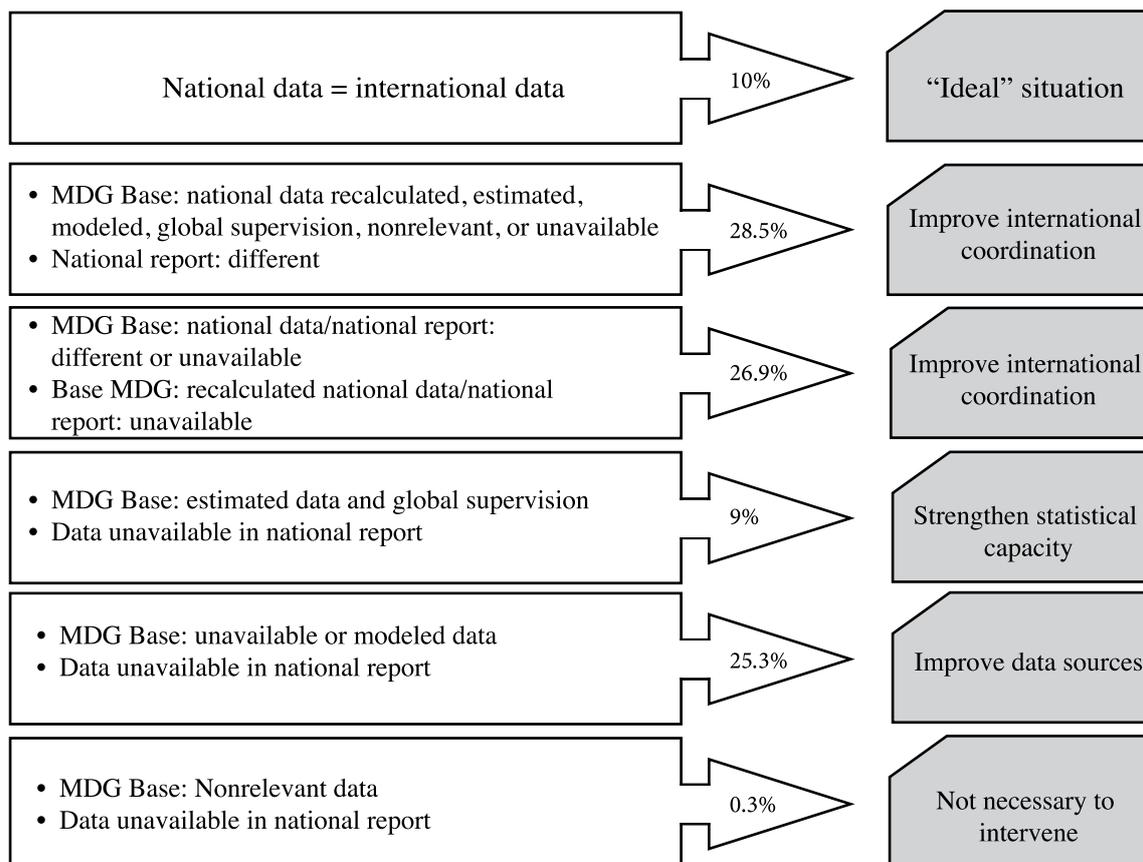
National environmental reports represent another area of sustainability reporting. The indicators used and the themes of the reports combine national concerns over environmental conditions and the human activities that affect and are affected by these conditions. They contribute, in whole or in part, to a wide range of international treaty processes in the Region, whose implementation (i.e., signed, ratified, etc.) is tracked by ECLAC (96). UNEP (70) has devised a sustainable development indicator specifically targeting evidence from national environmental reports.

In addition, at last count, 24 Latin American and Caribbean countries have published at least one report pertaining to the Millennium Development Goals (96); these reports can be found on the ECLAC website. One assumes that the goal of these indicators is full reporting by all Latin American and Caribbean countries; in and of themselves, however, they do not provide information about the efficacy of the information dissemination, nor are there clear transparency and accountability standards for the methodologies used to generate the information contained therein.

Reporting in the Region is extremely heterogeneous, reflecting differing priorities and capacities in each country. The lack of transparency in terms of the methodologies and data used to collect some of the reported data is a concern in many of the published reports. In their evaluation of the national and international datasets from 34 Latin American and Caribbean countries, Cecchini and Azócar (95) found that for 47 indicators pertaining to the

Millennium Development Goals, only 10% of the national and international datasets contained the same data, while 37% of the data were either different or not comparable. In 53% of the cases, no national data were found. The gradient of reporting steps is summarized in Figure 5-4, from their report. The authors found evidence of consistent, under-, over-, and inconsistent reporting about the indicator data reported nationally and internationally.

**Figure 5-4.** Steps to increase the use of national Millennium Development Goal (MDG) data in international databases



**Source:** Authors’ own preparation, based on national MDG reports and United Nations, Division of Statistics, 2006.

In addition, information is often available to the public through the Internet, particularly given the low cost of online publishing. The dissemination of this information to populations with little or no Internet connection and/or low literacy levels remains poor. Investments in local environmental initiatives are one way to address this issue and bring useful environment and health information to citizens. At the grassroots level, Schutz *et al.* (98) highlight the lack of guidance for developing inclusive approaches to address environmental health issues in the Region. UNEP’s (70) five-year report on the Latin American and Caribbean Initiative for Sustainable Development (ILAC) highlights the need for further investment in strengthening civil society, including investments in transparent processes, access to information programs, environmental justice initiatives, and inclusive and accountable decision-making processes.

## Risk assessment

In the field of environment and health, risk assessment takes many forms, and the predominant one was discussed above. In some cases, focused subregional assessments based on natural boundaries may be required. For example, in his review of neglected tropical diseases in the Latin American and Caribbean region, Horte (84) identifies 11 different subregions whose distinctive human and environmental ecology create different pathways

for pathogen transmission in the Region. He calls for greater emphasis on intersectoral approaches that better engage public health professionals, social service providers, and environmental organizations. The InterAmerican Heart Foundation and the Latin American Society of Hypertension recently began a Cardiovascular Risk Factor Multiple Evaluation in Latin America (CARMELA) to assess the prevalence of risk factors for heart diseases and stroke, including socioeconomic status. Environment and health risks are also included in broader economic risk assessments; for example, the World Economic Forum (99) included an analysis of climate change, deforestation, and environmental degradation as key risk factors (along with economic shocks, social inequities, and political stability) for the Region. In addition, training is part of a number of other programs, such as a recent UNEP workshop focused on risk assessment and risk management related to living modified organisms that complements its work under the Convention on Biological Diversity (100).

## Environmental and public health surveillance

The link between environment and health surveillance is clearly demonstrated by the split between the departmental “homes” for such programs. In Chile, Colombia, Guatemala, Jamaica, Peru, and Venezuela, for example, air quality monitoring is a program managed by the health authorities. In Barbados, Bolivia, Costa Rica, the Dominican Republic, Honduras, Nicaragua, Panama, and Uruguay, this function is assigned to the environmental department. The need for the health and environment sectors to collaborate in the design and implementation of environmental and public health surveillance is clear, as is the utility of the data collected by the two sectors (101). One major concern is the optimal location of monitoring stations for representativeness of population exposure.

Environmental surveillance programs are needed to provide timely, systematic, high-quality information to policymakers and to set priorities and monitor the effects of interventions. International organizations provide much of the statistical information on natural resources and the environment that is currently used. Information about national-level programs is also collected using questionnaires designed for that purpose. The information collected from both sources is published in the Environmental Statistics and Indicators Database for Latin American and the Caribbean (BADEIMA) and in ECLAC reports (96).

In its chapter on Latin America, the IPCC Working Group II report on impacts adaptation and vulnerability (53) highlights country-level efforts to implement adaptive strategies, for example “through the conservation of key ecosystems, early warning systems, risk management in agriculture, strategies for flood, drought and coastal management, and disease surveillance systems” (p. 584). The report goes on to state, however, that “the effectiveness of these efforts is outweighed by: lack of basic information, observation and monitoring systems; lack of capacity building and appropriate political, institutional and technological frameworks; low income; and settlements in vulnerable areas, among others” (p. 584). There are many groups trying to improve surveillance programs, such as the Training Programs in Epidemiology and Public Health Interventions Network (TEPHINET).

## Program evaluation

In 2003, the Inter-American Development Bank committed to evaluating its performance through a cross-sectional emphasis on performance related to the environment with the expectation that this would also enhance its poverty reduction and sustainable economic growth objectives—for example, through recognition of the value of natural capital. The strategy includes a series of output, outcome, and impact indicators for the Bank to use to monitor and evaluate its projects. In addition, the Bank is advocating the collection of data regarding selected trend indicators, particularly those related to environmental governance, institutional and policy development, the conditions of key natural resources and ecosystems, and the status of internationally agreed targets and goals (102). The Bank also supports program evaluations in other sectors. For example, the University of Buenos Aires, in cooperation with the IDB and PAHO, evaluated programs for decentralization and management of communicable disease control in Latin America (103), and the Bank itself has mandated an independent five-year review of its 2007 disaster risk management policy (69).

In their review of chronic disease surveillance in the Latin American and Caribbean region, Choi *et al.* (48) make several observations that are relevant to environmental and health surveillance in the Region in general. Among them is a call for regional “networks of networks,” both professional and institutional, that can help build national capacity, share technical innovations, improve information sharing, develop common methodologies (as

desired), and invest in common marketing strategies with a focus on strengthening in-house capacity. This approach would support a gradual decline in the surveillance activities directly undertaken by international organizations in favor of international support for more robust national institutions. These networks would not conduct surveillance themselves so as to strengthen national capacity and enhance professional opportunities. The authors sum up their approach with the acronym SCIENCE, which stands for strategy, collaboration, information, education, novelty, communication, and evaluation. The focus of the latter term is on the need for ongoing efforts to assess the design, implementation, and utility of surveillance programs to ensure that they are, in fact, used to support public health action.

Knowledge translation is gaining currency as both a field of study and a key priority for research organizations (including funding agencies). The term “knowledge translation” was coined by the Canadian Institutes for Health Research (CIHR) as “the exchange, synthesis and ethically-sound application of knowledge—within a complex system of interactions among researchers and users - to accelerate the capture of the benefits of research for patients through improved health, more effective services and products and a strengthened health care system” (104). Progress in the field is currently hampered by a lack of clarity regarding the terminology used, and a number of new definitions of knowledge translation and its related terms are in circulation (105,106).

Three critical issues influence debates over the translation of knowledge into practice. They include the contested nature of what constitutes evidence—indeed what constitutes knowledge; the need to consider context; and the degree to which “practice” should be seen as a complex system (i.e., not rational or linear) (107,108). The translation of knowledge into practice remains a critical challenge that warrants further investigation. The International Development Research Centre is involved in promoting the concept of knowledge translation in the Latin American and Caribbean region.

While there is currently no consensus in the literature on how knowledge may best be translated into action, there is widespread agreement that this is a major challenge in the health sector. In their study of the knowledge translation activities in 33 research funding agencies in nine countries, Tetroe *et al.* (105) point out that “Overall, the agencies appeared to take a more systematic approach to the expectations they had of researchers than to initiatives taken by the agency” (p. 151). They call for an investment in the science of knowledge translation in order to better address the gap between research, practice, and policy; improve the accountability of funding agencies; and, ultimately, improve public health outcomes (106).

## ■ Summary, priorities, and recommendations

### Summary

The Region should be able to invest more in the prevention of environmental health risks and the promotion of health-creating environments, and not only to respond to short-term emergencies. The political process of merging the health and environment agendas has been slow to begin and has never really materialized, despite the fact that major challenges remain in addressing basic priorities such as drinking water, hygiene, sanitation, indoor air quality, and exposure to lead or the more toxic pesticides. Such questions pertaining to governance are analyzed in detail in Chapter 3. Moreover, climate change and disappearing ecosystems services remain low on the real-life priority list. Even the countries identified as a priority for more vigorous interventions have not shown much improvement in real terms. However, other countries, such as Brazil, have seen massive investments in infrastructure, human capital, and poverty alleviation with tremendous improvements in some states, mainly through an orientation of growth in favor of poor people (109).

The traditional top-down approach apparently has not been working well enough in the Americas to address and significantly improve identified priorities, even in a period of economic growth such as the past decade. While there is no consensus on a scientifically recommended methodology for such a situation, the bottom-up approach now logically seems in order, if only to try an approach that has not really been supported so far by international and national organizations. Such a bottom-up approach is in line with the recommendations of Choi *et al.* (48) and the recent implications for governance created by the participatory Internet, as noted by the Organisation for Economic Co-operation and Development (110).

## Priorities

Investing in poverty alleviation and health-producing infrastructures and management improvements should remain the top priority. The needed infrastructure should address both educational, hygiene-, and disaster-related needs. The managerial improvements cover a wide range of topics, but for the purpose of supporting continued improvements in environmental health and health-promoting ecosystems services, long-term commitment is key to success and efficiency. It takes several years to create a good laboratory and the technical team to operate and maintain it at a good-quality level, and variable funding is a recipe for disaster and unreliable results upon which it would be unwise to base preventative policies. The same can be said for training a good epidemiologist, a good environmental health engineer, or any other critical personnel needed for sound decision-making at the political level. As White (111) mentions: “*Research capacities that take years to develop can be easily damaged through inadequate support, poor management, or other negative influences associated with both internal and external environments.*” The same holds true for most expert or technical personnel.

While the environmental health priorities already set several years ago by the health and environment ministers of the Americas (HEMA) will remain relevant once they are updated, the most pressing priority is probably to attach funding to their implementation for the long term.

Numerous examples of linking a source of revenue to a public health problem already exist, such as the taxes on tobacco for smoking prevention in several countries (36) or carbon taxes for environmental public health climate change adaptation programs (112), and could be emulated in the Region for more efficient and lasting policy implementation. This is in line with recent fiscal policy recommendations for development stemming from OECD (113) that concludes that:

*“Latin American governments are falling short in their use of fiscal policy as a development tool that can boost growth, reduce poverty and inequality, and provide high quality public goods and services.” (p. 2)*

The OECD also asserts that well-administered fiscal policy can be the basis of a renewed social contract between Latin Americans and their governments. One key element remains the need to deliver better and fairer public goods and services, and how success in this area can contribute to democratic consolidation.

## ■ Recommendations

### *A focus on national capacity building*

Greater emphasis should be placed on supporting national environmental and public health monitoring and surveillance systems—including professional development and dissemination of the information generated – in order to provide good-quality baseline and trend information to both policymakers and the general public.

A specific program to improve laboratory and monitoring capacity should be implemented, with comparability between subregions and countries in mind.

Since public health organizations collect significant volumes of complex data and need systems to monitor and assess the trends related to environmental exposures and related health problems, they need to provide their environmental health specialists with the most efficient geospatial decision-support technologies.

Health impact assessment should be integrated into new and existing decision-making processes at the strategic, program, and project levels. This requires dedicated national teams with an institutional basis.

### *Support services from international organizations*

International agencies should become more involved in supporting/requiring the widespread and proactive political measures mentioned above, as they engage with the governments of the Region. Without political will, support, and long-term commitment, this will not happen.

Another major role for international organizations should be to offer better services to support training and expertise development, networks, laboratory quality assessment and control (QA/QC), and information dissemination and knowledge translation for decision-making. A few standardized regional surveys conducted periodically

to measure progress in the key regional priorities in environmental health and ecosystems services for human health and well-being should also be part of the support services provided by international organizations.

### *Walking the talk*

The Region of the Americas is in need of a well-funded, long-term environmental health and sustainable development initiative. The creation of a fiscal mechanism to generate adequate sustained revenue for the preceding recommendations is actually the most important initial step that must be taken.

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## ■ Additional resources

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- Americas' Network for Chronic Disease Surveillance. <http://www.amnet.info>
- Central American Diabetes Initiative. <http://www.paho.org/English/AD/DPC/NC/camdi.htm>.
- Collaborative Action for Risk Factor Prevention and Effective Management of NCDs (CARMEN). <http://www.paho.org/english/ad/dpc/nc/carmen-info.htm>
- Database of Environmental Statistics and Indicators for Latin America and the Caribbean (BADEI-MA)–part of CEPALSTAT. <http://websie.eclac.cl/sisgen/ConsultaIntegrada.asp>
- DengueNet. <http://www.who.int/csr/disease/dengue/denguenet/en/index.html>
- Earth Charter. <http://www.earthcharterinaction.org>
- Environmental Health (Canada). <http://www.ncceh.ca/documents/evidence-review/how-new-analytical-geomatics-technologies-can-help-environmental-health>
- Foodborne disease surveillance system database (Sistema de Información para la Vigilancia de las Enfermedades Transmitidas por los Alimentos – SIRVETA): <http://www.panalimentos.org/sirveta/e/index.htm>
- GeoSUR. <http://www.geosur.info/geosur/index.php/en/>
- Global Assessment of Environmental Statistics. <http://unstats.un.org/unsd/envAccounting/ceea/assessment.asp>
- Global International Waters Assessment. <http://www.unep.org/dewa/giwa>
- Global SalmSurv. <http://www.who.int/salmsurv>
- Global Spatial Data Infrastructure. <http://www.gsdi.org>
- Hyogo Framework for Action. <http://www.unisdr.org/eng/hfa/hfa.htm>
- Inter-American Development Bank, data on Millennium Development Goals in the Region, with general social and macroeconomic data. <http://www.iadb.org/gl/>
- Inter-American Network for Disaster Mitigation. <http://www.oas.org/dsd/Nat-Dis-Proj/IADM.htm>
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- Intergovernmental Panel on Climate Change. <http://www.ipcc.ch>
- Millennium Development Goals. <http://www.un.org/millenniumgoals>
- Organization of American States. Database of Projects of Payments for Ecosystem Services in Latin America and the Caribbean. <http://www.apps.oas.org/pes/>
- Pan American Health Organization (PAHO), Virtual campus of public health. Available at: [http://www.paho.org/hq/index.php?option=com\\_content&view=category&layout=blog&id=1940&Itemid=3500&lang=en](http://www.paho.org/hq/index.php?option=com_content&view=category&layout=blog&id=1940&Itemid=3500&lang=en)
- PulseNet Latin America. <http://www.pulsenetinternational.org/networks/latinamerica>
- Regional Disaster Information Centre for Latin America and the Caribbean. <http://www.crid.or.cr>
- United Nations Environment Program's Finance Initiative. <http://www.unepfi.org>
- United Nations Global Compact. <http://www.unglobalcompact.org>
- United Nations Human Development Reports. <http://hdr.undp.org>
- United States Environmental Protection Agency (U.S. EPA), Integrated Risk Information System (IRIS); 2009. Available at: <http://cfpub.epa.gov/ncea/iris/index.cfm?fuseaction=iris.showToxDocs>
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- WHO Collaborating Centre for Research on the Epidemiology of Disasters' Emergency Events Database. <http://www.emdat.be>
- World Bank, Data on pollutants. <http://data.worldbank.org/topic/environment>
- World Resource Institute Earth Trends Database. <http://earthtrends.wri.org>

## ■ Notes

- 1 With the collaboration of Ray Bustinza and contributions by Maricel Garcia Melian, Manuel Romero Placeres and Mariano Bonet Gorbea of the Instituto Nacional de Higiene, Epidemiologia y Microbiologia de Cuba, by Marie-Eve Dufresne, Adam Probert, and Jacinthe Seguin of Health Canada; and by Zilma Gonzales and Sandra Owens.
- 2 World Health Organization (WHO). A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012;380(9859):2224-2260.
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- 6 United Nations Development Programme (UNDP). *Human Development Report 2013: The Rise of the South: Human Progress in a Diverse World*. Available at: [http://hdr.undp.org/en/media/HDR2013\\_EN\\_complete.pdf](http://hdr.undp.org/en/media/HDR2013_EN_complete.pdf)
- 7 United Nations Development Programme (UNDP). *Human Development Report 2013: The Rise of the South: Human Progress in a Diverse World*. Available at: [http://hdr.undp.org/en/media/HDR2013\\_EN\\_complete.pdf](http://hdr.undp.org/en/media/HDR2013_EN_complete.pdf)

# Toxicology development in the Americas: Lights and shadows

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## ■ Introduction

Health and life are key items on government agendas today, not only because they define the well-being, progress, and survival of the human species, but because of their multiple interfaces with a series of social determinants that, in the legal framework, make them basic rights of the citizens of the world. Hence, it is the social responsibility of the State to safeguard them (1). Clearly, it is the role of the State, consisting of all citizens and those who govern, to guarantee the right to health for the general population and workers in particular, with special attention to vulnerable groups (pregnant women, children, the elderly, and the sick), as declared in the constitutions of the majority of countries in the Region (2).

Toxicology, the science that studies the adverse effects of chemical agents on living things, is one of the oldest and most rapidly advancing disciplines in the field of health. The contribution of chemicals to technology development during the various phases of industrial growth is beyond question. Since the dawn of large-scale industrialization in Europe in the mid-19th century, chemicals have made it possible to transform raw materials into a wide range of basic chemical products useful for development. Indeed, they have played a major role in transforming agricultural societies into industrial and service societies, and from there to the time and information societies that have come to predominate in the past several decades (3, 4). The historical account provided by McWilliams illustrates how horizons expanded with the transition from biological and social control of pests to the development of synthetic pesticides in the United States between 1894 and 1927, making them a key factor in that country's agricultural development (5). Moreover, the scope and influence of this phenomenon can hardly be overstated, since it has crossed borders and shaped the development of agriculture in every country in the Region and the world over.

The constant demand for new and better materials and, hence, for new chemicals, is behind the major advances in high-tech areas such as electronics, bioengineering, and telecommunications. The technological and industrial age has put millions of chemical products in human hands, and the numbers continue to increase with the passing years, because new products are synthesized, approved, and marketed, and new compounds are produced through the interaction of existing active ingredients. To date, the American Chemical Society's Chemical Abstract Service (CAS), which lists and updates these products daily, lists 91.98 million inorganic and organic substances (6)—a combination of the substances manufactured each year for commercial purposes and the “unintentional” byproducts of industrial manufacturing and combustion processes. These byproducts can appear as contaminants in finished products, or as waste, air emissions, effluents, or soil pollutants (7).

Chemicals have transformed life and work in contemporary societies across the globe. The changes are themselves indicative of the growing importance, production, and multiple uses of chemicals. Their presence and benefits have helped to create and maintain a high standard of living in all the industrialized countries, as well as in countries in other stages of development. At the same time, their toxic potential has become increasingly visible, owing to their effects not only on human health (acute and chronic diseases, disability, and death), but on the environment as well, since vast quantities of natural and synthetic toxic substances are pumped into the environment and exceed the ability of ecosystems to assimilate, transform, or eliminate them, permanently altering the environmental balance. Environmental pollution, with its various causes and effects (such as the depletion of the ozone layer and climate change), and exposure to hazards, whose threats are in dispute (i.e., pesticides that have enabled agriculture to meet the global food demand and agents for household use), are among the manifestations of the presence of chemicals in everyday life. A continuing source of public concern due to its global implications is the role of chemicals in social behaviors and acquired habits, such as smoking, alcohol abuse, and illicit drug use (traditional or synthetic). Growing threats, such as the manufacture of the precursors used in the production of illicit drugs and the development and use of chemical weapons, are also matters of great concern.

However, the nature, variety, and quantity of the potentially toxic chemical substances (PTCSs) found in every country are highly dependent on factors such as the structure of the national economy and its agricultural and industrial sectors. Furthermore, many substances are released into the environment through economic activities such as power generation, automobile manufacturing, construction, the extraction of fossil fuels and minerals, metallurgy, pharmaceutical manufacturing, and transportation (8). Thus, production of these substances has increased enormously: from 1 million tons in 1930 to over 400 million tons today. These activities are found in industrialized and developing countries alike, including the Latin American and Caribbean countries (LAC), and have the potential to pollute any or all components of the environment (air, water, soil) and food (7).

Toxicology has evolved hand in hand with industrial development, beginning with *basic or fundamental toxicology*, which, classically, studies the general basis for toxic action (toxicokinetics and toxicodynamics), and has evolved to lay the foundations for *special or applied toxicology* (9). From this perspective, contemporary toxicology must be conceived as a broad science whose objective goes beyond its original interest, which was to study the impact of toxic substances on human beings, but is now concerned with applications in other areas, such as the environment, food, and research. Thus, the discipline today covers a range of specialized fields, such as clinical, molecular or chemical, veterinary, nutritional/food, occupational/industrial, forensic, environmental, experimental, and analytical toxicology (10).

Toxicology is closely linked with *sustainable development*, particularly in its occupational and environmental, rather than domestic, applications, since the harm and benefits appear through inertia, as few countries devote funds and efforts to studying such concerns (11). Clinical toxicology is more closely associated with routine medical practice and plays a role in health facilities and hospitals. Thus, its relation to sustainable development is not direct. In fact, toxicological diagnosis in the occupational and environmental settings faces diagnostic challenges that differ from those of clinical toxicology, which relies essentially on laboratory work and clinical semiology. In the case of the environment—a word that will generally be used here to refer to the work environment—toxicological manifestations can be subtle and long-range, with enormous latency periods (as with cancer caused by chemical agents), without biomarkers to signal chronic or subchronic exposure. It is here that epidemiology and toxicology intersect, since they must find different ways to make measurements, even in the absence of known biomarkers (12).

The most important field, however, and one considered fundamental to the creation of policies applicable to the range of issues that toxicology addresses, is the practice involved in setting safe limits for the use of chemical agents, also known as *experimental toxicology*. Thus, toxicology today involves work consistent with current scientific, technological, and social developments. Toxicologists must possess the knowledge and skills needed to recognize risk—i.e., the probability that a toxic substance will cause harm under certain conditions—so that they can set safe limits for the substance to ensure that it will not cause harm when used under the stipulated conditions and issue recommendations concerning its use, restrictions, or control, based on the dangers it poses (13). In addition, it should be borne in mind that toxicology is a multidisciplinary science and depends on other health and environmental disciplines (physiology, pharmacology, biochemistry, biology, physicochemistry, epidemiology, chemistry, forensic medicine, internal medicine, pathology, ecology, etc.). Toxicologists must therefore take advantage of the knowledge and methods of these disciplines to solve the complex problems inherent to their work. In short, their practice is also multidisciplinary, and the scope of their work horizontal, multisectoral, and cross-sectoral.

These advances have taken place in every corner of the Americas, albeit to a different extent in the North and the South. North America has driven and spearheaded the scientific development of toxicology through govern-

ment agencies that set policies and regulate the manufacture, use, application, and disposal of toxic waste. Their principal strategy has been the design and application of *risk management*, which has enabled government agencies in these countries to better understand and address a wide range of chemical hazards, by adopting effective methods for evaluating environmental and public health problems. The resulting regulations are extensive and varied, ranging from measures to protect the air and water to others to guarantee food and drug safety, along with safeguards for consumer products such as children's toys. Risk management is therefore considered an important public policy instrument for justifying technical and regulatory decisions, setting research priorities, and devising ways to determine the costs and benefits of policies and regulations (14).

The situation in LAC is utterly different. Industrialization, population growth, and industrial development have also evolved, but very unevenly, creating a series of health and environmental problems that have also impacted regional development. For example, the quadrupling of LAC's population since 1930 has resulted in widespread urbanization, which in turn has led to a sharp increase in the number of automobiles and, by extension, air pollution. Moreover, the rapid growth of the chemical industry has been characterized by its location in urban areas, whose size and density in some cases have grown out of control, jeopardizing the health of residents. The presence of industry only exacerbates these problems. In Venezuela and Mexico, for example, the petrochemical industry bears major responsibility for the countries' serious environmental problems (15). In short, the chemical environment has become highly complex, with the waste from energy generation, transportation, and industrial technology ending up as pollutants in the air, water, soil, and food. The greatest impact, however, is on the Region's productive apparatus, comprised largely of small and medium-scale industry and the growing and widespread "informal economy," in which the most vulnerable populations toil.

Given this situation, both the general population, exposed to the polluted environment, and workers, exposed to toxic substances in the workplace, are the focus of concern and research in the branches of toxicology that study prolonged low-dose exposure. The devastating impact of chemical accidents, with their massive public consequences, and even individual cases of accidental or occupational chemical poisoning, are but one aspect of the global problems that chemical substances pose for human health and the environment. The impact of the accident in Bhopal (India) on 3 December 1984, in which 42 tons of methyl isocyanate leaked from a pesticide plant owned by Union Carbide, is a case in point. The substance released decomposed into a number of highly toxic gases (phosgene, monomethylamine, and, most especially, hydrocyanic acid) that formed a lethal cloud enveloping thousands of people and animals, causing almost immediate death by asphyxiation. Many other people died trying to flee during the desperate, chaotic evacuation of the city. An estimated 6,000 to 8,000 people died during the week following the toxic leak, and at least another 12,000 died later as a direct consequence of the catastrophe, which affected more than 600,000 people in all, with severe consequences for 150,000 (16).

As a result of such incidents, decisions about measures to control chemical risks and prevent harm, which in the past were the province of toxicologists and health professionals, are now made at the highest local, municipal, and national political level. These government agencies are responsible for protecting the health of their populations and the environment and for minimizing harm to human health, the environment, and development while supporting development. They must furthermore comply with and enforce the regulations ensuring compliance by all members of the State (i.e., all citizens), so that all contribute to meeting these goals.

Ultimately, the function of governments as public policy- and decision-makers is essential to safeguarding the health of their populations and the environment in the search for social justice and equity. However, government cannot shoulder the entire burden. Effective interventions to promote equity in health are only possible through democratic processes marked by extensive civil society participation in the drafting of public policies that enjoy local and international support, the backing of scientific research on effective measures to promote health equity, and private-sector collaboration. With support from the World Health Organization (17), national ministries of health in the Region must take the lead, using the intersectoral, interinstitutional, and international platform for collaboration called for in the Health in All Policies document (18,19).

This chapter summarizes the available information on toxicology development, its scope, and its application in the Region of the Americas, highlighting the impacts of PTCS exposure on health and the environment, the potential gaps in knowledge, and the challenges that controlling those impacts pose in policy-making (e.g., and in risk management). A series of critical factors hinder sectoral policy-making aimed at protecting health and the environment from toxic agents. This chapter suggests some alternatives to foster prevention and real improvements in environmental and working conditions. These are described through experiences, strategic approaches, programs, and lines of action that have proven effective in managing existing problems. The importance of this chapter lies in the data and experience it offers to facilitate the health sector's active and effective use of applied toxicology in

decision-making to further sustainable development in the Region. The chapter concludes by outlining the main challenges to the use of toxicology and public policy-making for the proper management and control of chemicals.

## ■ Situation and trend analysis

*In order to describe and analyze interventions, programs, and plans for controlling chemical risks to sustainable development, the environment, and public health, recommendations and policies have been divided into several categories, ranging from the general to the particular, and from the international to the local. This section concludes with a critical analysis of the policies that have proven effective and those that have not, as well as the possible reasons for their success or failure.*

### Toxicology applications in environmental, occupational, and domestic settings in the countries and the Region

#### International guidelines and public policy recommendations

With the heightened government and public awareness and concern about pollution caused by economic activities that use, transform, and release chemicals into the environment, various international organizations have established programs to address the scientific aspects of the problems posed by these activities. Some United Nations agencies, such as the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO), have cooperative programs to deal with food contaminants and pesticides. In 1970, the Organisation for Economic Co-operation and Development (OECD) created what is now known as the Environment Policy Committee and in 1971 formed a task force to promote cooperative research with the goal of sharing information, assessing risks, and taking action to manage pesticide and industrial chemical risks.

It was in this context of growing awareness that the need arose for cooperative action at the international level to address a range of problems associated with chemicals, including potential risks to health and the environment from pesticides and the chemicals used in industry. In 1972, therefore, the United Nations General Assembly convened the Conference on Human Development to examine the state of the world environment, identify problems, and determine what actions were needed (7).

Evidence of health and environmental damage from the production, use, and release of chemicals aroused such intense international concern that in 1992 it was the principal issue debated by the Heads of State at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil, known to posterity as the Earth Summit. This conference produced Agenda 21, 1992 (20), which outlined the conceptual framework and general scope of the term *sustainable development*, including a wide range of elements and strategies needed to advance and implement the agenda. Chapter 19 in particular, “Environmentally Sound Management of Toxic Chemicals, Including Prevention of Illegal International Traffic in Toxic and Dangerous Products,” directly addresses the problems associated with PTCSS.

Since then, a number of global and regional programs aimed at controlling PTCSS have been created or strengthened to respond to the problems and challenges they entail and protect the vulnerable populations described in Chapter 19. These initiatives include the Inter-Organization Programme for the Sound Management of Chemicals (IOMC), launched in 1995, and the Intergovernmental Forum on Chemical Safety (21). Their purpose was to coordinate international efforts, hasten environmentally sound management of chemicals, and move toward the achievement of sustainable development goals. Participants in the IOMC include the following United Nations agencies: the United Nations Environment Programme (UNEP), the International Labour Organization (ILO), the Organisation for Economic Co-operation and Development (OECD), the United Nations Industrial Development Organization (UNIDO), the United Nations Institute for Training and Research (UNITAR), the Food and Agriculture Organization of the United Nations (FAO), and WHO, with WHO serving as the group’s secretariat.

Several events occurred after 2002, and major strategies for chemicals management were implemented:

- A. The Millennium Project was commissioned by the United Nations Secretariat, resulting in the definition of the eight Millennium Development Goals (MDGs) (22). To meet these goals, task forces were created. The MDG 7 task force (*Environmental Sustainability*) drafted a series of seven technical doc-

uments containing background information, scientific data, and comprehensive recommendations on how governments can respond to problems associated with environmental degradation. The mission of the Project and Task Force was to prepare a framework for action that could be useful to decision makers and environmental managers in their efforts to meet the MDGs. According to the final report of the Task Force, entitled *Environment and human well-being: a practical strategy*, efforts should include the adoption of global policies and measures that address the needs of developing countries and economies in transition and are formulated and applied with the full participation of those countries and economies.

The report also proposes that, regardless of their degree of industrialization, countries develop and execute programs for environmentally sound chemicals management, given the potential effects of these substances on human health, the environment, economic growth, and development. Such programs should be geared to protecting human health and the environment to guarantee truly sustainable global economic development (7). Clearly, the countries must engage in interinstitutional and intersectoral strategic planning at the national level to prevent and control the adverse effects of toxic chemicals. This planning is essentially a political commitment and public activity that the State must shoulder and share with all stakeholders in society. Since the main focus of most developing countries is development, decisionmakers, policymakers, and legal and regulatory authorities in these countries must remember and acknowledge that sustainable development can be furthered by minimizing adverse effects on health and environment. Thus, implementation of environmentally sound chemicals management at the global and national levels can contribute substantially to meeting the MDGs, especially those to eradicate poverty and extreme hunger, reduce infant mortality, improve maternal health, and achieve environmental sustainability (7). All such initiatives must also be consistent with the new Sustainable Development Goals (SDGs) now in discussion (UN, 2014), which will enter into force after 2015 (23).

- B. After three years of consultations, the Strategic Approach to International Chemicals Management (SAICM) was adopted at the first International Conference on Chemicals Management (ICCM1), held by UNEP in Dubai, United Arab Emirates, in 2006. The purpose of this multi-institutional initiative of the IOMC, IFCS, United Nations Development Programme (UNDP), and World Bank is to achieve environmentally sound management of chemicals throughout their lifecycles, so that by 2020 all are produced and used in a way that minimizes adverse effects on human health and the environment (UNEP, 2006). The 2020 target was adopted by the World Summit on Sustainable Development in 2002 as part of the Johannesburg Plan of Implementation (24). The strategy is characterized by its comprehensiveness, ambitious 2020 goal, intersectoral multi-stakeholder nature, backing from the highest political levels, emphasis on chemical safety as a key aspect of sustainable development, provisions for mobilizing resources, and official recognition and support from the governing bodies of key international organizations. ICCM1 also set strategic priorities and negotiated institutional agreements and terms of reference for the Quick Start Program Trust Fund, whose objectives center on: helping low-income countries develop or update their national chemical profiles; determining what is needed to achieve sound management; supporting institutional strengthening and development for managing plans, programs, and activities based on international agreements and initiatives; and fostering analysis, interinstitutional action, and public participation to implement SAICM, incorporating it in national strategies and setting cooperation priorities to advance these efforts (25). UNEP and WHO serve as the SAICM Secretariat and work with the IOMC to ensure proper monitoring of the strategy and follow-up to the international conferences that guide it. WHO Resolution WHA59.15, of 2006, urged the countries to make every effort to implement the Strategic Approach, and requested in particular that they take full account of health aspects when implementing chemical and occupational safety programs (24). The second ICCM2 and SAICM meeting was held in 2009 (26) in Geneva, Switzerland, during the run-up to the World Health Assembly. It provided the first account to that date of global progress in implementing the strategy. A number of emerging policy issues were addressed, among them nanotechnology, the presence of chemicals in consumer goods, lead in paint, and electronic waste. Several key results emerged. First, 20 indicators were defined, along with a baseline for evaluating the strategy's progress and impact in the countries in terms of the five SAICM objectives (risk reduction; knowledge and information; governance; capacity building and international cooperation; and illicit international trafficking). Secondly, \$20 million was allocated from the Quick Start Program Trust Fund to ensure that 80 developing countries could implement the strategy. In addition, the High-level Roundtable on

Public Health, the Environment, and Chemicals featured discussions on how, in the face of health and environmental impacts, to strengthen the role of the health sector and other social stakeholders during execution of the strategy. The roundtable suggested some areas in which the health sector could advance. However, UNEP acknowledged that, while important steps had been taken to ensure that chemicals are produced, used, and disposed of safely throughout the world and progress had been made in setting future priorities in some key areas, the results in terms of the target set in Johannesburg of minimizing the impact of chemicals on health and the environment by 2020 were disappointing (27). The third ICMM, ICCM3, was held in Nairobi, Kenya, in September 2012. A milestone in implementing the Strategic Approach, this meeting for the first time examined progress in gathering data on the 20 aforementioned indicators (listed in Annex 2). The report included information from 78 governments, 11 intergovernmental organizations, and 19 NGOs, six of which are in the private sector (28). A mid-term evaluation of the Quick Start Trust Fund Program was also conducted, based on the 30 satisfactorily completed projects and covering each of the emerging issues mentioned earlier. Bodies for examining the sustainability and financing of the Quick Start Fund were created, and additional elements were added to the global plan of action.

To begin the process and get it up and running, SAICM was structurally and functionally organized by region, making it possible to formulate and execute regional, subregional, and national action plans for achieving sound chemicals management. In relation to the LAC region, the SAICM Secretariat, which is based at the UNEP Regional Office for Latin America and the Caribbean, held four meetings. The object of the First Latin American and Caribbean Regional Meeting on the Strategic Approach to International Chemicals Management, held in Panama City, was to discuss comprehensive management of chemical products, implementation of the strategy, and formulation of the Global Plan of Action 2007-2009 (SAICM, 2008). Twenty-eight of the countries in the Latin American and Caribbean regional group (GRULAC) attended, along with seven United Nations organizations and five observer countries, including the United States and Sweden. The purpose of the meeting was to have each country incorporate nationally the various international conventions and programs on specific issues related to problems posed by chemicals. However, the major concern was the lack of planning and specific action to control hazardous substances in the countries—with certain exceptions, such as Argentina, Chile, and Brazil. The meeting began by defining the profile of the regional coordinator and the delegates of the Executive Board of the Quick Start Program Trust Fund and Regional Coordinating Committee. Two additional meetings were needed that year to consolidate the coordinating group and agree on the contents of a consultation on chemicals management in the different countries. In the end, eight countries (including the United States), one international governmental organization, and three NGOs reported that they had begun public awareness and organizational activities and were prepared to establish focal points as part of the preparatory activities for the next SAICM meeting (27).

The second GRULAC meeting was held in Kingston, Jamaica, in March 2010, and attended by representatives of 22 countries, four intergovernmental organizations, one subregional organization (COMISCA), and a number of social organizations. The issues raised included the need to adapt activities and move toward a regional SAICM Plan for LAC in which the health sector would play a key role, and to work on developing mechanisms to fund the activities of the plan (e.g., by expanding the Quick Start Trust Fund program). The need for a mechanism for reporting results and sharing information on progress in the subregion during the SAICM meetings was also discussed. Preliminary results showed that many countries had already updated their national toxic substances profile and had begun implementing control activities. A call was issued to prioritize certain interventions, such as those related to nanoproducts, electrical and electronic waste, and chemicals in consumer goods, in addition to the global campaign to eliminate lead from paint and ban perfluorides.

The third meeting was held in Panama in June 2011. Representatives of 23 countries attended, along with a number of guests and the usual intergovernmental organizations. The focus was on evaluating and providing technical assistance for implementing and updating the Strategic Approach in the Region and preparing the ICCM3 progress report. An online tool was provided to collect information from the countries. The countries used this tool to upload information for all of the reports, initially for the period 2006-2008, followed by preliminary information for the 2009-2012 period. It was requested that a health sector plan for SAICM be formulated, and the issue of the regional plan was again taken up.

Discussions on the structure and content of the plan continued, emphasizing both the need for clear priorities and the countries' desire to solve their local problems to ensure that the needs and execution of the plan were consistent with international programs and instruments. Finally, resolutions were adopted for action on nanotechnologies and nanomaterials manufacture, the handling of hazardous substances in the life cycle of electrical and electronic products, inclusion of the health sector in the regional SAICM process in LAC, funding for the implementation of SAICM in LAC, and the elimination of lead in paint.

The fourth GRULAC meeting was held in Mexico in August 2013, following up on the aforementioned issues. There was a consultation on endocrine disruptors, a review of the impact of lead in batteries in Central America and the Caribbean, and discussion of children's environmental health, along with the issue of highly hazardous pesticides. Progress was made on the Regional SAICM Plan, and priorities were set for achieving Goal 2020 under the coordination of the Regional Coordinating Committee (29).

- C. **Toolbox for decision-making in chemicals management:** Designed and implemented by the IOMC, this instrument is a guide for country decision-making on chemicals management through a horizontal approach to problems and solutions. It focuses on three objectives for chemicals management: a national pesticide management scheme; occupational health and safety systems; and systems for prevention, preparedness, and response to major threats. The structure of the guide allows the user to select the most appropriate and effective national actions for specific problems associated with chemicals in five steps: (i) analysis of gaps to detect problems and set priorities based on the national PTCS profile of the SAICM implementation plan; (ii) selection of the management objective (for now, only in the three fields mentioned); (iii) assessment of available resources in the country; (iv) presentation of a national scheme for managing the key elements (infrastructure for product registration, applications, surveillance, formulations, storage and transportation, distribution, waste, monitoring, quality control, information sharing, licensing, etc.); and (v) implementation of management solutions for each key element. At each stage, the instrument provides guides, manuals, and procedures for sharing and using information. Key elements emphasized are the creation of infrastructure, the development of a regulatory framework (criteria, regulations, and standards for safe management of PTCSs), and the strengthening of surveillance and control capacity (having a sufficient number of skilled inspectors)—the latter being a common weakness in the LAC countries. The toolbox was presented for review at ICCM3 in 2012. This initiative is ongoing and currently in the testing phase (30).
- D. The United Nations Conference on Sustainable Development (more commonly known as *Rio+20: The Future We Want*), held in June 2012, 20 years after the Earth Summit of 1992, was an opportunity to apply a global criterion to explore what can be done locally to safeguard our common future. The Summit began by acknowledging the changes that had taken place in the 20 years since the launch of Agenda 21, among them new multilateral agreements; greater awareness of the effects of climate change and the development of strategies to mitigate it through carbon dioxide emissions trading; the development of the green economy; the development of the organic-products market and of ecoquality seals; action to promote recycling; the development of biofuels (sugarcane, soy, and palm oil) and solar and wind energy; responsible management of PTCSs; and the development and industrial use of genetically modified organisms and nanomaterials (31). The Summit also noted that despite fewer major chemical disasters, such as oil spills, disasters of this nature continue to have devastating effects, while other problems have worsened. For example, mass production of plastics has led, in a highly visible way, to a nearly five-fold increase in plastic waste in the oceans. In addition, natural disasters (typhoons and floods) have become more frequent and intense, resulting in large-scale human and economic losses. Meanwhile, the growing demand for food, due to the expanding world population, has been accompanied by an enormous increase in pesticide use and in the demand for fertilizers and water for crop and livestock production, along with a significant decline in fish populations. As a result, organic farming has increased at an annual rate of nearly 13%. Widespread urbanization has led to an increase in steel and cement production for construction purposes; fuel consumption has grown as a result of the increase in air traffic (230%) and tourism (90%). The “global village” has grown massively thanks to the development of new communication technologies (the number of mobile telephones increased by 23,000% and the number of Internet users, by 29,000%). The balance sheet on environmental degradation, as well as on health and human development, presented the Summit with a very difficult and challenging picture. It was

therefore suggested that Rio+20 develop a roadmap for reducing poverty over the next 20 years, with the goal of achieving social equity by means of a green economy that fosters decent jobs and protects the environment through appropriate and sustainable use of resources—e.g., by promoting nonpolluting energy generation.

In their final declaration, the countries renewed their commitment to the Rio principles and sustainable development and pledged to doing everything possible to achieve the MDGs and comply with the provisions of the other agreements and declarations derived from the MDGs over the 20 previous years (31). They also agreed that sound chemicals and waste management is fundamental to protecting human health and the environment, pledging to strengthen whatever actions were necessary in their respective countries to meet the requirements of the Strategic Approach and to evaluate activities for the period, disseminate information to the public, increase the accountability of producers, and encourage research and development, sustainable design, and knowledge sharing, as needed.

### General policies governing chemical risk management

Because of the presence of PTCs at all levels of the consumer society, toxicology today has a cross-cutting presence in the health sector, with multiple cross-sector applications. Accordingly, public surveillance and control policies must have a similar cross-sector focus if they are to be executable, effective, and enduring. However, there are many controversies surrounding the issue of public control policies. There are also variations within and between geographical areas, since situations in the Region vary widely. On one hand, there is the powerful bloc of the North American countries, which, based on the regulatory advances and conditions established in the North American Free Trade Agreement (NAFTA), must comply with standards and laws that address the issue of toxicology; on the other, are the countries that are developing or in transition, where regulations are few and their scope is limited. These countries often copy other countries' regulations, which are difficult to implement in the context of underdevelopment, where lack of economic, technological, and human resources and/or the obstacles of bureaucracy and corruption hinder implementation and verification at the household, workplace, and environmental levels. A number of organizations, with support from USAID and Transparency International, have been studying and documenting corruption in Latin America, highlighting its varied, complex, and expansive nature. The phenomenon appears in many forms, ranging from incidental or chance events involving minor misappropriation, embezzlement, bribery, favoritism, or discrimination, to somewhat larger transactions, to action involving vast amounts of public funds given to special interests in return for political, economic, or commercial favors (32). These forms of corruption are considered "normal" when the corruption has been easy to identify and punish and when the conditions that gave rise to it are easy to eliminate, and "widespread" or "systemic" when there is less likelihood of detection and punishment and when conditions create incentives for greater corruption. The latter cases involve institutions, rules, and standards of conduct that have a corrupt *modus operandi*, motivating civil servants, politicians, and other social actors to follow suit; this is a serious destabilizing factor for democratic institutions, erodes the rule of law, and stifles economic growth and business competitiveness (33). The report of the transparency and anticorruption coalitions, whose members include NGOs from Peru, Paraguay, El Salvador, and Bolivia, clearly identifies some of the conditions that perpetuate corruption, among them politicization, personalization, failure to involve different stakeholders in decision-making, dependence on outside funding, conflicts, and poorly defined communication strategies (34).

However, since the countries of the North have used *risk management* to set the parameters for industrial development, toxicology, and public policy-making for the control of PTCs, we shall begin by reviewing the scope of these parameters. In the United States, the process began in the 1970s and was defined as identifying, evaluating, selecting, and executing activities to reduce risks to human health and ecosystems. The goal was to implement comprehensive, cost-effective, scientifically based activities to reduce or prevent risks, while taking social, cultural, ethical, political, and legal factors into account. U.S. government institutions such as the Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA) began adopting this approach.

It was not until 1990 that the U.S. Congress created the Congressional Commission on Risk Assessment and Risk Management to thoroughly investigate the implications and use of risk assessment and risk management in legislatively mandated programs for preventing cancer and other chronic human health problems potentially stemming from exposure to hazardous substances. The goal was to make the process more participatory. This resulted in the creation of a single framework for environmental health risk management, in which the Commission defined the principles for ensuring proactive decision-making on public policies that would: (i) include active participation

by all stakeholders in society; (ii) provide guidance for conducting research and characterizing, assessing, and reducing risks; and (iii) allow for the inclusion of emerging risks (35).

During the same period, McColl *et al.* stated that like all decision-making processes, risk management has its strengths and weaknesses. Its main strength lies in the scientific rigor with which uniform, logical methods are used for reaching decisions about highly complex technical problems, and its main weakness, in the rigid application of a series of steps governed by formal decision-making standards that exclude consideration of more human aspects beyond the scope of predetermined scientific criteria. Similarly, the complicated scientific jargon in the management reports used for decision-making makes it hard to disseminate information to the public and ensure that the information is understood, turning the process into a technocratic exercise that may be out of touch with social realities, impeding effective communication. In addressing these issues, the Canadian Network for Environmental Risk Assessment and Management, in which multiple social stakeholders participate, has a procedure in place to “define a rational level of tolerable or acceptable risk for an environmental hazard—by considering the severity and probability of harmful health effects, the amount of environmental exposure experienced by human populations, the sources and means of control for the contaminant, and the expected costs and benefits of various risk reduction strategies (36).”

In providing a rational scientific framework, risk management acquires a scope that transcends national boundaries, creating an impact at both the regional and global levels. The process is constantly under the microscope, since it is subjected to scientific, political, and public scrutiny. Moreover, because scientific management methods are becoming ever more complex and analytical techniques generate increasing amounts of information, more complex questions emerge, raising such issues as multiple exposures, multiple effects, and the susceptibility of different populations. The process has also expanded to include life cycle analysis and other aspects of costs, benefits, and compensation for risks. As a result, the assessment process has become very expensive and cumbersome.

In the past, public policies to control the importation, manufacture, use, application, and disposal of chemicals may have been timid or permissive, because knowledge about the above-mentioned risks and effects, as well as the necessary political will, were lacking. The Finkelman report (37), which assessed the situation of eight Latin American countries in 1985, verified existing data on the improper handling of chemicals, with consequences that included multiple accidents with serious consequences, the massive accumulation of chemicals, and damage to public health and the environment. This situation compromised both national development and public health. Chemical safety was in jeopardy, because there was little knowledge about the extent and nature of the uses, manufacture, and handling of chemicals. Progress was hindered largely by the absence of political will to create national control programs, the lack of intersectoral policy coordination, and the extent of the problems, which were unsolvable, given the limited capacities of the respective authorities and the health authorities' lack of leadership in public health. Further aggravating the situation was the fact that access to technical information was limited, and toxicology research, like chemical and toxicology laboratories, was scarce, unreliable, and still in its infancy.

Little by little, the chemical safety situation has been changing. Positive trends have been observed, though the main accomplishment in the past 30 years has been bringing problems that were once ignored to the forefront. For example, accidental contamination of food and drinking water with pesticides, due to poor handling, storage, transportation, and application practices, has created a higher per capita risk of exposure, since a larger proportion of Latin America's population lives in rural agricultural areas (38).

In recent years, WHO has deployed an array of activities to assess the health effects of chemicals as essential to the planning and execution of national environmental health programs.

### **General policies on the availability and dissemination of information about PTCs**

In order to secure the greatest possible benefits from advances in chemistry, toxicology, and technology and to shape public policy for the *safe or restricted use of chemicals* or the eradication (total banning) of the most hazardous ones, all users and stakeholders involved in chemical risk management programs must have sufficient coherent, accurate, and accessible information at their disposal. This requires national and international multidisciplinary efforts to jointly fill the large information and knowledge gaps concerning the adverse effects of the numerous chemicals to which people are exposed in everyday settings.

The absence of scientific information can be remedied by access to a multiplicity of websites and online sources that include databases, e-books, virtual libraries (both public and private), and scientific information centers open to the members of the academic, scientific, government, and international communities. These resources are accessible thanks to the development of communication technologies and the interest and support of many influential

international organizations in the field of toxicology, such as the International Union of Toxicology (IUTOX), the International Union of Basic and Clinical Pharmacology (IUPHAR), the United Nations Educational, Scientific, and Cultural Organization (UNESCO), WHO, the United Nations, and the International Program on Chemical Safety (IPCS).

Information dissemination is fundamental to making the *right to know* a reality for workers and the general public. Projects and activities are under way in the Region to disseminate information and raise awareness about the dangers of chemical risks to the general population through various didactic models that illustrate and explain toxic chemical interactions in everyday life. One example that deserves mention because it is available online in both English and Spanish is TOXTOWN (39). TOXTOWN was created by the U.S. National Library of Medicine for Spanish- and English-speaking users. It illustrates over 60 situations that can occur in everyday life in cities, rural areas, small towns, ports, and along borders, describing the dangers posed by chemical substances in residential settings, workplaces, and entertainment venues. It explains both the dangers to human health and the probable environmental impacts. The uninterrupted access it provides makes it a tool that the public can use to keep informed and adopt responsible attitudes toward chemical risks.

Another function of information dissemination is to facilitate the indispensable process of knowledge sharing between the general population and the technical advisers of decision makers. Here, technology makes use of other didactic and information models, such as the design and use of diagnostic matrixes of indicators obtained through networks of observatories such as Colombia's Network of Urban Environmental Observatories (OAU) (40). This network was conceived as an interinstitutional initiative to develop an instrument that would provide coherent systematic information on environmental quality in Colombia's major cities through urban environmental indicators accessible online to decision makers and the general public.

In this same vein, in order to meet the needs of chemical risk management, ministries of health, environment, agriculture, and similar institutions in the countries of the Region should develop and annually update the list of chemical agents approved, restricted, or banned in their respective territories. Elsewhere in the world, many industrialized nations have created systems for registering and inventorying chemicals, in some cases including a breakdown of their distribution by industrial sector.

In North America, Pollutant Release and Transfer Registers (PRTRs) are one source of information on the quantity of substances released into the environment. Environmental authorities have created programs such as the National Pollution Release Inventory (NPRI, Environment Canada)(41) in Canada, and the National Emissions Inventory in the United States EPA, 2009 (42). Mexico is currently putting together its own mandatory PRTR (43), which existed in a voluntary form until 2005. In Canada and the United States, industrial facilities that meet certain criteria must register the amount of each chemical substance that they release annually into the air, soil, or water or inject into the subsoil. They must also register the amount of each chemical transferred off-site for disposal, treatment, or recycling. The regulatory agencies in each government collect these data year after year and compile them in annual reports and databases that are available to citizens online (NAFTA-TLC, 2009) (44). In Mexico, the latest amendments to the *Federal Law for the Prevention and Integral Management of Wastes*, in effect since 2003, were made in June 2007; pursuant to the amended law, the country is now nearing the creation of its own PRTR (45).

A wide range of situations can be found in LAC. Some countries, such as Chile, with its Pollutant Emissions and Transfers Register (CONAMA, 2009) (46), have already made progress in creating their registers and inventories. Others, such as Costa Rica in Central America, and Trinidad and Tobago in the English-speaking Caribbean, have platforms that are poised for implementation. Nevertheless, many others, according to the Organization of American States (OAS), still lag behind in the process (47), a situation most likely due to limited resources and insufficient development of information technologies. The OAS, however, has been promoting, supporting, and urging these countries to begin designing PRTRs, strengthening their capacity to assess environmental impacts, and (preliminarily) uploading the data from the PRTRs to their national environmental information systems.

### **Chemical risk management policies in North America**

Within NAFTA, the Commission for Environmental Cooperation (CEC) (CEC, 2009) has created informative tools and general guidelines that have proven highly beneficial not only for North America, but the entire Region as well. To better understand the interaction between the environment and health, the CEC Steering Committee launched the Children's Health and the Environment in North America initiative in 2002, whose main purpose was to encourage cooperation and knowledge sharing among Canada, the United States, and Mexico and provide authorities with the information needed to adequately address environmental risks to children's health. This trina-

tional cooperation resulted in the publication of two very useful tools based on pollutant inventories up through a specified date. These tools provide predictive scientific analysis and can be expected to be adjusted as time goes by, thus fulfilling an indirect evaluative function. The two publications are: *Toxic Chemicals and Children's Health in North America* and *Children's Health and the Environment in North America: A First Report on Available Indicators and Measures* (48,49). These documents highlight the progress made and identify information gaps in terms of linkages between health and the environment (50). Although the issue of children's health and the environment was subsequently dropped as a priority, the results in this area are worth mentioning as an example for further action in the future.

The indicators directly related to toxicology work are described below, along with the particularities and findings associated with each.

### ***Industrial lead emissions***

In this section, PRTR data serve as an indicator for action and show trends in emissions of pollutants into the environment, including on-site emissions into air, water, and soil, as well as underground injection into wells and transfers to other locations. Information on children's exposure is not available, but the data gathered do indicate where steps have been taken to reduce or prevent the release of lead into the environment. The PRTR data cover industrial facilities subject to similar requirements in Canada and the United States. Canada showed an overall 46% reduction in on-site and off-site emissions of lead and lead compounds from manufacturing facilities between 1995 and 2000 (from 4,124 tons to 2,220 tons). Off-site transfers (primarily to sanitary landfills) accounted for the greatest proportion of releases, as well as for the largest proportion of reductions in the period in question.

Since Mexico's Pollutant Release and Transfer Register (PRTR) is not yet fully operational (51), the country does not have data for this indicator. The United States registered a 9% increase in lead and lead compound emissions from industrial facilities between 1995 and 2000 (from 19,392 tons to 21,211 tons). The largest reductions in lead emissions during the period were in the area of on-site air and soil emissions, while the greatest unit increase was associated with off-site releases (mostly involving transfers to sanitary landfills). The data from Mexico are primarily from coordinated research groups at public institutions (52-60); these data, at least in the case of lead, have been very useful for translating research findings into public policies and regulations.

In this connection, Mexico's efforts and experience over the past 25 years should be noted. Mexico has significantly reduced maternal and child lead levels, especially in the capital city (Cortez-Lugo *et al.*, 2003; Romieu *et al.*, 1996). These initiatives have had a major impact in terms of amending regulations and were part of a concerted effort by researchers, politicians, and industry that resulted in the publication of an environmental regulation on lead (61), including an occupational standard. Nevertheless, the problem of sites with lead contamination persists (58, 62), as do occupational and environmental exposures from ceramic glazing and para-occupational and occupational exposures in small enterprises. Notable in the rest of Latin America are the findings of a study by Romieu *et al.* (1996), which indicated that although 72% of Latin America's countries considered chronic exposure to lead an important occupational safety issue, only 50% had some type of legislation in this regard. The authors of the article suggest that there is an "urgent need" to encourage action for better prevention of workplace and environmental exposure to this substance in most of Latin America.

### ***Industrial emissions of certain toxic chemicals***

Under the requirements of the Canadian and U.S. PRTRs, 153 chemicals were reported on during the period 1998-2002. To monitor progress in reducing and preventing industrial emissions of these substances, the data from the PRTRs show the trends in on-site emissions into air, water, and soil, and underground injections, as well as off-site emissions (mostly disposal in sanitary landfills).

In Canada, on-site and off-site emissions of the 153 chemicals fell by 11% between 1998 and 2002 (from 154,000 tons to 137,000 tons), while the number of industrial plants submitting records during the period fell by 41%. The emissions reduction was achieved in part by a 33% reduction in the basic metals sector and a 36% reduction in the industrial chemicals sector. The sources of the data on industrial facilities are the National Pollutant Release Inventory (NPRI) in Canada and the Toxic Release Inventory (TRI) in the United States; the database includes certain chemicals that are released into the air, water, or soil, or are transferred off-site for subsequent treatment. Data on substances and industrial sectors are included only in cases where the Canadian and U.S. systems are comparable.

Data on Mexico are not available, but records and estimates from the *maquiladora* industry, for example, provide a general idea of the volumes involved (63).

The U.S. Centers for Disease Control and Prevention (CDC), in Atlanta, publish annual reports based on these same registers, combining them with periodic biological monitoring of the population. The CDC analyzes the common chemical substances and sectors registered both by the U.S. TRI and the Canadian NPRI for the following categories: known carcinogens, substances known or presumed to be toxic to development, and presumed neurotoxins. A single chemical substance may belong to more than one of these categories. Each year, certain industrial plants must inform these registers of the quantity of PRTR-listed substances they release to the air, soil, or water or inject into the subsoil in North America. For the purposes of the report, emissions are measured in metric tons (“tons”) or kilograms (“kg”). Total releases and transfers of these chemicals registered in 2002 in Canada and the United States and entered by category in their respective databases came to almost half a million tons of carcinogens and a similar quantity of substances recognized by the PRTR lists as toxic to development and reproduction, two and a quarter million tons of substances “presumed” to be toxic to development and reproduction, and over two and a half tons of “presumed” neurotoxins. The chemical substances from two sectors—basic metals and chemicals manufacturing – are responsible for a high percentage of total emissions. Other sectors, such as rubber and plastics manufacturing, are also major sources of emissions of these substances, as are paper and vehicle manufacturers. The three jurisdictions in North America that were the largest emitters of carcinogens on the two lists in 2002 were the U.S. states of Texas, Ohio, and Indiana, and the largest emitters of substances toxic to development and reproduction, Tennessee (United States), Ontario (Canada), and Texas.

It is encouraging that emissions of known carcinogens fell by 26% between 1998 and 2002. A similar trend was seen in emissions of substances toxic to development and reproduction, which fell by 29% in the United States and Canada during the same period (CDC, 2005). Although the PRTR data offer an important perspective on the vast quantities of chemicals that enter the environment each year, they tend to underestimate the real amounts, since the registers collect information only on some of the chemicals emitted by large industrial plants. Moreover, they exclude mobile and agricultural sources (for substances like pesticides), small sources, consumer goods, and natural sources.

Moreover, while the PRTR data provide information on chemical substances emitted or transferred, they do not provide direct data on human exposure. Thus, the levels of human exposure to most of the chemicals registered are not known. Since the health risks posed by those substances depend on quantity or dose of exposure, as well as toxicity, it is impossible, based solely on the PRTR data, to draw conclusions as to whether the emissions pose health risks to children or adults. In addition, toxicity involves a complex process with respect to “windows of vulnerability,” depending largely on factors such as the nature of the toxic effect, the potency of the substance, and the time at which exposure occurs. Despite these limitations, PRTR data are a valuable tool for devising a roadmap for providing protection, especially for children and other vulnerable populations.

Complementary to this, the National Report on Human Exposure to Environmental Chemicals (64) provides an ongoing assessment of the exposure of the U.S. population to environmental chemicals, using the biological monitoring method known as “biomonitoring.” This technique directly analyzes human exposure to chemicals by measuring either the chemicals themselves or the substances into which they decompose (metabolites) in samples of human bodily fluids such as blood, urine, and exhaled air. The CDC published the First National Report on Human Exposure to Environmental Chemicals in March 2001. The document presented the findings from an analysis of 27 environmental chemicals. The analysis used samples obtained from the 1999 National Health and Nutrition Examination Survey (NHANES) (65). The second report, released in January 2003, has data that were collected from biomonitoring exposure to 116 environmental chemicals (including the 27 covered in the first report) in the civilian population in the United States (excluding institutionalized individuals) during the years 1999-2000. The third report has information on 148 chemicals and is the most complete analysis so far of the U.S. population’s exposure to environmental chemicals. The laboratory at the CDC’s National Center for Environmental Health was in charge of all of the chemical analyses (CDC, 2005).

The CDC uses the NHANES survey to gather information on the health and nutritional status of the U.S. population. The information is obtained through interviews, medical examinations, and laboratory analyses. For the third report, the CDC measured the concentration of 148 chemicals in the survey’s respondents. The chemicals are divided into the following categories: metals, cotinine, polycyclic aromatic hydrocarbons, dioxins, furans and polychlorinated biphenyls, phthalates, phytoestrogens, organochlorine pesticides, organophosphorus pesticides, herbicides, pyrethroid insecticides, other pesticides, and carbamate insecticides.

Among the important information from the data is the ongoing *reduction of lead concentrations* in children's blood. The new data on lead concentrations in the blood of children aged 1 to 5 make it possible to calculate the number of children who have elevated concentrations of this metal (values equal to or greater than 10 micrograms [ $\mu\text{g}$ ] of lead per deciliter [dl] of blood). Between 1999 and 2002, 1.6% of children aged 1-5 had elevated blood lead concentrations, down from the 4.4% level recorded in the early 1990s. Thus, the data show that public health efforts to reduce the number of children in the general population with elevated lead concentrations are yielding positive results. However, another dataset indicates that certain populations of children at high risk for lead exposure (for example, children living in houses painted with lead-based paint, or where there is lead-contaminated dust) have elevated concentrations of lead in their blood, and this remains an important public health concern. Since no concentration of lead in the blood has been identified as safe, the emphasis should be on efforts to control or eliminate lead from the environment before children are exposed to it.

### ***Exposure to environmental tobacco smoke***

The effects of smoking have been widely studied and demonstrated. Life expectancy is shortened by 5 to 8 years in the absence of disease, and by 18 to 22 years if disease is present. A range of adverse effects are associated with tobacco addiction in active smokers: chronic obstructive pulmonary disease, heart attack, ischemic coronary pathology, aortic aneurism, lung cancer, sudden death, etc. However, smoking not only harms smokers but also the people around them, known as "passive smokers." Nonsmokers who are exposed to tobacco smoke exhibit higher morbidity and mortality from cardiovascular disease than the general population, shown even through studies with biomarkers such as cotinine. In addition, passive smokers are at increased risk of lung cancer, paranasal sinus cancer, and breast cancer. Children exposed to tobacco smoke have an increased incidence of acute and chronic respiratory symptoms, lower respiratory tract infections, otitis media, and sudden infant death syndrome. Tobacco smoke in the environment both causes and exacerbates bronchial asthma in children and adults. As for reproductive health, exposure to tobacco smoke can lead to early menopause and menstrual disorders. Newborns of mothers who are passive smokers are more likely to be underweight or small for their gestational age (66).

There are methods for monitoring the nicotine metabolites in the body. Cotinine is a nicotine metabolite whose concentration in the blood makes it possible to trace exposure to environmental tobacco smoke in people who do not smoke. Between 1988-1991 and 1999-2002, the median cotinine values in nonsmokers fell by 68% in children, 69% in adolescents, and approximately 75% in adults. Non-Hispanic African-Americans had concentrations twice as high as those of Mexican-Americans and non-Hispanic whites. Cotinine concentrations in children were more than double the concentrations in adults. Despite efforts to reduce exposure to environmental tobacco smoke in the general population, which have resulted in significant progress, exposure remains an important public health concern (67).

### ***Cadmium exposure***

Breathing large quantities of cadmium (Cd) can significantly affect lung function. Ingesting food or water with a high concentration of this metal seriously irritates the stomach and causes vomiting and diarrhea. Prolonged exposure to lower concentrations of Cd in the air, food, or water leads to its accumulation in the kidneys and may cause renal disease. Prolonged exposure also results in brittle bones.

Recent research has shown that a urinary Cd concentration of just 1  $\mu\text{g}$  per gram of creatinine may be associated with mild renal lesions (which may not be evident) and a greater risk of low bone density. The third report (CDC, 2005) indicates that 5% of the U.S. population aged 20 and older has a urinary Cd concentration equal or close to these values. Tobacco use is one of the most likely causes of Cd exposure.

These findings on Cd merit continuous monitoring and should stimulate further research on the public health effects of Cd exposure in this age group.

### ***Encouraging findings regarding exposure to organochlorine pesticides: aldrin, endrin, and dieldrin***

These three similar pesticides used to be widely used in agriculture, especially in cotton and corn production. Agricultural use of aldrin and dieldrin ended in the United States in 1970, and termite control with these chemi-

cals, in 1987. The manufacture and use of endrin was discontinued in 1986. These pesticides are still used in other countries, however. The findings of the third report (CDC, 2005) indicate no detectable, or very low, blood concentrations of each of these organochlorine pesticides.

#### ***Improved data on human exposure to dioxins and some related compounds***

This same report has data on 29 dioxins, furans, and polychlorinated biphenyls similar to dioxin, which can be detected today at levels lower than was once possible. The report presents the findings related to three of these chemicals for the first time.

This new information will significantly improve current evaluations to determine health risks from exposure to this family of chemicals in the U.S. population and, by analogy, in other countries in the Region.

#### ***Mercury exposure in women of reproductive age (16-49 years)***

Most of the mercury in the blood comes from the consumption of fish and seafood, which accumulate methylmercury from the water and soil. It is important to monitor exposure to mercury in women of reproductive age because of the adverse effects of blood mercury concentrations from food sources on fetal neurological development. The data in the third report (CDC, 2005), covering 1999-2002, indicated that all women of reproductive age had a concentration of below 58 µg/L, the threshold associated with harmful effects on fetal neurodevelopment.

However, the concentration of mercury in these women still merits more rigorous monitoring, since 5.7% of women of reproductive age had concentrations 10 times higher than the levels associated with effects on neurodevelopment. Determining what, if any, concentration of mercury is *not* associated with adverse effects remains an active area of research.

According to the EPA, coal-fired power plants are the principal source of mercury air emissions in the United States (68).

#### ***Better biomarkers of phthalate exposure***

Phthalates are plasticizers, the name given to a group of chemicals that soften plastics and vinyl and increase their flexibility and elasticity. Phthalate exposure is widespread. Recently identified markers provide a better indication of exposure. Although not mentioned in the third report (CDC, 2005), research in this area has advanced rapidly, and there are already research groups with standardized laboratory techniques and reliable data on the relationship between these substances and the reproductive health of male children (69-71) In general, biological monitoring of phthalates measures the substances' metabolites, whether primary or secondary, in urine. For example, to determine the concentration of DEHP (diethylhexyl phthalate), mono-(2-ethylhexyl)-phthalate, mono-(5-carboxy-2-ethyl-pentyl)-phthalate, and 2-ethylhexanoic acid (2-EHA) are used. Exposure to DINP (diisononyl phthalate) and DIDP (diisodecyl phthalate), which are widely used as plasticizers in the manufacture of polymers and consumer goods, is also monitored by measuring their metabolites in urine (72).

#### ***New measurements of some widely used pyrethroid insecticides***

Pyrethroids are the synthetic insecticides most widely used in households today. The third report (CDC, 2005) contains information on initial exposure to five frequently used pyrethroid insecticides. The findings point to widespread exposure to these substances, with tests in much of the U.S. population detecting 3-phenoxybenzoic acid, which is a metabolite common to several of these insecticides. According to the report, very limited scientific information is currently available on the potential effects of pyrethroid insecticides on human health at the concentrations found in the U.S. population.

#### ***Specific risk management policies in Latin America and the Caribbean (LAC)***

In the past few decades, the LAC countries have been obliged to make decisions, formulate policies, draft and publish regulations, and design programs for the control of toxic substances to comply with the mandates and trends in international policy. Progress, however, has been spotty and limited, because, despite the development of

policies, standards, and regulations, compliance has rarely been monitored or enforced, or else, it has only been partial and insufficient. That is why it has been hard to find comprehensive government initiatives similar to those of North America under free trade agreements in LAC. In fact, the North American influence is pervasive and serves as the basis for most of the regulations found in LAC countries. There is a common misconception, however, that, in risk management methodology, the countries of the North produce all the dose/response assessments, while those of the South only assess exposure and describe risks. It has been shown that research groups in Latin America, such as those of Brazil, Mexico, Argentina, and Colombia, are increasingly producing important high-quality toxicology and epidemiology studies (73-75), though admittedly, these contributions are not numerous. This imbalance is due to the fact that in LAC, the academic culture does not compel researchers to publish, whereas in North America, from the very start of their training, researchers are immersed in a culture of “publish or perish.”

For these reasons, SIACM is a breath of fresh air, spurring the preparation of national profiles and sparking optimism that these constraints can be overcome and effective chemicals management achieved. The LAC countries receive support and assistance from international governmental agencies, as well as useful recommendations, to further these efforts; at the regional level, these agencies include the institutions of the Inter-American system, with the OAS and its bodies for consensus building and democratic governance, and the Pan American Health Organization (PAHO). Many global institutions of the United Nations system, such as the ILO and WHO, have also contributed to the implementation projects and programs that are laying the foundations for chemical safety policies and solutions to the problems caused by the presence of PTCSs. Some findings on the problems created by certain toxic substances are reviewed below.

### *Pesticides*

With regard to the mass use of pesticides and their control, countries have been developing their own policies and standards, mostly through health codes formulated in the late 20th century, whose enforcement has generally been limited (Rodríguez *et al.*, 2002). For example, Colombia established its general public health policy in 1979 through the adoption of its National Health Code (Law 9, 1979), which included the general policy on PTCS management. This and other health and environment legislation passed in the 1990s served as the legal underpinnings for the technical standards and regulations issued on the use and management of pesticides, their toxicological classification, their environmental management, and epidemiological surveillance, as well as the banning of certain pesticides. Eventually, the National Pesticides Council was created (76), bringing all relevant stakeholders together.

Given the many common problems in border areas, in the 1990s the Andean Community of Nations (CAN), intent on harmonizing regulations, held discussions on this issue, using the above-mentioned regulations as the starting point. This led to an agreement to draft subregional policies, whereafter CAN approved and issued Decision 436, the “Andean regulation for the registry and control of chemical pesticides for agricultural use,” drawing on the laws and procedures implemented in Colombia. Decision 436 established harmonized requirements and procedures for the registry and control of chemical pesticides used in agriculture; it also issued guidelines for their proper use and management under authorized conditions to prevent and minimize harm to health and the environment, while facilitating their marketing in the subregion (77). This led to harmonization of the regulations governing the registry and control of chemical pesticides used in agriculture in CAN, consistent with the agronomic, health, social, economic, and environmental conditions of the member countries, the principles in the FAO’s International Code of Conduct on the Distribution and Use of Pesticides, and any guidelines issued by the competent international organizations on which the member countries agree. With regard to pesticide use, the countries are compiling inventories, based on these international guidelines. The problem of stored obsolete pesticides is a global issue not limited to the African and Latin American countries.

One initiative notable for its scope, impact, and results, as well as for its exemplification of multilateral international cooperation, is the Project on Occupational and Environmental Aspects of Exposure to Pesticides in the Central American Isthmus (78). This project developed successful programs to raise awareness about the pesticide problem and its control, in the context of a near tripling of pesticide importation and use between 1992 and 2001 in the Central American isthmus—an area considered one of the world’s highest per capita consumers of pesticides. It was estimated that at least 1.4 million agricultural workers in this subregion were exposed to pesticides and that the number of poisonings was much higher than in other countries in the Region of the Americas. For this reason, PAHO’s Environment and Health Division, in collaboration with the Danish International Development Agency (DANIDA), launched the PLAGSALUD project to deal with this public health problem and its resulting case-fatality and mortality rates and find mechanisms to control toxic substances. The project was rolled out in several

phases and produced major achievements in the countries where it was implemented. These include the diagnosis, management, and reporting of acute pesticide poisoning cases; the creation of epidemiological surveillance systems for acute pesticide poisoning; and the strengthening of standards and regulations on the importation, use, and controlled management of pesticides. The project strategy included education strategies and the publication of training manuals. The process also led to the emergence of other similar projects, such as PLAGBOL in Bolivia, where, with assistance from Danish cooperation since 2008, similar activities to eliminate pesticide exposure have been under way (79).

A further example is the Multilateral Fund for the Implementation of the Montreal Protocol, which has been providing economic aid to address pesticide problems in the developing countries. The Fund focuses on efforts to eliminate methyl bromide (one of the chemicals responsible for depletion of the ozone layer) as an agricultural fumigant, also used to ripen fruit harvested before its time (Buccini and Cortinas, 2004).

### **Lead**

Since lead comes from various sources, multiple initiatives have been undertaken to control it. According to the Plan of Action of the First Summit of the Americas held in Miami in 1994, the governments pledged to “develop and implement national action plans to phase out lead in gasoline.” The organizations that participated in the resulting programs were the World Bank, the Organization of American States (OAS), the Pan American Sanitary Bureau (PASB), the Inter-American Development Bank (IDB), the Latin American Energy Organization (OLADE), the U.S. Environmental Protection Agency (EPA), the U.S. Agency for International Development (USAID), the U.S. Department of Energy (USDOE), and the Puerto Rican Regulation and Permits Administration (ARPE).

Worth noting in this connection is the workshop held in Mexico in 1995, which brought experts and researchers together to examine the problem, its origins, consequences, and magnitude and to prepare a regional strategy to control lead in the Americas (80). While many objectives were put forward to address the problem, particularly with regard to the ingestion and inhalation of lead in occupational settings and the general environment, it is unknown whether its results have been monitored at the regional level, though, as mentioned above, its impact has been significant. The United Nations Environment Programme (UNEP) is known to have urged governments to eliminate lead from gasoline, and the majority have done so. The Stockholm Convention’s identification of vehicle emissions, especially from vehicles using leaded gasoline, as possible significant sources of dioxins and furans, is what drove the ban on leaded gas. The result has been a significant reduction of lead in the Region, although in some parts of certain countries this ban is not yet in place. In line with SAICM priorities, multisectoral campaigns have recently been launched to eliminate lead in paint and control artisanal recycling of batteries. Thus, governments and other stakeholders in a position to help eliminate these practices are still being encouraged to do so.

### **Mercury**

Mercury (Hg) is another important toxic substance with major impacts in the Region. The health consequences of exposure to inorganic (e.g., elemental) and organic Hg for humans and the environment are well known. In certain countries, such as Brazil, Venezuela, Ecuador, and Colombia, industrial and artisanal or informal gold mining operations use large quantities of metallic Hg for gold amalgamation (81). There are many other uses for mercury as well. The substance is present in measuring instruments (thermometers, barometers, etc.) still used in some of the Region’s hospitals, as well as in batteries, catalytic converters (in chlor-alkali production), and electrical devices.

Hg emissions from gold mining are a public health hazard for people living in the Amazon ecosystem, which includes parts of Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname, and Venezuela. Mercury exposure can occur from workplace activities (metallic Hg) or the environment (methylmercury) (82). Gold occurs as a solid, and metallic Hg is used to form the mercury-gold amalgam used for extraction. This method generates air emissions of the metal when the amalgam is burned in mining areas. In Brazil, indoor pollution has been found from the burning of the amalgam inside dwellings (83). Some aquatic microorganisms can convert elemental Hg into methylmercury in river sediments, and this form is more toxic than the inorganic form. Methylmercury is captured by plankton and algae and concentrated in fish through the food chain, where it is ultimately present in much higher concentrations than originally found in the environment (84).

In 2002, UNEP published the *Global Mercury Assessment* (85). This report showed that mercury concentrations in the environment had increased significantly since the dawn of the industrial age due to releases resulting

from human activities, seen in exposures throughout the world. In 2003, UNEP's regulatory body concluded that mercury pollution was a global problem that needed to be addressed through national, regional, and international action, both immediate and long-term, to protect human health and the environment. UNEP efforts have focused on the facilitation and delivery of technical assistance and on activities to boost national capacity and aid country efforts to address mercury pollution (particularly in developing and transitioning countries). UNEP launched a program to increase countries' understanding of the problem, determine its magnitude, and develop tools and strategies to address it. To this end, it held a series of regional and subregional workshops in 2004 designed to: (i) increase awareness; (ii) promote Hg-free products, technologies, and processes; and (iii) develop strategies to broaden the scope of risk communication targeting exposed populations (7).

Increasing awareness and discussion of the mercury problem has led to the elimination of medical instruments containing Hg in many member countries of the Health Care Without Harm Network. At the same time, organizations such as the American Nurses Association are also working toward this goal, with excellent results ([www.icn.ch](http://www.icn.ch)). On 4 August 2006, the First Latin American Conference on the Elimination of Mercury in Health Care reached agreement on its Declaration of Buenos Aires, sponsored by Health Care Without Harm in partnership with UNEP (86). This marked the official start of the Health Care Without Harm campaign in Latin America. The Canadian government had already signed on to the campaign, which existed as an institutional initiative in the United States as well. The object of the campaign is to reduce mercury use in the health sector to a minimum, since the sector is responsible for releasing mercury as waste into water and soil, and in some countries accounts for up to one-third of the mercury used. The campaign also promotes the elimination of other toxic substances used in the health sector, such as phthalates, and encourages the replacement of incineration with other practices to reduce the release of dioxins and furans. As a result, a coalition of over 440 groups in 53 countries was formed to secure *health care without harm* for workers through the Health Care Without Harm Network (71,87).

According to the latest United Nations report (88), 1,960 tons of mercury were released into the atmosphere in 2010, ultimately ending up in the water. However, while estimates are more accurate than they were in 2005, they are still subject to uncertainty, and the actual amount is believed to be somewhere between 1,010 and 4,070 tons. This mercury comes from three sources. Anthropogenic sources account for 30%. This includes new sources that have not been accurately measured, such as the production of vinyl chloride monomers, the secondary production of ferrous metals and alloys, and oil and gas extraction and transport. Another 10% comes from natural geological sources, while the remaining 60% is from the recycling of objects containing mercury that have been stored for many years, the majority of which are from human sources. The inventory shows that artisanal small-scale mining and coal burning are the largest component (35%) of the anthropogenic segment, followed by ferrous and nonferrous metals and cement production. The mercury released from small-scale artisanal mining is twice what was estimated to have been released in 2005, a situation exacerbated by the fact that many of these activities are illegal or unregulated. While Southeast Asia is thought to account for nearly half of these emissions, there have been similar increases in South America and Africa.

Mercury monitoring is incomplete at this point, limited to the North American Mercury Deposition Network (MDN), and has only recently come to include a number of other locations designated by the Global Mercury Observation System (GMOS). It is difficult to assess the impact of measures to reduce air and aquatic emissions. Assessment takes time, and the thousands of tons of mercury deposited in the deepest layers of the oceans can only be quantified by measuring concentrations in the fish and mammals that are part of the food chain consumed by humans. Climate change also complicates matters because of its profound effects on how mercury moves and is chemically transformed in the environment. Thus, the objective should be to continue measures to reduce emissions while conducting surveillance and monitoring using sentinel surveillance points to prevent the adverse effects of this metal.

Surveillance and monitoring should be maintained for several generations. Ongoing research and the development of toxicology techniques for mercury surveillance that are simple, economical, accessible, and noninvasive are part of this challenge. This was addressed by the Minamata Convention, concluded in Geneva in January 2013 (89). The Convention was adopted by 139 countries and signed in Japan by 92 countries in October 2013 (89). The Minamata Convention establishes controls, sets reduction targets for a large number of industrial products and processes that use mercury, and regulates the mining, exportation and importation, as well as storage and disposal of the metal. In 2014, at the 67th World Health Assembly in Geneva, agreement was reached on eliminating mercury from the health sector by 2021 (90).

## **Waste**

At the global level, the Basel Convention addresses international trade in, and the control of, waste (including chemical waste) (Buccini and Cortinas, 2004). Implementation of the convention is based on the following principles: (i) reducing or minimizing the generation of waste and treating or eliminating it near the source of its generation; (ii) reducing transboundary flows of hazardous waste; and (iii) providing assistance for these activities to developing and economically transitioning countries. However, efforts to fully adhere to these principles have fallen short. A 2002 World Bank report (91) determined that, though the cases and effects of exposure to toxic substances in developing countries were widely dispersed and had not been systematically studied, there was a close link between poverty, exposure to toxic substances, and development level, since, due to a variety of factors, poor populations are more vulnerable and exposed to PTCSs than the general population. The report made particular reference to living conditions and the immediate environment, since many poor people burn fossil fuels in enclosed spaces or live on the edge of, or within, industrial areas or sanitary landfills, where water sources are polluted and open-air burning of waste occurs in dumps and other sites. This type of habitat, combined with malnutrition, social exclusion, lack of awareness of the potential hazards of chemical substances, the abuse of agricultural chemicals, and child labor, perpetuates the harmful effects of waste on vulnerable populations.

The World Bank report also recognizes that the main priorities for aid in many developing countries are basic necessities (food, water, shelter, medical care, poverty reduction, etc.), and that the problems associated with chemicals have not been on the countries' lists of priorities for bilateral and multilateral development aid. The report considered it probable that poor people, particularly children, were more likely to have been exposed to high concentrations of chemicals and contaminants than their more privileged counterparts (Buccini and Cortinas, 2004).

It is also probable that rapid urbanization and growing rural-urban migration in the LAC countries increase the likelihood that poor people in both urban and rural areas will be exposed to toxic substances. The report also reveals that the percentage of the global human disease burden is higher in the countries and regions where the majority of the world's poor people live and that some of these places bear a double burden: the persistence of age-old scourges such as diarrhea and malaria, coupled with modern illnesses caused by pollution from pesticides, waste, industrial discharges, etc. (Buccini and Cortinas, 2004).

National and international policies for integral management of anthropogenic waste have been created as part of chemical risk management efforts, so as to minimize the impact on health and the environment. The results of these efforts in the Region have been limited, though many countries have developed and implemented plans in this regard, particularly in major urban areas. Such plans classify waste components by origin (municipal, commercial, industrial, domestic), with measurements expressed in volumes as a percentage of the total. Waste is also categorized by moisture and content to determine whether it can be recycled, treated, or sent for final disposal. Effective local waste management requires ascertaining per capita waste production by the population in a given area and creating mechanisms for its treatment and elimination, while at the same time fostering a civic culture that encourages practices that foster sustainable development (92). Local culture is probably the main obstacle to achieving the goal, since fostering changes in individual and societal behaviors in relation to waste can be slow and cumbersome and may take a generation.

### **Experiences with comprehensive regional approaches and initiatives**

#### ***The Health, Work, and Environment Program in Central America (SALTRA)***

This program is the product of lengthy collaboration in occupational health involving institutions from Sweden (National Institute for Working Life, NIWL) and Central America: the Center for Research on Health, Work, and Environment (CISTA) at the Universidad Autónoma de Nicaragua-León (UNAN-León), and the Regional Institute for Research on Toxic Substances at the National University of Costa Rica (IRET-UNA). SALTRA is an interuniversity, interinstitutional, and intergovernmental research, training, and development program, whose long-term objective is to promote occupational health in Central America. It is designed to develop national and regional capacities to prevent occupational and environmental risks through a public health approach and aims to sustainably improve the quality and effectiveness of production in the countries of the Region.

Current projects and activities focus on a variety of fields. One such project is developing the capacity to monitor occupational risks and harm to health. Governments and social stakeholders consider this vital for deci-

sion-making on policies and programs for the prevention and management of chemical risks. The project is under way in seven Central American countries. It has achieved a consensus on occupational health and safety indicators; produced a guide on the indicators, along with a series of national reports (by Costa Rica, Honduras, Nicaragua, Panama, El Salvador, Guatemala, and Belize) on these issues; and disseminated the findings of these reports (93). All the member countries in the subregion have been raising the profile of problems associated with chemicals management.

The self-assessment conducted at the end of the project's first phase (3 years into the 12-year project) indicated only 60% compliance with the goals set for 2008. However, SALTRA has succeeded in creating the countries' occupational health and safety profiles, along with a series of databases on the use and importation of pesticides and other chemicals (93). Using these data, matrices of occupational exposure to many of these substances were constructed. Collecting, systematizing, and interpreting this information proved far more difficult than expected, due to the scarcity of reliable information and the scattered and divergent nature of the information sources. Lack of experience with intersectoral cooperation and with gathering and systematizing information also hindered the process, as did the limitations of the working group's report-writing skills.

However, despite the incomplete results and difficulties in executing the project, work to develop chemical risk profiles continues as the basis for policies aimed at preventing harm to health and the environment.

### ***Community of Practice in Ecosystem Approaches to Health-Toxics in Latin America and the Caribbean (CoPEH-TLAC)***

Special mention should be made of the CoPEH-TLAC effort, which, with the sponsorship of the International Development Research Centre (IDRC), has quickly achieved success in terms of regional impact, number of publications, and the creation of regional teams. Although first conceived in the late 1990s and expected to get off the ground in 2004, its activities actually began in 2006, generating a great deal of scientific literature in the Region. Published in major journals, these studies have offered many practical solutions that have been evaluated at the local level—something not seen in previous years. The initiative has wisely created local working groups, motivating them to engage in research for action.

“Communities of practice” are networks of individuals and organizations that share concerns and interests regarding specific issues. According to a common definition, a community of practice is a group of participants (a community) with mutual interests and practices (an approach) that agrees to tackle a specific problem and work toward goals and objectives related to a specific matter (shared practice). Communities of practice respond to professional demand and are oriented accordingly. They can also develop and improve knowledge and generate innovative ideas. The important functions of communities of practice include helping to extend bilateral communication channels (provider-partner) and horizontal modalities (partner-partner). This means that in both modalities there is a communication-partnership pattern. The gender perspective and community participation are pillars of research for action under the initiative.

CoPEH-TLAC (94) is the Community of Practice in Ecosystem Approaches to Health-Toxics in Latin America and the Caribbean. It is a collaboration between the University of Quebec in Montreal (Canada) and organizations and institutions in Latin America and the Caribbean. Its central coordinating committee consists of: the Centre for Interdisciplinary Research in Biology, Health, Society, and Environment at the University of Quebec, in Montreal (Canada) (CINBIOSE-UQAM); the Regional Institute for Research on Toxic Substances at the National University of Costa Rica (IRET-UNA); the National Public Health Institute of Mexico (INSP); the Health, Environment, and Development Foundation, in Ecuador (FUNSAD); the Center for Women's Studies, in Chile (CEM); the Center for Sustainable Development (CDS) at the University of Brasilia; and the Biophysics Institute at the Federal University of Rio de Janeiro (UFRJ).

CoPEH-TLAC's general objective is to promote research on human health with an ecosystems approach (concepts, methods, and tools), linking the research to local policies and interventions to reduce exposure to toxic substances. The community of practice has strengthened technical and cooperative relationships between researchers in Canada and the Central American and Caribbean subregion. In the midst of the shadows that we mentioned in the southern parts of the Region and some portions of Central America and the Caribbean, this initiative is a ray of light, having become an instrument for strengthening resources of every type in the environmental sciences connected with human health.

### *Private-sector initiatives for integral chemicals management*

In the past few decades, a series of initiatives and practices have emerged in the chemical industry and related sectors to advance comprehensive risk management. This section will offer some observations on developments in toxicology and chemical risk management. Although some policies have been adopted in response to tragedies caused by chemical accidents, growing attention to developing environmental protection policies, along with recognition of the social determinants of health, has led to the adoption of approaches with a greater social impact.

- 1- *Cleaner production (CP)* involves the ongoing use of a preventive, integrated environmental strategy in productive processes, products, and services to reduce the risks to people and the environment. In terms of *productive processes*, this means conserving raw materials and energy, eliminating toxic raw materials, and reducing the quantity and toxicity of all polluting emissions and waste. In the case of *products*, it means reducing the adverse impacts that accompany product life cycles, from extraction of the raw materials to final product disposal. In *services*, it means incorporating the environmental dimension into the design and delivery of services (*definition adapted from UNEP*). Although cleaner production depends on legal mechanisms in countries such as Chile, and on the discretion of companies in others, such as Colombia, many countries in the Region have engaged in successful individual and collective activities yielding significant results. In Chile, for example (95), under the leadership of the Ministry of Economy, a CP policy was adopted, a National Cleaner Production Council was created, and clean production agreements (CPAs) were promoted with business and throughout the productive apparatus. By 2005, 35 such agreements had been signed in 27 productive sectors, with 2,500 companies and 3,560 production units participating, most of them micro, small, and medium-sized enterprises. It was estimated that the sales of these companies accounted for approximately 10% of the country's gross domestic product (GDP) and over 20% of its exports.

Another success story is that of Colombia, which instituted its national CP policy in 1997. In this case, execution is overseen by Colombia's National Center for Cleaner Production and Environmental Technologies (95), a nonprofit public-private corporation, founded in March 1998 and governed by the private legal framework. The Center was the product of a joint cooperation effort by local, regional, and national public institutions, businesses, trade unions, associations, universities, environmental authorities, and the Swiss government, operating through the Federal Office of Foreign Trade (BAWI) and the Federal Laboratories for Materials Science and Technology (EMPA), with institutional support in Colombia from the Colombian-Swiss Chamber of Commerce. The National Center for Cleaner Production and Environmental Technologies is located in Medellín, Colombia, and has eight regional hubs. While its main objective is to promote improved economic and environmental performance in the country's productive sector, its further goal is to become, by 2020, Colombia's main reference center for knowledge and technology transfer in relation to eco-efficiency, cleaner production, and environmental technologies. It is currently implementing important educational, research, and training projects to encourage the use of CP in all enterprises in the country.

- 2- The Responsible Care (RC) initiative (Canadian Chemical Producers Association, 2009) (96), launched in 1985 by the Canadian Chemical Producers Association in response to the Bhopal disaster, is a uniform code of ethics for the safe, environmentally sound management of chemicals. By subscribing to the code, the chemical industry pledged to implement activities responsibly, accept external controls, and follow social, environmental, and economic sustainability guidelines. This is a global commitment, requiring responsible management of chemicals throughout their life cycles and a commitment to social responsibility, informed by the principles of vigilance over products and services to protect people and the environment in a responsible, respectful, and participatory manner. It calls for complying with, and even going beyond, existing legislation and standards, as a means of inspiring others to sign on to this initiative. The ethical principles of the initiative are set forth in six codes of practice that cover the life cycles of chemicals, addressing: (i) community awareness and emergency response; (ii) research and development; (iii) industrial production; (iv) transportation; (v) distribution; and (vi) hazardous waste management.

The report, published 20 years after the launch of the initiative (Environmental Data Services, 2005) (97), states that it was endorsed and licensed by 52 industrial associations around the world but that its efficacy, credibility, and transparency are still being debated and called into question. Chemical

mega-accidents were continuing to occur, leading to lawsuits and litigation to obtain compensation for victims and communities; at the same time, regulations governing the control of chemicals were imposed to supplement industry efforts to implement responsible practices, such as those that ensure the *right to know* and the mandated creation of chemicals inventories in the United States and Canada. It became necessary to distinguish between the management of companies that complied with RC provisions and those that did not, and to sanction (or at least attempt to sanction) those that did not. However, given the very limited compliance, the perception that the industry was a “necessary evil” persisted. To give RC new impetus and strengthen its positive aspects, a Responsible Care Global Charter (Canadian Chemical Producers Association, 2009) was issued in 2005 that emphasized the value of transparency and responsibility. Three case studies were also published, showing the positive results achieved by improving product and business management systems and, thereby, improving chemical risk management indicators. Nevertheless, public opinion hardened, and there were calls for monitoring chemical companies, since despite the good intentions of RC, many had not signed on to the initiative, and chemical accidents were continuing to occur. Thus, the specter of Bhopal continued to haunt the public consciousness.

- 3- The Corporate Social Responsibility (CSR) initiative (98) gained real momentum in the 1990s, owing to globalization, accelerating economic activity, growing ecological awareness, and the development of new technologies. CSR is defined as active voluntary contribution to social, economic, and environmental improvement on the part of businesses, generally with the object of boosting their competitiveness and image, as well as their value added. Businesses have been enhancing their management capacities in regulatory, operational, economic, social, and environmental matters. Emphasis has been on companies’ responsibility, which cannot be delegated to other parties, to make their productive processes and marketing consistent with the social objectives of promoting sustainable human development, including chemical risk management, and protecting human rights. According to CSR, management should be based on commitment to, participation in, and the construction of a culture of self-regulation. Since the publication of the *Tripartite Declaration of Principles Concerning Multinational Enterprises and Social Policy* in 2006 by the International Labour Organization (99), there has been a major emphasis on promoting CSR, construed as the actions that businesses take to ensure that their activities have positive social repercussions, observing principles and values consistent with this objective in their internal methods and processes, as well as in relation to other social actors. From this perspective, a company’s main ethical responsibility to its workers and the community is to serve society by providing useful products produced under fair conditions, creating wealth as efficiently as possible, and respecting human rights through decent working conditions that guarantee occupational health and safety and foster workers’ human and professional development. The goal is to ensure that the company remains in business while seeking reasonable growth, at the same time respecting the environment and, insofar as possible, avoiding all types of pollution by minimizing the generation of waste and making rational use of natural resources and energy. Therefore, legislation, regulations, standards, and customs are observed, legitimate contracts and commitments are respected, and there is an equitable distribution of the wealth generated.

Although CSR is a voluntary initiative, it has been widely embraced, as its broader effect has been to increase profits while providing an additional strategic element for boosting commercial competitiveness. Its use is therefore encouraged for both SMEs (small and medium-sized enterprises) and large corporations, given the overall business structure of LAC. In line with this initiative, since 2004, the Multilateral Investment Fund (100), administered by the Inter-American Development Bank (IDB), has had a line of projects that encourages CSR. Successful projects have been executed in 13 countries in the Region, alongside regional initiatives such as the *Promoting Competitiveness through Corporate Social Responsibility (CSR)* initiative. This effort is designed to encourage and facilitate the adoption of CSR by businesses throughout the Region as a means of helping smaller companies boost their competitiveness through CSR measures that have proven effective for private-sector development. The Chilean firm RECYCLA Chile (101), for example, launched successful innovations in technology recycling and encouraged the reintegration of ex-convicts into society by giving them jobs in its plant, providing leadership in this field and increasing the company’s visibility in local and regional media. The positive impact of its image and reputation, which reached beyond Chile, gave it access to new partners and to national and international subsidies. Wide dissemination of its business model has put the company in

contact with entrepreneurs in several Latin American countries, where there is interest in replicating its socially responsible business model for recycling technology, which entails effective management of chemical substances.

Finally, the adoption of CSR in 2005 prompted the International Standards Organization (ISO) (102) to begin formulating an international standard (ISO-26000) governing CSR, which was published in 2010 as a voluntary guideline. The guideline does not define its criteria as requirements, and unlike the other ISO standards, no certification is issued for following it. ISO 26000:2010 is limited to strengthening and encouraging the voluntary commitment of businesses, clarifying for them the meaning of social responsibility, translating these principles and values into effective action for society, and sharing best practices for social responsibility. In 2014, as a complement to the new Sustainable Development Goals, the ISO published guidelines that combine ISO 26,000 with the sustainability reports (103) and corresponding International Frame of Reference (104). The purpose of these guidelines was to improve the understanding and reporting on short-, medium-, and long-term activities in the creation of society, management, and business values.

## Toxicology education and training policies in LAC

The aforementioned problems common to LAC countries are an indication that the Region is deficient when it comes to toxicology services in the public health sector, occupational and environmental services, and health care facilities. Despite the limited access to training programs and poor training, the growing demand for chemicals management, as well as the evaluation of chemical safety and regulatory control, must be met. This will require new generations of skilled toxicologists. This section describes some of the many deficiencies and disparities in basic toxicology education and training still found among the countries of the Region (Rojas, 2005). For example, in training for occupational health professionals, some curricula are outdated, lack inter- and multidisciplinary approaches, and are marked by an over-reliance on academic theory versus hands-on practice that is out of touch with current needs. Training is not easy. In addition to the challenges of improving basic training for toxicologists, there must also be a system for the ongoing training of workers and employers to guarantee implementation of the prevention and control practices that will safeguard their health (105).

The need to create and structure different specialties in rapidly growing areas of toxicology is increasingly apparent, and there is evidence that this growth will accelerate. There is also a critical need for new information on the management of toxicology problems. Thus, there are new specialties in toxicology, in addition to the traditional ones (clinical, forensic, experimental, analytical, descriptive, etc.). These new areas include environmental, occupational, genetic, biochemical, neurotoxicological, ecotoxicological, and immunotoxicological specialties, as well as reproductive and food toxicology.

Although educational programs have been buttressed in the past five years, the means for identifying and managing the adverse effects of the conditions cited above are still lacking. Thus, Latin America is considered vulnerable because of its lack of toxicology expertise. Greater emphasis should be placed on training in environmental health and toxicology, since toxicologists play a key role in assessing the adverse effects of chemical agents. Moreover, because toxicologists are involved in academia and research, assessment and management of chemical risks, and regulatory issues, it is essential that they be well trained and have extensive experience (106).

To fill the training gaps in these areas, many countries offer toxicology electives in different professional programs, along with required courses in such fields as medicine, pharmacy, chemical pharmaceuticals, bioanalysis, veterinary medicine, food, and cosmetology. The Region has a wide range of graduate programs in toxicology that issue diplomas, specialty certification or master's degrees, doctorates, PhDs, and postdoctoral certification. Online courses are also available, such as those offered by Argentina (UNSAM) (107). Programs of study vary widely in terms of objectives, priorities, and curriculum content, as well as the quality and quantity of research required for a degree. However, there have been few efforts to standardize toxicology training nationally or align it with that of other countries in the Region.

In Mexico, for example, the National List of Quality Graduate Programs (PNPC) (108), a listing of 1,072 accredited programs, contains only three in toxicology: a doctoral program and master's program at the National Polytechnic Institute's (Cinvestav) Center for Research and Advanced Studies, and a consolidated master's program at the University of Aguas Calientes. No graduate programs in areas related to environmental toxicology or ecotoxicology are listed. Even universities that offer programs in all the standard medical specialties offer no accredited speciali-

zations in toxicology. While the list includes five graduate programs in pharmacology, toxicology does not appear to figure prominently in any of them.

Other countries, such as Brazil, Colombia, and Uruguay, have accredited master's programs that are authorized by and registered in the national science and technology systems. However, the number of program graduates falls far short of the countries' needs for trained experts. In Brazil, toxicology training is virtually absent in most university curricula, except for analytic toxicology, which is taught in pharmacy schools. To bridge this gap, the National Network of Toxicology Information and Assistance Centers was formed; the National Health Surveillance Agency also offered a short (40-hour) course to Center members and public health personnel who treat poisoning victims, in addition to a three-month online course. Nearly 1,850 professionals were trained between July 2003 and July 2009 (109).

Consequently, there is a lack of toxicologists in LAC, and most work primarily in academic and research institutions. It is also common to see "self-styled" toxicologists, who work in that capacity based on their background in the health sciences or in areas of occupational health or environment and perform tasks that are usually the domain of toxicologists. This absence of qualified talent in LAC underscores the need to improve toxicology services in all countries. In the countries in the North, in contrast, the demand for professional toxicology services is published in social media, as toxicologists are considered essential talent in the chemical, pharmaceutical, food, and other industries. In LAC, this awareness is lacking among businesspeople and government authorities. Thus, toxicologists end up in academia, the only work environment in which they can remain current in their field and have an opportunity to conduct research and apply findings to a variety of problems in their region.

Finally, in the design of policies that nurture human talent in the areas where toxicology and environmental studies intersect, government participation and decision-making are important to safeguard public health. Only through such policies can the assessment of toxicology needs and problems be kept current.

**Certification of toxicologists:** The object of this process is to ensure that toxicology personnel have the appropriate skills and experience. As explained by Albores *et al.* (2000), the idea is to develop basic training for Latin American toxicologists, that is comparable to that available elsewhere. This training would include a general toxicology curriculum that can be used to certify all toxicologists in LAC, where the certification and licensing process varies widely and there are no standard criteria. In developed countries, such as the United States, certification for toxicologists requires not only a review of their credentials and experience in the field, but a passing grade on their "boards" (rigorous tests of their knowledge) (American Board of Applied Toxicology, ABAT (110); American Board of Forensic Toxicology, ABFT (111); American Board of Veterinary Toxicology, ABVT (112); and American Board of Toxicology, ABT (113). In some LAC countries, certification by a national toxicology association or academic institution requires merely the verification of credentials (114).

Certification mechanisms vary among and within countries. In Mexico, for example, individual certification is less important than accreditation of the academic program in which the professional received the training. When the National Council of Science and Technology (CONACyT) certifies a program, the program is put on the National List of Quality Graduate Programs (PNPC) (CONACYT, 2009). This register supports the program by offering scholarships to students and instructors in the educational system who wish to receive training through those programs. In Argentina, toxicology is on the list of medical specialties approved by the Health Ministry (through Resolution 1337 of 14 November 2001) and is recertified by the Argentine Medical Association through the Association of Forensic Medicine and Toxicology.

The limited toxicology education and training available in LAC creates serious inequities between toxicology professionals and other health professionals. New education and training policies must therefore be developed and their application extended to occupational, environmental, and domestic settings. In addition to modifying, enriching, and requiring toxicology-related contents in country curricula, governments should require the schools of public health at institutions in the health, environment, and agriculture sectors to offer such courses to ensure that students have the training they will need to perform their duties. This would foster greater awareness and preparedness with respect to the dangers of exposure to chemical agents, under the tutelage of the State. Curricula, from primary school on up through the university, should also include prevention, and efforts should be made to increase public understanding of these issues (NIOSH, 2004).

To meet these objectives, joint action by governments, universities, and private industry is needed, with emphasis on toxicology as a science, to create synergies and promote training and effective toxicology practice. Progress in this area and improved treatment capacity can generate sound public policies for the regulation, assessment, management, prevention, and control of PTCSSs.

## Toxicology research policies

Research policies in the Region vary widely, not only between North and South, but within the South and even within individual countries (i.e., between the national and local level). There is greater uniformity in Canada and the United States, which have larger research budgets and government agencies with their own research centers to support policy-making, among them the Environmental Protection Agency (EPA), the Agency for Toxic Substances and Disease Register (ATSDR), and the National Institutes of Health.

Research groups elsewhere in the Region have individual differences based on whether they are located in country capitals or the provinces, in research centers or public universities, the latter of which regard research as just one of their four main activities: teaching, application, research, and extension programs. Most LAC countries have a research, science, and technology council or similar entity. Mexico's CONACyT, Chile's CONIyt, Colombia's Colciencias, and Venezuela's FONACIT establish research policies with different degrees of sophistication. They include policies in toxicology, workers' health, environmental health, and sustainable development. The systems issue periodic calls for research proposals by sector (field of knowledge) and region (political/geographic division), based on specific needs, usually in public health. Issues related to toxicology are routinely part of broader subject areas and given no independent consideration. Efforts at the State or regional level, through North-South exchange, and policies that promote networks, have had an effect on policy.

The situation described above, however, is marked by contrasts. In Mexico, which has perhaps the most advanced system (<http://www.conacyt.mx/>), research policies cover a wide range of topics, such as human resources development through graduate fellowships, postdoctoral positions, sabbatical leave, evaluation of and support for graduate programs that meet certain quality criteria, and the creation of a national system of researchers; this latter includes output-based incentives in the fields of physical mathematics, biology and chemistry, medicine and health sciences, humanities and behavioral sciences, biotechnology and agricultural sciences, social sciences, and engineering. While toxicology cuts across several of these fields, toxicology research output in LAC is not on a par with that of the developed countries of the Region, even though it is the largest area of science and technology in LAC. In Argentina, numerous groups are engaged in different lines of research, such as clinical toxicology, analytical toxicology, genotoxicity, chemical carcinogenesis, pesticides (epidemiological, environmental monitoring, mechanistic studies, etc.), ecotoxicology, environmental toxicology, food toxicology, metals and nonmetals, drugs subject to abuse, etc. (115).

The countries' efforts are yielding tangible results with respect to the different PTCSSs, as follows:

- a. **Pesticides and agrochemicals.** The most recent findings on the health effects of pesticides are from a 2004 Canadian publication and can be examined in detail in that document and related articles, which discuss both carcinogenic effects (solid tumors, leukemia, and non-Hodgkins lymphoma) and noncarcinogenic effects (reproductive, genotoxic, and dermatological effects, as well as the effects on children, to which a special section is devoted) (116). This research reviewed the literature available in English, Spanish, French, and Portuguese published since 1992; publications were selected using rigorous methodological criteria that excluded articles that failed to meet quality control standards and articles on organochlorines, since these latter have been reclassified as persistent organic compounds. There was a dearth of articles in Spanish, since many of the works in the original list did not meet quality control standards. However, some Latin American articles published in English were included. Of the roughly 350 articles reviewed, only 11 of the 79 Spanish-language articles were included. Approximately half of the articles were from the Americas, though more than 90% of these were from Canada and the United States. The issue of pesticides and agrochemicals, however, continues to be the object of scientific research in the Region in which numerous research groups and institutions are involved.
- b. **Organochlorines and lindane.** Articles published by groups conducting research in the Region on the effects of these compounds on health have been high in quality but relatively few with respect to the worldwide literature. These substances are associated with harmful effects on the reproductive system, among them breast cancer. Cryptorchidism merits special attention due to its link with testicular dysfunction, with a sequential connection between these pollutants and prostate and testicular cancer. With regard to research-for-action initiatives, NAFTA and its entities have created a regional model through the Commission for Environmental Cooperation (CEC) (CEC, 2006), which has recognized

that exposure to organochlorines such as lindane and other isomers of hexachlorocyclohexane (HCH) could pose a risk to health and the environment (CEC, 2006). The three NAFTA countries are slated to work together to implement the activities outlined of the CEC action plan. Key among them is the creation of a trilateral working group to implement the North American Regional Action Plan (NARAP) on environmental monitoring and evaluation (117). The group includes experienced national representatives and will be responsible for overseeing these activities. Other international initiatives will also be launched to reduce emissions from other sources of lindane around the world.

Canada's ban on agricultural and veterinary uses of lindane took effect on 1 January 2005, and the country has committed to evaluating and managing the risks associated with its use as a drug in the health sector, its only remaining use. The country will also address issues associated with the management of lindane waste, encourage scientific research, and increase education and the dissemination of information about the issue. Mexico agreed to phase out all agricultural, veterinary, and pharmaceutical uses of lindane through a priority-based approach. The United States received requests from all of its lindane registrants for voluntary cancellation of all remaining registrations of pesticides with lindane in the country, and it plans to approve such requests from producers. It also reviewed the six remaining uses of lindane for treating seeds and determined that they did not meet the criteria for renewed registration. Efforts will be made to develop alternatives to lindane for treating lice (pediculosis) and scabies and to raise awareness through initiatives to address the remaining uses of lindane as a drug in child health applications. Finally, El Salvador recently banned a long list of pesticides in response to the severe chronic kidney disease of unknown origin found in some agricultural workers (118). Although that policy decision does not cite a cause for this epidemic in Central America, it does reduce dangerous exposure, prevent harmful health effects that would otherwise be likely among workers, and contribute to environmental preservation.

- c. **Lead.** Research on lead in the Region is an example of research for action, providing a model for cooperation, organization, and impact. Systematic research made it possible to rapidly influence policy, establish timetables for industrial changes, and demonstrate that lowering concentrations reduced harm. Mexico not only amended its regulations in many related areas, such as gasoline, paint, and glazed earthenware, but also laid the foundation for legislation on environmental exposure (NOM, 2000). Recent decades have witnessed the development of a vast network of information on the health effects of lead exposure. As more and more reliable information has come to light, there has been greater recognition that even the lowest levels of exposure constitute a public health risk. The less obvious effects of exposure to low concentrations of lead merit further attention, as this is an equally serious problem that potentially affects a large number of people, particularly vulnerable populations (populations that are needy, malnourished, and have little or no access to health services). In Colombia, for example, reports of occupational exposure to lead contain striking data. The Cárdenas study reports that 60.3% of workers had concentrations of erythrocyte zinc protoporphyrin above 70 mg/dl, while blood lead levels were between 15 and 369 µg/dl, with a median level of 88 µg/dl (119). Moreover, as Schwartz observes, people in Colombia continue to be exposed to lead not because exposure is thought to be harmless, but because reducing it costs money, although continuing exposure also has its costs (120). In the rest of LAC, measuring and reducing lead levels are costly undertakings. Lead poisoning among children is preventable and poses a significant challenge for public health programs throughout LAC.
- d. **Mercury.** The most significant advances with respect to mercury exposure are attributable to two sources, cited above. The first is the Community of Practice in Ecosystem Approaches to Health of Latin America and the Caribbean (CoPEH-TLAC), which conducts research on toxic substances and has generated scientific information and important methodological advances. This has resulted in the formation of high-caliber, cutting-edge research groups that employ holistic, creative, and novel approaches, filling important gaps by incorporating the gender perspective and community participation. The second is the regional campaign on "health care without harm" coalition (Health Care Without Harm, 2006), which has made real progress in eliminating mercury from the health sector. Assessments in countries throughout the world, such as the one conducted in Mexico, have shown that thermometers and amalgams alone are responsible for six tons of mercury discharges into water each year. Activities also include training for cleaning up spills, alternative designs for instruments, and the phasing out of mercury. The campaign includes a project in six Member States that assesses the life cycle of fish, the frequency with which women of reproductive age eat fish, and the mercury concentration in this popu-

lation, since the harmful effects on reproductive health and neural tube development have been amply documented in the Region and elsewhere. Guidelines used and tested in Mexico and Ecuador were recently published, with support from the University of Massachusetts Lowell (121); PAHO recently published other similar materials (PAHO, 2013).

In 2001, the Curriculum Vitae Latinoamericano y del Caribe (CvLAC) online platform was created to support progress in science and technology and improve access to and the availability of skilled human resources in these fields in developing countries. This is a strategic technical cooperation project of the PAHO Research Coordination Program (122), whose main objectives are to collaborate in the development of science and technology management and facilitate collaboration, scientific exchange, and technological innovation, both nationally and internationally, as an aspect of sustainable and equitable development. The CvLAC platform permits the integration and sharing of information from the CVs of all individuals involved in the countries' science, technology, and innovation systems. In this forum, in which most of the Region's countries participate, researchers and their findings can be catalogued and described by research group, company, or institution, as well as by fields of knowledge and projects (123).

Another important regional project is the Regional System of Online Information for Scientific Journals of Latin America, the Caribbean, Spain, and Portugal (LATINDEX), which can be consulted free of charge (124). This project is the fruit of cooperation between science and technology institutions in 17 Ibero-American countries and international cooperation agencies (Wikipedia, 2009). It has its own information system on science journals published in the Spanish- and Portuguese-speaking countries. Since 1997, it has had a directory of academic journals published in the countries of the region. To date, it lists 17,755 such journals (current and past) from 30 countries. LATINDEX also includes 3,301 e-journals that can be consulted directly online, and a high-quality catalogue created as a specialized reference service for additional information on the features of each publication. This source covers 4,000 journals that meet the system's editorial criteria (LATINDEX, 2009).

Thus, the CvLAC, LATINDEX, and BIREME projects facilitate online consultation of a systematized collection of knowledge, experience, and scientific output by anyone engaged in research, innovation, and technology development. Thanks to these regional efforts, access to scientific information and output in the Ibero-American countries is easier today, increasing the visibility to research conducted in the Region and contributing to priority setting and the creation of incentives to formulate projects in different fields of knowledge (125), especially health, sustainable development, and toxicology.

- e. **Research on occupational cancer.** Research on cancer in general and on the origins of occupational cancer in particular remains a universal public health and sustainable development concern. In 1999, it was estimated that occupational exposure among European men could be responsible for some 13% to 18% of malignant lung tumors, 2% to 10% of bladder tumors, and 2% to 8% of laryngeal cancer cases, while the respective percentages for women were on the order of 1-2% to 8%, 0% to 5%, and 0% to 1% (126). According to an epidemiological analysis of cancer in the 20th century and projections for the future by Peto (127), some 4- 10% of cancers may be associated with occupational exposure. Other studies estimate that occupational carcinogens are responsible for at least 152,000 deaths per year and nearly 1.6 million disability adjusted life years (DALYs) (128). Though some research groups dispute these figures, it is clear that the growing cancer epidemic demands special attention, along with more effective interventions to eliminate or minimize exposure to carcinogens in the workplace.

Thanks to research, numerous PTCs have been recognized, documented, and catalogued as occupational carcinogens, many of which have been mentioned throughout this text. Yassi *et al.* (2001) breaks them down into five broad groups: organic, inorganic, asbestos and synthetic mineral fibers, radiation, and viruses. However, the list of occupational carcinogens published by the National Institute of Environmental Health Sciences in the United States (129) indicates the inventory of chemicals recognized as human carcinogens is much larger—around 160, only 28 of which are confirmed, with 27 probables and 113 possibles. According to the disease burden study of Driscoll *et al.* (2004), the most thoroughly documented types of cancer are lung cancer, leukemia, and malignant mesothelioma. Others, such as bladder, liver, nasal cavity and middle ear, bone and cartilage, and skin cancer, have a lower incidence; there is currently a lack of data on exposure and risk with respect to these cancers. Based on its research data, the IARC has defined and classified various types of cancer-causing substances and agents, categorizing them in groups 1, 2A, and 2B. Although many of these substances are present in the general environment, it is recognized that a substantial number of them are involved in occupational exposure, and that exposure to most of them is pre-

ventable. It should be noted it was not until 2013 that diesel fuel was included in group 1, which calls for innovative measures to control diesel emissions.

In short, research and statistics on occupational cancer in the Americas are extremely varied, given regional differences in work, social protection, access to health services, and legal frameworks in the countries (130). For example, Driscoll *et al.* (2004) estimated that the fraction of lung cancer attributable to workplace exposure in Canada, Cuba, and the United States was 5% (estimated data, 2002), while this figure was 8% for the rest of the Americas; it was also estimated that the percentage of deaths from malignant mesothelioma in these same countries in 2002 was 0.7%, in contrast to 2.2% in Argentina, Brazil, Chile, Colombia, Costa Rica, El Salvador, Guyana, Honduras, Mexico, Panama, Paraguay, Uruguay, Venezuela, and the Caribbean countries. A review of exposure to crystalline silica reveals similar disparities. For example, it is estimated that in Brazil, only 5% of the working population is exposed, while in Bolivia, Chile, and Colombia, between 15% and 22% of miners suffer from silicosis; the respirable fraction of crystalline silica has also been related to lung cancer and other respiratory diseases (131). Similarly, exposure to pesticides and solar radiation among agricultural workers is a source of concern and a cause of occupational cancer in various parts of Costa Rica (132).

It is estimated that at least one-third of all cancer cases are preventable; that, in the long term, prevention is the most cost-effective strategy for combatting the disease (133); and that the only way of preventing it is to minimize or eliminate exposure to carcinogens. The Finnish Institute of Occupational Health (FIOH) therefore created an information system on exposure to occupational carcinogens (CAREX, for *CARcinogen EXposure*), making it possible to estimate the extent of exposure to carcinogens and number of workers exposed (134). Some countries, including Canada, Costa Rica, Colombia, Guatemala, Nicaragua, and Panama, have created their own CAREX on the same model to provide information on which to base national policies and plans for the study, registration, prevention, and control of occupational cancer. Canada, for example, created its CAREX (135) and announced a national strategy for the control and prevention of occupational and environmental cancers, with the object of promoting policies for the investigation, control, and prevention of these types of cancers (Canadian Strategy for Cancer Control (136,137). In Costa Rica, the TICAREX included 27 carcinogens and 7 groups of pesticides, serving as the basis for regulations to control or ban these substances (138).

Another strategy consists of making the registration of occupational cancers mandatory. Argentina, for example, has regulations governing the registration and reporting of carcinogenic substances entering the country, as well as for reporting workplace exposure and monitoring workers in industries subject to reporting (139). By 2006, there were over 500 registered companies whose workers are monitored by workplace risk administrators (140). Brazil also created a mandatory reporting system for occupational diseases that records cases of occupational cancer; however, its research has centered on seeking methods for calculating the proportion of cancer among workers attributable to exposure. The Brazilian system places particular emphasis on developing job-exposure matrixes (JEMs) (141), while also working to establish a CAREX. In a similar vein, based on research over the past decade, Colombia designed and published a manual of carcinogenic agents (*Manual de Agentes Carcinógenos*) (142). It also created a job-exposure matrix (Colombia, CAREX), a National Plan for the Prevention of Occupational Cancer, a technical regulation for the prevention of occupational cancer, and an epidemiological surveillance system for occupational cancer (SIVECAO), currently being tested in several regions in the country (143,144).

In the international arena, WHO (2008) has conducted a number of initiatives aimed at controlling the most recognized causes of cancer: (i) the Tobacco Free Initiative (tobacco being considered the principal preventable cause of cancer); (ii) initiatives to promote changes in diet (related to obesity and overweight); (iii) initiatives involving infectious diseases (HBV and HVC, HPV, and *Helicobacter pylori*); (iv) initiatives on exposure to ionizing radiation (different types of skin cancer); and (v) initiatives on occupational and environmental exposure (asbestos, anilines, benzene, etc.). WHO is has two vigorous campaigns under way for the global elimination of carcinogens, namely: asbestos elimination and control of exposure to silica, in coordination with its regional offices and the ILO. At the same time, PAHO has been promoting similar initiatives in the Americas (PAHO, 2008). To this end, it has organized a regional Latin American and Caribbean cancer prevention and control network and is drafting a plan of action to reduce the incidence of occupational cancer in the Americas and improve the quality of life of workers with cancer. The respective lines of action include policy-making and lobbying; monitoring and surveillance to provide adequate follow-up for workers; health promotion and cancer prevention; and cancer diagnosis and treatment. The network's current efforts are focused on creating a regional CAREX to provide up-to-date information, based on empirical data, for public policymakers and decision makers in the Member States (145). In this connection,

a regional training workshop was held in 2014 to harmonize methods and findings in each of the countries and motivate other countries to create their own CAREXs. This will facilitate more accurate estimates of the burden of disease associated with occupational cancer and the formulation of policies for the control, eradication, or replacement of carcinogens detected in the workplace (PAHO, 2008) (130).

### Toxicology laboratories (services)

Analytical toxicology is a branch of toxicology that is intimately related to all other areas of the field. Therefore, professionals in disciplines related to toxicology should, at a minimum, be familiar with general aspects of the work performed in toxicology laboratories. Chemical-toxicological analysis is a process designed to detect and/or quantify toxic agents in an environmental or human sample. This is very important in all areas where toxicology is applied: population health, environmental health, and occupational health, as well as clinical toxicology, internal medicine, and forensic medicine. Functional and quality-control aspects of toxicology are essential in different fields:

- a. **Environmental and occupational toxicology**, which consists of environmental monitoring and the biological monitoring of exposed persons, measures the organism's exposure to exogenous chemical agents, always in comparison with a series of reference values. The purpose of such monitoring is to recognize the early biological effects of the interaction between toxic agents and "target" organs (146,147). Environmental toxicology laboratories detect and quantify toxic substances in an ecosystem that pose direct or indirect risks to human health. Such laboratories analyze water, foods, soils, and air. Comprehensive evaluation of people, including biological and environmental monitoring of toxic agents, is a systematic methodological resource that contributes to the characterization of toxic agents and, more importantly, the adoption of timely measures to prevent and control exposure. On another front, ascertaining the concentration of these agents in the media through which people are usually exposed (water, air, food, and soil) permits inferences about the severity of their adverse effects, which can vary (148).
- b. **Toxicology laboratories** also play an important role in determining the *toxicokinetics* of substances—assessing an organism's absorption of chemical agents, their distribution and accumulation, their biotransformation, and their excretion. These laboratories also study *toxicodynamics*, since chemical-toxicological analysis can determine the relationship between dose and the signs or symptoms that toxic substances can produce (148). For animal toxicity assays (experimental toxicology), all necessary measurements in animal fluids and tissues used for prospective or retrospective assessment of chemical substances are conducted in toxicology laboratories.
- c. In the field of **clinical toxicology**, laboratories not only assist doctors in diagnosing cases of poisoning and issuing prognoses, but also aid the post-poisoning monitoring of patients to determine whether toxins are still present in the body (and, if so, at what concentrations).
- d. Laboratory work is also important in forensic medicine. Tests can confirm alleged poisonings and identify and quantify the toxic substance involved through biological samples (including the viscera); any poisoning, even if seemingly accidental, may have medical-legal or worker-employer implications, depending on the autopsy findings. A forensic toxicology laboratory also investigates events with forensic implications involving toxic substances, as in the case of illicit drug use (149).

**Quality control:** To obtain reliable results from analyses, the *accuracy, precision, and detection threshold* of the method used must be considered. This is facilitated by intralaboratory, interlaboratory, or international quality assurance or control programs. Participation in quality control programs is an excellent tool for certifying work, since the difference between permissible and impermissible concentrations is sometimes very small, and lack of precision can lead to errors in treatment, prevention, and/or control measures. Analytic methods make an important contribution to prevention and diagnosis of the adverse effects of toxic agents. In addition, more sensitive analytic techniques involving more sophisticated equipment are constantly emerging, making it possible to quantify minute amounts of harmful substances, whose effects generally go undetected by those charged with safeguarding the population's health (Rojas, 2001).

The capabilities of toxicology laboratories in the LAC countries are limited. It is not unusual to find that there are no fully equipped laboratories to make all necessary analytical determinations and properly assess occupational or environmental exposure. Since only some techniques are in common use, private companies or government

agencies are forced to send samples to other laboratories, thus introducing additional possibilities for errors in findings, since biological or environmental samples can be contaminated when divided. Moreover, the accuracy, precision, and reliability of findings can be open to question when different analytical techniques are used.

Where work-related analysis is required, it is usually government institutions (ministries of health or labor, social security administrations, or their associated entities) that have the laboratories equipped for the purpose. Given the heavy laboratory workloads, findings often take longer to produce than desirable. And while academic institutions, especially universities, have laboratories, they are more focused on research than on providing services to the public. Some companies have their own equipment for environmental or human assessments, but their findings are often challenged. Argentina has public and private laboratories with widely differing objectives. Most of the private laboratories focus on assessing populations of workers exposed to PTCs or identifying drug abusers. The public laboratories, in contrast, devote themselves to work of the type mentioned above, participate in studies that measure biomarkers of exposure to environmental pollutants, investigate analytes in biological media responsible for acute poisonings, and conduct toxicological research, among other activities. With regard to **quality control programs**, very few laboratories are certified (Ceprocor, in Córdoba, with ISO 17025 certification, is one exception). A few have quality management systems, and another few have external or internal quality control systems (Villamil, personal communication).

For all these reasons, PAHO is promoting the creation of an inventory of public health laboratories that will include environmental health and occupational health laboratories, with the purpose of strengthening and invigorating laboratory networks to fill the gaps discussed above. These networks will make it possible to establish engineering and hygiene mechanisms to effectively control environmental hazards (150).

Finally, all research with human subjects to study the effects of chemical substances is subject to the bioethics standards that have been carefully formulated at the global level, a process that is still under way. There have been intense debates surrounding ethical practices in occupational and environmental health, experimentation with mutagens and teratogens, and work with experimental models to gain an understanding of the toxicokinetic and toxicodynamic mechanisms of human subjects and populations. These issues must be resolved in favor of respect for the basic precepts of bioethics and human rights.

## Cooperation and communication to solve toxicology problems

### Toxicology networks and related areas

The availability of state-of-the-art information, knowledge, and technology is achieved by the constant sharing of information among professional toxicologists, academics, workers, and employers, as well as professionals from other related disciplines (occupational health, environmental health, occupational hygiene and safety, chemical emergency management, etc.). Accordingly, efforts have been made to foster the creation of professional networks for sharing and generating knowledge, better known as *knowledge networks* (WHO, 2008). One key area in which PAHO has been active is *information management*. One of the most important achievements in this area has been the timely and appropriate dissemination of information at all levels, since the need for those who manage information to share it has led to the creation of regional networks comprised of entities and experts in the field of toxicology. The main objectives of these networks are to encourage information sharing, harmonize reports on poisoning cases, standardize laboratory techniques, and establish protocols for the treatment of poisoning cases (151). Knowledge networks are the highest expression of human beings as knowledge producers and of their need to exchange, share, and transfer what they learn and create (knowledge) through interaction in technology platforms made possible by the globalized society (152). Since the 1990s, these platforms have led to in-depth discussions of knowledge networks. Although some networks, such as those of Brazil and Mexico, consist of toxicology information and advisory centers, this is not true in other countries. Here, such networks also include other institutions that deal with issues involving chemical substances—institutions such as civil defense agencies, firefighters, customs services, universities, and ministries of health, agriculture, environment, and industry.

While some LAC countries lack their own toxicology networks, many toxicology professionals and experts from related disciplines throughout the Region actively participate in these forums for information and knowledge sharing. These virtual networks are a great help in promoting the health of the general population and workers in the countries of the Region. The features, objectives, and importance of these networks vary. The fact that they are administered via the Internet facilitates and boosts their capacity for international communication and work in synergy with experts in different countries. Networks also make it possible to publicize courses that users can take

for professional enrichment and training, without having to leave their place of origin. Finally, they are useful, user-friendly, accessible sources for solving problems caused by exposure to toxic agents, since they provide a venue for discussing, sharing, and recommending interventions based on users' experiences and advice from participating experts. There are some 46 networks on health, work, and the environment in the Region, with approximately 25,000 participants from over 50 countries around the world (153).

### **International technical and financial cooperation (IDB, PAHO/WHO, UNEP, World Bank)**

Mention has been made throughout this chapter of the different ways in which international cooperation agencies have been supporting policies, programs, plans, and projects for comprehensive management of the risks associated with chemical substances. All that remains to complete the regional picture is a more detailed description of the structure, scope, and impact of the PAHO/WHO network of Collaborating Centers in occupational and environmental health. This network, which operates in and contributes to the Region, has been largely responsible for many of the aforementioned advances in education and research in toxicology related to public health, sustainable development, and environmental health. Seven of these centers are devoted to issues in environmental health; one, to water issues; four, to controlling tobacco use and to consumer health; and 14, to occupational health (154). Although most are in North America, the remaining centers, located in Brazil, Chile, Colombia, Costa Rica, Cuba, Grenada, Mexico, and Peru, have made valuable contributions to work in these areas and to solving problems in occupational and environmental toxicology. The WHO/PAHO Collaborating Centers, together with their programs and contact information, can be found on the WHO website at: <http://apps.who.int/whocc/>.

Finally, most of the countries in the Region have online toxicology information centers that can be consulted for both routine and emergency questions about toxic agents.

## **■ Emerging challenges for regional toxicology development**

The identification of challenges is directly linked to priority setting. Both, however, are subject to the possibilities and constraints of science and technology development in the countries, as well as the political will of each country to overcome the constraints. This chapter has described the problems, identified information gaps, and suggested directions for research to meet regional needs and build capacities and competencies in toxicology. Only through joint efforts resulting from synergies among societies' stakeholders can agreements be reached and common goals adopted for the development of regulatory frameworks and public policies to improve installed capacity and institutional problem-solving capabilities, provide more skilled human resources, and advance toxicology research to benefit the Region's population. This final section contains thoughts that merit attention in this regard.

### **The unfinished agenda**

Despite the policies in place and the advances in applied toxicology and epidemiology to address problems in occupational, environmental, and public health, many questions persist. Some of these are described below:

- a. ***Prioritizing chemical risk management in public policy.*** The first element to consider is the inclusion of risk management when setting priorities for comprehensive health and environmental policies centered on chemical risk management and control. At the same time, it will be necessary to review, evaluate, and reorient the national policies already in place. This means redistributing tasks and rethinking lines of work for effective control of toxic chemicals, changing existing procedures, allocating greater resources for that purpose, more effectively applying the findings of investigations by relevant institutions, examining the complaints lodged by communities, and increasing the number of activities devoted to the inspection and monitoring of exposed areas and individuals, in addition to evaluating the results of these efforts.

#### **CHALLENGE:**

- Effect, strengthen, and/or improve the transfer of findings from toxicological, epidemiological, and social research to decision makers.

- Implement the findings.
- b. **Education and training in applied toxicology.** Questions that arise in this area include: *Have the benefits of toxicology training in terms of reducing toxicological risks and providing a rationale for policies, regulations, and standards for practices in this area been sufficiently demonstrated? What place does toxicology training have in the hierarchy of measures for preventing and controlling these risks?* Although there are some programs in the Region and some government institutions in the countries that support and share responsibility for providing training in occupational and environmental health, and environmental education in general, this is not the case in the field of toxicology. An interesting option would be to encourage and create North-South/South-South networks for knowledge and exchange to increase the number of competent, trained professionals serving the Region.

## CHALLENGE:

- Formulate an education and training policy for toxicology and its various branches to promote sustainable development.
- c. **Information management and chemical risk communication.** Experience shows that countries that lack basic data on the mortality and morbidity associated with exposure to toxic agents (in terms of various socioeconomic indicators) find it hard to improve health equity. In this regard, a significant debt with the peoples of the Americas remains. Addressing this issue is the first step toward bridging information gaps and guaranteeing the right to know along with other human rights.

## CHALLENGE:

- Improve the registration, use, prohibition of, and restrictions on chemical substances, ensuring that every country creates a national PTCS inventory.
- d. **Institutional capacity.** The serious institutional limitations with respect to analytical toxicology in LAC are another key element that affects all areas in which it is applied: work, environment, education, and surveillance systems. To improve the effectiveness and efficiency of surveillance and control authorities in the Member States, institutional capacity must be strengthened in government agencies and various levels of social organizations—communities, trade unions, cooperatives, and associations.

## CHALLENGE:

- Create networks of toxicology laboratories to remedy the inability of existing public health laboratories to meet the needs of the Region.
- Guarantee the presence of quality control programs in toxicology laboratories.
- e. **Applied solutions.** The final element is to focus on activities with comprehensive solutions and sound chemical risk management practices in both existing high-priority economic activities and emerging ones. Artisanal gold mining, for example, is a very dangerous activity, because it exposes entire families to mercury fumes. Another example is the *maquila* industry, which has created extensive social, economic, and health problems in certain countries in the Region due to multiple exposures to agents in electronics components and the use of toxic substances such as solvents, acids (chromic, nitric), bases, gases, metals (Pb, Ni, Cr), resins, etc. The consequences of occupational exposure and the wastes that are harmful to the environment are known and have been the subject of numerous studies (155).

## CHALLENGE:

- Support the creation of chemical risk management systems in the countries and their respective chemical risk maps, with support from SAICM.
  - Adopt the strategies and other mercury control methods stipulated in the Minamata Convention.
- f. **Old enemies that still cause problems.** Controlling exposure to silica, asbestos, and the multiplicity of chemical agents that cause a wide variety of chronic diseases and occupational cancers remains a matter of concern.

## CHALLENGE:

- Develop effective programs to control exposure to dust, fumes, and aerosols produced by carcinogenic substances.
- Develop comprehensive national plans for the prevention of occupational and environmental cancers.

## New challenges

Within the above-mentioned lights and shadows, there are other problems that deserve special mention:

- Chemical control of **illicit crops** due to the ecological disaster that they both entail, and the controversy surrounding the use of glyphosate to eradicate them. These crops are unequivocally linked to the quality of the registries maintained by the Andean countries dealing with this problem, where the precautionary principle should prevail. How can the carcinogenic effects of a toxic substance be monitored in the absence of a good national cancer registry? How can the reproductive effects of these substances be evaluated? Surveillance, control, and evaluation will only be possible through relevant research or data from studies in other parts of the world—not an ideal approach, since the problem in question is unique and regional.
- **Indiscriminate felling of trees** in regions such as the Amazon rainforest, where mercury is released through lixiviation into water sources, contaminating the fish that are the staple of the native population's diet (82). What is happening in other regions?
- The **absence of biomarkers** to determine chronic and subchronic exposure. This is another major problem that can be evaluated and solved through the joint efforts of toxicologists and epidemiologists, particularly in relation to exposure as prevalent and consequential as exposure to organophosphorus pesticides, to mention but one case (156). Complex creative methods must be considered that, even in the absence of biomarkers in the strict sense, will make it possible to establish associations and thus lay the technical foundations for control.
- The identification, evaluation, treatment, and inventorying of **contaminated sites**. This is an area where progress has varied widely across the Region and much remains to be done (157,158).
- **Nanotoxicology**. This is a new technology that is beginning to make it possible to posit and detect harmful health effects from new technologies and forms of production.
- Compulsory application of the **precautionary principle**, given the uncertainty linked with new chemical products and their toxic potential.
- The search for and use of "**sentinel events**" that serve as early warnings of health effects from toxic substances in the environment. One example is "time to pregnancy" (TTP). This is an indicator of fertility, or the number of menstrual cycles without the use of contraceptives that it takes a couple to achieve a clinically detectable pregnancy. Prolongation of this time may indicate reproductive losses due to problems during gametogenesis, the transport of gametes in the male or female reproductive tract, fertilization, migration of the zygote to the uterus, and the implantation and initial survival of the fetus. This indicator is a way of measuring reproductive losses in the period during which most of these events occur. Approximately 31% of conceptions are lost early on, even before the pregnancy is recognized by the woman. This methodology was proposed in the mid-1980s as a way to explore the toxic effects of some agents in the environment on human reproduction, among them exposure to pesticides, coffee,

cigarette smoke, polychlorinated biphenyls, nitrous oxide, ethylene glycol esters, styrene, solvents, toluene, formaldehyde, lead, oil, and oily substances. The prospects for using this methodology are constantly improving, given the relatively low cost of collecting the relevant data (159).

- The **application of genomics to toxicology**, known today as “toxicogenomics.” This is a way of understanding the interactions between genes and environmental toxins in terms of health effects. The challenge is to make this useful to the population as a whole through surveillance and screening for early detection of damages, as opposed to individual clinical applications, which are costly and are therefore available only to small elite entities. Studying the epigenetic effects of the action of environmental toxins, or their interaction with other nutritional or occupational stressors, requires experimental and epidemiological research covering more than one generation. New methods and scientific partnerships are therefore needed to shed light on transgenerational associations.

## ■ Conclusions and recommendations

The complexity of the issue makes simple, detailed solutions impossible. However, it is clear that a more uniform and collaborative regional constellation of policy/research/action will yield better results at lower cost. Regional North-South cooperation, as well as cooperation within the individual countries, will facilitate better use of resources and lay the foundation for creating an information system for reference and cross-reference to improve evaluation, training, research, and the periodic amendment of legal frameworks, along with other benefits.

The designation of regional reference laboratories as serious, rigorous quality control programs governed by a policy of cooperation with provincial and outlying centers will provide more abundant options for research. Although many studies have been conducted at the personal initiative of individuals or by small groups of researchers, the laboratories involved, though serious and well-equipped, are not certified, even when they belong to public universities, and are therefore unable to publish their findings in prominent international journals. This minimizes their impact on public-interest policy-making. The ideal would be to standardize the quality criteria used in some of the countries in the Region under a Pan American standard.

Achieving these goals requires better risk communication at all levels to create the connection between science and policy that has yielded positive results in cases such as that of lead in Mexico. Such cases should proliferate and become routine. In this connection it is important to consider:

- Ways of supporting the formulation or modernization of public policies, existing programs, and interventions, based on the lessons learned, in order to use toxicology to optimal effect to foster sustainable development in the countries.
- Research needs, based on empirical data and the measures required.
- The lack of development in occupational and environmental health in Latin America as one of the major constraints to chemical risk management. Without the support of these disciplines, in the form of skilled human resources, installed laboratory capacity, technology, and knowledge, toxicology as a discipline will never fully develop.
- Proposals for strengthening education.

*In light of the above, policies for **environmentally sound chemicals management** should be essential elements of all public policies in the countries, regardless of their level of development, given the effects that chemicals can have on human health, the environment, economic growth, development, and, ultimately, sustainable world development.*

## ■ Annex 1: List of major networks connected with toxicology and its different areas of application

- a) CNTC (Canadian Network of Toxicology Centres) ([http://www.envbio.uoguelph.ca/f\\_ritter.shtml](http://www.envbio.uoguelph.ca/f_ritter.shtml)). This network was created in 1988. In 1992, funding was allocated for a National Toxicology Program, with various specific objectives that can be summarized as: understanding the management of toxic substances and their adverse effects, and training and research in this field.

- b) RENACIAT (National Network of Centers of Toxicological Information and Care, Brazil) (<http://portal.anvisa.gov.br/wps/content/Anvisa+Portal/Anvisa/Inicio/Agrotoxicos+e+Toxicologia/Assuntos+de+Interesse/Rede+Nacional+de+Centros+de+Informacao+e+Assistencia+Toxicologica>).
- c) RETOXLAC (<http://www.bvsde.paho.org/bvstox/e/retoxlac/retoxlac.html>) is a list for discussions on toxicology, promoted by the Pan American Health Organization (PAHO/WHO) and the Pan American Center for Sanitary Engineering and Environmental Sciences (CEPIS/PAHO). It is also a regional and international forum for discussion and dissemination of information on toxicology in Spanish, Portuguese, and English, in which all toxicologists and interested professionals are free to participate.
- d) REDARTOX (Argentine Toxicology Network) (<http://www.msal.gov.ar/images/stories/ministerio/intoxicaciones/redartox/directorio-redartox-2011.pdf>) was created in 1999 as part of the Ministry of Health's National Poisoning Prevention and Control Program, in collaboration with international organizations such as the International Program on Chemical Safety/World Health Organization (IPCS/WHO) and the Pan American Health Organization/World Health Organization (PAHO/WHO). REDARTOX is a network of the country's toxicological clinical care units (including toxicology information and advisory services and clinical toxicology laboratories). Its objectives are to: (i) improve the sharing of information; (ii) contribute to the standardization of registers and regulations; (iii) promote multicenter research, training, and prevention activities and analytical quality control programs; (iv) create virtual antidote and laboratory standards banks; and (v) promote training in clinical toxicology and applied epidemiology.
- e) RITA (the Toxicology Information and Alert Network of Chile) (<http://www.ritachile.cl>), is a program of Chile's Ministry of Health (MINSAL). Created in April 1999, it began registering and standardizing the recording of consultations for poisoning, toxicological analyses, and the availability of antidotes. It also records incidents involving hazardous materials, which, though less numerous than individual consultations for poisoning, carry risks for both people and the environment, making them no less important (Capote *et al.*).
- f) RETOMEX (the Toxicology Network of Mexico [<http://www.retomex.org.mx>]) was created on 17 August 2000 during the Second Meeting of Heads of Toxicology Information Centers. It is an open forum for anyone whose work is related to toxicology. Its objective is to maintain free-flowing dynamic professional relationships among its members for sharing information and creating uniform criteria, with the overarching purpose of strengthening all its members.
- g) REPATOX (Panamanian Toxicology Network). This network was created to increase information sharing, standardize the reporting of poisonings to facilitate work based on empirical evidence, standardize laboratory techniques, and establish protocols for treating cases of poisoning.
- h) Red de Seguridad y Salud de los Trabajadores de Venezuela (Workers' Safety and Health Network of Venezuela, [RED\\_SEGURIDAD\\_Y\\_SALUD\\_OCUPACIONAL@yahoo.com](mailto:RED_SEGURIDAD_Y_SALUD_OCUPACIONAL@yahoo.com)). This network is a forum for sharing experiences in occupational health and safety. Broad in scope, it includes employers; workers; prevention personnel; government employees, and teachers, and students, and researchers interested in disciplines such as occupational hygiene and safety and occupational health and medicine, and people in the professions associated with occupational health, including toxicology, in Venezuela.
- i) RSST (the Occupational Safety and Health Network of Peru) (<http://mx.groups.yahoo.com/group/rsst/>) is the product of a joint effort by PAHO and the ILO to raise awareness about issues and share experiences and knowledge among occupational health and safety personnel and experts in the Region. In operation for over 15 years, it is the oldest such listing, with over 1,800 subscribers (Varillas).
- j) Salud Ambiental (Environmental Health, [http://www.eListas.net/lista/salud\\_ambiental](http://www.eListas.net/lista/salud_ambiental)) is a list created by the Sociedad de Ecología Médica y Social to increase communication and information in environmental health and related sectors.
- k) SINITOX (National Toxicopharmacological Information System, Brazil, <http://www.fiocruz.br/sinitox>).
- l) REPIDISCA (Pan American Information Network on Environmental Health, [http://www.paho.org/English/HEP/hep\\_repidisca.htm](http://www.paho.org/English/HEP/hep_repidisca.htm)), created by PAHO/WHO in 1982. Located in Lima, Peru, its objective is to disseminate information on environmental health, environmental epidemiology, environmental toxicology, sanitation and environmental engineering, water and waste, healthy cities, health in the home, hazardous waste, and occupational health.
- m) International Occupational Safety and Health Information Centres of the ILO (CIS/ILO, <http://www.ilo.org/safework/lang--en/index.htm>). An information and knowledge management system of the ILO

- program on occupational safety and health, its objective is to provide relevant information to prevent workplace accidents and occupational illnesses. To this end, it draws on the assistance of over 135 national, regional, and international focal points (CIS centers), covering more than 120 countries.
- n) EXTOXNET Innovase (United States) offers pesticide information and provides access to Pesticide Information Profiles (PIPs). Its Toxicology Information Briefs (TIBs) describe some concepts in environmental toxicology and chemistry. The network also provides information in other formats: toxicology issues of concern (TICs), factsheets, news about toxicology issues, newsletters, resources for toxicology information, and technical information.
  - o) WHO/PAHO REQUILAC (<http://www.bvsde.ops-oms.org/requilac/e/requilac.html>) is a network open to all interested Spanish, Portuguese, and English-speakers of any nationality. Its participants are professionals with diverse educational backgrounds who are interested in one or more aspects of chemical emergencies.

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## ■ Annex 2

### List of SAICM indicators

<i>Category of SAICM objectives</i>	<i>Indicator</i>	<i>Short name</i>
Risk reduction	1	Use of chemicals management tools
	2	Key categories of chemicals subject to risk management
	3	Agreements on hazardous waste management
	4	Periodic monitoring
	5	Priority setting for risk reduction
Knowledge and information	6	Provision of information on harmonized international regulations
	7	Risk communication to vulnerable groups
	8	Research programs
	9	Websites providing information on chemicals
Governance	10	Commitment to implementation of SAICM
	11	Mechanisms for coordination of multiple stakeholders
	12	Implementation of international priorities
Capacity building and technical cooperation	13	Bilateral institutional strengthening and technical cooperation support
	14	Priority setting in relation to strengthening needs
	15	Regional cooperation on sound chemicals management
	16	Development aid programs that include sound chemicals management
	17	Support from the SAICM Quick Start Program Trust Fund
	18	Institutional strengthening projects with support from other sources
Illicit international trafficking	19	Illicit international trafficking in chemicals
	20	Illicit international trafficking in hazardous waste

**Source:** Summary of data collected using the SAICM online instrument

# Risk prevention in vulnerable populations

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## ■ Introduction

The human race has never been faced with such enormous challenges: a changing climate, the emergence of new diseases and the re-emergence of forgotten ones, epidemiological transition, new technologies, industrialization, the growth of cities, water stress, loss of biodiversity, electronic waste, thousands of new chemical compounds, new production of old chemicals driven by patent expiration, new eating habits, peak oil, basic grains used to produce biofuels, extensive travel facilitating the worldwide spread of exotic species and pathogens, use of genetics to modify species, ecotourism that harms protected areas, not enough jobs, mass use of addictive drugs, young people without hope, the forgotten elderly.

Today's challenges add to the perennial challenges: water pollution, biomass burning in marginal urban and rural areas, communicable diseases, unhealthful environments, species extinction, degraded ecosystems, deforestation, desertification, population growth, poor waste management, persistent pernicious poverty, environmental inequity, complex vulnerability contexts, and at-risk populations.

Different fields of knowledge have defined vulnerability in terms of their areas of specialization. Thus, there are many definitions of this concept. Nevertheless, the common denominator is the existence of a hazard or risk; as Lavell (1) points out, it is impossible to talk about vulnerability without the presence of a hazard and vice versa, with hazard understood as the probability of an event occurring that is harmful to society. Wilches-Chaux goes further and sees vulnerability as a dynamic system arising from the interplay of multiple factors, resulting in the inability of a community to respond appropriately to a given risk (2); the author defines this interplay of factors as overall vulnerability. Thus, overall vulnerability includes, *inter alia*, physical, economic, natural, social, political, technical, ideological, cultural, educational, ecological, environmental, and institutional vulnerability (2). The fact that there are different degrees of vulnerability requiring different levels of mitigation should also be considered in these definitions.

This chapter addresses the environmental vulnerability of communities, understood as the particular susceptibility of certain population groups to chemical, physical, or biological hazards. It is not intended as a treatise on this topic but does aim to highlight several useful points for decision-making. Thus, it focuses on three general aspects: i) differences in human susceptibility throughout the different stages of development; ii) the particular vulnerability of marginalized groups, with a focus on indigenous peoples and migrants; and iii) an introduction to several fields that have emerged in the search for tools to improve health promotion for vulnerable groups in our society.

## ■ Development- and age-related vulnerability

### Prenatal vulnerability

Exposure to a chemical, physical, or biological agent during an organism's development can have serious consequences for its health, because the growing organism is extremely vulnerable to such risks. In the embryonic and fetal stages, cells multiply, move around, and differentiate, and some must even die for tissues and organs to reach functional maturity. These processes involve multiple cellular signals that, if changed, can lead to alterations in development. The major manifestations of these alterations are death of the organism, structural abnormalities, altered growth, and functional impairments (3). Importantly, the appearance of some type of manifestation depends not only on the dose of the hazardous substance but on the critical time in which the exposure occurs. In other words, a single exposure can produce different effects on different organs or tissues depending on when it occurs. These critical periods of susceptibility to exposure, called "windows of susceptibility," are different for each organ and tissue, because they depend on the specific development of each (3).

Windows of susceptibility have attracted renewed interest, because while manifestations of in utero exposure may be expressed at birth (low birthweight, congenital malformations, infant mortality, etc.), they can also appear in childhood (asthma, cancer, and neurological and behavioral effects) or even in adulthood (degenerative neurologic disorders, cardiovascular diseases, or cancer) (3).

In 1988, reports began to appear correlating low birthweight with the emergence of diseases throughout life (4,5). These papers led to development of the hypothesis of the fetal origin of disease, which posits that in utero events that affect growth are capable of permanently altering fetal structures and physiology in ways that could increase the risk of cardiovascular diseases or diabetes at an advanced age (4). In this case, birthweight is actually a physical reflection of what might be happening at the cellular and/or genetic level. This led to an increase in research attempting to correlate in utero chemical exposure with the appearance of illnesses during childhood, adolescence, and adulthood.

The fetal origin of disease hypothesis has been reinforced by recent studies (5). For example, *smoking* during pregnancy has been associated with low birthweight, and an increase in vaginal cancer has been reported in adolescent girls whose mothers were exposed to the drug *diethylstilbestrol*. In addition, prenatal exposure to *lead* has been linked to delays in child mental development, and in utero exposure to *methylmercury*, to profound adverse effects on neurodevelopment (5).

The mechanisms that produce these effects are not entirely clear, but those associated with changes in the regulation of gene expression have been attracting major attention in the scientific community (6). For example, it is known that some pesticides (including dieldrin, toxaphene, lindane, atrazine, and a variety of fungicides) can increase gene translocation (6); many compounds alter DNA methylation level; cadmium causes changes in DNA repair; several air pollutants and other compounds, such as DDT and arsenic, activate inflammatory genes; and various toxic substances amplify genes and alter mRNA stability, protein degradation, and/or transposon activation (6). All these mechanisms may be activated during prenatal exposure, yet their significance for most compounds remains unknown; however, for example, prenatal epigenetic changes in DNA methylation from polycyclic aromatic hydrocarbons have been associated with the onset of asthma in children (7). Furthermore, it has been suggested that prenatal exposure to lead may act via changes in the expression and function of the N-methyl-D-aspartate (NMDA) receptor as a cause of schizophrenia (8).

Over 85,000 synthetic compounds are currently registered for commercial use, 2,800 of which are produced in quantities of 500 tons or more per year; as a result, these latter might be more associated with cases of human exposure (5). Unfortunately, fewer than half of these 2,800 compounds have been evaluated for their potential toxicity to humans, and fewer still for their toxicity to children or during development; thus, their potential toxicity is unknown (5).

Furthermore, it should not be forgotten that, under normal conditions, exposure involves a mixture of chemicals, and if the toxicity associated with the mixture's components is not known, calculating the toxicity associated with the entire mixture is much less likely. How many of those compounds are capable of crossing the placental barrier? The precautionary principle should be applied, and thus, women who are pregnant or trying to become pregnant should use risk assessment information to avoid exposure to hazardous chemicals (e.g., exposure to wood smoke during food preparation or exposure to chemicals in the workplace); hence, the importance of producing good risk communication programs targeting this sector of the population.

## Child health

“Children are not small adults” is a phrase that has gained increasing traction in recent years. Based on documents from WHO (9,10) and the Commission for Environmental Cooperation of North America (United States, Canada, and Mexico) (11), the Pan American Health Organization (12) has stated that children are the social group most vulnerable to environmental risks, for the following reasons, among others:

- *Distinctive physiology* (13). Children’s bodies are different; e.g., neonates have almost 30% more water than adults, mostly extracellular. Their metabolism is higher, and they therefore use more oxygen per kilogram of bodyweight. Certain bone characteristics (e.g., containing more water and fewer minerals and a fivefold increase in calcification between the first year of life and age 11) make metals that bind to bone—such as lead—more able to reach the nervous system. Myelination of the nervous system continues until adolescence, which facilitates organic compound binding. Furthermore, the blood-brain barrier is immature at birth, facilitating uptake of toxic substances by the central nervous system. At the least, infants have greater pulmonary absorption (inhalation rate relative to lung surface area is 60 times greater in children than in adults), greater gastrointestinal absorption (gastric pH is more alkaline in neonates), and dermal absorption (greater skin surface area relative to bodyweight).
- *Lower detoxification* (13). In general, newborns have lower levels of phase I detoxification enzymes (which carry out oxidation, reduction, or hydrolysis) and phase II detoxification enzymes (conjugation reactions), with activity peaking by the ages of 12–16 years. Both natural phenomena pose a risk, since lower enzyme activity confers lower detoxification capacity. Moreover, increased activity may produce more carcinogenic secondary metabolites (common during intermediary metabolism of various organic compounds). Neonates have lower renal excretory capacity for at least the first six months of life. Elimination half-lives of substances used as indicators of liver function (e.g., bilirubin) are longer in neonates. All the above indicates that children, especially newborns, have different detoxification capacity and lower excretion.
- *Stage of development*. Children’s bodies rapidly develop. If their cells and organs are exposed by toxic agents, the effects of this exposure can be more serious than they would be in adults. For example: lungs increase in size, structure, and elastic fiber content until the age of 18–20; in contrast, the full complement of neurons is reached in the first two years of life.

The result of all the differences between children and adults is that children respond differently to exposure. This can be illustrated by two facts: it has been estimated that given proportionately similar exposure, blood concentrations of some gases and fumes (e.g., styrene) will be greater in children than in adults (14). Furthermore, an analysis of toxicokinetic parameters of 45 drugs administered orally to children aged 2 months to 18 years found that the compounds’ half-lives were 3.2 times greater in children than in adults (13).

Children are more susceptible, not only because of their stage of development but because they have particular pathways of exposure. For example, they have greater dermal exposure from diaper use, breast milk intake (many pollutants are eliminated from the mother’s body through this route; persistent organic compounds provide a clear example), greater contact with the soil, greater time spent in places where they may inhale more particulates, and the characteristic curiosity and activities of their stage of life, which expose them to environments that might pose a risk (9–13). For example, when soil is contaminated by lead, children are more exposed than adults, not only because they ingest a greater number of soil particles, but also because a child’s body absorbs up to five times more lead than an adult’s—hence the assertion that the child is not a small adult. Thus, it follows that environmental regulations that protect adults do not always protect children.

## Adolescent health

Adolescence is a critical stage, since according to WHO, almost two-thirds of premature deaths and one-third of the burden of disease in adults are due to behaviors that begin in adolescence (e.g., smoking, limited physical activity, unprotected sex, etc.). Moreover, the effects of childhood exposure to dangerous toxic agents might be expressed in adolescence (the case of lead is a good example, since prenatal and/or childhood exposure are expressed as intellectual changes in the adolescent, which in turn may lead to violent behavior).

In conjunction with this, it should also be noted that the biology of adolescence is distinctive, and its features give some toxic agents the opportunity to affect the function or maturity of different organs. Not only does the reproductive system reach maturity in this stage of life, but the respiratory, immune, skeletal, and central nervous systems do as well (15).

Adolescence is a critical time not only for a higher risk of accidents but for the risk of certain infectious diseases (e.g., sexually transmitted infections). It has also been demonstrated that lung development is particularly affected in adolescents exposed to air pollution (16).

Pharmacokinetics at this stage is also distinctive, due to changes in blood volume, respiratory parameters, and metabolic needs (15). Finally, exposure pathways appear that are particular to adolescence—e.g., changes in dietary patterns may allow greater exposure to toxins present in food; while voluntary exposure—e.g., to drugs, tobacco, and alcohol—is also characteristic of this age.

## Health of the elderly

The elderly population is growing worldwide, and while this fact poses a challenge for society everywhere, this segment of the population is growing faster in Latin America. For example, from 1950 to 2050, life expectancy in the region will increase by 55%, and it is expected that by 2050 there will be 200 million adults over the age of 60. Poverty and unemployment, with all their implications, are concentrated in the elderly population, which can therefore be considered a vulnerable group (17). Older people face significant risks, from poor oral health to accidents or fractures, in addition to serious illnesses (e.g., cancer) and chronic degenerative diseases (e.g., hypertension and diabetes). This scenario makes the elderly very susceptible to exposure to dangerous agents and infections, because the body no longer responds appropriately to stressors (the increase in mortality among the elderly from exposure to high temperatures during heat waves is but one example of this fact). Certain changes in old age have been better studied from a pharmacokinetic, rather than a toxicokinetic, perspective. Several of these are discussed here (18).

Gastrointestinal absorption is apparently unaffected by age. However, body fat tends to increase and body water content to decrease with aging. This leads to an increase in the volume of distribution for lipophilic drugs, which in turn leads to an increase in elimination half-life. Serum albumin decreases with age, while  $\alpha_1$  acid glycoprotein increases. The effects of these changes are not clear, but in some patients, especially those who are malnourished, a rapid drop in albumin levels could heighten the effects of certain drugs as a consequence of the increased serum concentration of free drug, that is, unbound to proteins (18).

It is known that liver metabolism of drugs that use the cytochrome P450 system declines with age. For these drugs, clearance can diminish up to 40%. On the other hand, the conjugation system that uses glucuronic acid, for example, apparently does not change in old age (18).

Renal function declines with age, which affects compound excretion, thereby changing the half-life of chemical agents that are eliminated through the urinary tract. Both tubular and glomerular functions are diminished in the elderly (18).

All these changes applied to the world of toxic environmental agents lead to the conclusion that old age is a highly susceptible stage of life. Changes in compound absorption, distribution, metabolism, and excretion, along with changes in nutrition and cellular function, may produce greater susceptibility to toxicity mechanisms associated with environmental chemical agents.

Another matter in old age that should be addressed is disability. For example, it is known that the prevalence of falls in Latin America is higher than in the United States and that the risk of falls increases with age and can be due to the cumulative effect of many health problems, including diabetes, urinary incontinence, and depression. Consequently, timely prevention and appropriate community interventions could reduce falls and prevent greater disability in old age. It is estimated that women 60 years of age will live only 74% of the rest of their lives free of disability, compared to 83% for men of the same age. As the population ages, health systems face the challenge not only of increasing life expectancy but lengthening disability-free life expectancy (19).

## ■ Vulnerability from marginalization

### Poverty in the Americas

According to the ECLAC report *Social Panorama of Latin America 2012 (20)*, 29.4% of Latin America's population lives below the poverty line (i.e., nearly 168 million people), with 11.5% living in extreme poverty. Almost 75% of the poor reside in urban areas and half of those in extreme poverty, in rural areas (20). There is no single and simple solution to the fact that poverty is a factor in vulnerability to environmental health risks, (e.g., climate change and its health effects). This section therefore analyzes two scenarios to illustrate this issue, one focusing on native peoples (indigenous communities), and the other on migrant workers. As will be seen, **vulnerability to the environment** from marginalization in each scenario is reflected with various indicators.

### Native groups

An estimated 45 million indigenous people live in Latin America and the Caribbean, accounting for 10% of the region's total population and 27% of its rural population. Indigenous people belong to 400 native peoples, distributed across 24 countries (21), and are often concentrated in specific geographic regions.

Being indigenous is not a vulnerability factor in itself. Vulnerability is associated with the marginalization in which many indigenous communities live. Thus, there are conditions associated with not having enough good-quality drinking water; the use of biomass for heating and food preparation; exposure to pesticides (agricultural, domestic, and public health) and other agricultural chemicals; the endemism of vector-borne diseases (malaria, dengue, Chagas disease, etc.); poor waste and excreta management; poor housing conditions (e.g., from the accumulation of soot in ceilings); and social problems such as illiteracy, addictions such as alcoholism and smoking, domestic violence, unemployment, and lack of access to health, education, and legal services. These problems are embedded in a setting where natural resources are degraded from excessive logging, forest fires, changes in land use and subsequent soil exhaustion, the extinction of species, mass energy use, etc.

Poverty among indigenous peoples also leads to child labor; migration; low-paid, high-risk jobs (exposure to pesticides, brick factories, waste recycling, small-scale mining, etc.); diseases of poverty, such as communicable diseases, undernutrition, and malnutrition; the growth of human settlements in risky areas; and poor education of parents and children. All of this leads to poor intellectual development, compounding the problems. Vulnerability cannot be remedied with isolated assistance-based measures, such as delivering ecological stoves to indigenous communities or providing them with clean drinking water. Combating vulnerability in indigenous communities requires comprehensive programs that comprehensively address social, ecological, environmental, and public health problems.

Equity should take precedent in any intervention policy. For example, in some Latin American countries, such as Guatemala and Mexico, certain indigenous communities have worse health statistics in terms of child stunting than Yemen or Bangladesh. Furthermore, chronic malnutrition in Guatemala and Ecuador is twice as high in the indigenous population than in the nonindigenous population. On the one hand, the indigenous population is poor, but being indigenous increases the probability of being so; thus, the probability of being poor from being indigenous is 11% higher in Peru, 13% higher in Bolivia, 14% higher in Guatemala, 16% higher in Ecuador, and up to 30% higher in Mexico. In Mexico in particular, in 2002, economic gains of indigenous groups had fallen to only one quarter of those of nonindigenous groups (22).

Few places understand as well as indigenous communities that the definition and concept of health must go beyond the simple absence of disease; however, indigenous people are also sick—of inequity.

### Migrants

Migration in Latin America can be divided into three types: regional migration, to countries outside the Region; intraregional migration, between Latin American countries; and domestic migration, between different regions within a country. Regional migration in 2006 was estimated at close to 25 million Latin American and Caribbean migrants, with the United States being the top destination (18 million), followed by Spain (1.2 million). Intraregional migration reached nearly 3 million people, with Argentina, Costa Rica, and Venezuela being the main countries of destination. Finally, domestic migration occurs primarily among agricultural workers; in the Ameri-

cas, this phenomenon is perhaps most widespread in Mexico, where nearly 250,000 farm workers migrate from the indigenous southern regions to the agricultural fields of the north (23).

An important dimension of migration is the health risks migrants face and their public health implications. Migrants travel with their epidemiological history, their degree of exposure to infectious agents, their genetic and lifestyle-related risk factors, their culturally-based health beliefs, and their susceptibility to certain conditions. They also carry the vulnerability present in their original communities. If, for instance, immunization coverage is low in the country of origin or return, the original population risk will be carried to the destination country until coverage for migrants reaches the same level as that for the host population. Similarly, if the prevalence of a given communicable disease or any neglected disease is higher in the country of origin or return, migrants will have a greater likelihood of being affected by the condition and/or transporting it across borders. Conversely, when diseases have a high prevalence in destination countries, migrants may be affected and take them back to their country of origin or return. There is also evidence that certain noncommunicable diseases, such as hypertension, cardiovascular diseases, diabetes, and cancer, are an increasing burden on migrant populations and impose heavy demands on the health systems of destination countries (24).

With respect to migration, two new threats should be taken into account: persons displaced because of violence and persons displaced because of vulnerability to phenomena associated with climate change. On this last point, floods, hurricanes, extreme temperatures, crop losses, and, especially, droughts resulting from water stress, are factors that can drive population movements.

## ■ Environmental vulnerability scenarios

As explained in the introduction, the concept of vulnerability implies both the presence of a hazard and the inability of a community to respond appropriately to it. Environmental alterations produced by the presence of chemical, physical, or biological factors may be considered a hazard, and vulnerability would accordingly be defined as the inability of the population to respond to the presence of these environmental risks. The result of this interaction would be a health risk.

Vulnerability to toxic agents can be attributed to several factors: 1) an individual's susceptibility to toxicity mechanisms (the concept of windows of susceptibility has already been described and the question of the fetal origin of adult disease discussed); 2) malnutrition, which lowers defense mechanisms; 3) marginalization, which facilitates exposure to toxic substances and keeps the population from receiving prompt care from competent medical services; and 4) the simple fact of living in a high-risk area where contaminants have entered pathways to human exposure.

High-risk areas can be found in many locations, including agricultural areas (pesticides and other agricultural chemicals); mining regions (metals); oil production zones (aromatic organic pollutants); industrial zones (metals; gases, including sulfur dioxide and carbon monoxide; and particulates); communities with polluted surface water (biological and chemical pollutants); aquifers (natural pollutants, such as fluorine and arsenic); indigenous communities (firewood smoke, polycyclic aromatic hydrocarbons, carbon monoxide); garbage dumps (polybrominated compounds); and slums with microindustries (toxic mixtures, human settlements in risk areas).

The situation in environmental vulnerability scenarios is complex. On the one hand, contamination is commonly due not to one but several pollutants (mixtures of toxic chemical and/or biological agents), which can be present in more than one environmental pathway (air, water, soil, sediment, dust, food, etc.); thus, the people affected tend to be pregnant women, children, adolescents, adults, and/or the elderly. On the other hand, numerous contaminated sites are located in disadvantaged areas where malnutrition and lack of medical services are common factors. The conditions outlined above lend nuances to vulnerability that are very specific to each location, making it hard to measure and to prioritize the steps that can be taken to reduce it.

Below are several examples of environmental vulnerability scenarios, offered to demonstrate that the concept of community social development involves multidisciplinary intervention in environmental vulnerability.

### Children's environmental health in indigenous communities

Two of the biggest environmental threats to indigenous communities in several countries in the Region are wood smoke and water pollution. Smoke from firewood causes acute and chronic respiratory problems, and water pollution leads to diarrheal diseases. This is important, since respiratory and gastrointestinal illnesses are among the leading causes of child morbidity and mortality in Latin America and the Caribbean.

Notwithstanding, other effects are also associated with these environmental risks. For example, in addition to exposure to particulates and gases (associated with respiratory damage), contact with wood smoke also involves exposure to other chemicals such as polycyclic aromatic hydrocarbons (PAHs), formaldehyde, and carbon monoxide. In fact, in a Teének community in San Luis Potosí, Mexico, child exposure to PAHs was found to be 30 times higher than the level in an unexposed community (25). Such a high PAH level could not be explained solely by exposure to wood smoke (since children do not spend much time inside the house during food preparation); a search for other potential sources of exposure found soot (a greasy substance that accumulates on ceilings, walls, and floors in rooms where firewood is burned) with extremely high PAH levels.

Neonatal exposure to PAHs has been linked to childhood asthma (7). There is also some evidence of neuropsychological harm, and it has even been found that pyrene (one of the most abundant PAHs) lowers vitamin D concentrations by causing the vitamin to break down. Here, it is also important to point out that some PAHs are genotoxic and have been found to be associated with certain types of cancer (26). Finally, exposure to wood smoke, closely linked to PAHs, lowers birthweight, with an adjusted relative risk of 1.64 (27). Given all of the above, it is not surprising that high genotoxicity has been found in indigenous people exposed to wood smoke. These findings led to the adoption of a series of measures in the Teének community to decrease exposure to these compounds and their potential health effects. These measures included removing soot from rooms and subsequently installing a stove with a vent pipe to prevent indoor pollution. Implementing these measures led to a significant reduction in exposure to PAHs and genotoxicity, in addition to a reduction in carbon monoxide exposure (25).

These studies demonstrated the importance of exposure to wood smoke, soot, carbon monoxide, and PAHs in children exposed to these substances as early as in the womb. Exposure to wood smoke could put children at risk for asthma (from exposure to PAHs) and low birthweight (the latter of which could also stem from the malnutrition common in marginalized groups). Furthermore, due to genotoxic damage to immune cells and to possible vitamin D deficiency, children could suffer from some level of immunosuppression. In addition to the health risks from exposure to PAHs and malnutrition in these populations, another health effect that should be considered is the risk of learning disabilities. All of the above-mentioned conditions make children more vulnerable to marginalization and exposure to certain environmental risks.

Indigenous communities face other environmental hazards (e.g., vector-borne diseases such as dengue, malaria, or hantavirus; smoke from the burning of refuse; and the use of insecticides and other agricultural chemicals). By way of illustration, a study conducted in a Zoque community in Chiapas, Mexico, found that 90% of households burned refuse on their property (another source of PAHs and particulates). Furthermore, courtyards in 60% of dwellings contained items (such as tires or containers) that contribute to the risk of dengue, and when dengue appears, insecticide spraying is frequent (28).

In Zoque children, blood levels of DDT and DDE and of lindane were found to be 10 and 40 times the respective national averages. Blood-lead levels were also higher than safety guidelines in 10% of children, and finally, exposure to PAHs proved to be 27 times higher than the reference value. Furthermore, 23% of children were stunted and 63% showed signs of malnutrition. The Zoques have the same children's environmental health problems as the Teénaks, plus additional ones because they live beside a polluted river. Thus, numerous gastrointestinal infections were detected: 70% of children had parasites and 87% had microorganisms in pharyngeal exudate, several of them pathogenic (28).

Since environmental vulnerability in indigenous communities is reflected in children's health status associated with environmental conditions, it is important that public policies aimed at improving socioeconomic indicators not preclude work to identify and analyze environmental vulnerability factors and develop proposals to lessen their impact. As noted, education is a very important component in any society; thus, any intervention should take into account intellectual deficits in children and young people caused by marginalization and exposure to certain types of chemicals.

## Children's environmental health in slums

In Latin America, slums or shantytowns go by many names. Favelas are very rudimentary structures built on the fringes of major cities. The term evokes Brazilian neighborhoods, but has now been accepted in the Spanish language and no longer refers only to single dwellings but to clusters of them. In Venezuela, slums are called "barrios" or "suburbios;" in Colombia, "tugurios;" in Argentina, "villas miserias;" in Peru, "barriadas;" and in Mexico, "ciudades perdidas," "colonias de paracaidistas," or simply "barrios pobres." The urbanization of poverty has been a sweeping phenomenon that is increasing by the day. Today, 58% of Latin America's poor live in urban areas (29),

and due to the large number of slum dwellers living in poverty, the marginalization of slums poses one of the greatest challenges to health promotion and, therefore, environmental health.

The definition of a slum has evolved, and according to some studies, it could be said that living conditions in them have also changed. Slum dwellings may now be made of some type of permanent material, not just sheet metal and cardboard; they have electricity and always a television set. Although slums have improved in appearance, another way of looking at them is that their problems remain; only their face has changed. Furthermore, as a result of the urbanization of poverty, slums are no longer found only in large cities but also in medium-sized and small cities, meaning that they have increased in number and are more widely distributed.

These new slums have novel health problems, and those related to environmental health are critical. Research in a slum in the city of San Luis Potosí, Mexico, illustrates this point; indicators from the slum were compared with data obtained in a reference area in the same city (30). The study data are devastating. It was found that slum children had more than double the prevalence of dermatitis, gastrointestinal infections, diarrheal diseases, anemia, malnutrition, pathogenic bacteria in the upper respiratory tract, and parasitosis than children in the reference area. Parents' educational level was seven times lower; income, four times lower; basic sanitation was totally inadequate; and there was overcrowding, child labor, the use of firewood, and refuse burning. Furthermore, smoking was twice as common and more insecticides were used. In such a complex scenario, slum children are more exposed to lead, fluorine, polyaromatic hydrocarbons, and lindane.

The risk in this slum can be visualized in the child who is exposed to both environmental vulnerability factors, including chemical exposure, and poverty. It is therefore not surprising that a high percentage (59%) of children had a low IQ. In this group of children, low IQ was significantly correlated ( $p < 0.05$ ) with dental fluorosis, blood-lead levels, malnutrition, overcrowding, child labor, use of firewood in the home, and refuse burning (30).

According to United Nations Population Fund data, urban poverty is worsening by the year. Between 2000 and 2030, the urban population of Latin America and the Caribbean will grow from 394 to 609 million. Furthermore, it is anticipated that more than half of that growth will occur in cities with fewer than 500,000 residents (31).

In this context, slums are a consequence of intense urbanization in the absence of urban planning on the one hand, and a complete lack of social policies in rural areas on the other.

Populations move from rural to urban areas in search of better living conditions. A comparison of the indicators of slum dwellers with those of indigenous communities indicates that this objective has not been met. It can be concluded that in each case, children's environmental health requires urgent attention because, unfortunately, marginalization and environmental vulnerability persist in both these types of communities, although the determinants can vary.

### Children's environmental health indicators / community biomonitoring

Rural indigenous or urban slum scenarios have a common denominator: children are exposed to multiple chemical and biological agents (bacteria, parasites, viruses, allergens, etc.). Similar situations are found in mining areas, agricultural regions, and around oil and petrochemical industry operations. Xenobiotics and exposure levels may change, but there will always be children simultaneously exposed to chemical and biological agents.

Latin America has an abundance of marginalized indigenous regions, urban slums, mining towns, agricultural areas, industrial zones, oil fields, large metropolises (vehicular, industrial, and natural pollution), and, in addition, aquifers contaminated with organic compounds, arsenic, fluorine, and microbiological pollutants.

Thus, the environmental threat in the Region appears in the form of toxic chemical and/or biological agents. Furthermore, the Region also has a marginalized, often malnourished child population, ignorant of its risk. **This scenario of a vulnerable population threatened by physical, chemical, and biological contaminants clearly illustrates the context of environmental vulnerability.** In many cases, the environmental conditions responsible for various acute and chronic health effects, from before birth to old age, may lower the quality of life and, in other cases, even lead to death. Thus, these conditions should be addressed with multidisciplinary approaches to identify and analyze these effects and devise environmental and health policies to mitigate them.

Vulnerability scenarios are marked by a complex interaction among multiple factors, including the following:

- Geographical (coasts, riverbanks, deserts, highlands, tropical areas).
- Environmental (cities, rural areas, industrial parks, mining regions, agricultural and livestock regions, etc.).
- Social (illiteracy, poverty, and lack of health infrastructure, medical services, clean drinking water, excreta disposal, refuse collection, and other services).
- Cultural (indigenous populations, urban and rural populations).

All the above variables—which are linked—may affect exposure to hazardous agents, as well as the health impact on different population groups. Therefore, in this context the question again arises of how we should study environmental vulnerability in complex scenarios.

The answers are not simple, but there are some elements that can guide us. First, environmental vulnerability in Latin America must be addressed by **multidisciplinary primary care programs** and by following the WHO guidelines. Thus, to combat environmental vulnerability, more than hospitals, we need health workers on the ground. WHO has indicated that disease prevention and health promotion activities could reduce the global disease burden by 70% (32).

However, the previous point comes up against a harsh reality, since there are many vulnerable communities throughout the Region and—as noted—they are very diverse. Consequently, a second factor can be identified, which is that a **methodology involving the use of indicators** should be put forward to evaluate vulnerability. As noted in the WHO Committee on Social Determinants of Health report *Achieving Health Equity: From Root Causes To Fair Outcomes* (33), these indicators will be useful in monitoring the progress of assessment-based programs and measures that are put in place.

These types of indicators and different statistical tools can be used to develop maps and designs for evidence-based interventions (30), prioritizing intervention programs that change more than one indicator (e.g., a change in the use of firewood as a fuel for indoor food preparation has positive effects on several indicators: it decreases exposure to several pollutants, improving the respiratory and nervous systems; modifies ergonomics for women in terms of the burden of carrying firewood; protects women, since they do not have to go searching for firewood to the same extent; and reduces the demand for firewood, protecting forests and replacing this energy source with a less polluting one).

Indicators could also include biomarkers of exposure to chemical or biological substances. There have been several efforts to monitor toxic substances in different scenarios, the best initiative in this area perhaps being the National Biomonitoring Program of the U.S. Centers for Disease Control and Prevention (CDC). Furthermore, two studies have been conducted in Mexico on the use of biomarkers as indicators to identify environmental vulnerability (34,35). Open population studies have led to the development of measures that have reduced exposure to toxic substances and, thus, to health hazards (e.g., children exposed to PCBs were identified, and subsequent elimination of the pollution source prevented further exposure and a greater number of people being exposed to these toxic agents). In this regard, the experience of using biomarkers of exposure and effect as indicators to complement community environmental vulnerability indicators (pesticide use, water quality, firewood use, domestic burning of refuse, nutritional level, location of pollution sources, etc.) has been highly positive.

However, the proposal to conduct biomonitoring in populations exposed to chemical substances is constrained by the limited knowledge possessed by the Region's health workers about environmental toxicology. Thus, while managing some types of acute poisoning is the responsibility of physicians with expertise in this field, and several Latin American countries have set up Toxicology Information and Assistance Centers (CIAT), no similar agencies have been created to monitor and reduce the effects of chronic environmental poisoning. In fact, this problem is almost completely ignored at the primary care level.

Accordingly, a community clinical toxicology center should have teams consisting of professionals that address various aspects of **vulnerability**. Key to its good operation would be for it to have or be associated with a high-quality laboratory, in addition to having qualified staff to operate it. In the pursuit of health promotion, this center would need to be regional (covering a limited geographical region), multidisciplinary, and able to easily link with other institutions and/or different government and civil society structures (36).

## ■ New threats and required measures

New threats to the health and safety of vulnerable populations include global environmental change, including climate change; the appearance of new chemical compounds; biofuels; the emergence of new pathogenic microorganisms (such as the influenza A(H1N1) virus); electronic waste management; global health problems (a concept coined to explain the ease with which a disease can now travel from one region of the world to another); the appearance of chemical components that can affect the endocrine system (endocrine disruptors); and many others.

These new threats affect everyone, but to a greater extent individuals who are more susceptible. Coordinated local, national, regional, and global interventions are needed to address these threats. Below is a list of 12 measures pledged to protect one of the most vulnerable groups: children.

During the World Health Organization's Third International Conference on Children's Health and the Environment, held in June 2009 in the Republic of Korea, the participants agreed to a pledge for action that included 12 measures (37):

1. Advocate for the recognition, assessment, and consideration of hazardous environmental influences on children's health and development;
2. Contribute to raising the political profile of children's environmental health locally, nationally, regionally, and internationally;
3. Raise awareness about global climate change, green growth and children's environmental health synergies;
4. Train, educate and inform children, parents and key stakeholders at all levels (including health-care workers, environment professionals, nongovernmental organizations, industry and policy-makers) about children's health and the environment;
5. Integrate children's environmental health into existing public health programmes, especially into primary health care programmes, regional initiatives, international conventions and other programmes that address children and their environments;
6. Develop and strengthen specialized children's environmental health centres in order to prevent, diagnose, manage and treat environment-related illnesses and conditions;
7. Encourage collaborative CEH research studies that create new knowledge, incorporating biomarkers of environmental exposure and related health effects;
8. Advance the development of children's environmental health indicators. Ideally, these should be an expression of the link between environment and health, targeted at an issue of specific policy or management concern and presented in a form that facilitates effective decision-making;
9. Evaluate and document the efficacy of CEH-related interventions taken to date;
10. Establish dedicated partnerships and networks on CEH issues as a platform for improving health and the environment;
11. Strengthen communication among CEH stakeholders as an integral component of advancing progress, creating new channels and engaging the media in raising awareness about and championing children's environmental health issues;
12. Develop innovative funding mechanisms and opportunities that incorporate the environment into major health, development, education, housing and welfare projects, and into the context of international conventions, in order to promote and facilitate country implementation of CEH activities.

It is clear from this list that the proposals include different levels of intervention, sectors, and actors, as well as multiple fields of knowledge. They illustrate the combination of integration and a multidisciplinary approach toward a common goal—i.e., the improvement of children's environmental health—and here, it should not be forgotten that WHO considers children's environmental health to encompass intrauterine life through adolescence (age 18).

## ■ New tools

### New biomarkers: Molecular biology

Considering the breadth of this issue, we will confine ourselves to pointing out that the relationship between exposure to toxic agents and gene expression (gene-environment relationship) is a rapidly growing area of research (PubMed cites 295 reviews and 1,153 articles on this issue). Accordingly, molecular studies will gradually have wider applicability in the analysis of environmental vulnerability. In this context, some of the lines of research with the greatest impact are: i) studies of environmental exposure and the development of epigenetic effects that measure DNA methylation in specific sequences, which in turn correlates with the level of gene expression; ii) studies on genomics, proteomics, and metabolomics, which are turning out to be highly relevant to the study of toxicity mechanisms; iii) new relationships among nutrients and mechanisms for detoxification or immune system stimulation (e.g., the new roles being attributed to vitamin D in these fields); iv) recognition that endocrine systems can communicate among themselves through cellular signals; and v) recognition that many toxicity mechanisms are shared across species, which opens up an innovative field: that of shared health (biota and humans).

### New approaches: Comprehensive environmental health

Good environmental health implies a good quality of life under an ecosystem approach; i.e., that humans should be regarded as one participant more in a whole ecosystem. Consequently, environmental factors that can affect the population are not reduced to chemical, physical, or biological agents that can directly affect health, but, in affecting the ecosystem, affect the quality of life. Such factors include climate change, the breakdown and thinning of the ozone layer, desertification, loss of biodiversity, and deforestation.

For practical reasons, methods for assessing human and biota (ecological risk) health risks have been developed independently. However, it is increasingly recognized that there is a need for better levels of protection for humans and the other components of the environment. Thus, there is a need to design a methodology for integrated risk assessment that considers both the human population and other ecological receptors in a single process (38). In environmental matters, decisions cannot be entirely appropriate if they only partially consider the protection of humans or other species of flora and fauna. In many cases, environmental pollution affects nonhuman receptors more, due to greater exposure or their greater sensitivity to negative effects. Lack of integration often leads both the assessors of human risk and the assessors of ecological risk to obtain seemingly contradictory data about the nature of the risks associated with a contaminated site.

Finally, a work plan is needed that would include social, environmental, ecological, and human health indicators; i.e., total integration to address the full complexity that comes from integrating all receptors, established dynamics, and vulnerabilities.

### New approaches: The post-2015 development agenda from a community perspective

Numerous meetings are currently being held to define the post-2015 development agenda. It is still too early to see the new list of goals, but what *is* clear now is that whatever goals are finally adopted will have to influence global elements, including climate change and noncommunicable diseases, two issues that the current Millennium Development Goals (MDGs) do not specifically address.

Although no one disputes the benefits of having indicators to point the way toward integrated social development, it should not be forgotten that achievement of the MDGs is measured using national averages, and that while averages may point to progress, they also indicate that a percentage of the population has not met the required indicators and therefore remains in underdevelopment.

Aggressive measures are needed to tackle the problem of underdevelopment. For example, one way to complement top-down public policies is to draft bottom-up community plans that will help make government measures more successful. To be useful, these plans should be developed from a perspective that includes aspects of human rights, equity, and integration with ecosystems. To accomplish this, in addition to the new SDGs, various United Nations agencies have devised plans that will need to be reviewed, such as those on human security, the social determinants of health, and those that fall under the concept of “one health.”

Interdisciplinary social development programs with plans for community application would have another advantage—the inclusion of communities, which facilitate immediate development of successful prevention proposals in public health. Diabetes will not be controlled by building hospitals; however, disabilities in the most vulnerable sectors of our society are on the rise.

## ■ Recommendations for decision makers

- i) There is an urgent need to design and implement a regional maternal and child environmental health program for indigenous groups. One of the priorities of such a program should be protecting women—i.e., women of reproductive age who live and work in an environment permeated with smoke from refuse burning, domestic firewood use, and sometimes wildfires. Protecting women protects future mothers and thereby prevents malnutrition and the exposure of future children to environmental chemical agents.
- ii) To address the chronic effects of exposure to environmental agents, we suggest a health care model that includes multidisciplinary groups within the framework of a new area of study: community clinical toxicology. The goal of this new approach is to strengthen toxicology research and treatment centers so that their knowledge can be used to improve community health, without neglecting the hospital care they already provide so successfully (36).
- iii) There is an urgent need for comprehensive programs to provide care for growing vulnerable groups, including the elderly and families exposed to chemical substances, such as those who work on or live near farmland and slum dwellers.
- iv) In a world in which the human impact on natural resources is only increasing, new development plans are needed. This will require the development of a methodology for integrated risk assessment, with the following objectives: i) to improve the quality and efficiency of the assessment process through the exchange of information about health outcomes and the findings of ecotoxicology studies, and ii) to inform the environmental decision-making process with sound arguments (38). The integration of environment and health needs to happen now. Issues such as water quantity and quality, soil degradation, loss of forests, climate change, and other problems are just as important as poverty, lack of fair wages, gender inequity, and the health and safety of the population. So many needs in so many sectors make it necessary to adopt comprehensive intervention programs based on technical evidence, programs that can only be developed by multidisciplinary teams.
- v) Local (municipal, community, etc.), regional (state, provincial, departmental), and national governments should create teams of experts for comprehensive attention to the MDGs, with each community or region of the country adapting proposals from international organizations to its own needs. To this end, there is also a need to develop and validate community development indicators, useful for measuring achievements. These teams of experts could create a network in the Americas and the Caribbean to streamline knowledge and resources in the Region. In this regard, other concepts, such as human security and those related to social determinants of health, should be reviewed.
- vi) Attention to emerging problems or the worsening of existing ones requires the development of new technologies and new competencies. Governments should therefore promote science and technology, as well as the development of new educational initiatives, for which multidisciplinary plans can provide innovative perspectives.

## ■ Recommendations for scholars

- i) As already noted, good environmental health implies a good quality of life under an ecosystem approach—i.e., that humans should be regarded as one participant more in a whole ecosystem. New lines of research that could stem from this approach should be developed in the context of the recommendations issued by the WHO Commission on Social Determinants of Health (see links below).
- ii) In a world where nanotechnology and genetics are rapidly transforming industrial innovation and, with it, economic plans, adherence to ethical standards and the precautionary principle should not be secondary, so as to prevent potentially toxic products from entering the market under the rationale that social priorities are being served. Furthermore, when embracing new technologies (such as biofuel pro-

- duction) consideration should be given to the needs of vulnerable communities (i.e., grain production for a proper diet).
- iii) Researchers should share the results of their research on the health effects of environmental agents (physical, chemical, or biological) with society—especially, research on the fetal origin of postnatal diseases. These studies should serve as the basis for developing innovative protection plans in which new environmental regulations take the health of all social and age groups into account. As a result, opening channels of communication between academia and government sectors must be a priority.
  - iv) The creation of interdisciplinary groups of scientists is very important for gaining a better understanding of environmental risks in different ecosystems and fostering the concept of resiliency in both human communities and other components of the ecosystem.
  - v) Finally, indicators should be chosen that make it possible to measure vulnerability in different scenarios, through coordination with primary care programs. Although in a first attempt, indicators could be chosen for evaluating the MDGs, a potential constraint is that the available information may not be broken down to the community level. Thus, without discarding these indicators (MDG-type), whatever indicators are adopted for the analysis of community-level environmental vulnerability, the list should always contain the use of **biomarkers of exposure for chemical and biological monitoring** obtained by sampling a representative number of children in the community studied. Accordingly, programs for biological monitoring or biomonitoring of children (or other susceptible groups, such as women of reproductive age) should be implemented in areas of high environmental vulnerability, always selecting the most useful biomarkers for the critical contaminants in each area. In this regard, it is worthwhile noting the use of neuropsychological and respiratory tests to evaluate mental health and the respiratory system—aspects of health that are seriously affected in vulnerable groups by exposure to chemical and biological contaminants.

## ■ Conclusions

This chapter has addressed some vulnerabilities. Although not analyzed here, others, such as those linked to gender, pregnancy, individuals with chronic diseases, etc., are equally important. Multiple vulnerability factors were also examined that take the concept of environmental health beyond the traditional linkage of pollution with disease. In the age of nanotechnology and genomics, new progress should be linked to the solution of environmental, ecological, and health problems. Now more than ever, science must be relevant to reality and offer viable and effective multidisciplinary solutions. Poverty is globalizing, climate change is affecting every country, and international interdependency in health (e.g., A(N1H1) influenza epidemic) is becoming clearer by the day. Consequently, the concept of developed and developing nations may be applicable to the economy, but in matters of vulnerability and environmental health, the world is a whole and, as long as the risks of some affect others, it will have to be viewed as an underdeveloped world. In this scenario, programs with a regional scope should be established and nations should confront the vulnerabilities of some as the vulnerabilities of all.

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## ■ Links

Social determinants of health

[http://www.who.int/social\\_determinants/en/](http://www.who.int/social_determinants/en/)

Children's environmental health

<http://www.who.int/ceh/en/>

[http://whqlibdoc.who.int/publications/2006/924157237X\\_eng.pdf](http://whqlibdoc.who.int/publications/2006/924157237X_eng.pdf)

Climate change

<http://www.ipcc.ch/>

Green growth

<http://www.oecd.org/general/oecdworkongreengrowth.htm>

Millennium Development Goals

<http://www.un.org/millenniumgoals/>

Human security

<http://new.paho.org/hq/dmdocuments/2010/CD50.R16-e.pdf>



# Environmental health indicators for decision-making

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Alfonso Ruiz

## ■ Introduction

Constructing sustainable development and environmental health indicators is a complex process that is not confined merely to compiling the data needed to formulate figures usually pertaining to a population denominator. It is a process that must be firmly grounded in a clear and explicit understanding of the concept of development and its sustainability, in addition to establishing the interplay between health and the environment.

Development, environment, and health are intimately linked. Any development model generates environment impacts related to the use of available resources, the opportunity for members of a society to enjoy such resources, the ensuing environmental degradation, and the action taken to guarantee sustainability.

Development should be sustainable. According to Confalonieri (1), sustainability is the characteristic of a process or situation that can be maintained indefinitely. It is a concept applicable to development, the environment, and the population. The sustainability of our environment is currently being threatened by global environmental changes resulting from such processes as urbanization, land use, loss of biodiversity, climate change, etc.—all of them with a direct impact on our health.

Sustainable development must support human well-being in the broadest sense of the word, encompassing education, safety, the material basis for a decent life, health, good social relations, freedom, and opportunities. These aspects of well-being are consistent with our fundamental human rights, including the right to the highest attainable standard of health or, summarizing, the “right to health.” This includes the right to medical care as well as to the essential conditions for health (2).

Sustainable development and environmental health indicators must take all determinants essential for health into account. The indicators are therefore cross-sectoral by nature and this, as with other public health approaches, poses logistical problems because data collected from different sources for different purposes must be coordinated. Figure 8-1 depicts the relationships between health determinants and how they interact with health and the environment (3).

The Commission on Social Determinants of Health, established by the World Health Organization (WHO), published its report, *Closing the gap in a generation. Health equity through action on the social determinants of health*, in 2008 (4). This commission was set up in 2005 to “marshal the evidence on what can be done to promote health equity, and to foster a global movement to achieve it.” The report proposes a new approach to development, emphasizing how the health of the population depends on the circumstances in which people are born, grow, live, work,

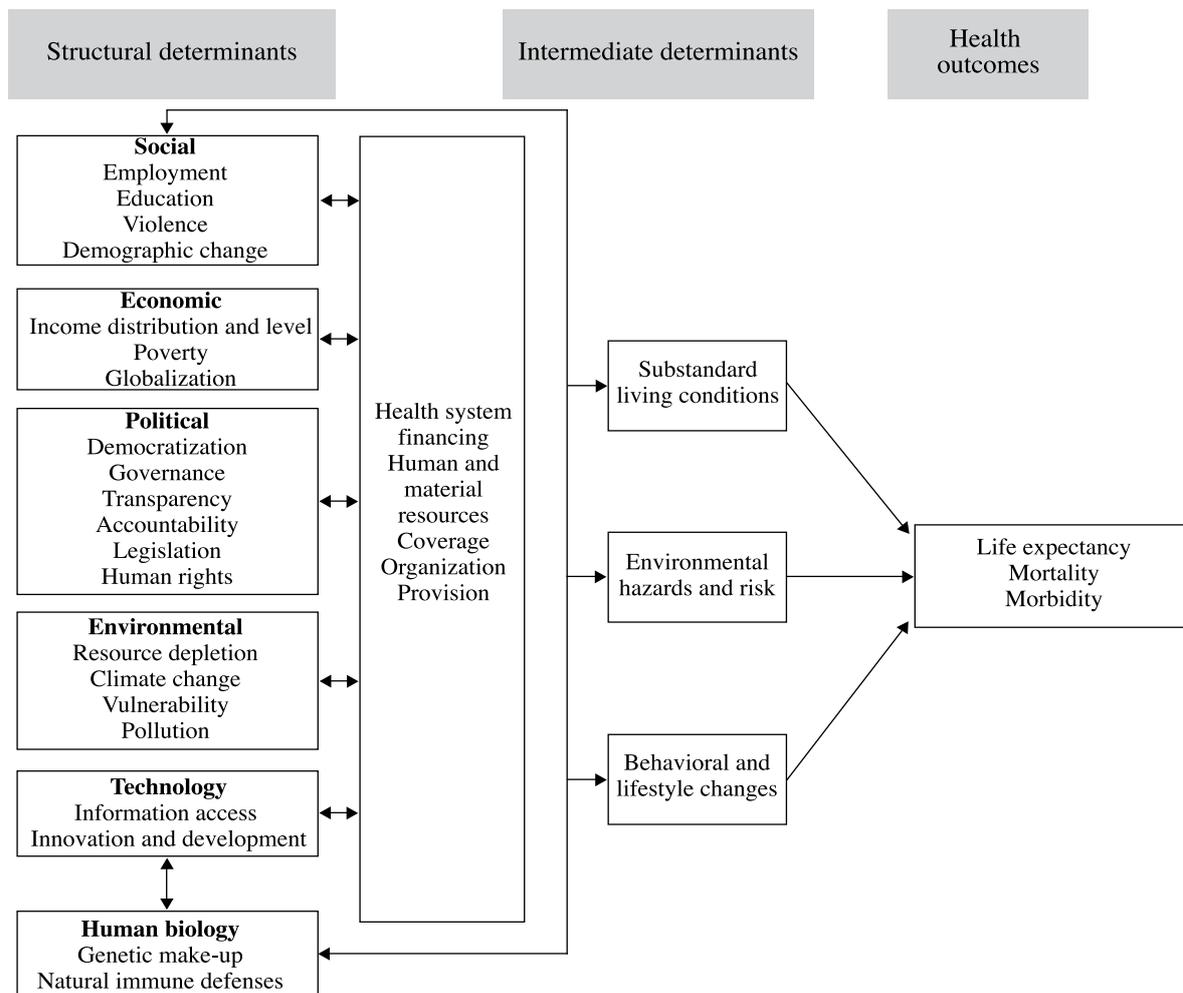
and age. It highlights how inequities in living conditions are shaped by deficient social programs and policies, unjust economic pacts, and political mismanagement. It calls for action on the social determinants of health and the participation of all public sectors, civil society, local communities, business, and international organizations and forums.

To implement policies that will support action on the social determinants of health, in which the environment plays a key role, we need indicators that will enable us to advocate for new conditions and illustrate what existing conditions and trends could be modified with appropriate interventions. Right now, State and health sector reform processes have begun to alter the distribution of environmental authority and responsibilities. Additional efforts are now required to improve data collection and encourage the participation of various sectors and the community in constructing relevant indicators.

Another implication for environmental health indicators in decision-making stems from the need for territorial disaggregation. Indicators, such as “regular access to drinking water” do not reflect differing intervention needs if they are estimated as a national or regional average, given the huge disparities between different population groups. This calls for territorial disaggregation according to the specific contexts of each country to generate indicators that elucidate the priority areas requiring intervention.

One of the greatest challenges in constructing these indicators is garnering the support and participation of social and administrative stakeholders, including local, subnational and national governments, ministry authorities, assorted agencies, and the general public. These indicators should constitute a fundamental tool in evaluating and managing risks in our society.

**Figure 8-1.** Health and health determinants: Interactions between health and the environment.



**Source:** Loyola E. Progress on Children's Environmental Health in the Americas. International Conference for the Evaluation of Global Health Strategies. Florence, Italy. 2006.

## ■ General criteria for constructing indicators

An indicator condenses large volumes of data into a general expression and reduces complex phenomena to simple, unambiguous messages. Indicators convert data into information that can be interpreted by policymakers and the general public alike (5). They can play a key role in highlighting the main problems or identifying trends and thus, aid decision-making, policy-making, and progress monitoring. Since the 1990s, Briggs (6) and other authors have defined environmental health indicators as those that link the environment and health, address a specific aspect of political or administrative interest, and are presented in a manner that facilitates their interpretation for effective decision-making.

This type of indicator has been used to (7):

- Monitor trends in the state of the environment to identify potential risks to health.
- Monitor health trends resulting from exposure to environmental risk factors to guide policy-making.
- Compare the environmental health status of areas or countries so as to target action where it is most needed or help allocate resources.
- Monitor and assess the effects of policies or other interventions on environmental health.
- Raise awareness about environmental health issues among different stakeholders (including policymakers, health officials, industry, the public, and the media).
- Investigate the potential links between environment and health as a basis for informing health interventions and policy-making.

Furthermore, a series of conditions must be met to guarantee the usefulness of indicators, ensuring that they adhere to common definitions and can be communicated in a standardized fashion to evaluate trends over time and facilitate comparability. These conditions are (8):

### Scientific validity:

- Credibility: based on a known linkage between environment and health.
- Sensitivity: sensitive to changes in the conditions of interest.
- Consistency: comparable over space and time.
- Strength (robustness): unaffected by minor changes in methodology, scale, or data.
- Representativeness: represents the conditions and areas of concern.
- Accuracy: based on reliable data.
- Scalability: capable of being used at different scales.

### Utility:

- Relevance: responds to a policy issue or practical concern.
- Transformability: related to a condition amenable to influence or control.
- Comprehensiveness and acceptability by those to whom it is addressed.
- Timeliness: kept up-to-date.
- Specificity: targets an explicit issue.
- Measurable: based on available data and manageable methods.
- Cost-effectiveness: capable of being constructed and used at acceptable costs.

The experience in constructing environmental health indicators is extensive. The United States of America (9), Canada (10), and the European Union countries (11) have developed reference and methodological frameworks that have enabled them to select and monitor environmental health conditions (12). The World Health Organization (WHO) has supported this process through initiatives such as the Global Action Plan for Children's Health and the Environment and the development of the Environment and Health Information System (ENHIS).

Indicators are not only quantitative; there are also qualitative indicators that express perceptions of exposure levels. Housing conditions (i.e., overcrowding, lighting and ventilation conditions) as perceived by residents have been compared with objective measurements (number of windows, or ventilation facilities), obtaining rather consistent results between qualitative perceptions and the objective evaluations.

Another aspect to consider when constructing indicators is quality control issues; for example, assessing the integrity of the information sources or the reliability of the primary data collection process. These elements are generally assessed using two criteria: the validity or true value, and the precision or reliability of the measurements. The former is evaluated relative to reference standards. So, for example, when evaluating air quality conditions using particulate matter values, calibrated equipment must be used, showing the parts-per-million in a unit of time, and under data collection conditions that adhere to international standards. This would be a valid measurement because it indicates the true particulate matter concentration. The latter criterion, replicability, means that with repeated measurements under similar conditions, the same observer, or several observers, will obtain consistent results.

When analyzing indicators, once their validity and replicability have been verified, estimates must be made to relate the measurement to other quantities, thus facilitating comparisons. For instance, it is useless to talk about absolute numbers when referring to weekly work-related accidents in a business if they are not associated with the number of active workers in the business. Thus, two work-related accidents in a small business with 10 employees are not the same thing as in a company of 50 employees: the risk or likelihood of accidents is higher in the smaller business. Hence, when developing indicators, it is essential to consider the denominators, as they facilitate comparisons within the same site over different time periods or between different sites.

Other aspects to be considered when analyzing indicators are related to the sample selected for the measurement. The sample must represent the conditions the investigator wants to show but must also be large enough to yield reliable estimates. How many measurements must be made to obtain accurate estimates? For example, how many water samples must be taken to representatively and specifically estimate the water quality in a locality? In technical terms, this is expressed as reducing measurement uncertainty or error.

Finally, when talking about environmental health, one cannot expect to find isolated exposure to a particular pollutant, as exposures are usually multiple, each contributing in its own way to the health problem. For example, the interaction between genetic susceptibility and environmental exposure is complex. This type of analysis must include a range of variables to estimate to the extent to which each contributes to the health problem and the interactions between the different variables. This is accomplished by using multivariate models that explore the weight of the different variables, determining whether they are correlated or whether they impact the health problem when they occur simultaneously. Thus, the incidence of lung cancer in workers exposed to asbestos fibers in the workplace differs depending on whether or not the workers smoke. In epidemiology, this is considered an interaction, and its analysis is vital to understanding the effect of environmental exposure on health outcomes.

Recently, the use of multivariate multilevel models has been increasing. These models are designed to explain how different health events relate in individual situations or within a broader context (i.e., at higher levels). For example, it is very different to observe individual aspects of the exposure of an asthmatic person to allergens in the home than to consider this same person and the levels of air pollution to which he or she may be exposed. A multilevel analysis would help explain the role of air pollution (higher-level analysis) in asthma attacks in individuals (first level).

We can therefore conclude that the potential for the construction, analysis, and application of indicators is enormous.

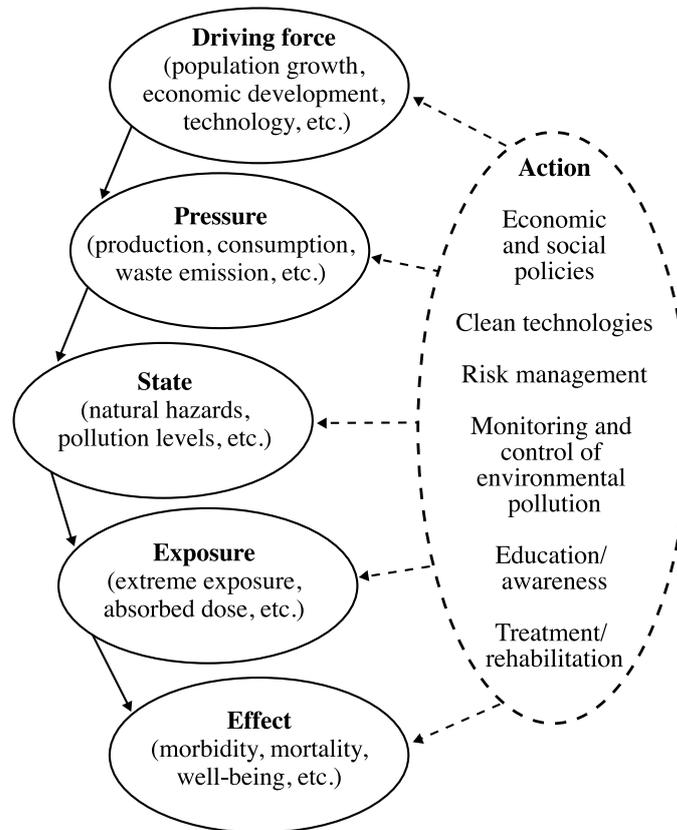
## ■ Conceptual models for sustainable development of environment and health indicators

The experience across Latin America in developing environmental health indicators is marked by different histories and conceptual frameworks, namely (13):

1. **Pressure-State-Response (PSR) model**, developed by the Organisation for Economic Co-operation and Development (OECD) in the 1990s. According to this model, human activities capable of altering the environment (e.g., industrial CO<sub>2</sub> emissions) exert *pressure* on the environment. The *state* refers to the consequences of this human activity, and the changes generated (e.g., climate change). Finally, the *response* is the action taken to prevent, reduce, or mitigate the effects of these changes in the environ-

- ment (e.g., reducing emissions or reforestation). This model underscores the importance of integrating economic and environmental aspects but does not consider health-related aspects. Conceptually, it is a simple, straightforward model that has been more widely used in developed countries. These types of indicators are very general but do not permit alert values to be set.
2. **Pressure-State-Impact-Response (PSIR) model of the GEO (Global Environmental Outlook).** This methodology was designed by the United Nations Environment Programme (UNEP) in the 1990s, and introduced the “impact” dimension into the previous model. The *impact* refers to the way in which environmental changes affect ecosystems or social well-being. This model includes a more comprehensive view and the possibility of establishing alerts. However, to construct this model, data from investigative processes are needed, many of which have yet to be conducted in Latin America and the Caribbean.
  3. **Health and Environmental Analysis for Decision-Making (HEADLAMP).** This model was proposed by WHO in the 1990s and further develops the concepts of the previous model with the addition of environmental *exposure* and *effects*, referring to how the environment impacts human health. The DP-SEEA model, as described below, is a derivation of this one (14).
  4. **Driving forces, pressure, state, exposure, effects, action (DPSEEA) model.** In this model, a *driving force* could be, for example, population growth, economic and technological development, and so on, whereas production processes and the consumption of goods and services or waste disposal exert *pressure* on the environment. The *state* of the environment refers to pollution levels, environmental changes that threaten human health, natural hazards, the availability of natural resources, etc. *Exposure* refers to the entry routes of substances, exposure levels, target organs, etc. *Effects* refer to morbidity, mortality, and loss of population well-being. Finally, *actions* consist of the formulation and implementation of economic and social policies, clean technology, risk management, environmental improvement, educational programs, legislation, and prevention and control measures. There are also some issues with data collection with this model, since it demands systematic monitoring to detect changes in the state of the environment and assess exposure levels (Figure 8-2).

Figure 8-2. Driving forces, pressure, state, exposure, effects, action (DPSEEA) model (15)



This model was used in Brazil in a water quality surveillance system that was expanded to the DPSEEA framework. Integrated into the National Health Information System, it is operating as an environmental health surveillance system (16). The indicators included in this system are monitored annually in each state and the country as a whole.

5. **Multiple Exposure-Multiple Effect (MEME) model** (17). This is a simplified extension of the previous model and includes multiple links between exposures and health effects. It is then used to develop both preventive and remedial actions to modify the relationships.

The “Making a Difference: Indicators to Improve Children’s Environmental Health” initiative, launched in 2003, was based on this model. It incorporates data on the contexts, exposures, health effects, and action taken for various groups of childhood illnesses, including perinatal, respiratory, and diarrheal diseases, insect-borne diseases, and physical injuries. By way of illustration, the following is a schematic outline of the “Physical injuries” model (Table 8-1).

**Table 8-1.** Multiple Exposure-Multiple Effect (MEME) model

<i>Physical injuries</i>	<i>Actions</i>
<b>Contexts:</b> <ul style="list-style-type: none"> <li>• Political instability</li> <li>• Urban development</li> <li>• Poverty/inequality</li> <li>• Population growth</li> </ul>	Political reform Social policy Economic policy
<b>Exposures:</b> <ul style="list-style-type: none"> <li>• War and conflict</li> <li>• Poor housing (physical hazards such as falls and burns)</li> <li>• Inadequate waste collection</li> <li>• Hazardous chemicals in the home</li> <li>• Inadequate water supply</li> <li>• Use of open water sources</li> <li>• Inadequate play space</li> <li>• Poor urban planning</li> <li>• Child labor</li> </ul>	Conflict resolution Improved planning control Housing improvement Sanitation/engineering Child labor laws Urban regeneration Policing and crime control Road traffic management Education Disaster preparedness Accident investigation
<b>Health outcomes:</b> <ul style="list-style-type: none"> <li>• War-related accidents</li> <li>• Falls and burns</li> <li>• Poisonings</li> <li>• Animal attacks and bites</li> <li>• Drowning</li> <li>• Road accidents</li> <li>• Occupational accidents</li> </ul>	Improved emergency services Medical services Health surveillance

**Source:** Adapted from Briggs, D. *Making a Difference: Indicators to Improve Children’s Environmental Health*. WHO, 2003. Geneva, Switzerland. Figure 7, pg. 9.

6. **Environmental burden of disease.** This method employed by WHO (18) makes it possible to measure and compare the health of populations or social groups affected by environmental impacts, assess the course of the health effects produced by these impacts, compare and assess the importance of the various risk factors at a given time, evaluate the results of the action taken, and set priorities and guidelines for decision-making, environmental management, and resource allocation. The DPSEEA model described above is used together with disability-adjusted life years (DALYs), years of potential life lost (YPLLs), and years lived with disability (YLDs). This model employs two methodological approaches, one based on exposure and the other on scenarios, to estimate the burden of disease attributable to environmental impacts using the indicators listed above. Constraints include estimates that are not always reliable, due to lack of data on diseases—especially noncommunicable diseases potentially associated with environmental impacts.

This model has been used to create country profiles with general indicators such as population, per capita income, urbanization, poverty, life expectancy, etc., as well as the burden of disease attributable to selected risk factors, such as improved drinking water, sanitation, air quality, and environmental burden of disease by categories such as diarrhea, respiratory infections, asthma, malaria, accidents, etc. For further information, see [http://www.who.int/quantifying\\_ehimpacts/en/](http://www.who.int/quantifying_ehimpacts/en/).

7. **GEO Health model (19).** This model emerged following the declaration issued by the Ministers of Health and Environment of the Americas (MSMAA) at their meeting in Ottawa in March 2002. At this meeting, the ministers committed to strengthening existing strategies and programs to promote cleaner environments and better health through policies designed to be fairer, to combat inequality and poverty, and to promote sustainable development.

The conceptual framework of this project is based on a socioenvironmental context in which socio-economic, political, and institutional macrostructures, as well as the characteristics and functions of ecosystems, are included in the economic development framework. At the center of this model are the characteristics of the population and its territorial distribution, technology skills, resource extraction and utilization, and waste disposal in the midst of poverty and inequity, all within the framework of globalization.

From this derives environmental impacts affecting health that are mediated by the vulnerability of the population. The principles of this project are an interdisciplinary approach, intersectoralism, and the participation of social stakeholders. The model comprises the concepts of driving forces, pressure, and state. However, before proceeding to exposure, effects, actions, and interventions, it includes an assessment of the environmental impact, socioenvironmental vulnerability, and health risks, where exposures and effects are interrelated. The model leads to both technical management and political action, where environmental interventions can be proactive, reactive, or remedial (Figure 8-3).

The methodological approach for the GEO Health process is a blend of the PSIR model (used to draft UNEP's GEO reports) and the methodological approach developed by the HEADLAMP project of UNEP, the U.S. Environmental Protection Agency, and WHO, based on the DPSEEA chain model. The GEO Health analysis tool integrates all these components to construct indicators and indexes (integrated indicators) that best characterize the environment-health relationship. Figure 8-4 summarizes the GEO Health model based on the DPSEEA chain.

This differs from other methodological approaches, including the HEADLAMP model, in that:

- It includes the participation of social stakeholders through open discussions on socioenvironmental issues and their reflection in human health in the area under study.
- It mobilizes social actors interested in participating in the drafting of a local or municipal agenda that identifies environmental problems and indicates the related priorities.
- It integrates each component of the DPSEEA chain – i.e., driving force, pressure, state, exposure, effect, action (Figure 8-2).
- It mobilizes social stakeholders to participate in integrated environment and health management through actions geared to conservation, protection, and the promotion of healthy environments and social well-being.

The GEO Health methodology, as shown in Figure 8-5, divides the indicator construction process into three different stages:

1. Participatory interdisciplinary and intersectoral assessment of the problem.
2. Identification, selection, and analysis of indicators and construction of integrated indicators.
3. A participatory management process, with actions based on the priorities identified in the integrated environment and health indicators. Implementation and monitoring of intersectoral actions thereby constitute a way to continuously improve the quality of the information and social participation.

## Country profile of environmental burden of disease

### Colombia

Population	45.6 million
GNI/capita	6,640 US\$
% urbanization	73%
% persons living in cities greater than 100,000 inhabitants	41%
Population below the poverty line (national)	64% (1999)
Population below the poverty line (international, < US\$ 1/day)	7% (2003)
Under age 5 mortality rate	21/1,000 live births (2006)
Life expectancy	74 years (2006)

### Environmental burden of disease for selected risk factors, per year

Estimates based on national exposure and WHO country health statistics 2004

Risk factor	Exposure		Deaths/year	DALY/1,000 cap/year
Water, sanitation, and hygiene (diarrhoea only)	Improved water:	93%	2,100	2.3
	Improved sanitation:	86%		
Indoor air	SFU% :	20%	2,400	0.9
Outdoor air	Mean urban PM <sub>10</sub> :	42 µg/m <sup>3</sup>	2,600	0.4
Main malaria vectors	<i>A. darlingi</i> ; <i>A. neivari</i> ; <i>A. nuneztovari</i> ; <i>A. albimanus</i> ; <i>A. aquasalis</i>			
Main other vectors	<i>Lutzornyia trapidoi</i> ; <i>L. olmeca</i> ; <i>Triatoma dimidiata</i> ; <i>Rhodnius prolixus</i>			

### Environmental burden of disease (preliminary), per year

Estimates based on Comparative Risk Assessment, evidence synthesis, and expert evaluation for regional exposure and WHO country health statistics, 2004

DALY /1,000 cap	(World - lowest: 13. highest: 289)	31
Deaths		45,100
% of total burden		16%

Environmental burden by disease category [DALY/1,000 capita] per year

Disease group	World's lowest country rate	Country rate	World's highest country rate
Diarrhoea	0.2	2.5	107
Respiratory infections	0.1	1.2	71
Malaria	0.0	0.2	34
Other vector-borne diseases	0.0	0.3	4.9
Lung cancer	0.0	0.2	2.6
Other cancers	0.3	1.5	4.1
Neuropsychiatric disorders	1.4	2.9	3.0
Cardiovascular disease	1.4	2.0	14
COPD	0.0	0.8	4.6
Asthma	0.0	0.9	2.8
Musculoskeletal diseases	0.5	0.8	1.5
Road traffic injuries	0.0	2.6	15
Other unintentional injuries	0.6	3.6	30
Intentional injuries	0.0	7.5	7.5

### Other indicators

Use of unleaded gasoline	No	(2006)
Overcrowding	27%	(1993)
Malnutrition (% stunting)	16%	(2005)



Figure 8-3. GEO Health model (20)

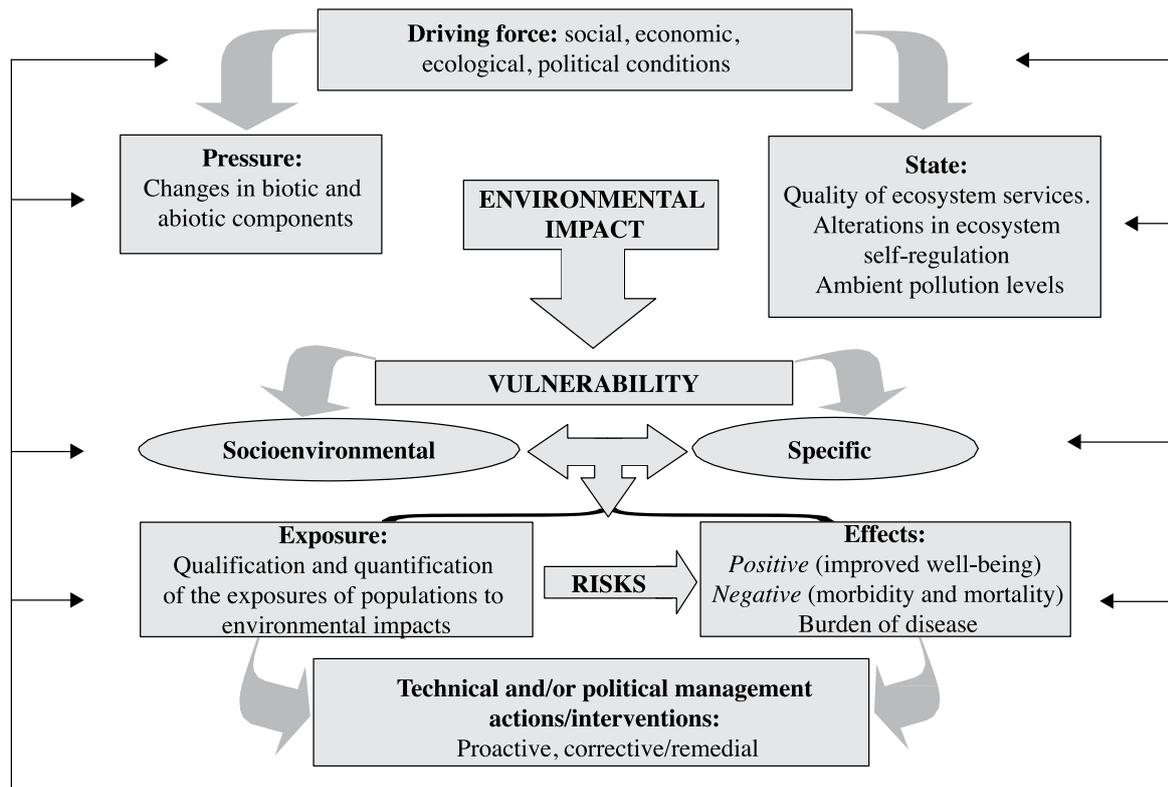


Figure 8-4. GEO Health model based on the DPSEEA chain (21)

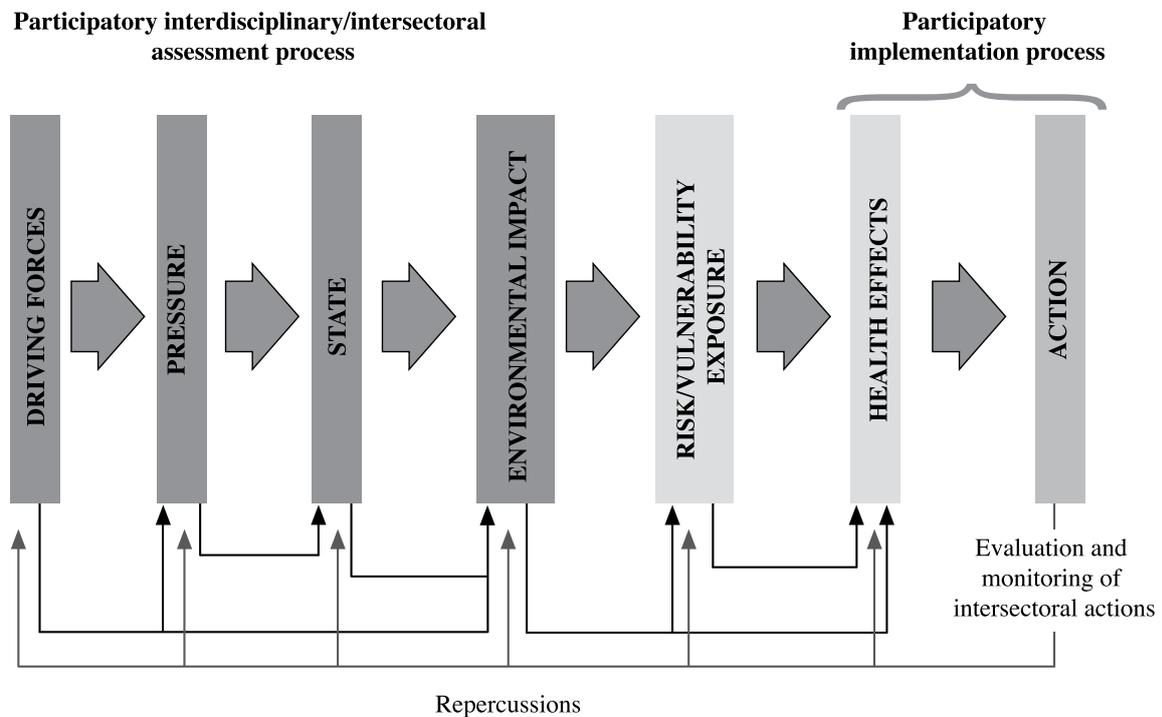
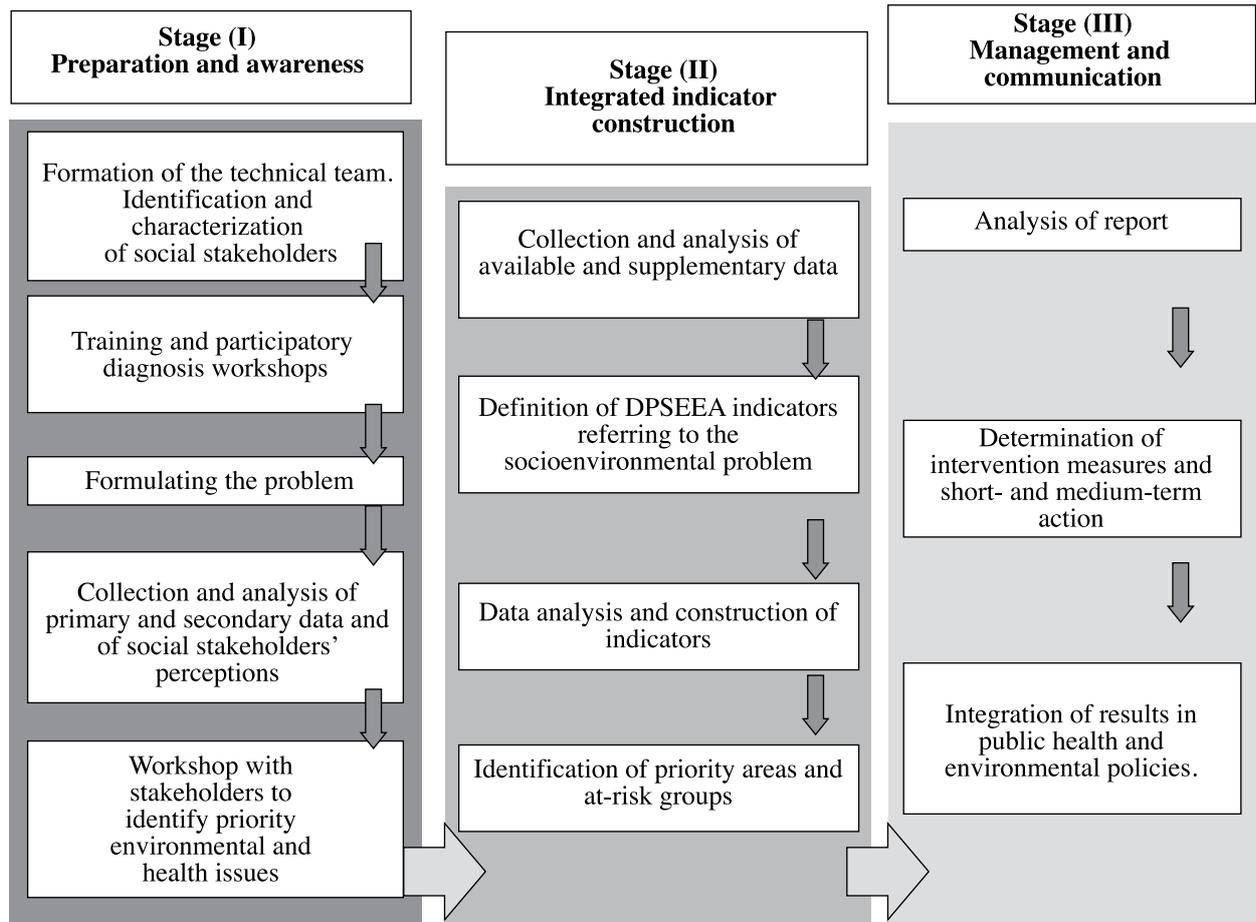


Figure 8-5. Methodology of GEO Health process



Steps in assessing perceptions of health and environment issues during the preparation and awareness stage of the GEO Health process:

1. Identify and characterize social stakeholders.
2. Capacity building and participatory diagnostic workshops.
3. Define methods to be used in workshops.
4. Generate a list of the specific health and environmental problems for the topic, based on the rapid participatory diagnostic (RPD) and collection of predetermined secondary data.
5. Analyze the problems dynamically with predetermined groups.
6. RPD: Create a detailed profile of socioenvironmental problems across the territory according to priorities.
7. Organize environmental and health problems in order of importance according to the social stakeholders involved in the GEO Health process.
8. Identify proposals and the priorities for action.

## ■ Case studies: Construction of environmental health indicators in the Americas

### Case 8-1

#### ENVIRONMENTAL HEALTH SURVEILLANCE IN QUEBEC OVER THE PAST DECADE

Pierre Gosselin

##### Context and institutions

Despite great interest in Quebec in establishing an integrated surveillance system for health problems linked with the environment over the past 20 years, it was only in the late 1990s that conditions were finally ripe for the development of this essential public health function.

In fact, it was the simultaneous arrival of the Internet and effective online data storage and mapping instruments that created this favorable context. The institutional framework, however, greatly limited the implementation of new environmental health projects, since surveillance responsibilities had not been assigned to the competent environmental health teams. Furthermore, many critical data were not held by the public health network but by numerous other government departments (environment, natural resources, municipal affairs, etc.) and data exchange was still not common practice.

The amendment of Quebec's Public Health Act (22) in December 2001 would mark a major restructuring of surveillance in Quebec, granting greater authority to public health sectors previously excluded from surveillance activities to make up for lost time. Environmental health was part of this group. This reform promoted the notion that surveillance is primarily a public health function and that the Ministry of Health and the regional public health authorities must publish annual reports on the health status of the population, pursuant to a 10-year public health program.

This legal obligation, together with the respective budgets, marked the beginning of a vast reform supported by different research projects to explore the new technologies (a). The law also empowered public health authorities to request other government agencies to give them access to the data needed for this surveillance function.

##### Methodologies

The first steps in this process consisted mainly of a needs analysis conducted with users in the field and a detailed analysis of the available data and its quality. For health professionals, the needs identified included easy access to the data compiled (on health and territorial matters), data on known hazards, and environmental data to calculate exposure.

Various methods were then used to draw up a list of representative indicators for the area of interest, gradually building consensus between experts and users. The result was a list of 41 indicators in 2004, with the data to analyze 26 of them. A research and development plan was drafted for the remaining 15 indicators, especially for components on climate change and sustainable development. This plan constitutes an important instrument that justifies long-term investments in this area.

A conceptual model based on the one adopted in 2002 by the Data Council of the U.S. Department of Health and Human Services was used to select the indicators (b). However, this model evolved in Quebec to incorporate the modern concept of ecosystem services (c,d), relatively unknown outside the field of environmental health.

##### Main results

In 2003, this important work on data, its organization, and access led to the creation of a real-time surveillance system for West Nile virus, which had just appeared in North America (e). Then, in 2006, an initial general health and environment assessment (f) was published within the framework of the report *Rapport national sur l'état de santé de la population du Québec* (National Report on the Health Status of the Population of Québec), covering all aspects of public health.

Published every five years, this report looks at 26 environmental health indicators and interprets them. Other annual or occasional surveillance reports are published on topics such as asbestos and pleural mesothelioma (g), pollen allergies (h), and chemical poisoning (i).

The research and development efforts also provided interesting results for the future (j). An initial survey of population attitudes and behaviors with respect to climate change in 2005 (k,l) will most likely be repeated

sporadically. In 2011, a real-time heat-wave surveillance system was set up across the province (basic systems were set up in 2005-2006 in almost all regions), and in 2012, a system for other extreme weather-related phenomena (such as storms, floods, or forest fires) and their health impact was set up. These projects are part of a broad governmental plan for adaptation to climate change, which also includes surveillance of certain zoonotic and vector-borne diseases, as well as other risk factors.

### Problems and lessons learned

One of the initial problems of this reform was making environmental health an integral component of surveillance functions, which had exclusive routines and spheres of activity. Once this first step was taken, we had to clearly explain our objectives and the type of future collaboration that would be necessary to our colleagues and external associates (i.e., other government departments with important data). These conversations were generally productive, but some were more drawn out than others. Negotiations are fruitful when environmental health professionals end up expanding their scope of activity into such important fields as environmental justice, methods for harmonizing databases, etc. Finally, we must also begin to think about replacing colleagues who leave or retire and retaining experts. This is difficult due to the highly specialized nature of this field, especially in the areas of spatial-temporal or climate time series analyses.

### Conclusions and recommendations

New projects have been launched, especially to examine the interaction between climate and certain known risks, such as air pollution, zoonoses, and vector-borne diseases. Other less documented issues are also being investigated (i.e., hip fractures and falls on icy roads and sidewalks, or strokes) that could be subject to surveillance depending on future results.

The process should be embarked upon with a long-term vision, prioritizing the quality of the basic data (research, pollutant measurements, morbidity and mortality measurement, use of medical services, etc.). A 10-year plan guarantees results, provided that it has financial backing and a competent team and that greater interaction can be established between the various public health and environment sectors, taken in the broadest sense.

The next challenge—in fact the next generation of surveillance and analysis studies – will consist of better integration of individual exposures, examining how they relate to diseases or health problems, and monitoring, through cohorts for example. Better use of surveys, especially interviewing the same people periodically over extended periods, will lead to better analysis of cause-and-effect relationships than simple cross-sectional studies. Proper monitoring of environmental pollutants will be another prerequisite.

Surveillance is the cornerstone of any public health system and continues to be the primary essential function: erroneous data leads to unsound decision-making, depleted budgets, and too few results. The immediate inclusion of risks to the environment and ecosystems in surveillance is vital.

### List of data categories and indicators used in Quebec

#### Environmental:

- Recreational water quality (above microbiological and cyanobacteria standards).
- Drinking water quality (above microbiological and chemical standards).
- Number and duration of warnings to boil water or not drink it.
- Wastewater treatment situation.
- Exposure to tobacco smoke.
- Number of days with poor air quality (exceeding PM<sub>2.5</sub>, O<sub>3</sub>, NO<sub>2</sub>, SO<sub>2</sub>, and CO time and day limits).
- Air emissions of the principal pollutants generated by motor vehicles.

#### Health:

- Carbon monoxide poisoning.
- Other chemical poisoning.
- Reportable infectious diseases related to environmental conditions.
- Prevalence of allergic rhinitis.
- Cancers (respiratory tract, pleura, kidneys, thyroid, brain, lymphomas) associated with environmental exposure.
- Mortality and hospitalization rate, by region, for certain conditions (asthma, respiratory problems, cardiac arrhythmia, ischemic heart diseases, birth defects, miscarriages, low birthweight) associated with environmental conditions.

**New:**

- Noise.
- Indoor air quality.
- Exposure to pesticides.
- Health determinants, risk factors, morbidity, and mortality related to extreme weather conditions.
- Monitoring of some ecosystem services (agricultural soils, parks, etc.).

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**Case 8-2****PROPOSED BASIC ENVIRONMENTAL PUBLIC HEALTH INDICATORS FOR THE U.S. – MEXICO BORDER REGION**

Gosselin P, Furgal Ch, Ruiz A.

*Environmental Public Health Indicators for the U.S.-Mexico Border Region. Concept Document.*

PAHO. U.S.-Mexico Border Field Office. 2001.

This initiative, which dates back to the beginning of this century, has its origins in the La Paz Agreement, signed in 1983, when the Mexico-U.S. Border XXI Program was established to address socioeconomic conditions in the border region, characterized by rapid urban population growth, industrial and agricultural development, migration, poverty, and informal human settlements, with the consequent impact on the environment and health of the population living in the area along the border between the two countries.

This binational Border XXI Program brought together different sectors and institutions to share epidemiological and public health information that would be used to guide social and health care policies in the border region. Core health data from sister cities, mortality profiles, and environmental health surveys were included. A framework was also created for collaborative health and environmental protection, as well as the proper management of the countries' natural resources.

Various organizations and agencies participated in this initiative, among them the Pan American Health Organization (PAHO), the Centers for Disease Control and Prevention (CDC), and the U.S. Environmental Protection Agency (EPA), together with the Secretariat of Environment and Natural Resources (SEMARNAT) and the General Environmental Health (DGSA) and Epidemiology (DGE) Directorates of the Secretariat of Health of Mexico. The primary goal is to promote sustainable development in the border region, seeking a balance between social and economic factors and environmental protection in border communities and ecological areas. The goals are:

1. Improve public health in the border region.
2. Increase efficient use and protection of water resources.
3. Develop infrastructure for water treatment and solid waste treatment and disposal.
4. Meet national air quality standards.
5. Increase information exchange and cross-border notification capacity.
6. Increase communities' ability to respond to environmental emergencies in the border region.
7. Increase local technical capacity.
8. Increase effective enforcement and compliance with U.S. and Mexican environmental laws.

The indicators used to monitor the scope of each goal were defined. Some constraints in data collection were also identified: the same terminology was used with different definitions, the available data were not comparable, and the health impact could not be measured with the data compiled.

The recommendations issued by this border initiative were to promote acceptance of the various program components by participating communities, a quality control and assurance program for laboratory services, and data quality management and evaluation to continue the process in the future.

## Case 8-3

### **INTEGRATED ENVIRONMENTAL AND HEALTH INDICATORS FOR WATER-BORNE DISEASES: GEO HEALTH PILOT STUDY IN SÃO PAULO, BRAZIL**

*Sandra Hacon*

The great Brazilian metropolis of São Paulo, located almost on the Tropic of Capricorn, has an estimated population of over 11 million, distributed unevenly across a territory covering 1,509 km<sup>2</sup>, at an average altitude of 760 m above sea level. The city, one of the largest in the world, is divided into 96 administrative districts (ADs). Given the availability and quality of the secondary health data at this geographical aggregation level, São Paulo's ADs were adopted as the spatial unit of analysis for the GEO Health São Paulo pilot study.

The GEO Health process generated indicators for all components of the conceptual framework. For example, using the RPD research tool, vulnerabilities and exposure situations were identified, contributing to the development of the most appropriate indicators for the vulnerability and health effects components.

#### **Background**

In response to the declaration of the Ministers of Health and Environment of the Americas, signed in Ottawa in March 2002, in 2003 UNEP and PAHO, with technical collaboration from the Oswaldo Cruz Foundation (FIOCRUZ) (Ministry of Health of Brazil), decided on a joint project for integrated health and environment assessments. Many institutions and experts from Latin American and Caribbean countries also came on board.

The primary objective of the GEO Health project was to develop an integrated environment and health assessment strategy that would grant subsidies to decision makers and public policymakers to promote a healthier environment and improve the health and well-being of the population.

During project implementation, eight methodologies on the relationship between the environment and health were initially evaluated (*a*). Next, a document was drafted outlining a methodological approach for the various steps in the participatory, interdisciplinary, and intersectoral assessment process. This was presented to the Latin America and the Caribbean working group in San José, Costa Rica, in 2004. A technical glossary was prepared by members of the U.S.-Mexico Foundation for Science. In 2005, discussions were held in Mexico City on strategies for conducting

pilot projects based on case studies to make methodological adjustments to include sector-wide, thematic, and ecosystem approaches (*see note in Case 8-1*).

The Municipal Green and Environment Secretariat (SVMA) was responsible for thematic definition of the GEO Health pilot study in Brazil, selecting the problems related to sanitary conditions in the districts of São Paulo as the environmental dimension. In 2008, a workshop was held in São Paulo city to discuss the progress and results of the pilot study. Members of the UNEP and PAHO teams, experts, and representatives from various government agencies responsible for health and the environment in Brazil attended this event.

### Entities involved

Several organizations and social stakeholders were involved in conducting the pilot study in São Paulo to identify and assess the environmental factors affecting health and to select potential areas for implementation of the GEO Health project.

UNEP forged partnerships with the SVMA of São Paulo City Hall to conduct the GEO Health pilot project, with the National School of Public Health of the Oswaldo Cruz Foundation (ENSP/FIOCRUZ) serving as the implementing institution. The SVMA, the Municipal Health Secretariat (SMS), and the Primary Care Coordination Office also took part in the GEO Health project. The SVMA was responsible for environmental policy and management for the city of São Paulo.

### Setting priorities

The 96 administrative districts (ADs) of the city of São Paulo were divided into four quartiles in descending order, based on the results of the two DPSEEA integrated indicators:

- The 25% closest to 1: quartile with “very poor” conditions.
- The next 25%: quartile with “poor” conditions.
- The next 25%: quartile with “good” conditions.
- The last 25%, closest to 0: quartile with “very good” conditions.

Districts with “very poor” results in the two integrated indicators are considered Priority Level 1; those with “very poor” results in at least one of the two integrated indicators are considered Priority Level 2; finally, those with no “very poor” results were considered not a priority.

Analysis of the integrated indicators revealed that the health effects of water-borne diseases evaluated in relation to the environmental health situation were concentrated in 14 ADs in the city of São Paulo, home to 25% of the population. These ADs (Priority Level 1) showed very poor results in both integrated indicators. Also, another 7 ADs (17.6% of the population) had very poor results in one indicator (Priority Level 2). Unquestionably, intersectoral interventions to correct or mitigate this environmental impact could help improve the health conditions of 42.5% of the population of São Paulo. Figures 8-6, 8-7, 8-8, and 8-9 show the map of São Paulo, divided into ADs and classified according to priority levels for interventions to combat water-borne diseases associated with environmental degradation of the city’s water supply.

The figures present the results of some integrated environment and health indicators for water-borne diseases, revealing the sanitary conditions of São Paulo as an environmental issue. (c)

### Achievements

The principal outcomes from the construction of the integrated indicators made it possible to identify areas (ADs) in São Paulo where actions that alter driving force, pressure, or state patterns would have the greatest impact on the health of the population. Each component of the DPSEEA chain proposed for GEO Health is presented in order of importance. This differs from the isolated interpretation of the classic health (epidemiological) or environment (sanitary) indicators, because some determinants are considered in the construction of the indicators through the different components of the chain. We can therefore learn about health or environmental conditions through a spatial unit of analysis and then classify them by intervention priority.

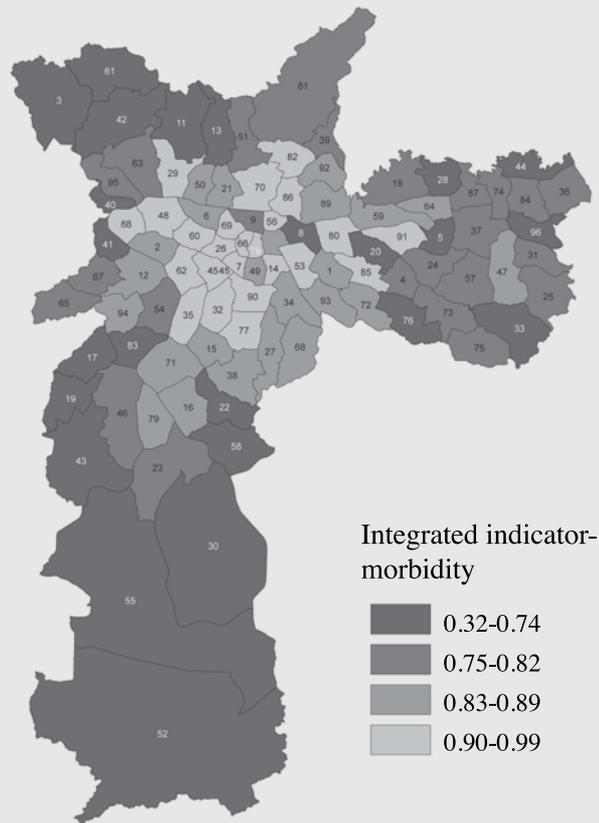
The GEO Health pilot study in São Paulo shows that including social stakeholders enriches the discussion, promotes the decentralization of public administration, and introduces greater flexibility in the role of public policy-making bodies. The participatory process emphasizes local negotiations, facilitates management by institutions, and maximizes the socioenvironmental management process, fostering greater participation by the social stakeholders committed to environmental and health integration.

The participation of community leaders in this pilot study was fundamental in highlighting and discussing environmental health problems, which are still not portrayed or discussed officially in the public policies of the State.

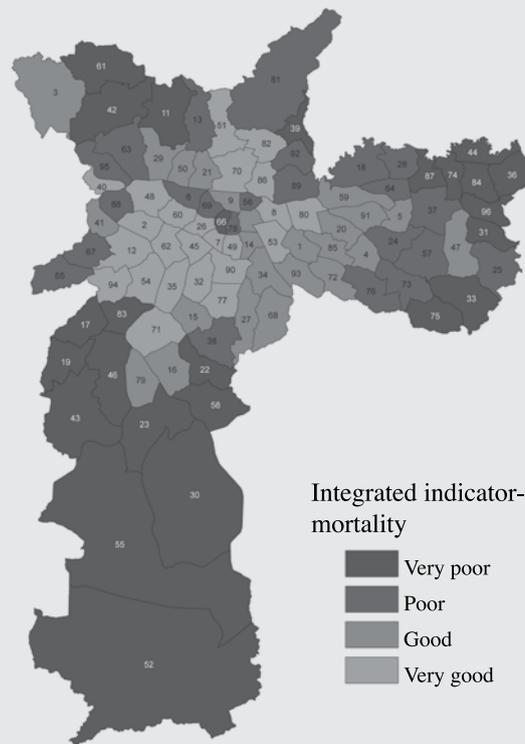
## Problems

One of the greatest challenges during the GEO Health pilot study in São Paulo was the constraints related to the quality and quantity of the data, time series, registries, and processing of updated primary exposure data, used as indicators of exposure, vulnerability, and diseases in the sanitary conditions of residential areas. Technological capability is another constraint across the Latin American and Caribbean region. In such cases, the GEO Health process must strengthen local capacity, use indirect indicators, and—if necessary—generate primary data that is easy to collect and process.

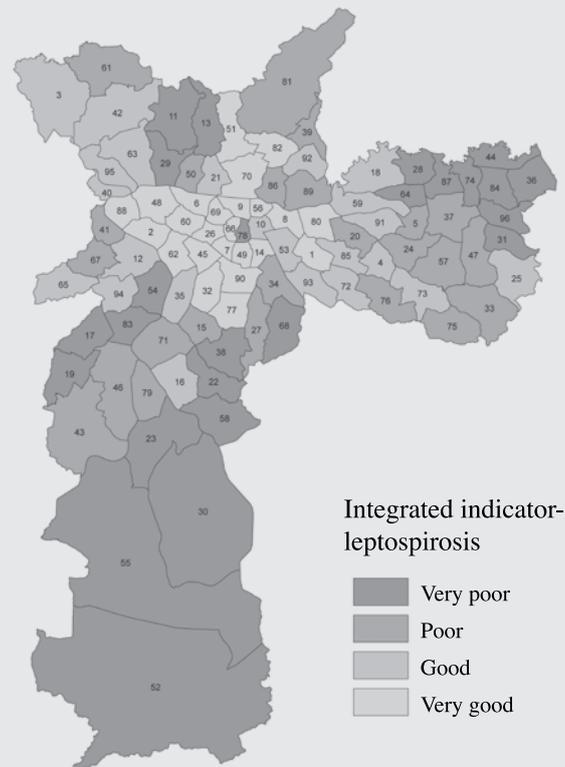
**Figure 8-6.** Integrated health and environment indicator for water-borne diseases by AD. São Paulo, 2007. Integrated indicator—morbidity



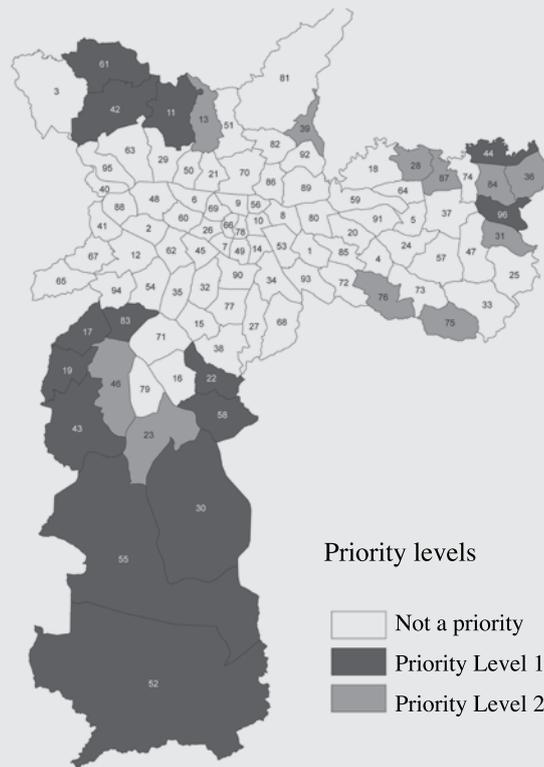
**Figure 8-7.** Integrated health and environment indicator for infant mortality by AD. São Paulo, 2007. Integrated indicator—mortality



**Figure 8-8.** Integrated health and environment indicator for leptospirosis by AD. São Paulo, 2007



**Figure 8-9.** Priority areas. Integrated health and environment indicator for water-borne diseases and infant mortality. São Paulo, 2007.



### Outlook

Constructing integrated health and environment indicators for the city of São Paulo made it possible to identify the principal environmental sanitation issues of concern to the population and determine the priority areas for integrated environment and health management activities or interventions in this area. These indicators also led to the detection of situations of extreme health impact that are rarely considered health problems as they are related more to sanitation. These situations call for discussion using an integrated environment and health approach, not only in the state of São Paulo but in other regions of Brazil as well.

Primary environmental care is still not fully or effectively part of the government or private-sector agenda, although it is mentioned in official documents. Deficiencies in basic health services are concentrated in the poorer sectors of society. These new “environmental burdens” must therefore be added to the other burdens to which these poorer sectors are exposed, without a health sector capable of diagnosing these so-called “new diseases” associated with the economic transition to more complex development processes currently under way in Latin America.

### Conclusions and recommendations

GEO Health represents an advance in environmental assessment methods that previously were geographically based and tended to generalize health determinants, using risk assessment methods that tended to generalize environmental determinants as well. GEO Health broadens the environmental health approach by exploring the interactions between the degradation or loss of environmental services and the effects on the conditions and quality of life of the human population. We believe that health is more effectively interpreted this way—not as the mere absence of disease, but in the wider sense of physical, psychological, and social well-being. The results of the pilot study in São Paulo showed that GEO Health is a participatory, interdisciplinary, and intersectoral methodological instrument conceived and designed to foster social empowerment and the formulation and implementation of policies that can promote a more sustainable quality of life. (d)

This pilot study confirmed once again that, even though São Paulo is one of the areas with the highest GDP in Brazil, the quality of life (associated with social well-being and the reduction of social costs related to health) in the city is still not a priority issue on the environment and health policy agenda.

Given the appalling environmental degradation, further pilot studies that consider the diversity of socioenvironmental problems in Latin America and the Caribbean are needed, as are indicators of the social well-being of communities.

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## Case 8-4

### INTERINSTITUTIONAL HEALTH INFORMATION NETWORK (RIPSA, INTERAGENCY HEALTH INFORMATION NETWORK)

João B. Risi Jr.

The Ministry of Health in Brazil and PAHO/WHO set up the Interagency Health Information Network (RIPSA: *Rede Interagencial de Informações para a Saúde*), based on Brazil's Unified Health System (SUS) and a 1995 analysis of problems in developing health policies. The Federal Constitution of 1988 and the Organic Health Laws of 1990 provide the legal underpinnings for this action.

The experience made it possible to integrate public health and health care, strengthening decentralization with information to improve municipal management, developing mechanisms to enable the various stakeholders to reach consensus, and fostering social participation through conferences and health councils.

The principal strategies focused on providing appropriate information for decision-making, systematizing multiple sources of data on health conditions and their determinants, and designing methodologies to support public health policy management. The strategy was supported by disseminating the lessons learned from successful experiences to key segments of society.

The available information sources are:

- Scientific databases (BIREME).
- National health information systems (Ministry of Health).
- Special surveys on health issues (Ministry of Health).
- Social policy analysis (IPEA).
- Sectoral information system (other sectors).
- Demographic censuses and socioeconomic surveys (IBGE).

Some of the achievements worth mentioning include: the availability of complete national databases accessible online to different users (DATASUS), professional training on the unified information system in conjunction with universities, systems for scientific and technical production through BIREME, improved epidemiological analysis of Ministry of Health data, information for management control through agreed indicators, and management reports.

The structural weaknesses include the existence of numerous information systems, each with its own objectives and designs, overlapping registries, and lack of uniform coverage and quality, and unsystematized national health surveys characterized by periodicities and methodologies that are not comparable and administrative discontinuity.

The principles of this Interagency Network are: non-interference in the management of participating institutions; discussions in representative forums; decisions in the form of proposals adopted by consensus; and implementation consistent with technical political will. The Interagency Workshop (OTI, *Oficina de Trabalho Interagencial*) is responsible for the Network, and is the entity to which the Technical Secretariat and thematic and indicator committees report. This network generates periodic reports on the situation and trends in various matters, using standardized indicators on a regular basis. Further information is available at: [www.datasus.gov.br/idb](http://www.datasus.gov.br/idb).

In conclusion, the study benefited from the political and financial backing of the Ministry of Health and the cooperation of PAHO, which made a consistent, neutral, and flexible contribution, a legitimate spirit of cooperation, specific work processes open to contributions, respect for institutional autonomy and collegiate decisions, stable and qualified institutional collaborators from the technical and academic sphere, and certified available products.

The outlook includes cooperation with states and municipalities, implementation of a national health information policy that will promote the interoperability of national information systems and surveys, improved analysis tools, the use of information in decision-making, and consolidation of the unified health information system (SUS).

## ■ Outlook for environmental health indicators in the Region of the Americas

This initiative continues in the Region of the Americas with ongoing activities designed to select environmental health indicators that allow trends in the different countries of the Region to be monitored. A search was conducted of all information sources related to these indicators, and in 2008, a roundtable discussion was held with country experts and staff from the PAHO Sustainable Development and Environmental Health Area. The information was again validated in a workshop held in March of that same year, after which the following indicators were selected:

### INDICATORS SELECTED FOR ENVIRONMENTAL HEALTH MONITORING: REGION OF THE AMERICAS, 2009

#### I. Sociodemographic and economic context

1. Human poverty index (% of population below the international poverty line)
2. Human development index
3. Urban growth rate
4. Under 5 mortality rate
5. Economically active population
6. Number of children under 14 who work
7. Proportion of jobs in informal sector
8. Proportion of families with a female head of household

**II. Global environmental changes**

1. Energy use per capita (kilograms of oil equivalent)
2. CO<sub>2</sub> emissions per capita (metric tons)
3. Incidence of vector-borne diseases (malaria, dengue)

**III. Outdoor air pollution**

4. Mean annual TSP (total suspended particulates) and PM<sub>10</sub> concentrations in urban areas
5. Number of days in which ambient air quality standards are exceeded
6. Proportional mortality due to acute respiratory infections in children under 5

**IV. Indoor air pollution**

7. Proportion of towns in which solid fuels are used

**V. Fresh and potable water**

8. Improved access to water sources (% of total population)
9. Improved access to water sources in rural areas (% of rural population)
10. Improved access to water sources in urban areas (% of urban population)

**VI. Sanitation**

11. Proportional mortality from an acute diarrheal disease
12. Proportion of population with improved access to sanitation (urban and rural)

**VII. Food and nutrition**

13. Availability of calories per capita (Kcal per day)
14. Proportion of children with low birthweight <2,500 grams
15. Prevalence of malnutrition

**VIII. Housing and urbanization**

16. Population living in poor neighborhoods (percentage of population living in informal settlements)

**IX. Solid waste management**

17. Percentage of population with regular waste collection services (or solid waste)

**X. Violence**

18. Annual homicide rate by sex, all ages
19. Annual suicide rate, all ages

**XI. Road safety**

20. Mortality from injuries caused by traffic accidents/100,000 population, all ages, by sex
21. Proportional mortality from injuries caused by traffic accidents, by type of victim
22. Number of vehicles per 100,000 population (motorization index)
23. Motorcycles, total vehicles (vehicle fleet) (percentage)

**XII. Workers and occupational health**

24. Work-related accident rate
25. Mortality from work-related accidents
26. Hepatitis B virus vaccination coverage for health workers
27. Number and rate of cases and deaths from pesticide poisoning

**XIII. Tobacco**

28. Prevalence of smoking in adults
29. Prevalence of smoking in young people aged 13-15
30. Proportion of young people aged 13-15 exposed to second-hand smoke
31. Number of tobacco control policies at federal and national levels

**XIV. Natural and man-made disasters**

32. Number of events and people affected, by type of disaster

For each indicator, there is a technical form that includes a detailed description of the indicator, its components, and how it was constructed. See Annex 8-1.

Other recent initiatives by the Pan American Health Organization include:

1. The Atlas of Children's Health and Environment in the Americas. This graphically illustrates the status of the various indicators in each country in the Region with maps that facilitate rapid identification of countries requiring greater attention. [http://new.paho.org/hq/index.php?option=com\\_docman&task=doc\\_download&gid=17194&Itemid=](http://new.paho.org/hq/index.php?option=com_docman&task=doc_download&gid=17194&Itemid=)
2. Children's environmental health data and indicators.

The conference held in Rio de Janeiro in 2012 (Rio+20) established the importance of recognizing health as a major factor in sustainable development, which requires universal access to health services and strategies to promote sustainable cities with affordable transportation, adequate housing, clean energy, access to water and basic sanitation, decent work, and food security.

Green urban transportation is recognized as a way to improve air quality and, therefore, reduce the incidence of chronic noncommunicable diseases; proper weather-resistant housing and the use of clean energies will substantially improve maternal and child health; and better infrastructure for health care facilities, with access to clean energy, water, and basic sanitation, will improve the quality of health services.

Pursuant to Resolution 66/288, "The Future That We Want," adopted in 2012 by the United Nations General Assembly, WHO indicates how improvements in health can help measure gains in the three pillars of sustainable development: social, environmental, and economic. It recommends healthy development indicators involving six of the topics addressed in the Assembly (1): sustainable cities (2), food (3), employment (4), water (5), energy, and (6) disaster risk management. The disaggregated content of the indicators for each of these subjects can be consulted at: [http://www.who.int/hia/green\\_economy/en/#](http://www.who.int/hia/green_economy/en/#).

**Sustainable health and development indicators, Rio+20 (23)***Healthy cities:*

- Proportion of the urban population exposed to air pollution limits above WHO recommendations
- Proportion of housing that has access to water and clean energies and is weather-resistant

*Safe and healthy transportation:*

- Proportion of the urban population with access to public transportation (within a distance of 1 km)
- Proportion of urban roadways with infrastructure for pedestrians or cyclists

*Energy:*

- Proportion of dwellings using clean technologies or fuels for cooking and heating

*"Green" jobs:*

- Proportion of workplaces meeting basic occupational safety and health standards (air and water quality, lighting, ventilation, protection against exposure to chemical substances or radiation)
- Rate of nonfatal accidents and occupational diseases, by gender, type of employment (formal or informal) and sector of the economy

*Water:*

- Proportion of the general population with access to safe drinking water and basic sanitation services
- Percentage of financial resources allocated to integrated water resource management

*Food:*

- Proportion of the population with access to healthy food
- Proportion of the population that suffers from malnutrition or obesity
- Prevalence of anemia in women of childbearing age
- Proportion of daily calorie intake from saturated fats, in adults

*Health care:*

- Proportion of healthcare facilities with access to clean energy and adequate drinking water

*Governance:*

- Proportion of territorial macroprojects in which health benefits are integrated in all phases from planning to execution
- Number of health impact assessments per year per country

## CHILDREN ENVIRONMENTAL HEALTH DATA AND INDICATORS BY COUNTRY IN THE REGION OF THE AMERICAS

1. Child population in the Americas
2. Projection of number of children in urban areas
3. School-age population
4. Infant mortality rate
5. Gini index and infant mortality rate
6. Mortality rate from acute respiratory infections and acute diarrheal diseases in the population aged 0-19
7. Proportional mortality from acute diarrheal diseases and acute respiratory infections the population aged 0-19
8. Proportional mortality from diseases caused by the contribution of known environmental factors in the population aged 0-19
9. Prevalence of acute respiratory infections in children under 5
10. Burden of disease attributable to environmental exposures in the population aged 0-19
11. Prevalence of children exclusively breastfed up to the age of 6 months
12. Prevalence of malnutrition in children under 5
13. Child mortality from nutritional deficiencies
14. Correlation between literacy, poverty, and malnutrition in females under 19
15. Incidence of birth defects according to the PAHO list (Q00-Q99) (folic acid)
16. Proportion of school-age children (aged 5-14) who are overweight or obese (UNICEF)
17. Access to improved water sources and child mortality
18. Access to improved sanitation systems and child mortality
19. Urban population without access to drinking water or sanitation, and malnutrition, by poverty level
20. Child parasitism rate (helminths, *Entamoeba*)
21. Proportion of children living in homes where biomass fuels or coal are used
22. Proportion of young people aged 13-15 exposed to second-hand smoke
23. Indoor air pollution monitoring and probability of respiratory symptoms in certain places, in the under-19 population
24. Percentage of young people (aged 13-15) exposed to second-hand tobacco smoke in the home
25. Students who support smoking bans in public places (proportion)
26. Current prevalence of cigarette smoking in young people (aged 13-15)
27. Estimated population under 19 living in cities that exceed national air pollution standards (average annual PM<sub>10</sub> concentration)
28. Prevalence of serum lead levels  $\geq 10$  micrograms/dl in children aged 1-5
29. Incidence of child pesticide poisoning and pesticide import rate
30. Incidence of malaria and dengue in children
31. Proportion of children living in inferior housing
32. Proportion of children living in overcrowded conditions
33. Number of child deaths due to natural disasters, by type
34. Number of children registered at primary schools
35. Schools with access to water and sanitation facilities
36. Child mortality due to road traffic accidents
37. Proportional child mortality due to unintentional injuries
38. Number of children under 14 who are working
39. Progress toward Millennium Development Goals

## ■ Conclusions and recommendations

Information is the most critical tool for reducing uncertainty in decision-making. The design, construction, collection, analysis, and utilization of environmental health indicators makes it possible to analyze the current situation in countries and their various subnational and municipal levels, uncovering situations that merit targeted interventions—situations that often go undetected, as they are concealed in national averages.

This information also facilitates vulnerability analysis and action planning for the prevention and mitigation of situations prejudicial to public health and assessment of the impact of the resources invested or the action taken.

There are legal frameworks that support the generation of this information—frameworks that derive from the health codes of each country and the current International Health Regulations approved by the Member States of the World Health Organization.

The data required for the construction of these indicators are, by and large, compiled in the statistics and sectoral registries of the different countries, but quality, reliability, and comparability standards must be met. Secondary sources include registries on environment-related morbidity and mortality, registries on household utilities coverage and basic sanitation conditions. Primary sources include national surveys and studies aimed at answering specific questions—for example, national health surveys that investigate, in representative population samples, the coverage, of basic services, pet ownership, housing conditions, and many other aspects.

These data are systematically collected by different international organizations and may be available online, as are the PAHO/WHO basic indicators and situation analyses, publications by the Economic Commission for Latin America and the Caribbean (ECLAC), indicators to monitor attainment of the Millennium Development Goals, World Bank statistics, and material from other agencies.

Experiences such as those presented in this chapter highlight the importance of having the political will to generate useful information for decision-making, technical and financial support from national authorities at all levels, regular support, and the involvement of public employees from different sectors; promoting opportunities for consensus-building where the information is used in decision-making; and respecting the autonomy of each entity involved, while at the same time facilitating the availability of good evidence-based data and trend analyses presented in a manner easily assimilable by different publics.

Another key aspect noted in the experiences is encouraging the participation of different stakeholders, primarily the community.

Of the various conceptual models presented for the construction of environmental health indicators, the one that merits special mention is the DPSEEA (driving forces, pressure, state, exposure, effects, and action) model. Like the GEO Health model, this tool permits a comprehensive overview of environmental issues and systematically guides action to inform decision-making.

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## ■ Annex 8.1. Sample technical template for indicator construction

WORK-RELATED ACCIDENT RATE	
General considerations	
<i>Issue</i>	<i>Work-related accidents</i>
<i>Type of indicator</i>	<i>Health outcome</i>
Rationale	<p>Accidents in the workplace constitute a major problem for workers, their families, businesses, insurance systems covering such contingencies, and countries.</p> <p>In many countries, the losses from work-related accidents represent a significant percentage of the gross domestic product, as well as a very sizable burden of disease. These and other related aspects hinder development and increase poverty.</p> <p>This indicator measures the rate of work-related accidents in a country's workforce in a given period. The rate reflects the probability that a work-related accident will occur in this population group.</p>
Issues in indicator design	<p>As with other measurements of health effects, one of the major problems with this indicator is the availability and quality of the data. Although an acute and often serious event is involved, many such events are not reported for a number of reasons, including:</p> <p>The definition of work-related accident varies from country to country. The same holds true for the reporting of such accidents, which is closely related to the coverage provided in each country by insurance systems and the notification of occupational risks. Coverage rarely reaches satisfactory levels when there is a high degree of informal employment. In other cases, especially in areas far from major urban centers, less severe accidents are not reported due to problems accessing health care services to treat the injury. When insurance premiums for work-related accidents are linked to company performance, many accidents are not reported out of fear that premiums will be hiked.</p> <p>In some countries, reporting may include only workplace accidents requiring medical attention, while in others, all accidents, regardless of whether they required medical attention, must be reported. Differences may also be observed with respect to where the accidents occurred—on the way to work (<i>in itinere</i>), for example; some countries consider these events work-related, while others do not. Furthermore, some countries have decided to include accidents occurring while traveling between two work sites.</p> <p>Major variations can be observed between countries in terms of what is considered the reference group (denominator). In some countries, it may be the working population covered by the social security system, while in others, it may be the population that visits the public health services.</p> <p>The indicator design should therefore take the context and purpose of the indicator into account, as well as the completeness and reliability of the available data.</p>
<b>Specification</b>	
Definition	This rate corresponds to the ratio of work-related accidents registered in a country in a calendar year relative to the total number of workers in the reference group of the country midway through that same year.
Terms and concepts	<p><b>Work-related or occupational accident</b> (ILO definition): an unexpected and unplanned occurrence, including acts of violence, arising out of or in connection with work which results in ... a personal injury, disease, or death.</p> <p><b>Commuting accident</b> (ILO definition): an accident occurring on the habitual route ... between the place of work or work-related training ... and the worker's principal or secondary residence, the place where the worker usually takes her/his meals, or the place where she/he usually receives her/his remuneration; which results in death or personal injury.</p> <p><b>Reference group</b> (denominator): total number of workers in the country where the occupational accidents occur. If, for example, the indicator only includes occupational accidents among workers who are covered by a country's occupational risk insurance system, the reference group (denominator) should only include the total number of workers in this system in that same country.</p>
Data needs	<p>Number of work-related accidents reported in the country in a calendar year.</p> <p>Total number of workers in the reference group midway through that same year.</p>

<b>Specifications</b>	
Data sources, availability, and quality	<p>Data can be obtained from the following sources:</p> <ul style="list-style-type: none"> <li>• National labor authorities in each country, or their designated agency.</li> <li>• National health authorities in each country, or their designated agency.</li> <li>• National social security authorities in each country, or their designated agency.</li> <li>• Official statistics institute in each country.</li> <li>• The International Labour Office (ILO). Laborsta Database (<a href="http://laborsta.ilo.org/default_S.html">http://laborsta.ilo.org/default_S.html</a>)</li> </ul> <p>For the Region of the Americas, the following sources may also be consulted:</p> <ul style="list-style-type: none"> <li>• ILO: ILO Caribbean Office and Multidisciplinary Advisory Team.</li> <li>• ILO: Subregional Office for Central America (which covers Costa Rica, Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, and Panama)</li> </ul> <p>The best sources of information are generally the authorities and local health services, but access to their records is often hindered by poor communication and limited personnel to manage the information. Another way to obtain information is through specific field surveys, but their cost can pose a serious constraint.</p>
Level of spatial aggregation	Country.
Average period	Annual (calendar year).
Computation	<p>The indicator can be calculated as a ratio, namely:</p> $100,000 \times AT_{pr}/PR_{tot}$ <p>Where:</p> <p><math>AT_{pr}</math> is the number of work-related accidents reported in the reference population during the period of interest;</p> <p><math>PR_{tot}</math> is the total number of people in the reference population (the population in which the accidents occurred and appearing in the numerator) in the country midway through the period of interest.</p>
Units of measurement	Number of work-related accidents per every 100,000 members of the reference group.
Example	<p>Assuming that 467,814 cases of work-related accidents are reported among the 5,945,653 workers in the insurance system that covers these events in a country during one year, the value of the indicator is calculated as follows:</p> $100,000 \times 467,814/5,945,653 = 7,868.2 \text{ work-related accidents per } 100,000 \text{ insured workers per year.}$
Interpretation	<p>This rate measures the incidence of work-related accidents in the worker reference group in a country for a given period. The rate reflects the probability that a work-related accident will occur in this group. When comparing the indicator between countries, it should be borne in mind that the rate of work-related accidents in a country is highly dependent on the distribution of workers among the different economic activities. Thus, a higher work-related accident rate is to be expected in a country where workers are largely employed in high-risk activities, such as mining, agriculture, or construction, than in a country where the majority of workers are in lower-risk jobs, such as services.</p>
Variations and alternatives	There are potential variations in this indicator; for example, it may focus on different age groups, economic activities, or insurance companies. In some cases, stratification by sex could also be useful.
Related indicators	<ul style="list-style-type: none"> <li>• Mortality rate from work-related accidents.</li> <li>• Fatalities rate from work-related accidents.</li> </ul>
Useful references	<p>ILO. Resolution concerning statistics of occupational injuries (resulting from occupational accidents). Adopted by the Sixteenth International Conference of Labour Statisticians (October 1998). Available at: <a href="http://ilo.org/global/statistics-and-databases/standards-and-guidelines/resolutions-adopted-by-international-conferences-of-labour-statisticians/WCMS_087530/lang--es/index.htm">http://ilo.org/global/statistics-and-databases/standards-and-guidelines/resolutions-adopted-by-international-conferences-of-labour-statisticians/WCMS_087530/lang--es/index.htm</a> .</p> <p>ILO. Laborsta, an International Labour Office database on labor statistics. Available at: <a href="http://laborsta.ilo.org/default.html">http://laborsta.ilo.org/default.html</a>.</p>

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# The role and challenges of environmental health laboratories in the Americas

Josino Costa Moreira José Lobos  
Leiliane C.A. Amorim  
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## ■ Introduction

The expression “environmental health,” which constitutes one of the foundations of this chapter, is often understood as a generic term that allows for different personal interpretations. Therefore, to facilitate an understanding of the role of and challenges faced by laboratories in this field, the authors must first explain what they mean by environmental health. For the purposes of this analysis, we will employ the concept as defined by WHO (1), whereby environmental health “comprises those aspects of human health, including quality of life, that are determined by physical, chemical, biological, social, and psychosocial factors in the environment. It also refers to the theory and practice of assessing, correcting, controlling, and preventing those factors in the environment that can potentially affect adversely the health of present and future generations.”

In addition to including the key environmental factors with an impact on human health, this concept underscores the need for knowledge and the implementation of measures to mitigate or prevent harmful effects on the environment for present and future generations.

WHO also defines the role of environmental health laboratories: they are the tools necessary for evaluating the physical, chemical, biological, and toxicological characteristics of environmental samples, as well as the discharges and emissions received by the environment, in addition to determining the magnitude of their effects on ecosystems, including human environments, both indoors and outdoors.

In order to perform these roles, through the analysis of representative samples taken from the environment, laboratories should be prepared to infer information about the quality of the environment and the effluents, emissions, and waste that can pose health hazards to the biota, including human populations. This means that laboratories must have duly trained personnel, adequate facilities and instruments, active quality management systems, and sufficient resources to ensure their scientific, technical, and economic sustainability, thus enabling them to conduct studies and research and generate the information necessary for evaluating all environmental health impacts.

In this regard, laboratories can be considered agents for the delivery of services required for the generation of primary data. Such data, in turn, are essential for decision-making, for guiding the implementation of decisions, and for monitoring their effectiveness. In other words, the laboratory plays a key role throughout the decision-making process, from the earliest stages through monitoring and final assessment, and is responsible for producing the primary information necessary at all stages.

As Sexton (2) notes, this process therefore constitutes a direct interface between science—which is tasked with generating basic information—and policy- or decision-making. According to this author, science should be understood in its broadest sense to encompass research and development, monitoring and data collection, review and interpretation of technical investigations, and assessment of health and environmental risks, as shown in Figure 9-1.

In the field of environmental health, the procedure for evaluating the human health risks generated by exposure to chemical substances or pathogenic agents harmful to health usually encompasses the stages laid out in Figure 9-1, which also shows the stages at which the contribution of analytical laboratories is essential.

Although risk assessment is at the foundation of the decision-making process, a detailed description of this procedure is outside the scope of this chapter and can be found elsewhere in this book or in other sources.

As shown in Figure 9-1, only rarely will a single laboratory be able to meet all demands, as the factors that affect environmental health are wide-ranging and, more often than not, it is necessary to work with information from different sources. In addition, the unique characteristics of each environment can influence the information obtained; hence, the need for indicators to evaluate the comparability of measurements obtained in the different ecosystems (as long, of course, as they are amenable to comparison).

Indeed, relationships between the biota and the environment are reciprocal and multiple, and every effect on the environment sooner or later is bound to have an effect on the biota itself. The concept of environmental health put forward by WHO sheds light on these relationships and reveals their complexity.

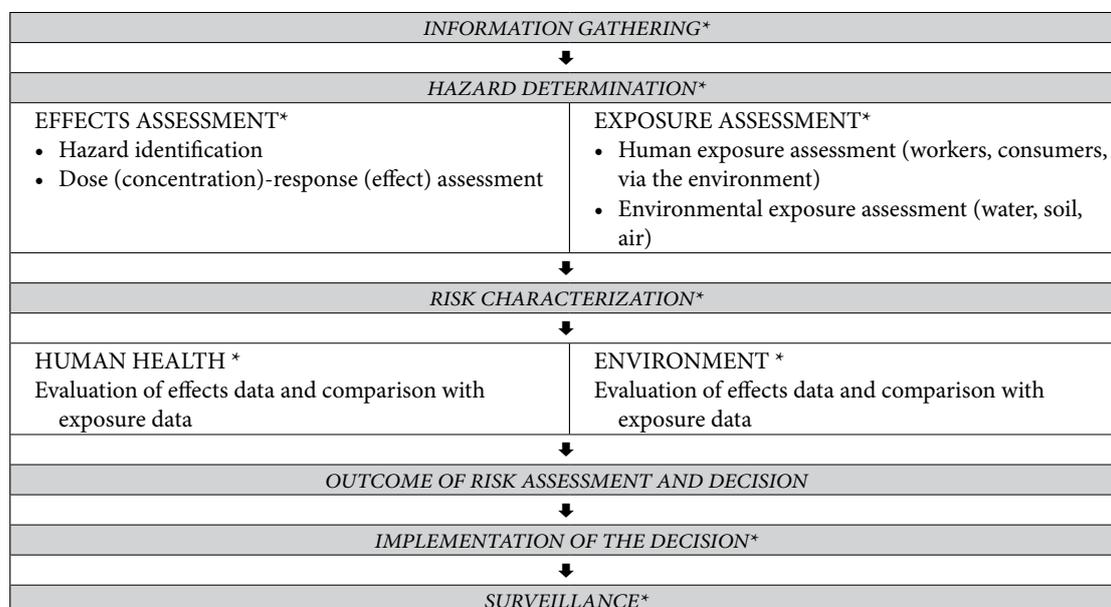
However, the environmental health is a product of the interaction of various factors operating at different levels of intensity within complex processes that transcend the traditional biological, physical, and chemical components of the environment. These factors—of a social, economic, political, environmental, technological, and biological nature—can be mutually or jointly related to generate intermediary factors that influence the health and well-being of populations, as shown in Figure 9-2.

In addition, according to Sexton (2), decision-making can be understood as a continuous process characterized by the generation of information by means of scientific procedures at one end and decision-making at the other. All stages of this process are influenced by critical judgments and extrapolations, as shown in Figure 9-3.

Sexton also analyzes different concepts of the relative importance of “science” in decision-making. However, whatever the concept employed, the better the quality of the scientific information, the better the decision-making.

Given the complexity of these relations, environmental changes can affect humans differently and in several aspects; hence, their study should preferably be an interdisciplinary pursuit. This means that understanding the effects of the environment on health requires a wide range of information obtained through a scientific approach based on a process that integrates the knowledge of experts from a wide variety of specialties. This remains one of the major scientific challenges to be overcome, since, although some initiatives of this type are already under way, the vast majority of current research is still conducted using a unidisciplinary approach rather than an interdisciplinary and multidisciplinary approach, as it should be.

**Figure 9-1.** Stages of the decision-making process in situations involving exposure to chemical substances (3)

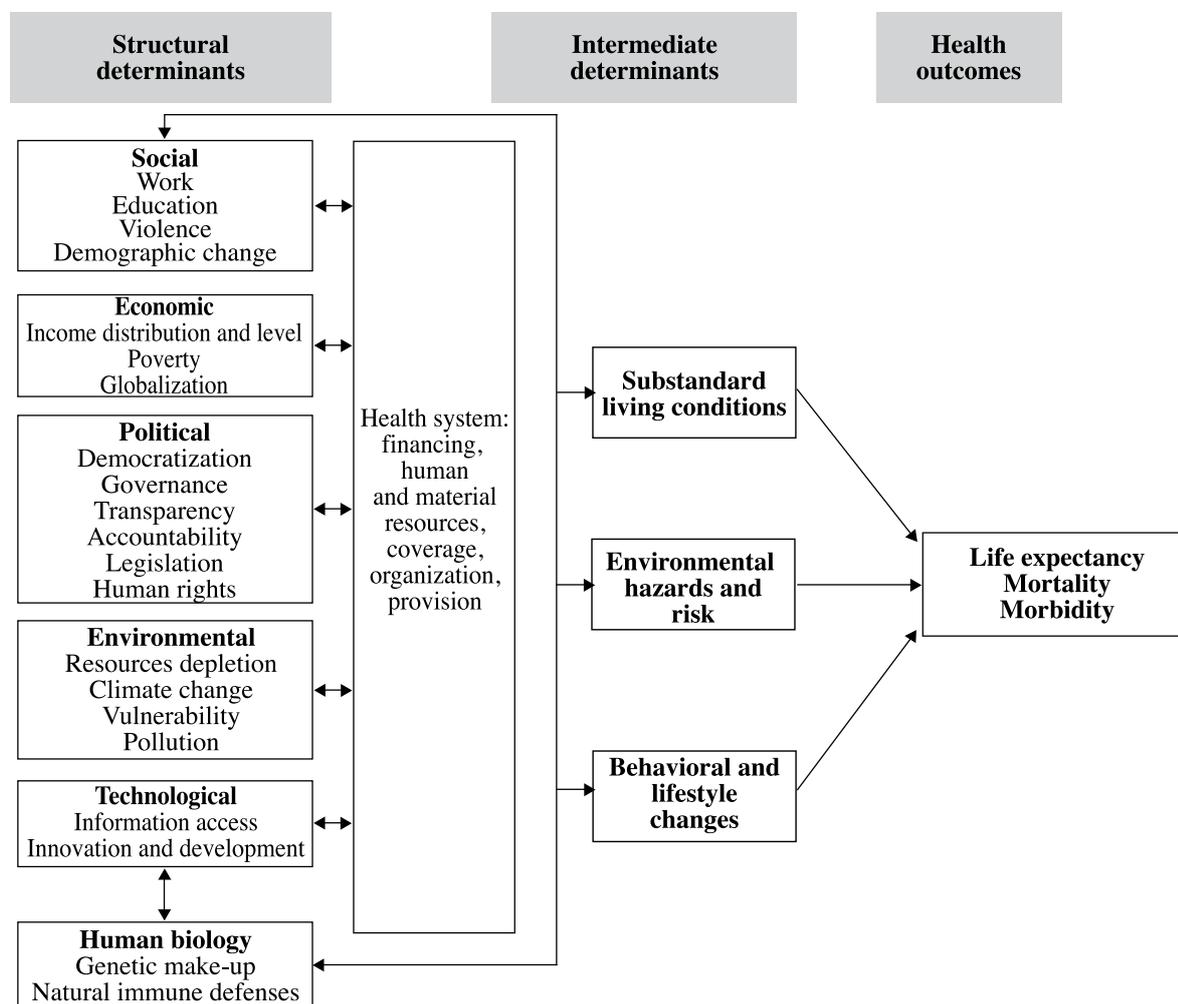


\* Stages at which the involvement of environmental health laboratories is indispensable. Adapted from the European Commission.

According to UNEP data (5), the environmental alterations that decision makers currently face range from issues for which solutions with proven effectiveness are already available to problems that have yet to be solved completely. In all cases, science plays a critical role by producing and providing the best possible information for good decision-making.

In other words, the quality of the decisions proposed or adopted depends on the quality of the information available and used. This holds true in the Western hemisphere as a whole, but it is particularly important in regions where institutional fragility is greatest—i.e., in Latin America and the Caribbean. Consequently, this chapter will focus on analyzing the role of environmental health laboratories in this subregion. We will present some ideas that we believe to be important for increasing the efficiency of environmental risk assessment processes and, therefore, ensuring a better quality of life for societies in these regions.

**Figure 9-2.** Health and its determinants: Interactions between health and the environment



**Source:** Loyola E. Progress on Children's Environmental Health in the Americas. International Conference for the Evaluation of Global Health Strategies. Florence, Italy, 2006. Extracted from PAHO (4).

**Figure 9-3.** Factors that influence the stages of the decision-making process

<i>Science</i>	<i>Science policy</i>	<i>Policy</i>
<b>Factors affected by personal values</b>	<b>Judgments affected by both personal and societal values</b>	<b>Policies affected by societal values</b>
<ul style="list-style-type: none"> <li>• Effects on generating, analyzing, and interpreting facts</li> <li>• Effects on assumptions, inferences, and extrapolations</li> <li>• Effects on attitudes and approaches to uncertainty</li> </ul>	<ul style="list-style-type: none"> <li>• Effects on decisions about the use of science in the formulation and implementation of policy</li> <li>• Effects on decisions about the development of policy for science</li> </ul>	<ul style="list-style-type: none"> <li>• Effects on goals, objectives, and priorities</li> <li>• Effects on decisions about acceptability or unacceptability of risks</li> <li>• Effects on decisions about the tradeoffs between the costs and benefits of the government intervention to prevent or reduce unacceptable risks</li> </ul>

*Source:* Extracted from Sexton (2).

## ■ Monitoring of human contamination by xenobiotics

Due to scientific, technological, and industrial development, people are being exposed to an ever-growing number of xenobiotics, whether through food, the environment, or even for therapeutic purposes. In fact, xenobiotic contamination of the human body has been associated with several idiosyncratic reactions and diseases.

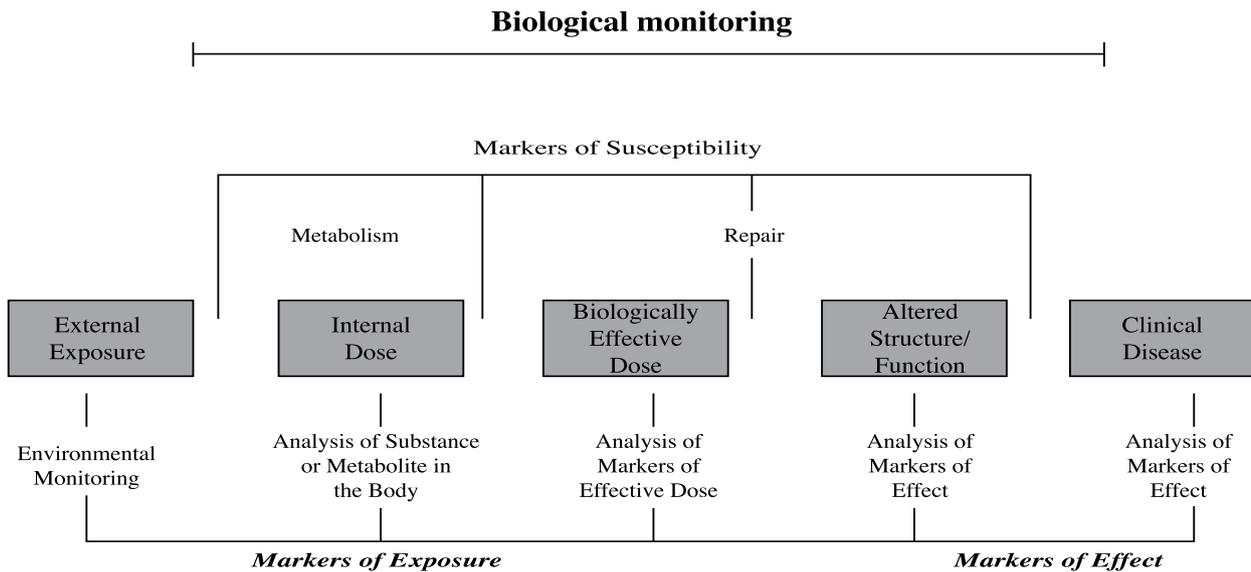
To counteract and/or prevent the risks resulting from chemical contamination, enzymatic systems that exist in different organisms are capable of metabolizing (or biotransforming) xenobiotics into less toxic products. This process usually generates substances that are more water-soluble and less reactive than the original molecules, so as to facilitate elimination. This is particularly important when the contaminants are persistent and lipophilic, as their tendency to build up in the fatty tissues of the body (bioaccumulation and/or biomagnification) predisposes to their consequent biological effects. However, there are several cases in which biotransformation produces metabolites that are even more toxic than the original substance, a phenomenon known as bioactivation.

From a toxicological standpoint, the risks and effects of changes in environmental conditions on quality of life can be assessed by qualitative and/or quantitative evaluation of environmental and biological markers (biomarkers). Within this context, it is the primary role of every laboratory to produce reliable, comparable results (traceable to a reference standard) to permit accurate assessment of such alterations.

These markers can be divided into three categories: biomarkers of exposure, biomarkers of effect, and biomarkers of susceptibility, as shown in Figure 9-4 (6).

When the monitoring process specifically refers to the determination of a given chemical substance and its effects on the human body, it is known as biomonitoring (7).

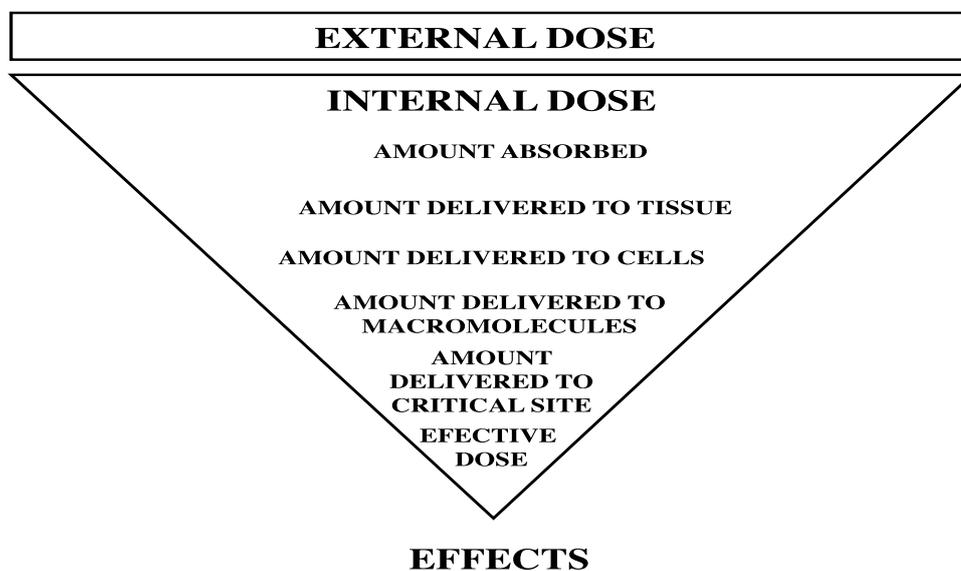
Figure 9-4. Schematic representation of the types of biomarkers used in biological monitoring.



Source: Reference (6)

**Markers of exposure** include the unaltered molecule itself, its metabolites, or products of their interactions with target molecules or cells. These markers can be further subdivided into indicators/markers of external dose or potential dose, of internal dose or absorbed dose (a measure of the toxic agent and the products of its metabolism in the biological medium), or of biologically effective dose (a measure of interactions between the toxic agent and biomolecules). The relationship between these markers, represented by the toxicodynamics of a toxic agent in a living body, is shown in Figure 9-5.

Figure 9-5. Schematic representation of the toxicodynamics of a toxic agent in a living body



Source: Reference (8)

During environmental monitoring, concentrations of the contaminant and the products of its degradation are evaluated in the various environmental substrates (air, soil, water, food, etc.) capable of acting as pathways for human contamination. This makes it possible to identify the sources of exposure and adopt measures to prevent exposure to biologically effective concentrations. However, it does not provide a reliable picture of the destinations of the toxicant in the body.

Examples of these markers include lead concentrations in air and blood, phenol (benzene) or 1-hydroxypyrene levels in urine, or DNA adducts or proteins in blood.

**Markers of effect** are biological parameters measured in the organism that reflect interactions between the xenobiotic compound and biological receptors, including qualitative or quantitative changes in biochemical or physiological functions or other measurable organic alterations, including behavioral changes, that are known to be associated with health risks. Examples of this category of markers include the activity of the cholinesterase enzyme in blood, phosphorylation of neuropathy target esterase in lymphocytes, and cytogenetic biomarkers (chromosomal aberrations, sister chromatid exchange test, micronucleus and comet assays).

**Markers of susceptibility** are indicators of a natural or acquired ability of the body to respond to the threat posed by exposure to a given xenobiotic. These markers are preexisting and exposure-independent. Susceptibility is the result of genetic factors, such as polymorphisms of the genes that encode enzymes involved in the biotransformation of xenobiotics (e.g., cytochrome P450 isoforms, esterases, paraoxonases, glutathione-S-transferases, acting in isolation or together) or in gene repair, or the result of acquired factors, such as pathological or physiological changes, exposure to other agents, etc.

The existence of different enzyme isoforms is an important factor in the between-person differences observed in the body's absorption, biotransformation, mechanism of action, susceptibility to harm, and ability to repair damage caused by a given xenobiotic; this results in different dose-response relationships for different population groups. For example, the influence of a polymorphism in a cytochrome P450 family gene on the metabolism of given organophosphorus compounds is such that formation of the oxygen-analog (organophosphate oxon) metabolites of these compounds can vary as much as 40-fold due to interindividual variability in these enzymes.

Metabolism exhibits significant individual variability, which is affected not only by genetic aspects (polymorphisms), but also by environmental aspects, age, gender, lifestyle, diet, and health condition (presence of certain diseases) (9). Consequently, the formation of reactive intermediates and their reactions with biomolecules—considered an essential step in the development of adverse effects—are also influenced by these variables, as well as by the nature of the electrophile, its availability, and any steric hindrances caused by tertiary protein structure (10).

In the particular case of enzyme activity assessment, these values are generally influenced by countless variables (genetic, physiological, environmental, etc.), and the individual him- or herself should be used as a reference whenever possible. The reference range for serum cholinesterases, for instance, is 8 to 18 U/ml. However, due to the wide variability of this parameter, baseline cholinesterase activity should be measured once the individual has gone at least four months without coming into contact with substances having anticholinesterase activity. A 15–25% reduction in baseline activity of the enzyme is already indicative of human contamination: the greater the reduction, the greater the contamination.

The use of biomarkers for biological monitoring has both advantages and disadvantages. The advantages include the ability of these parameters to express all modes of exposure and their relations to human behavior in an integrated manner. Biomarkers can identify even low levels of exposure and can be used to establish causal links and identify especially susceptible groups; thus, they play essential roles in model validation, supporting interventions and facilitating evaluation in public health, etc.

However, biological monitoring does not identify source of exposure, mechanism of action, duration of exposure, or toxic dose. In addition, its reliability is highly dependent on the quality of the testing laboratory, and many xenobiotics lack established reference ranges that would permit better interpretation of the results of monitoring (11).

The assessment of outcomes found through biological monitoring usually involves the comparison of pre-established values (reference ranges) with an appropriate reference. These ranges are based on assessment of a representative portion of the healthy general population, through analysis of the concentrations of the substance of interest in biological fluids or tissues (blood, plasma, urine, hair, breast milk, etc.). In general, reference ranges are defined by the 2.5th and 97.5th percentiles—i.e., approximately 5% of measurements obtained from “healthy” individuals will be located outside the range. The percentile method is used because it does not require knowledge about the distribution of the data and is able to identify the range that contains a given percentage (95%) of the values of a set.

Reference ranges can be influenced by factors such as age, sex, habits, etc. In addition, “normal” values may be altered when exposure to the chemical agent is altered. For example, biological concentrations of any given xenobiotic tend to decline some time after its use is prohibited or banned.

Reference-range concentrations for environmental contaminants play an important role in environmental health research, since they provide information on the prevalence and magnitude of exposures that can be used to compare concentrations in individuals already known or suspected to have been exposed to a specific source of chemical substances. These data are useful in interpreting the results obtained from exposed populations or subgroups.

Discussions on the importance and limitations of reference ranges are found in the work of Jung and Adeli (12) and Katayev *et al* (13).

In general, several biomarkers can be used to evaluate a given xenobiotic; their selection depends on factors that mainly comprise the toxicokinetics of the compound of interest and knowledge of its mechanism of action (14). Table 9-1 lists the major metabolites used for biomonitoring of human contamination from selected pesticides.

**Table 9-1.** Metabolites of selected pesticides used for biomonitoring of human contamination (15)

	<i>METABOLITE</i>	<i>TOXIC SUBSTANCE</i>	<i>SUBSTRATE FOR ANALYSIS</i>
<b>ORGANOCHLORIDES</b>	<b>p,p'-DDT</b>	<b>p,p'-DDT</b>	Adipose tissue, milk, blood, urine
	Dieldrin*	Aldrin	Blood, adipose tissue, serum, milk
	Anti-12-hydroxyendrin, endrin*	Endrin	Urine
	Heptachlor epoxide*	Heptachlor	Milk, serum, adipose tissue, urine
	Mirex*	Mirex	Serum
	β-hexachlorocyclohexane*, γ-hexachlorocyclohexane*, Pentachlorophenol*, 2,4,6-trichlorophenol*, 2,4,5-trichlorophenol*	Hexachlorocyclohexanes	Serum or urine
<b>ORGANOPHOSPHATES</b>	<b>Alkyl phosphates:</b> Dimethyl phosphate*	Malathion, dichlorvos, dimethoate, temephos, fenclorpos, mevinphos	Urine
	Dimethyl thiophosphate*	Azinphos-methyl, dimethoate, fenclorpos, fenitrothion, malathion	
	Dimethyl dithiophosphate*	Azinphos-methyl, dimethoate, malathion	
	Diethyl phosphate*	Parathion, phorate, terbufos, quinalphos, demeton, diazinon, dichlofenthion	
	Diethyl thiophosphate*	Diazinon, demeton, parathion, phorate, quinalphos	
	Diethyl dithiophosphate*	Disulfoton, phorate	
	<i>p</i> -nitrophenol*	Parathion, parathion-methyl	
	3,5,6-trichloro-2-pyridinol*	Chlorpyrifos, chlorpyrifos-methyl	
	3-methyl-4-nitrophenol	Fenitrothion	
	Malathion mono- and dicarboxylic acids*	Malathion	

	METABOLITE	TOXIC SUBSTANCE	SUBSTRATE FOR ANALYSIS
CARBAMATES	Methyl (5-hydroxy-1H-benzimidazol-2-yl) carbamate Methyl (4-hydroxy-1H-benzimidazol-2-yl) carbamate	Benomyl	Urine
	1-naphthol	Carbaryl	
	2-dimethylamino-4-hydroxy-5,6-dimethylpyrimidine 2-methylamino-4-hydroxy-5,6-dimethylpyrimidine	Pirimicarb	
	2-hydroxyphenyl-N-methylcarbamate 2-isopropoxifenol *	Propoxur	
	Carbofuran phenol*	Carbofuran, benfuracarb, carbosulfan, furathiocarb	
OTHERS	<i>trans</i> -Chrysanthemumdicarboxylic acid	Allethrin, bioallethrin, phenothrin, resmethrin, tetramethrin	Urine
	<i>cis</i> and <i>trans</i> -3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane-1-carboxylic acid*	Cyfluthrin, cypermethrin, permethrin	
	<i>cis</i> -3-(2,2-Dibromovinyl)-2,2-dimethylcyclopropane-1-carboxylic acid*	Deltamethrin	
	3-phenoxybenzoic acid*	Cypermethrin, deltamethrin, permethrin	
	4-fluoro-3-phenoxybenzoic acid*	Cyfluthrin	
	2,4-diphenol*	2,4-D	
	2,4,5-trichloroacetic acid*	2,4,5-T	
Aminomethylphosphonic acid (AMPA)	Glyphosate		

\* Denotes metabolites or substances used by the U.S. Centers for Disease Control and Prevention (CDC) as biomarkers for the assessment of human contamination through environmental exposure.

Source: Adapted from Araoud (15) and Kaneko (16).

## ■ Primary information for decision-making: A need and, at times, a responsibility

Information, a word so often heard and used, entails a series of complex successive activities. In its broadest sense, it involves the existence of a dataset that only acquires meaning and utility once the data have been grouped, organized, and processed according to a given criterion.

We know that two classes of information exist: primary and secondary. In our case, we are driven by primary information. Primary information is collected for a particular purpose, generates data referenced to a population, interest groups, and their area of influence as its main output, and serves as a key input for good decision-making by government agencies.

Some of the objectives that drive the creation of primary information warrant mention:

- To obtain up-to-date information on the immediate environment and external groups that can be evaluated and used in institutional actions;

- To identify sources of reliable, directly accessible information;
- To evaluate the desires of interest groups and assess existing standards;
- To generate information that contributes to the mitigation of risk, the optimization of decision-making, and the operation of the agency that has requested or will receive the data.

At this point, it is worth asking who is primarily responsible for generating primary information. The response is almost immediate: the “public agencies” that intervene in the assessment and management of risk as it pertains to health and the environment (ministries of health, the environment, public works). The information may come from academia (universities), if the data was generated for that purpose. Given the strategic nature of primary information, its acquisition and institutional use are also the responsibility of all civil servants.

Data generation should be as structured as possible so that its maximum level can be achieved. In this regard, the main factors to be considered in terms of the quality of information are (17):

- **RELEVANCE:** the extent to which the information meets the needs of the research at hand.
- **ACCURACY:** the reliability of the information.
- **TIMELINESS:** data should reflect the current situation at the time of their use.
- **IMPARTIALITY:** the objectivity with which data were collected.

Primary data cannot be obtained inexpensively. Due to technological and scientific advancement, the data generated at any given time, even if obtained using the best available equipment and state-of-the-art technical standards, will rapidly become outdated. Equipment quickly becomes obsolete, despite the care of its operators, and will inevitably need replacement. Continuous staff training is a vitally important factor in ensuring the reliability of data. Ongoing training motivates technicians, who gain confidence in the use of modern equipment. There is a tacit rule that any increase in cost and time is offset by an improvement in the time needed to adapt the information obtained to our actual needs.

It should be emphasized that it is absolutely impossible to evaluate the extent of a problem and plan solutions if there is a possibility that the analysis parameters are unreliable or inappropriate. Mistakes may be made or appropriate action may not be taken on time, which is equally unacceptable. Thorough knowledge of the problem at hand will save time and resources, both monetary and human, which, if limited, may then be allocated to other purposes.

## ■ International and national mandates in support of information generation

The existence of important prior action notwithstanding, the year 1992 marks a watershed moment for this issue, with the “Earth Summit” held in Rio de Janeiro, Brazil. The presidents and other heads of government of the countries that attended adopted a plan of action for sustainable global development known as Agenda 21. From this emerged a program of action designed to mitigate climate change, protect biodiversity, and eradicate the generation of toxic substances.

In 2000, the Latin American and Caribbean parties to the Millennium Declaration agreed to meet the Millennium Development Goals by the year 2014, which posed challenges to every country. One of these challenges is “to ensure environmental sustainability.”

In 2002, the World Summit on Sustainable Development was held in Johannesburg, South Africa (7). Its objective was to review Agenda 21 and renew the states’ commitment to “sustainable development.” Among the goals set, access to drinking water and the improvement of human health—with particular emphasis on policies for the reduction and elimination of hazardous chemicals in the environment—were stressed. For Latin America and the Caribbean, emphasis was also placed on fostering South–South cooperation (18).

The items on the Cooperative Agenda of the Meeting of Health and Environment Ministers of the Americas, held in Mar del Plata in 2004 (19), included a commitment by governments to tackle policies that are their exclusive purview: regional cooperation on key issues (preservation of water resources, management of hazardous substances, children’s health), allocation of (human and budgetary) resources to aid the work of decision makers, and involvement of civil society organizations in the decision-making process.

To support compliance with these and other international agreements and as a continuation of their environmental health protection policies, the countries involved generated large quantities of legislation related to this

purpose. The constitution of nearly every Latin American and Caribbean country makes a commitment to environmental stewardship and care for the health of the population. By way of example, the constitutions of Argentina, Brazil, Mexico, and Paraguay all enshrine these values.

An interesting aspect is the diversity of government agencies with responsibilities in connection with the environment and sustainable development and tasked with implementing the respective mandates. In some countries, the highest authority is a minister, secretary, or other cabinet-level official. In others, this power lies with professional organizations that participate in various aspects of public administration.

Concerning the decentralization necessary for the implementation of sustainable development and environmental policies, it is clear that national governments cannot be the ones to implement such policies, as it is impossible to regulate legislation for an entire country, especially in nations with a large territory. Generally speaking, in nations with a federal system of government (as is the case of Argentina, Brazil, and Mexico), there are national laws and state/provincial laws, and the two may or may not coincide. In some cases, there are also municipal laws to contend with. In unitary states, national legislation is globally applicable, even if adjustments to the smaller-scale context of municipalities are required. This is a generalization, and, in view of the range of differences observed, a detailed classification is impossible to compile (20).

The vast majority of the countries in the Region have general environmental laws that differ in scope, some of them much more detailed than others. From this basic legislation and the corpus of specific laws and decrees arises a series of control elements common to many nations. A cursory examination reveals that the following themes are shared by all:

- Management of hazardous waste (including pathogenic agents).
- Environmental impact assessments for the establishment of industrial plants.
- Environmental certificates and environmental affidavits.
- Registries of hazardous waste generators and carriers.
- Cross-border movement of hazardous waste (Basel Convention).
- Establishment of limits for the disposal of waste (solid, semisolid, and liquid) into bodies of water.
- Classification of water resources by pre-determined uses.
- Management of drinking water.
- Control of gaseous emissions.
- Presence of toxic pollutants in the biota.

Two further aspects, although not addressed in environmental laws, are related:

- The presence of toxic pollutants in human beings; and
- Judicial intervention to enforce the law and generate forensic evidence.

All monitoring by government agencies, the usual tasks involved in generating basic information from the data provided by regular state monitoring, reports from private industry verifying compliance with environmental permits, judicial interventions, and a myriad of other activities require the constant generation of basic data. This task, in turn, requires laboratories (for the most part, official ones) with sufficient, necessary, rapid, reliable, and accurate response capabilities.

The law cannot be enforced if the evidence is built on questionable foundations. It bears emphasizing that, when it comes to effects on the environment and health, scientific advancement is constant, and each new pollutant is followed by a new law and a mechanism to verify compliance with it.

## ■ Current situation and outlook for Latin America and the Caribbean

There has long been interest in learning about the current situation of laboratories operating in fields relevant to environmental health in the Americas, and there have been some experiences in this context.

In 2000, an analytical intercalibration exercise organized by the Oswaldo Cruz Foundation, GTZ, and PAHO was carried out. Twenty-three regional laboratories from nine countries participated, with a view to comparing the results obtained in the measurement of lead levels in human blood. This exercise was carried out in two stages.

During each stage, two blood samples with a known concentration of lead were sent to the laboratories for analysis. The results obtained in the first stage were highly inconsistent, with some laboratories reporting concentrations 40 times higher than the actual value (21).

Taking the outliers found in one of the standard samples of this testing stage (110 and 2,700 µg/l) as an example and considering that clinical assessment and an environmental survey, followed by remediation measures, should be conducted when blood lead levels exceed 200 µg/l in children (22) and 300 µg/l in workers with occupational exposure (23), it is evident that the results of a risk assessment and, hence, the mitigation measures necessary to address the problem, will be completely different with such divergent results.

Based on the results obtained in the first stage, some remedial measures were adopted, namely the provision of validated, standardized methods and reference-standard samples to laboratories whose results were deemed unsatisfactory. These measures contributed to a substantial improvement in the results reported in the second stage.

Another study consisted of an evaluation of 40 laboratories in 18 countries in the Latin American and Caribbean region, conducted jointly by the Oswaldo Cruz Foundation, the U.S. Centers for Disease Control and Prevention, and CEPIS/PAHO (24). Although the number of participating laboratories was acceptable, it was much lower than expected, and the distribution of laboratories did not cover the whole region. Some countries, such as Jamaica, contributed a relatively large number of laboratories, while others that are important from a scientific, technological, and regional standpoint did not even participate. Of the laboratories evaluated, only 14 claimed to already have quality management systems in place. This study showed that, on average, the laboratories' capacity to measure basic environmental parameters was 86%: 37% for nutrients, 68% for toxic metals in general, 46% for lead, 39% for cadmium, 39% for copper, 30% for mercury, 20% for toxic organic waste and chlorinated pesticides, 11% for phosphate compounds, 51% for markers of organic load, and 62% for microbiological quality indicators. All laboratories participating in this study were part of the Network of Environmental and Health Laboratories of Latin America and the Caribbean (RELAC) and for the most part were affiliated with ministries of health and of the environment, water companies, and universities. The study also found that 58% of the laboratories evaluated used modified methods without any type of validation.

Another interlaboratory study conducted by CEPIS/PAHO in collaboration with the International Atomic Energy Agency (IAEA) showed that around 25% of water-quality data had an error rate in excess of 20%, with the acceptability of the results varying with the complexity of the measurement (25). While extensive efforts have been made to improve analytical capacity and implement quality assurance for the data reported by environmental and health laboratories in the Latin American and Caribbean region, the capacity, reliability, and comparability of measurements of environmental parameters under specific conditions are still limited.

Although laboratory organization and internal procedures are beyond the scope of this chapter, to meet the requirements for primary data, analytical laboratories must demonstrate that they have proven quality and competency. Beyond adhering to criteria for quality and comparability of results, laboratories that work with biological samples (human or otherwise) must follow the basic tenets of biosecurity (26,27) and ethics set forth in the respective manuals and codes of ethics of each profession or in the relevant legislation.

A publication by the Public Health Leadership Society provides an analysis of the ethical aspects of public health (28). This document briefly states the underlying ethical principles of these tenets, focusing on social aspects and human interdependence, institutional factors, and the interdependence between human beings and the environment.

As established in Annex C of the ISO 15189 standard, all should adhere to the general principles of ethics in health, which consist of protecting the well-being and interests of the sick. Furthermore, all patients should be treated equally, without discrimination. It is likewise important that records for the identification of samples and specimens contain only the essential data and that patients have prior knowledge of the information that will be collected and its purpose. This standard also includes ethical criteria for the collection of primary samples, the dissemination of results, the security of laboratory records, access to those records, and the use of samples for purposes other than that for which they were originally collected.

In animal studies, laboratories should follow the tenets of ethics for animal experimentation. Several texts are available on this matter, among them a document by the Nuffield Council on Bioethics (29).

As environmental health laboratories often handle hazardous equipment (sharps, etc.), samples (biological fluids, etc.), or reagents that can pose risks to human health and the environment, proper handling and disposal of their waste is equally important to prevent these facilities from becoming a source of undesirable contamination. For this reason, laboratories must have appropriate manuals and procedures for the management of waste, whether of chemical or biological origin, with particular emphasis on the importance of adopting measures to reduce waste

production. Several of these manuals, such as the Duke University Laboratory Safety Manual (30), are easily available online.

Once organized in accordance with international standards, the laboratory should be certified for the analyses and measurements in which it is considered to have expertise—i.e., it should obtain formal recognition that it is capable of performing these assays in a competent manner.

## Reliability in laboratories

A laboratory's accreditation by a nationally or internationally recognized organization is an important stage in certifying the quality of the laboratory's work, and consequently provides a measure of reliability to the user of laboratory-generated information. The requirements for considering a laboratory reliable are widely described in internationally accepted standards, such as the ISO standards, particularly ISO/IEC 17025 for testing or calibration laboratories, ISO 15189 and its amendments 1 (2008) and 2 (2012) for medical laboratories, and the Good Laboratory Practices (GLP/OECD). Although there are some differences between the requirements in the ISO 17025 standard and the GLPs, there is substantial agreement and overlap between the two systems. In addition, laboratories are free to choose which system to adopt (31).

In Latin America and the Caribbean, the ISO standards are the ones that have been the most widely adopted.

A laboratory's credibility can be confirmed by an accreditation agency only when that agency certifies, through tests, inspections, and assessments, that the laboratory meets the managerial and analytical quality requirements set forth in the reference standard for the tests, measurements, and calibrations performed.

As is to be expected, accreditation confers a series of benefits for the laboratory, giving it an edge over unaccredited laboratories in tenders and other competitions for projects and services.

Accreditation is even more important in Latin America and the Caribbean, because, in most of the countries of the Region, decisions are based on data produced by a variety of laboratories, ranging from government-owned facilities (research institutions, universities, hospitals, etc.) to private concerns. It should be noted that the fact that a laboratory is accredited does not mean that all its results are correct; rather, it justifies greater user confidence in its results.

The importance of accreditation is even greater when one realizes that many of the current issues are not of local origin, but rather regional or global; thus, their assessment requires comparison of the results from different sources. It is known that environmental changes, unprecedented in human history, are already affecting the health of ecosystems, with major implications for human health and well-being. Anthropogenic changes to the environment have led to the contamination of food and the pollution of water, air, and soil by hazardous chemicals, exposing the entire biota to their harmful effects. It is estimated that more than 2 million deaths annually are the result of these effects, due to indoor or outdoor air pollution; the *per capita* availability of properly treated drinking water is declining, and water pollution remains the leading environmental cause of death and disease. In addition, biomes are being subjected to unsustainable exploitation, whose effects are already being felt throughout the biosphere. Scientific forecasts suggest that, unless immediate steps are taken to control these factors, their effects may extend to the entire planet, reaching catastrophic proportions in some areas. The "Global Environment Outlook" reports provide detailed descriptions of these situations (5).

This clearly shows the need for urgent decision-making to prevent or minimize these harmful effects. Comparison of the results obtained by different laboratories is often necessary for this purpose. Hence, it is essential that the best possible scientific information be generated—that is, to ensure that the data obtained are based on recognized scientific criteria, including reliability, traceability, and comparability.

We believe these reasons are sufficient justification for implementing a strategic plan to improve regional laboratories so as to ensure that the information they produce is scientifically consistent, up-to-date, and complete, thus preventing questionable decisions and scientific conflicts.

Although several Latin American laboratories are already duly certified by national and international accreditation bodies and have all the necessary mechanisms for quality management in place, none has the entire range of capabilities needed to evaluate the effects of the environment on human health. Consequently, it is believed that the best regional strategy would be follow-up and monitoring of the laboratories by means of efficiency tests integrated into a regional strategic plan. This model would ensure the quality and comparability of the data generated and help strengthen the participating laboratories. In addition, given the complexity of the risks resulting from episodes of environmental pollution and of the uneven economic and social development among the countries of the Western

hemisphere, setting up laboratory networks would be the best way of producing the information needed for decision-making while taking regional particulars and strict scientific requirements into account.

These networks would facilitate formal scientific and technical cooperation among participating laboratories, permit the establishment of information systems and regional databases, encourage equivalence in methodological and analytical quality across laboratories, contribute to the implementation of a quality management system (thus facilitating the exchange of reference materials and participation in laboratory performance assessments), foster the development of continuing education programs, and facilitate the sharing of experiences and resources, the strengthening of national networks, and laboratory participation in environmental surveillance programs.

Some initiatives for establishing a unified network of laboratories in Latin American and Caribbean countries are already under way, especially in the environmental field. One of these initiatives has led to the creation of a network known as RELAC, comprising 84 laboratories from 18 countries in the Region.

However, it is worth reflecting on whether a network made up of laboratories devoted to a single scientific specialty (i.e., a thematic network) would be able to meet a demand characterized by the complexity of interactions among the factors that influence environmental health. Certainly not, as the complexity of the relationship between environment and health requires a multidisciplinary or interdisciplinary approach and the involvement of a large number of stakeholders, as noted in other chapters of this book.

Some laboratory networks have already been established in the Americas, among them the Inter-American Network of Food Analysis Laboratories (INFAL) and RELAC. In addition to these international networks, the majority of countries have their own national networks.

In Brazil, for instance, the Ministry of Health, by means of Ordinance 2,031 of 23 September 2004, created the National System of Public Health Laboratories. This system comprises four national networks: the National Network of Epidemiological Surveillance Laboratories, the National Network of Environmental Health Monitoring Laboratories, the National Network of Health Surveillance Laboratories, and the National Network of High-Complexity Medical Laboratories. Pursuant to article 2 (codicil) of this decree, “these networks were structured into sub-networks by issues or programs, indicating the respective reference laboratories, their geographic service areas, and their roles.” This recognizes the complexity of environmental health issues, the need for a multifaceted approach, and the need to establish networks according to the nature of the problem to be addressed.

This decree established the hierarchical structure of the laboratory networks, the management structure of the system, and the roles of the participating laboratory facilities.

Ordinance 70 of 23 December 2004, issued by the Secretariat of Health Surveillance (32), supplemented Ordinance 2,031 by establishing the eligibility criteria for including national and regional reference laboratories in the national networks of environmental and epidemiological surveillance laboratories. The first criterion for a facility to be designated a reference laboratory is the implementation of a quality management system compliant with NIT-DICLA 083 (clinical laboratories), NBR ISO-IEC 17025 (analytical testing and calibration laboratories), or NIT-DICLA 028 (analytical testing laboratories and good laboratory practices) standards.

Nevertheless, maintenance of a laboratory—and, particularly, a laboratory network – capable of producing high-quality results and data is not an inexpensive undertaking and requires constant investment. In middle-income countries and developing economies like the majority of Latin American and Caribbean nations, the problems requiring urgent intervention far exceed the resources available, and the resources to maintain even a laboratory, much less a laboratory network, are very limited. These countries face so many urgent problems requiring solutions and such a scarcity of the resources necessary to tackle them that it is usually impossible to set priorities; often, not even the most basic priority has been set or addressed, which means there will frequently be overlap and substitution of priorities.

The generalized environmental pollution and shortcomings of health programs observed in the majority of countries are clear examples of this situation. Industrial activities that damage the environment are common, as is responsibility for high environmental risk. Consequently, efforts must focus not only on fighting diseases that are endemic in the region, but also on preventing the reemergence of diseases that have already been eradicated and on reducing the risk of exposure to toxic substances.

In this scheme of things, priority is not given to environmental surveillance to address the most urgent cases. This, in turn, has a direct impact on official laboratories, which are usually obsolete, incompetent, and inactive, or have limited resources.

Such a situation is obviously difficult to manage. However, public priorities should be based on reliable scientific results, including high-quality scientific work performed by trained technical personnel. Regardless of whether the data is provided by public or private institutions, what matters is their quality.

In the particular case of Latin America, practically all the data used in setting priorities have been obtained from work and research conducted largely by public institutions (universities, government-run regulatory laboratories, hospitals, institutional laboratories, etc.), even when some private laboratories have provided analytical services on a research contract basis. However, the quality of such data is open to question, since the majority of laboratories operating in the fields of health and environment lack quality assurance mechanisms or systems. This hinders, and sometimes even precludes, the comparison of tests between laboratories. Therefore, if one attempts to draw conclusions or set priorities on the basis of such results, the resulting situations will be very different: can a priority set on the basis of any such result be considered valid?

Nonetheless, these facilities must continue to provide services, due to the lack of other international and national sources that could support the material and human infrastructure of such laboratories. For example, in Latin America, there are no sectorally allocated resources for environmental or public health laboratories: resources are either insufficient or used for other purposes.

To overcome these difficulties, it is advisable that laboratories acquire equipment scaled for their needs and develop, validate, and use simpler, more economical methods, avoiding the procurement of excessively and unnecessarily sophisticated equipment. Equally important is the in-house development and use of validated assessment methodologies, which can be used both for the production of final data and for preliminary analyses, thus curtailing unnecessary expenditures for the proper transport and preservation of samples. Unfortunately, the procurement of equipment taking into account not its purpose, but characteristics such as novelty (the latest model is always more attractive than older ones), sophistication, automation, or over-dimensioned analytical capacity (e.g., devices with detection or quantification thresholds much lower than actually needed), is very commonplace in Latin America. It should be emphasized that these characteristics entail added cost, usually in the form of onerous methods and upkeep, which may be inconsistent with the laboratory's capabilities. In addition, not all participating laboratories in a given network need equally sophisticated equipment. In other words, network laboratories should be ranked in terms of the validated methodologies they have adopted, establishing a cooperation dynamic among facilities.

In addition, a network may be composed exclusively of either public laboratories, public and private facilities, or private laboratories alone. Although the interests of public and private laboratories tend to differ, the efficiency of different types of networks in terms of the production of high-quality information can be equivalent, depending on the control mechanisms in place. From an economic standpoint, a network of private laboratories will, *a priori*, require less financial investment, as its maintenance costs can be passed on to the clients of the constituent laboratories. There is, however, a concern that the results of private laboratories could be biased, particularly in countries where the interests of economic groups run counter to those of the public. Conversely, a network composed exclusively of public laboratories will not only contribute to continuous professional development and to maintaining a staff of technicians proficient in all aspects of the relevant decision-making processes, but can also lower set-up and operating expenses through the sale of services (performing tests, selling reference standards, materials, and validated methodologies, etc.), or even the mechanism known as the "polluter pays" principle. This principle is an important means of ensuring that economic agents are aware of the environmental risks they create and will thus improve their preventive measures.

At any rate, whatever their composition, networks require ongoing investment if they are to continue to operate. Due to regional characteristics, a network comprising only public or nonprofit laboratories appears to be the best option for the Region. Therefore, the occasional sale of services should be considered a short-term response so as not to preclude efforts to secure more stable and equitable funding mechanisms.

Only integrated and coordinated work will ensure that the Region of the Americas has sufficient, high-quality analytical data. It will then be possible to detect environmental and health problems throughout the Region and plan surveillance operations targeting human health and the environment. The following section proposes a plan for this purpose.

## ■ Regional strategic plan: Network creation, capacity-building, and quality development for environmental health laboratories in Latin America and the Caribbean

The logical framework that served as the basis for developing the regional strategic plan was devised jointly during a seminar on strengthening the Latin American and Caribbean environment and health laboratories of the

RELAC network (22), held in July 2006 in Lima, Peru, and attended by representatives from 18 countries of the Region. This plan was developed to tackle what are considered the key problems of the Region, which include lack of local awareness of the actual and potential risks of environmental factors to public health; lack of infrastructure for measuring indicators for control and monitoring of the environmental factors that affect public health; lack of skilled personnel and capital for the development of these laboratories; the need to boost laboratory capacity, especially in terms of the quality of analyses; greater participation by the authorities in the implementation of quality management systems for these laboratories; and the need for national systems for certification and accreditation of environmental laboratories (Figure 9-6).

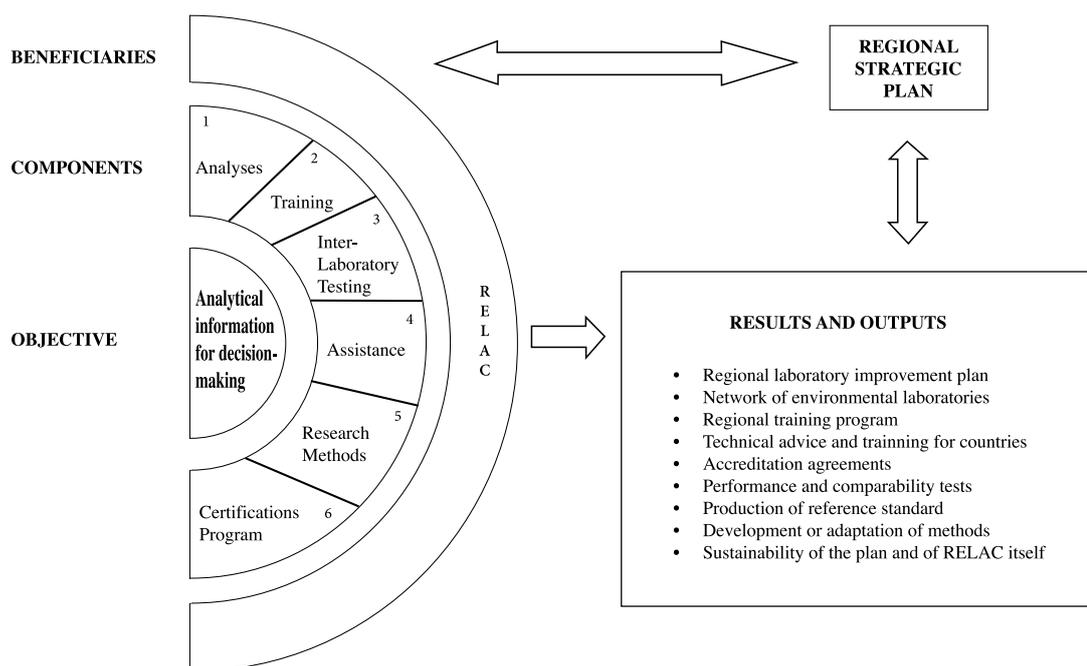
To overcome the key problems and weaknesses observed in the Latin American and Caribbean region, it was decided that the strategic plan should include the following activities:

1. Ongoing assessment of the situation of environmental and biological analytical information (including occupational data) and of the capacity and quality of national public and private laboratories, based on national qualification systems, national legislation, and current regulatory standards.
2. Training of laboratory staff and technicians in quality management systems, qualification pursuant to the requirements of current standards and methods for measuring environmental and biological parameters under specific conditions.
3. Development of joint projects, interlaboratory studies, research tools, and direct technical assistance.
4. Accreditation of laboratories to achieve comparability of information on environmental and biological contexts.
5. Partnerships and cooperation agreements with technical and financial cooperation agencies, such as PAHO, IAEA, and CAN.
6. Partnerships and agreements with collaborating centers, centers of excellence, and environmental and biological laboratory networks sharing common interests, such as INFAL, RILCA, and RACAL, as listed in Table 9-2. A list of national metrology laboratories is available at <http://www.nist.gov/iaao/national.cfm>.
7. Interaction with groups requiring the laboratories' services (e.g., water surveillance, epidemiological surveillance, and environmental surveillance programs).

**Table 9-2.** Examples of centers of excellence, collaborating centers, and accreditation agencies operating in the Americas

<i>Acronym</i>	<i>Name</i>	<i>Website</i>
ECL	Environmental Chemistry Laboratory	<a href="http://www2.epa.gov/aboutepa/about-environmental-chemistry-labotatory-ecl">http://www2.epa.gov/aboutepa/about-environmental-chemistry-labotatory-ecl</a>
CDC	Centers for Disease Control and Prevention	<a href="http://www.cdc.gov">http://www.cdc.gov</a>
CTQ	Center of Toxicology of Quebec	<a href="http://www.inspq.qc.ca">http://www.inspq.qc.ca</a>
NRC-INMS	NRC Institute for National Measurement Standards	<a href="http://www.cisti.nrc.ca/inms">http://www.cisti.nrc.ca/inms</a>
FIOCRUZ (Collaborating Center for Health and Environment)	Fundação Oswaldo Cruz	<a href="http://www.fiocruz.br">http://www.fiocruz.br</a>
CETESB	Companhia de Tecnologia de Saneamento Ambiental	<a href="http://www.cetesb.sp.gov.br">http://www.cetesb.sp.gov.br</a>

<i>Acronym</i>	<i>Name</i>	<i>Website</i>
INHEM	Instituto Nacional de Higiene, Epidemiología y Microbiología de Cuba	<a href="http://www.cubanhealth.com/centros_instituciones/inst_higiene.htm">http://www.cubanhealth.com/centros_instituciones/inst_higiene.htm</a>
COPETTICOAT	Comisión Nacional del Agua	<a href="http://www.conagua.gob.mx">http://www.conagua.gob.mx</a>
IMTA	Instituto Mexicano de Tecnología del Agua	<a href="http://www.imta.gob.mx">http://www.imta.gob.mx</a>
INS	Instituto Nacional de Salud	<a href="http://www.ins.gov.co">http://www.ins.gov.co</a>
ENI	Instituto Nacional del Agua	<a href="http://www.ina.gov.ar">http://www.ina.gov.ar</a>
IGME	Instituto Geológico y Minero de España	<a href="http://www.igme.es/">http://www.igme.es/</a>
INFAL	Rede Interamericana de Laboratórios de Análise de Alimentos	<a href="http://www.panalimentos.org/rilaa/e/index.asp">http://www.panalimentos.org/rilaa/e/index.asp</a>
RILCA	Rede Ibero-Americana de Laboratórios de Qualidade da Água	<a href="http://www.facebook.com/RilcaFC">http://www.facebook.com/RilcaFC</a>
RACAL	Red para el Análisis de la Calidad Ambiental de América Latina	<a href="http://www.racal.org/index.html">http://www.racal.org/index.html</a>
CAN	Andean Nation Community	<a href="http://www.americaeconomica.com/zonas/can.htm">http://www.americaeconomica.com/zonas/can.htm</a>
IAEA	International Atomic Energy Agency	<a href="http://www.iaea.org/">http://www.iaea.org/</a>
PAHO	Pan American Health Organization	<a href="http://www.paho.org/">http://www.paho.org/</a>

**Figure 9-6.** Basic structure proposed for the environmental laboratory network of Latin America and the Caribbean.

*Source:* Extracted from CEPIS/PAHO .

The plan would have the specific objective of ensuring that environmental parameter measurement capabilities are appropriate to the problems faced by the Region and that analytical quality makes it possible to obtain reliable, comparable results that can facilitate decision-making for public health risk assessment and management; this stage is considered a priority at present. To this end, it would be necessary and urgent to increase the level of technical proficiency and competence to meet the quality standards and satisfy the legal requirements of each country; promote quality assessment of laboratory analyses through performance testing; foster the development of local networks; establish and maintain technical and scientific cooperation among laboratories; and contribute to the strengthening of national accreditation systems by training a laboratory evaluation team and national accreditation bodies.

These measures would ensure sustainable support for environmental and occupational laboratories in the Region, as well as laboratories trained in quality assurance, sampling, and measurement of physicochemical, microbiological, and toxicological parameters, with quality control programs.

Based on the results of the joint deliberations, a logical framework for the regional strategic plan was constructed to translate these data into practice, giving special emphasis to the goal, purpose, results, and activities of the plan, as well as the indicators, means of verification, and assumptions for these events (33).

## ■ Conclusions

In the past 20 years, public authorities in the countries of the Region have displayed increased interest in environmental and health issues at the national, regional, and global levels, reflected in the creation of environmental management agencies, the inclusion of environmental issues in the constitutions reformulated during this period, the enactment of environmental laws, the development of environmental education programs, activities to raise awareness among the general public, etc. Nevertheless, the reality is that environmental degradation in Latin America and the Caribbean has continued at the rate of previous decades and, in several areas, has actually worsened, with major health implications.

Despite the enactment of environmental legislation, the degree of implementation and compliance with such laws remains low; therefore, **society holds the respective government agencies responsible for adverse outcomes.**

In most cases, environmental agencies in the Region were established after the 1980s, during the so-called “debt crisis,” which led to cutbacks in government budgets, directly affected human resources and infrastructure, and **compounded the difficulties faced by these agencies in fulfilling their mandates.**

This situation prevented generation of the basic data necessary for decision-making and enforcement of environmental and health standards. Hence, securing the necessary resources **requires creativity and optimization of the limited resources available.**

Considering that the relationships between the biota and the environment are highly complex; that environmental risks derive from the unique characteristics of different environments and populations; that many pollutants exceed local or regional limits; and that it is very difficult for a single laboratory to meet the demand for analytical services in environmental health, it is essential that the sharing of knowledge and experience among countries of the Region be made mandatory so that decisions can be based on information produced by several laboratories.

Good decision-making depends on the quality (reliability, traceability, and comparability) of the available information and, although laboratories in Latin America and the Caribbean are improving, they still leave much to be desired in terms of meeting analytical quality targets.

It is important to consider that preparing a laboratory for certification involves a series of stages that can be encouraged and facilitated through interlaboratory cooperation. For this reason, consideration has been given to developing a regional strategy for the generation of high-quality information and to establishing national and regional laboratory networks so that member laboratories can obtain the necessary accreditation. We view such accreditation and the laboratory networks themselves not as an end, but as a means of obtaining consistent technical and scientific improvements in laboratory capacity in the Region.

The Regional Strategic Plan should be implemented and the existing activities of thematic networks of national and regional laboratories in Latin America and the Caribbean should be exploited. What is largely lacking is political will and allocation of the resources required for effective implementation of priority activities.

Integrated networks should be created that permit better comprehensive, multidisciplinary, or interdisciplinary approaches to tackle environmental and health-related issues. Consideration should be given to the characteristics of the problem addressed, approaching it from a broader perspective by incorporating a greater range of knowledge, especially in a continent as environmentally and socially diverse as the Americas.

The implementation and upkeep of a network of laboratories with the desired characteristics are not inexpensive and will require ongoing investment and political will. To this end, we must call for political will and not wait until environmental health issues and their potential threats to human health have materialized. It is also important to fight to ensure the necessary investments so that laboratories can fully respond to the challenges they face.

Therefore, the authorities tasked with policy-making, decision-making, and the implementation of programs for the surveillance, prevention, and reduction of environmental risks must promote capacity building among personnel and laboratories alike, so that decisions involve as little subjectivity as possible.

The academic community must develop methods that are novel, valid, and tailored to regional characteristics, promote ongoing human resources education, and support national networks within their specialties.

We believe that the Regional Strategic Plan has laid the foundations for strengthening laboratories in Latin America and the Caribbean. Political and economic aspects have yet to be defined so that environmental surveillance in the Region can receive the attention it warrants.

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## Cities and determinants of health

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*“The contemporary city is cursed. The old parts are stifling and the new parts are horrible: air pollution, noise pollution, eyesores, and violence of every kind. But this is no reason to reject humankind’s most beautiful invention.”*

*Genovese architect Renzo Piano, interview in “Le Monde” (21 June 1996), cited in La Città Gioiosa*

### ■ The city as an environment for human development and health

Settlement has wrought the biggest changes in the course of human social development; hence the need to study the phenomenon of urbanization to understand its effects on health. Since the classical age, the city—the *polis*—has been considered the ideal place for human beings to flourish physically, socially, and spiritually. Public spaces offer a venue for social interaction; gardens, joy, and meditation; the entertainment district, theater and, other performing arts; and parks, leisure, and amusement. Since the days of the ancient Greeks and Romans, cities have been the seat of power and decision-making, where human destiny is determined. Their deterioration and loss of traditional functions, therefore, is seen as harmful, ultimately undermining the possibility of healthy growth for people in every sense.

The close relationship between cities and human development arises from both the risks and opportunities that the urban environment offers people at the different stages of life (1). The reasons why cities affect people’s health are many and mainly involve the macro- and microenvironmental changes at work inside them—the subject of the book of which this chapter is a part. Therefore, the vision described here overlaps with that of other chapters in this book to establish the principal correlations between cities and health. Cities, with all their complexities, are where the survival and quality of life of our societies are most in play. Everything that happens in them is critical to the determinants of health, either contemporary or prior to the biological, social, and spiritual life of human beings.

The growth of cities and urbanization began accelerating in the 15th century and continued with the Industrial Revolution of the 19th century, creating advantageous conditions for access to socioenvironmental benefits with positive health impacts. However, urban congestion and overcrowding were also a fact of life, facilitating the emergence and spread of diseases, especially infectious diseases. John Snow’s classic studies of the cholera epidemics in Victorian London led to significant changes in the provision of drinking water and sewage disposal, in addition to focusing attention on the overcrowding associated with poverty. It was precisely in this period that living conditions and environmental conditions began to be considered determinants of health and disease (2).

Interventions in the city environment yielded positive results in terms of reducing infectious diseases associated with water and sanitation, while vaccination brought a major reduction in contagious diseases to urban populations in the industrialized world. This was accompanied, however, by an increase in other determinants that fostered the emergence of chronic disorders associated with new lifestyle factors: sedentary habits, poor diet, smoking, and the abuse of alcohol and other addictive substances.

The early 21st century has witnessed a heterogeneous “demographic and epidemiological transition” in the different urban spaces (3). From the human development perspective—understood as the optimal deployment of human potential in a protective and stimulating environment—cities and urbanization offer people many more opportunities than potential harm. However, in today’s cities there is also the risk of infection, as they may be foci for the rapid transmission of emerging epidemics with a major impact, among them influenza, an acute respiratory infection that caused the century’s first pandemic (4).

Considering the complexity of the phenomena and with a view to promoting the health of cities and their residents, major international initiatives have been launched, such as UN-HABITAT (United Nations Human Settlements Program), whose aim is to help countries make their cities safer, healthier, greener places that offer better opportunities—places where everyone, especially the urban poor, can live with dignity (UN-HABITAT: For a Better Urban Future). This and other similar initiatives invite experts from every nation to promote innovative, interdisciplinary, intersectoral action. It is now recognized that the existing social protection programs, especially in the most sensitive stages of individual development, operate more efficiently and have a greater impact in urban settings but do not achieve much in rural areas, where poverty is higher (Table 10-1).

**Table 10-1.** Urban and rural poverty in Latin American and Caribbean Countries (per 1,000 live births)

<i>Urban and rural poverty in Latin American countries</i>				
<i>Poverty</i>				
Country	Year	Urban	Rural	Total
Bolivia	2007	59.9	77.3	60.1
Chile	2001	15.5	12.9	15.1
Ecuador	2010	22.5	53	32.8
El Salvador	2009	33.3	46.5	37.8
Guatemala	2006	30	70.5	51
Haiti	2001	45	88	77
Peru	2010	19.1	54.2	33.1
Paraguay	2010	24.7	48.9	34.7

Source: The World Bank World Development Indicators 2012

Protection of the reproductive process, the care of children and early stimulation, and intellectual and social education are issues better addressed in cities than in isolated rural areas.

At the dawn of the 21st century, the percentage of the population living in urban areas was 50%, while another 50% was living in rural areas or otherwise dispersed. The Latin American and Caribbean region has a higher proportion of urbanization, which currently stands at around 80%. Urbanization has been extraordinarily rapid in recent decades, with a dynamic that has far exceeded the capacity to adequately manage the process through reasonable urban planning policies. This raises concerns about “urban governance” as a prerequisite for the success of social policies—an issue that will be addressed below.

Campbell and Campbell posit that the cities of the future will take highly varied forms, but population densities will decrease, populations will be older and poorer, and decentralized government will place a heavier burden on health services, since this new urban structure is closely related to the emergence of chronic noncommunicable diseases (5).

The main concerns are the unhealthy urban areas typical of the second half of the 20th century and the megacity slums, known variously as *favelas*, *tugurios*, *villas miseria*, or *pueblos jóvenes*, depending on the country. Migrants from the countryside live in these ramshackle areas, where urban poverty takes hold with all its accompanying disadvantages and inequities. A third of city inhabitants—1 billion people—reside in these unhealthy urban settings, with deleterious consequences for health, especially in areas where poverty is rife. Between 2005 and 2008, the WHO Commission on Social Determinants of Health (Subcommittee on the Knowledge Network on Urban Settings) devoted great attention to this issue, since in addition to their dense pockets of poverty, cities reflect the great inequality found in societies (6).

Another area studied in cities is the quality of life in communities, especially with respect to public health. Here emerges the concept of “healthy cities,” which addresses the issue of urban development as it relates to health through integrated analyses and widely disseminated strategy proposals (7). Examining the structure of the social determinants of health as expressed in cities, this analysis reviews the health situation of Latin American and Caribbean populations, offering examples of successful policies and solutions.

## ■ Relationship between cities and health

Urbanization is an irreversible process that for several centuries has been making cities responsible for the health of individuals and their communities. In terms of health, cities create opportunities, challenges, benefits, and harm. The benefits include access to basic urban services (drinking water, sanitation, energy, housing) and basic social services (health, social protection, safety) and the opportunity to participate in community social networks. The risks of urban development include unhealthy conditions in settlements created with no planning, environmental pollution (mainly air pollution), overcrowding in makeshift dwellings, insecurity and crime, loss of protective networks due to gang violence, and traffic accidents.

It has been known for many centuries that the structural and functional characteristics of cities are essential determinants of health. However, rapid urban population growth has resulted in an uneven distribution of benefits. Inequality and inequity have become the main focus of analyses of what is happening in cities. The results of studies on poverty—defined essentially by income and the capacity to purchase a basket of basic food products—are used to distribute benefits, especially in urban areas (8). Traditionally, health professionals struggle to add years to life and life to years, a mission that goes beyond the classical specialties in medicine and calls for collaborative, interdisciplinary, cross-cultural work—and that is the source of public health’s potential to promote and protect people in their communities (9).

## ■ Cities in Latin America

Describing the reality of Latin American cities is an enormously complex task. Aside from the obvious differences in size and population, from megalopolises such as Mexico City and São Paulo to small semirural villages in Central and South America, numerous differences make the Latin American urban phenomenon not only heterogeneous but also shifting and diverse. Viewed in terms of the progress in Latin American cities, this heterogeneity reflects three processes of transformation and transition under way in the cities of the developed world: the rural-urban transition, demographic change, and the transition from developing cities to fully modern ones. The status of these transformations largely determines the problems and challenges faced by each particular city.

### From the rural to the urban world

Migration from the countryside to cities in the developed world began mainly in the 19th and early 20th centuries. Industrial cities like London already had over a million residents by around 1820, while Chicago and New York reached the same population by the turn of the 20th century. In Latin America, meanwhile, only three cities had more than 500,000 residents in 1900 (10).

Country-to-city migration began in the most advanced and modern Latin American countries in the 1920s, while in other countries it remains a developing phenomenon. This historical difference explains the radically different urbanization rates in the Region today. In its urbanization forecasts for 2010, ECLAC (11) puts the countries of the Region in four categories: countries in advanced urban transition (close to 90% urbanization: Argentina, Chile, Uruguay, Venezuela); countries in full urban transition (75-80% urbanization: Brazil, Colombia, Mexico, Peru); countries in moderate urban transition (60-70%: Bolivia, Ecuador, El Salvador, Nicaragua); and countries in delayed urban transition (under 55%: Guatemala, Haiti, Honduras). The urbanization rate must be taken into account to understand the problems and challenges facing the cities of the continent. In terms of material needs, countries that have not yet completed their country-to-city transition will have a greater need to provide low-cost housing and basic services to the new populations arriving in the cities. Unfortunately, slums and shantytowns will continue to grow on the outskirts of cities in some countries.

In sociocultural terms, the rural migrant population—less educated and less skilled than city dwellers—poses significant public policy problems when it comes time to consider issues such as social cohesion and assimilation. Nearly a hundred years ago, the University of Chicago’s school of urban sociology (the “Chicago School”) detailed

the social costs of migration to the big city (12). These considerations are probably still valid for understanding the phenomenon of migration. When rural dwellers migrate, they leave their social networks and reference points for their values behind, entering an environment where community and sociocultural homogeneity are unimportant, creating anxiety and frustration. Thus, when social groups arrive in the city, they are not only poor but lack their most important cultural reference points, further hindering their assimilation.

### From "young towns" to mature cities

A second transition, whose spearhead is in Latin America's cities, is the constant, radical aging of the population. Lower fertility and birth rates (13) and longer life expectancy at birth are systematically increasing older populations in every country in the Region: between 2000 and 2025, 57 million older persons will join the 41 million already living there. The Region's most populous countries (Brazil and Mexico), together with Colombia, Argentina, Venezuela, and Peru, will account for most of that number, but the smaller countries will also experience a significant increase, especially after 2025 (14).

An aging population poses unprecedented problems in Latin America. First, the countries must deal with an ever-shrinking percentage of economically active population (which jeopardizes the opportunities for future development), while at the same time supporting an older population that is growing day by day. This implies the need to generate social resources to safeguard the standard of living of people who stop working and to pay for the costly health care required by a population with growing needs. In this context, public health is taking on the task of fostering determinants that will guarantee the quality of life of older persons, while respecting the culture of each cohort. This means ensuring that they have decent places to live, move around, and relax in and access to adequate health plans and other necessities. Latin American cities appear unprepared to tackle this challenge. Older persons should be valued, protected, and considered important members of society (15).

### From underdevelopment to modernity

Finally, the most significant transition facing Latin American cities involves the step from underdevelopment and poverty to fully modern societies and cities. Although no Latin American country can be considered a fully developed society, the differences between countries are as significant as they are in the other aspects discussed above. Three groups of countries can be distinguished in Latin America: poor countries, with urban poverty rates above 40% (e.g., Bolivia, Haiti, Honduras, Nicaragua, and Paraguay); countries with intermediate levels of poverty, with rates of 25-40% (e.g., Brazil, Ecuador, and Mexico); and countries with less poverty, with rates below 25% (e.g., Argentina, Chile, Uruguay, and Costa Rica) (16). Significant sociodemographic differences are also observed.

For example, while life expectancy at birth is below 70 years in the poorest countries of the Region (and as low as 60 years in Haiti), it stands at over 75 in the wealthiest countries. Furthermore, while infant mortality rates in the poorest countries exceed 30 per 1,000 (59 per 1,000 in Haiti), they are below 12 per 1,000 in the wealthiest countries (17). It is worth noting that this almost linear relationship between poverty and low vital indicators breaks down in the case of Cuba, a country with low per capita GDP that boasts high life expectancy at birth (77.5 years) and low infant mortality (5.8 per 1,000) (18).

These large differences reflect the greater capacity of the wealthiest countries to control causes of mortality that are typical in the third world, especially infectious diseases and child malnutrition. Early in this century, in countries like Guatemala, Haiti, and Honduras, more than 15% of children under 5 suffered from malnutrition, in contrast to Chile, where the figure was just 0.8% (the lowest rate on the continent) (19). It is therefore important to analyze the differences in access to health networks (at least in urban areas), public health expenditure, and the existence of mass disease prevention plans.

Concerning access to networks, while some countries have achieved nearly 100% drinking water and sewerage service coverage in urban areas, others continue to grapple with major problems connected with urban drinking water supply and pollution caused by human waste (20). Furthermore, the inequity in health expenditure in the Region is staggering: the wealthy countries of the Region annually allocate more than US\$150 per capita to public health, while the figure for the poorest countries (for which reliable data are available) is less than \$50 per capita, and below \$25 in countries such as Guatemala and Paraguay (21).

The enormous differences among countries and cities across the continent make their respective sanitation and health problems radically different:

Cities in the poorest countries, and especially slums, are often breeding grounds for infectious diseases, malnutrition, and health problems, not to mention high rates of urban violence—a phenomenon that will be addressed later in this chapter.

In contrast, the wealthiest countries of the Region have seen a substantial increase in diseases associated with higher levels of development. There are more psychiatric problems (depression and anxiety), and obesity rates and deaths from heart attack are on the rise, due largely to the sedentary urban lifestyle. Thus, for example, while more than 7% of children under 5 in Chile and Argentina are obese, the figure is less than 2% for children in El Salvador, Honduras, and Colombia (22).

Despite the tremendous sociodemographic heterogeneity of Latin American cities, there is something they share: the high level of inequality found in most of the countries of the Region. In fact, no region in the world is more unequal than Latin America; it is therefore no surprise that despite certain recent progress in the Region, only sub-Saharan Africa has higher levels of inequality.

These enormous inequalities imply that even the wealthiest cities in the continent have problems characteristic of the developing world. These problems tend to be concentrated in the poorest districts and slums—areas that often have income, education, and service levels comparable to those of much poorer cities. Meanwhile, even the poorest countries of the Region have development-related health problems, usually concentrated in the more affluent parts of cities.

The size of cities and their growth rates in different parts of the world varied widely in the last century. Population increase has been much faster in the poorest regions (Table 10-2), meaning that the poor now live primarily in cities and these cities are bigger. This poses new problems for developing public and social policies different from those of the previous century (Table 10-3).

**Table 10-2.** Number of cities in the world, by population

Population	Number of cities	Economic level	
		More developed	Less developed
>10 M	21	4	17
5-10 M	37	6	31
1-5 M	496	118	378
0.5-1 M	507	107	400
Total 0.5-10 M	1,061	235	826

**Source:** NRC. *Cities Transformed*. Washington, D.C.: National Academy Press; 2003.

**Table 10-3.** Urban population by geographic area

Geographic area	Years/population (millions)				Growth rate (%)		
	1950	1975	2000	2030	1950-1975	1975-2000	2000-2030
Asia	244	592	1,376	2,679	3.5	3.4	2.2
Africa	32	102	295	787	4.6	4.2	3.3
Europe	287	455	534	540	1.8	0.6	0.04
Latin America and the Caribbean	70	198	391	608	4.2	2.7	1.5
North America	110	180	243	335	2	1.2	1
Oceania	8	15	321	32	2.5	1.7	1.1

**Source:** NRC. *Cities Transformed*. Washington, D.C.: National Academy Press; 2003.

## ■ Social determinants of health and cities

The new systematization of what Wilkinson and Marmot call the “social determinants of health” offers an appropriate analytical framework for the factors that should be considered in cities. These authors have put together an already classic list of determinants:

- social gradient
- stress
- early life (0-8 years)
- social exclusion
- work
- unemployment
- social support
- addiction
- food
- transport

According to the WHO Committee on Social Determinants of Health, social determinants can be grouped into two categories (23):

- structural: those that determine social stratification, such as income, education, gender, race, and sexuality; and
- intermediate: those that underlie the social stratification and determine differences in exposure and vulnerability to factors that affect health, such as working and living conditions, housing, and access to health care.

A superficial analysis immediately confirms that these determinants have much to do with the city and its main environmental aspects: indeed, all social structures and interactions are urban phenomena. The social gradient—across which we see that the highest levels of dependency pose the greatest risk of disease and death—is the most important determinant according to Wilkinson and Marmot. The fact that work and unemployment have an impact on health is well documented in abundant literature and is also central to this approach. The analytic framework also considers stress (as a psychosocial mediator of organic threats), as well as social exclusion (as an intermediate factor) and the capacity of social networks to protect individuals. Finally, three factors closely linked to city life—addiction, transportation, and the availability of good food and access to it—form part of the analytic framework of health and disease.

The correlation between social determinants and urban health was studied by the Knowledge Network on Urban Settings of the WHO Commission on Social Determinants of Health (CDSS-KNUS). This exercise in policy analysis and proposals, promoted by the late Director-General of WHO, Lee Jong-wook, and inspired by Michael Marmot, was conducted at the WHO Kobe Center and dealt with urban planning and health issues (24,25). The working group found that, from the health standpoint, the following are the main aspects to consider in urban settings:

- The regions of the world with the greatest and most rapid urban population growth are also those with the largest populations living in slums, suggesting that urbanization in itself is a determinant of health and that poverty leads to the creation of slums and fosters ill health. The relationship between unhealthy urbanization and its results is channeled by various structural, environmental, work-related, and other mechanisms. People living—or surviving—in these conditions do not enjoy what could be called “full citizenship.”
- Urban poverty and unhealthy living are associated with powerlessness in communities that do not have a voice or the ability to impose their needs. The process needed to change this situation leads to “healthy governance,” understood as that which adequately considers the health of communities in its plans and programs.

- The poorest segments of cities are even more exposed to environmental conditions that foster classical and emerging infectious diseases such as SARS, HIV/AIDS, and the now-imminent flu pandemics.
- One of the biggest health problems in cities and among their poorest populations is the disproportionate incidence of traffic accidents due to poor road conditions and the use of unprotected vehicles such as bicycles and motorcycles.
- Insecurity and violence, linked to vulnerability and the progressive usurpation of public space by gangs of drug traffickers, pose physical and mental health risks to the residents of poor shantytowns in new cities.
- Poor nutrition, insufficient food intake, and lack of access to healthy food are another problem in poor urban areas. Malnutrition on the one hand, and obesity and overweight on the other are characteristic of nutritional imbalance, a problem that particularly affects poor urban settlements on the periphery of large cities. This trend is exacerbated by the lack of places to safely and effectively engage in physical exercise.
- An important factor in correcting inequalities in poor settlements is to set up community-based health services nearby that focus on primary care with a strong health promotion component. This strategy can rally people around health professionals, educators, and local leaders to develop policies and interventions from a health services standpoint.

## ■ Housing and neighborhood: The basic unit for human living

Housing constitutes the basic functional unit for people in cities: it is the environment that people inhabit throughout the life course and is a fundamental determinant of their quality of life. Housing should have characteristics that meet the cultural and demographic needs of each population, and social policies should consider it a priority issue. There is a need for social policies that place special emphasis on the situation of vulnerable groups, offer comprehensive and innovative solutions, and promote intersectoral and interdisciplinary participation.

Housing is therefore not an urban development issue but a human development challenge. To ensure a healthy environment and surroundings, dwellings should include basic sanitation and clean, structurally sound physical spaces. Neighborhoods—environments shared by human groups living in different housing arrangements—are organized around dwellings. The neighborhood context gives rise to relational dynamics that promote support networks aimed at achieving safe and healthy psychosocial spaces that are free from violence (physical, verbal, and emotional abuse).

Cities have generally grown almost spontaneously, apace with the rural-urban migration of the past decades. However, governments have been unable to properly manage this process, resulting in the burgeoning of slums in urban fringe areas where planning and basic services (i.e., utilities and transportation) are lacking, and above all, where the quality of housing is poor or extremely poor. In the year 2000, 1 billion people around the world lived in these precarious circumstances, with enormous costs in terms of the social exclusion and ill health resulting from poor housing conditions. Between 2000 and 2012, the percentage of urban slum dwellers in developing countries fell from 39% to 33%. More than 200 million people received access to improved water sources and sanitation facilities or dwellings that were less crowded and built to last. This achievement exceeds the goal of significantly improving the living conditions for at least 100 million slum dwellers, long before the target date of 2020 (26).

Poverty in Latin America declined from 29.4% of the total population in 2011 to 28.8% in 2012, meaning that 167 million people in Latin America and the Caribbean were living below a poverty line of less than US\$2.00 a day. About 66 million of them were living in extreme poverty or indigence—that is, on less than US\$ 1.00 a day (27).

Housing deficiencies or shortages and lack of sanitation are reiterated determinants of excess mortality—factors associated with poverty levels and spatial inequity in Latin America and the Caribbean (PAHO/WHO: *Health in the Americas*, 1998). For this reason, PAHO has facilitated the Healthy Housing Network through its Collaborating Center for Health in Housing, currently coordinated through the Inter-American Network on Healthy Housing (28).

Today, the right to housing is enshrined in the Universal Declaration of Human Rights of 1948 and holds a significant place in the aspirations of broad sectors of modern societies. Understood as a basic good that permits the enjoyment of other basic rights, housing is considered an essential component of the international system for the protection and promotion of human rights.

People have the right to a dwelling with secure tenure and located in a safe place—one that is structurally sound and has sufficient space for the needs of the family group residing in it. It is important that housing have basic servi-

ces (drinking water, excreta and wastewater disposal, solid waste collection), household effects, and safe consumer goods. A dwelling's design, choice of site, construction, use, and maintenance all involve the concepts of "peridomiciliary area" and proper and hygienic use, which include the dwelling's social and geographic location, building materials (safety and quality of materials), construction process, layout, quality of finishes, overall surrounding context (communications, energy, neighborhood), and the health education of its residents (healthy lifestyles and living conditions).

In 1995, PAHO proposed six principles that identify health risks:

1. Protection against communicable diseases, which includes:
  - safe drinking water;
  - excreta disposal;
  - solid waste disposal;
  - surface water drainage;
  - personal and domestic hygiene;
  - hygienic food preparation;
  - secure housing (sufficient space, ceilings, floors, etc.).
2. Protection against injuries, poisoning, and chronic diseases:
  - characteristics of housing and furniture (includes protection against adverse weather conditions and other environmental risks);
  - indoor air pollution;
  - lower risk of exposure to chemical substances;
  - protection against workplace hazards.
3. Reduction of psychosocial stress factors:
  - avoidance of overcrowding;
  - sense of security;
  - private social recreational space;
  - noise reduction and access to green areas and services;
  - dwelling easy to clean and organize.
4. Improvement of household environment, including access to services such as:
  - police and emergency services;
  - social and health services;
  - cultural and recreational services.
5. Proper use of housing:
  - a dwelling will be healthy only if its residents use it properly.
6. Protection of the most vulnerable population groups:
  - women and children;
  - the poor;
  - displaced or migrant populations;
  - the elderly, chronically ill, and disabled (29).

One of the interesting proposals aimed at implementing this holistic vision of the functions of housing in society is the Healthy Housing initiative. This WHO initiative considers housing conditions a relevant factor in the health of residents and promotes housing-related activities that protect health. It enjoys the strong political backing of several Latin American governments, as well as strong community engagement and action. As part of the initiative, groups of experts from different sectors propose innovative systemic proposals for handling new urban scenarios (30).

The University of São Paulo has created a specialized scientific center, the Center for Study, Research, and Documentation on Healthy Cities and Municipalities (CEPEDOC). In Colombia, the University of Valle School of Public Health tackles issues related to health promotion through local development. Major challenges include meeting the growing demand for housing, developing special programs for vulnerable groups (the poor, the elderly, the disabled, migrants), and planning and protecting healthy neighborhoods and spaces. In Rio de Janeiro, priority has been given to interventions in neighborhoods where violence and corruption are rife. The government has made tremendous efforts there to dismantle drug trafficking networks and subsequently intervene to support families; a successful example of this is the old Santa Marta slum.

In Chile, mass housing construction over the past 15 years has reduced housing shortages, and many Latin American governments are imitating its financing model. The Chilean government has also made great efforts to provide housing to vulnerable groups, and its public housing policy has been considered a success. Nevertheless, while some urban problems have been solved, others of a social nature have arisen.

Many of Chile's housing problems originated in the 1970s, when the Chilean Ministry of Housing and Urban Planning promoted history-making, subsidy-savings-credit programs. In response to these programs, some entrepreneurs purchased large tracts of land on the outskirts of Metropolitan Santiago, where new housing developments went up, resulting in segregation, fragmentation, insecurity, and overcrowding, since aspects such as support networks and the mobility of residents were not addressed. As a result, 20-30 years after purchasing their own home, residents have differing perceptions about their quality of life. Considering them to be social stakeholders, some studies indicate that 64.5% would like to move out of their home and neighborhood, 13.4% feel unsafe and find their homes too small, and 12.4% mention the housing development's isolation and lack of services and parks.

From another standpoint, the quality of housing has an impact on public health, especially in terms of the risk of contracting infections. Arthropods can breed in poorly built dwellings. In Latin America, one hears references to "Chagas shacks"—traditional rural dwellings in the Region of the Americas built with adobe walls and straw or *quincha* ceilings, creating an ideal habitat for the biological vector of the *Trypanosoma cruzi* parasite to thrive and breed. Current vector control programs have shown that even when the vector is eliminated inside the dwelling, it returns to the peridomestic area (31,32). The transmission of enteric diseases such as parasitosis and soil-transmitted helminth infection is also affected by housing conditions, especially earthen floors and poor sanitation (drinking water, sewerage, etc.) (33).

More in-depth investigation is needed to better understand housing-related risk factors and their impact on health, prepare guidelines on the principles of healthy housing, and protect communities through training programs for community facilitators and agents. Sustainable healthy alternatives include strengthening the Ibero-American and Caribbean Forum on Best Practices in healthy housing, promoting community action on projects for community construction of healthy housing, and a comprehensive approach to health. Suggested lines of action include formulating healthy policies, implementing sustainable and healthy alternatives, and promoting an understanding of public spaces and the ties that residents forge in spatial systems.

People take ownership of their housing and leave imprints on the places in which they live. They also attempt to carve out private spaces for themselves and their family and to personalize their own space. There are tradeoffs between privacy and visibility vis-à-vis the neighbors. In public housing, encounters (both positive and negative) occur in common areas. Everything related to the interior of dwellings, from the size and distribution of spaces to household goods and storage, has an impact on people's quality of life and health, since dwellings protect people from environmental inclemencies (temperature, humidity, wind, etc.), vermin (reservoirs of disease—i.e., mice, arthropods, etc.), and accidents (stairs, large windows, balconies, etc.) (34). Dwellings should be adapted to human beings in their different stages of the life course and to families in the different stages of the family cycle. This is the kind of safe housing that should be provided for children and older persons (35-37).

An intersectoral interdisciplinary approach to complex problems is needed. Ducci *et al.* conducted an action-oriented research project in Los Navíos (Florida commune, Santiago Metropolitan Region), a housing development representative of hundreds of others built in Chile. This development, with a population of 13,000, consisted of 2,569 basic dwellings delivered to residents in 1990 under government programs. A joint assessment with the community came to the conclusion that it was hard to get a clear picture of the real situation of residents there. Although the population was apparently middle-class, disguised poverty, violence, and insecurity were observed—very difficult problems to address and mitigate. The development was functionally isolated from the rest of the city and lacked green spaces; furthermore, a nearby sand pit 250 m in diameter and over 50 m deep posed a hazard (38). Similar situations have been found in settlements built in environments hazardous to the health of their residents—for example, atop old garbage dumps or next to deposits of lead residue (Arica, 2003). These environmental conditions pose a particular hazard to children, who are still developing (39).

In response to the demand for assessment models, Mexico proposes the 3cv+2 model, which has provided 52 real estate companies in several states with a simple methodology to assure the quality of housing construction. During its two-and-a-half years of use, companies have, for the first time, prepared reports on the quality of construction processes, yielding physical evidence of an improvement in the overall quality of the housing that can be verified by all those involved in its construction (40).

Healthy dwellings and neighborhoods depend not only on the quality of the construction, but also on how people live together in them. In Brazil, three projects on community-use buildings (Fubá, Campinho Olympic

Village, and the Macacos community-use space —part of the Favela-Bairro slum project) emphasize leisure and recreational programs as key to addressing the problems of exclusion and urban poverty (41). After listening to residents' demands and studying the blueprints of the place, an urban space was created that integrated all the variables involved in the search for a coordinated physical and social environment, formally and spatially configuring a solution for each aspect (road layout, urban planning, landscaping, buildings, public spaces, and infrastructure).

With regard to the spatial growth of cities, Chilean researchers conducted a study of several large cities, including Santiago, Valparaíso, and Concepción, and medium-sized cities, including Chillán, Los Ángeles, and Temuco. This study found that the spatial growth of cities causes:

- Changes in the urban climate and the deterioration of air quality as a result of uncontrolled pollution; the intensification of urban heat islands; and the reduction or loss of cool islands.
- The reduction, deterioration, and loss of plant cover, including croplands, natural areas, and valuable ecosystems such as wetlands.
- Loss of the quality environmental services offered by natural landscapes inside and surrounding cities.
- Loss of biodiversity and reduction and loss of natural habitats and wildlife corridors and areas.
- Increased socioenvironmental segregation within cities.
- Environmental injustice and discriminatory concentration of adverse effects (including diseases related to the urban environment) in the most vulnerable social sectors.
- Growing commodification of land, natural resources, and environmental services: markets represent only consumer-focused uses and do not consider the environmental and social costs; speculation and privatization of community property.
- Growing disconnection and conflict between the structure and dynamics of natural and constructed spaces; overload of the carrying capacity and resiliency of urban ecosystems.
- Lack of institutions and instruments for environmental planning and assessment of urban spaces.
- Need for integration of strategic environmental assessment in urban policies, plans, and programs; and for effective environmental impact assessment of public and private investment projects that severely disrupt the urban environment (42).

These conditions are found in most Latin American cities, highlighting the new problems that are emerging.

In the United Nations Millennium Declaration of September 2000, 191 countries adopted eight Millennium Development Goals (MDGs), including 18 targets related to extreme poverty and hunger, education, gender equality, health, environmental sustainability, and partnership for development. Several of these targets focus on human settlements, including Target 10, which seeks to halve the proportion of people without sustainable access to safe drinking water, and Target 11, which seeks a significant improvement in the lives of at least 100 million slum dwellers by 2020 (United Nations, 2000). To collaborate in meeting these targets, ECLAC has developed a line of research—Urban poverty: an action-oriented strategy for urban governments and institutions in Latin America and the Caribbean. This project explores the features of urban poverty in order to more accurately determine the technical support needed by countries and municipalities to achieve the MDGs (43).

## ■ Urban violence and safety (violence, crime, and health)

Although there is a real empirical basis for the strong association between Latin American cities and crime, it should be noted that the continent is extremely heterogeneous in this regard: in some historic periods and cities, violent crime rates have been relatively low, while at other times, some of these cities have been among the most dangerous on the planet. High crime rates tend to be concentrated in certain countries and major metropolitan areas, while small cities and towns remain relatively safe, with the exception of countries with rural guerrilla insurgencies. This can be seen in the distribution of homicides per 100,000 population in different cities of the subcontinent.

**Table 10-4.** Homicides per 100,000 population

<i>Intentional homicides in Latin American cities</i>			
<i>Country</i>	<i>City</i>	<i>Rate per 100,000 pop.</i>	<i>Year</i>
Argentina	Buenos Aires	3.9	2007
Bolivia	La Paz	5.2	2006
Brazil	São Paulo	10.8	2009
Colombia	Bogotá	17.1	2010
Ecuador	Quito	13.8	2006
Paraguay	Asunción	10.6	2006
Peru	Lima	3.9	2004
Uruguay	Montevideo	6.5	2007
Venezuela	Caracas	122	2009

**Source:** United Nations Office on Drugs and Crime. *Homicides in the most populous city. Homicide statistics city data* (44).

Much has been written in the past decade about how dangerous some Latin American cities are and the social and economic consequences of this situation (45). The media report every day on homicide rates in cities such as São Paulo, Rio de Janeiro, Medellín, Caracas, Mexico City, and certain Central American cities; films are made, books are written, and public policy measures are designed to fight this scourge. The presence of drug cartels and organizations whose main source of income is kidnapping has systematically reduced tourism and foreign investment in these cities, critically affecting their levels of development (46).

However, the seriousness of the violence and crime in some Latin American cities tends to obscure other concurrent conditions not often described or studied in the depth they merit and that undoubtedly have negative impacts on the health of the population.

These local conditions are associated with the appearance of a violent, marginalized sociospatial structure in Latin America: the ghetto. Ghettos are characteristic of some cities in the developed world (especially the United States) and have come to replace traditional urban poverty in the continent (47). This new sociospatial structure is present in most Latin American cities, even where crime rates are low in the city as a whole.

Ghettoized poverty<sup>1</sup> implies a transformation of interpersonal relations within a given territory and a change in the way its residents define their relationships with different social structures, constructing a set of expectations and values that differ from those considered “normal” by the larger society (48,49). While the material want of traditional poverty used to hide behind solidarity and organization among residents, ghettoized poverty—fostered by the growth of sociospatial inequality and the structural transformations of today’s society, especially in the job market—causes desperation, isolation, and a change in values that complicates ghetto dwellers’ integration in the larger society (50).

The three aspects of ghetto life that most negatively affect the health of residents are related to the culture of violence, fear, and drugs.

## The culture of violence

Aside from what is traditionally considered “crime,” life in the ghetto fosters other situations of violence that are not often considered in the specialized literature (51): organized or personal violence—frequently associated with drug or alcohol use—becomes omnipresent in everyday life and may be resorted to as a means of solving any problem or venting any frustration.

<sup>1</sup> Ghettoized poverty (from the Italian: “ghetto”): Populations that undergo an ultimately modifiable process of ghettoization, characterized by an involuntary spatial concentration of poor or marginalized people with a high degree of social homogeneity; physical or psychological boundaries that are difficult to cross; and a heavy stigma associated with the space, in which the accepted social rules lose their validity, creating a ghettoized perspective.

In this context, ghettos are places with high rates of both domestic (52) and peer violence, especially among adolescents, where everyday social relationships with the outside world (teachers, physicians, nurses, etc.) take on a violent tone, stemming from the stigmatization of ghetto residents and their response to the aggression against them by the rest of the population.

This culture of violence not only has a direct and measurable impact on the health of the population, visible in the countless cases of domestic violence seen in physician's offices and hospitals and in the hundreds of people treated at these centers after fights or street brawls; it also has an indirect impact, tending to normalize and breed violence in the population—a psychological effect that is hard to quantify and hard to eliminate through public policies.

### The culture of fear

The climate of violence leads many families to try to protect and distinguish themselves from those involved in criminal activities by isolating themselves behind high walls, barred windows, and guard dogs.

Aside from closing people in, isolation disconnects them from their surroundings. It becomes common to hear people say “I don't talk to anyone here,” making each family an isolated unit without networks and social contact. Fear causes people to stop spending time in public spaces and to venture out only at certain hours, effectively surrendering these spaces to the people involved in crime.

Fear also causes public transportation systems to shut down at certain hours, police and ambulances to fail to arrive, and the government to lose its authority in the area. From a public health standpoint, we used to be concerned only about the existence and availability of health care networks for the poorest sectors, but today, even though a large portion of poor people have access to health networks in several Latin American countries, these networks are underutilized, either for fear of leaving home at certain hours or for fear of gang reprisals against anyone who has dealings with a government worker—a physician or nurse, for example. As a result, many people with a health problem wait until morning to seek care or simply go to hospitals far from their place of residence, causing frequent patient overloads in certain facilities, especially the best-located ones.

### The drug culture

Individual drug use in itself is a major public health problem. Latin America has sobering statistics on the use of drugs—especially cocaine—and the violence associated with it. Many countries in the Region have drug prevention plans, especially in schools, and programs to fight the production and sale of drugs. This means simultaneously working on two fronts: discouraging demand and reducing supply.

**Table 10-5.** Cocaine use in selected countries

Country	Annual prevalence of illegal cocaine use (percentage of the population aged 15-64)
Spain (highest in Europe and the world)	3.0
United States (highest in the Americas)	2.8
England	2.4
Italy	2.1
Bolivia	1.9
Chile	1.76
Ecuador	1.2
Guatemala	1.2
Panama	1.2
Australia (highest in Oceania)	1.2
Venezuela	1.1

Country	Annual prevalence of illegal cocaine use (percentage of the population aged 15-64)
Nicaragua	0.95
Colombia	0.8
South Africa (highest in Africa)	0.8
Israel (highest in Asia)	0.6

Source: UNODC, 2007.

However, drugs should also be understood in their sociospatial context, associated with the lifestyles and value systems prevalent in some urban areas. At the microspatial level, ghettoized areas exist where drug use is not only socially acceptable but, in fact, drug trafficking is the main source of income for many families, breaking the ties that link these families to the job market and the social values associated with it. It is contexts like these that we refer to as the “drug culture.” (53)

In the first place, drug traffickers—wealthy professional criminals—are losing ground in the drug business to family clans sunk in poverty or youth gangs that are both drug vendors and users. Furthermore, there is a general lack of concern among addicts and their social connections about basic aspects of self-care such as personal appearance, a healthy diet, and proper prevention of sexually transmitted diseases. Finally, using and selling drugs ends up being legitimized by the community and considered simply one more strategy for overcoming poverty or integrating into a society that denies it other forms of upward mobility.

Though traditional crime-fighting plans should not be abandoned, they are not enough to remedy this situation of violence, fear, and drug legitimization. Militarizing urban spaces, as countries such as Brazil and Colombia have done, can help break up criminal organizations and reduce the number of weapons in private hands, but it is rather inefficient at promoting a transformation in values and culture that will lead to a complete rejection of urban violence. New ways of tackling the problem of gangs are needed since, in addition to their criminal nature, they play a major role in developing an antisocial identity in adolescents (54).

In the ongoing debate about whether or not to criminalize drug use, it is recognized that drug dependence is a chronic, recurrent public health problem and that there is a need to take a gender approach and engage civil society in the formulation of drug control policies (55).

Comprehensive urban development and jobs plans have been implemented in several countries with decayed urban areas. Good examples of comprehensive policies to curb urban violence include the *200 Barrios en Chile* (“200 Neighborhoods in Chile”) plan, aimed at transforming selected decayed areas through improved housing and infrastructure and training and jobs programs for the population; the *Favela-Bairro* plan for slums in Brazil, designed to improve the lives of vulnerable urban groups through their active engagement in problem-solving; and the *Bogotá, ¿cómo vamos?* (“Bogotá, how are we doing?”) initiative in Colombia.

Along the same lines, the United Nations Human Settlements Program (UN-HABITAT) is working to promote 100 healthy cities. Its objectives include social inclusion, better governance, and opportunities for at-risk urban youth, while exploring and developing new ways to foster community-based citizenship (56). UN-HABITAT helps cities identify priorities in urban governance and evaluate their progress toward equality in urban life. Its research findings are collected in the *Global Report on Human Settlements and State of the World's Cities*.

## ■ Other health-related urban factors

There are different ways of looking at healthy cities, both from the causal perspective and in terms of preventive or palliative action. This section examines some of these perspectives.

### Obesity, sedentary lifestyle, and chronic diseases

Urbanization and sedentary living have led to an increase in “lifestyle” diseases and health events such as hypertension and heart attacks. In urban areas, there is an observed reduction in physical activity, with excessive use of electronic games and longer hours in front of the television, significantly reducing energy expenditure. This behavior is especially prevalent in children and adolescents but is also present in other age groups.

Automobile use, limited physical labor, and high energy intake are common in urban areas, especially in the highest social strata. These are risk factors for obesity and related illnesses (57). Because obesity is now considered a global pandemic that must be quickly curbed, it should be taken into account in the design or redesign of cities. Ways of addressing this situation include initiatives that promote pedestrian activity and attempt to reclaim cities for pedestrians, among them: protecting and maintaining sidewalks; reclaiming street corners and improving pedestrian crossings; ensuring that the legally established spaces for these crossings are kept vehicle-free; creating pedestrian itineraries; increasing the permeability of artificial barriers created mainly for transportation infrastructure; improving access to public transit systems; and amending municipal regulations (58).

In Chile, the sedentary lifestyle is a serious public health problem. Studies on quality of life conducted in the year 2000 by the Ministry of Health and the National Socioeconomic Characterization Survey (CASEN), show that 73% of the population does not engage in any kind of physical activity, 18% does so once or twice a week (playing soccer or going for a walk on Saturday or Sunday), and only 9% does 30 minutes of exercise at least three times per week. The latest National Health Survey (2003) shows that almost 90% of the population is sedentary and that this figure rises with age and is higher among women than men. In light of this situation, the government has proposed policies to promote physical activity and reduce the determinants of the sedentary lifestyle.

It is necessary to encourage the development of multisectoral public policies aimed at creating equitable environments for health promotion that empower individuals, families, and communities to make healthy decisions and live healthy lives (59).

### Natural disasters, health, and cities

Hurricanes, floods, landslides, and heat and cold waves are examples of natural disasters. Other disasters include those of man-made origin. Disasters have become an important part of how health systems are organized, since their consequences demand a rapid response. This makes it important to understand what is meant by “preparedness” or response capacity.

Natural disasters can have particularly serious health consequences in cities, given their highly dense populations. Furthermore, since many cities lack adequate urban infrastructure and planning, they are in a poorer position to survive the fury of the elements. This is seen with urban settlements that crop up in hazardous places—for example, on hillsides, the slopes of volcanos, or near watercourses, garbage dumps, or toxic waste sites. Not a single city in Latin America is exempt from these types of unstable conditions (60).

Cities are exposed to natural and man-made disasters—mass crises characterized, among other things, by a lack of preparedness, environmental stress, drama, organizational confusion, exhaustion of resources, environmental hostility, and deficient infrastructure. The impact of each disaster is closely related to the nature and dimensions of the phenomenon and to the response capacity of a city’s support systems. According to the literature, a major disaster hits a city somewhere in the world every seven months.

Natural disasters can cause an unexpected number of deaths, injuries, or diseases in the affected community, potentially exceeding the local health services’ capacity to treat the victims and requiring outside assistance. If the devastation includes the local health infrastructure, such as hospitals, a timely response to the emergency will be impossible.

Some disasters impact the environment and the population by increasing the risk of communicable diseases and environmental hazards. These, in turn, increase morbidity and premature mortality and reduce the future quality of life of the population while at the same time causing food shortages and trauma.

**Table 10-6.** Classification of disasters

<i>Classification of disasters</i>			
Natural	Technological	Complex	Mixed
Earthquakes	Fires	Terrorism	Droughts
Floods	Gas leaks	Complex emergencies	Desertification
Hurricanes	Leaks of hazardous substances	Wars	Forest fires
Tornados	Accidents: air, railway,	Epidemics	Effluent leaks
Tsunamis	maritime, road, multiple,	Pandemics	Oil spills
Volcanic eruptions	tunnel		Minefields
Landslides			

The term “chaos management” has been coined to describe disaster response, since it has been shown that the damages associated with a disaster are the sum total of the damage inflicted by the disaster itself and the damage caused when managing it.

An interesting theory postulated in disaster management is vulnerability theory, according to which less vulnerable systems suffer less damage than others, even when facing the same intensity of aggression. This theory deals mathematically with systems that show unpredictable and apparently random behavior and helps identify the variables requiring timely action (61).

In every disaster there is an agent that acts on the city with varying degrees of intensity, either briefly or over an extended period, producing widespread suffering and human drama in its various forms, fraying the fabric of employment and resulting in very long periods of reconstruction or even abandonment.

When dealing with disasters, it is important to evaluate the situation and conduct a risk assessment that considers the nature of the disaster, the approximate number of victims, the additional hazards, environmental vulnerability, the availability of rescue services and security forces, the time needed to solve the problem, and the immediate and medium-term needs.

The organized community can deploy various responses, which should include advanced planning, strategy development, security, a chain of command, simple relief, and control of ambulances (route and loading point). A specific, interdisciplinary professional approach to disaster preparedness should be taken—one that would equip the community with specific prevention strategies in advance of disaster management (62).

## Urban transportation

Urban transportation is very important for the quality of life and health of the population. Transportation is closely related to population distribution, urban layout, and residents’ travel patterns (i.e., commuting). Environmental management of urban transportation should be a linchpin of public policy in all cities. Urban planners remind us that the goal of urban transportation is to move people—not vehicles—with efficient use of resources (particularly fuel), people’s time, and the environment (air, urban land), as well as safety (minimizing traffic accidents) and social equity, based on the principle of equal quality for all (like other public utilities such as water, electricity, gas, and telephone service) (63).

Unfortunately, vehicular traffic in cities degrades the quality of urban life. As the degree of saturation increases, the following effects are observed:

- Congestion: longer travel time, traffic lines, and involuntary waits.
- Risk: increase in the number and seriousness of traffic accidents.
- Pollution: increase in air pollutant emissions.
- Noise: increase in noise level and vibration in streets and buildings.
- Segregation: longer distance and time crossing traffic.
- Intimidation: less use of streets for other purposes (leisure, play, walks).
- Visual intrusion: visual field blocked by vehicles and infrastructure; public transportation made inaccessible; difficulties using public transportation.

Innovating and implementing new urban transportation systems are inherently difficult. The launch of the Transantiago public transportation system in Santiago (Chile) in 2007 created numerous problems in five critical areas, requiring: more buses; buses and trains that run more often; route changes; decongestion of the subway system; and better information for users. Normal operations were achieved only very gradually, with a gradual increase in the number of buses, expanded schedules, new routes, extensions of existing routes, buses and trains that run more often, and shorter waiting periods at stops. This was accompanied by a change in contracts and the management of the financial administration agency (64).

## ■ Opportunities and strategies to improve health in cities

In these early years of the 21st century, cities offer an opportunity for interventions with a major health component. Beyond the problems described in this chapter, political and health authorities are called to design and implement healthy urban policies with suitable innovative approaches to the financing of housing and urban deve-

lopment at all levels. This implies meeting certain requirements and taking advantage of the facilities offered by the proximity and concentration of people in urban spaces. However, such interventions must occur in the context of good governance, defined as good management of processes and institutions leading to positive health outcomes (65). This concept also involves the revitalization of traditional community engagement, but through institutional mechanisms suited to the local spaces and citizenry, moving beyond the standard rhetoric that has ultimately had little effect on the world.

A pro-health urban government is one whose development policies and plans include explicit health-impact components. All strategies for developing user-friendly spaces are recommended for undertaking preventive interventions to promote exercise, access to healthy markets and community institutions with prevention programs, and the promotion of social protection networks. Making health criteria and respect for people's needs part of infrastructure planning implies fostering safety, user-friendly traffic spaces that physically protect people and alternative transportation (e.g., bicycle lanes), and basic services near population centers, in addition to the well-known features of healthy housing.

Beyond the social determinants discussed above, the best chance of improving health in cities probably lies in primary health care networks. Many assessments indicate the need to reinforce this strategy, especially in light of the 30th anniversary of the Declaration of Alma-Ata, which provided global political backing for the effort (66). Much-needed local empowerment can be promoted by interesting initiatives such as meetings on urban best practices (II Ibero-American Meeting on Urban Best Practices) (67).

From the standpoint of building human capital in cities, which is a tool for consolidating one of the pillars of pro-development public policies, experiences around the world have shown that notwithstanding their defects and problems, urban areas offer the best conditions for implementing effective policies to promote access and equity in health care and, thus, fight poverty (68).

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# Climate change and health

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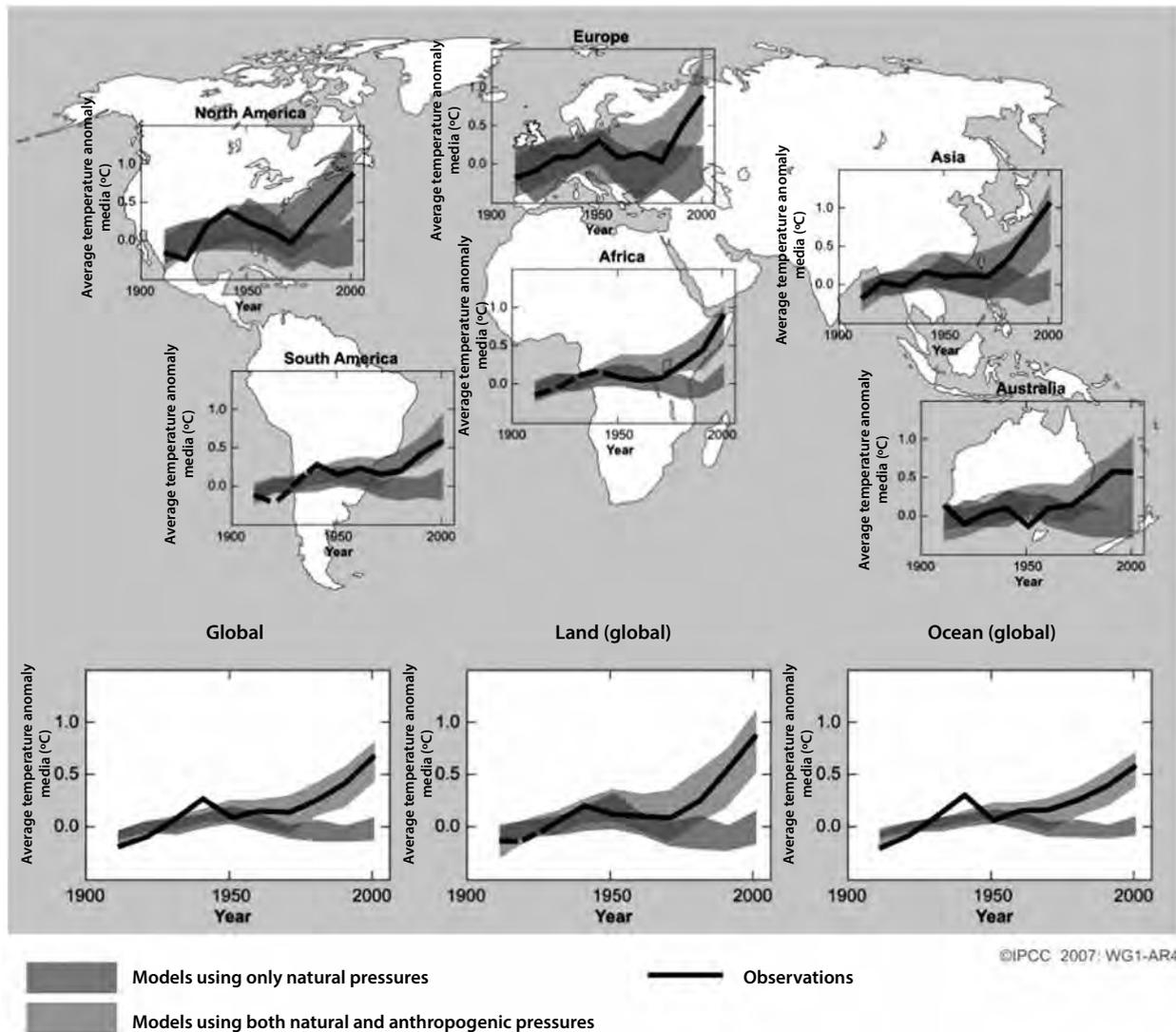
## ■ Summary

According to the United Nations Intergovernmental Panel on Climate Change (IPPC), by 2100, average global temperatures are projected to increase by 1.8°C to 4.0°C, sea levels will rise, and hydrologic extremes (floods and droughts) will intensify. The number of pathways through which climate change can affect the health of populations makes this environmental hazard a potentially major and complex risk to public health. Direct pathways through which climate change can adversely affect health include heat-related morbidity and mortality; flooding and storms, with associated trauma and mental health concerns; air pollution, especially from ground-level ozone and, potentially, from aeroallergens (e.g., pollen and mold); and infectious diseases, particularly those that are water- or vector-borne. Climate change will also have a significant impact on crop and livestock production, as well as on the viability of fisheries. The number of people at risk for hunger could double by mid-century. Preparing for climate change involves primary mitigation of greenhouse gas emissions, as well as the planning of adaptation measures for a changing climate regime. Comprehensive health impact assessment of global climate change will ultimately need to account for both the co-benefits and unintended consequences of policy changes in the energy, transportation, agriculture, and other health-relevant sectors.

## Past trends and future climate projections

Surface temperatures in the mid- to late 20th century appear to have been warmer than they had been during any similar period in the past 600 years in most regions, and in at least some regions, warmer than in any other century for several thousand years (1). This warming trend is accelerating rapidly. From 1906 to 2005, the average global temperature warmed by 0.74°C. Projections by the United Nations Intergovernmental Panel on Climate Change (IPPC) indicated that, by 2100, average global temperatures will increase by 1.8°C to 4.0 °C (Figure11-1).

**Figure 11-1** Temperature changes relative to the corresponding average for 1901-1950 (degrees centigrade) from decade to decade from 1906 to 2005 over the Earth's continents, as well as the entire globe, global land area, and the global ocean (lower graphs).\*



\* The black line indicates observed temperature change, while the shaded bands show the combined range covered by 90% of recent model simulations. Lighter shading indicates simulations that include natural and human factors, while darker shading indicates simulations that include only natural factors. Dashed black lines indicate decades and continental regions for which there are substantially fewer observations. (Reprinted with permission.)

**Source:** IPCC, Fourth Assessment, Summary Report for Policy Makers, 2007.

Climate warming will also have an effect on the world's hydrologic cycle. Higher temperatures evaporate soil moisture more quickly (leading to severe droughts), but warm air can hold more moisture, resulting in heavy precipitation events. Such "hydrologic extremes" (floods and droughts) are very much part of climate change scenarios and a matter of substantial concern to public health professionals. Warmer temperatures also cause the sea level to rise from the thermoexpansion of salt water and melting of terrestrial glaciers. By the end of this century, the sea level is estimated to rise by 18 to 59 cm from thermoexpansion alone. Since 1961, the sea level has risen by approximately 2 mm per year on average. Arctic sea ice extent has declined by 7.4% per decade, and snow cover and glaciers have shrunk in both hemispheres.

## Hurricanes and sea surface temperatures

Sea surface temperatures have steadily risen over the past 100 years, and especially, over the past 35 years. The period 1995-2004 recorded the highest average sea surface temperature on record (2). Hurricanes only form in regions where sea surface temperatures are above 26°C (3). During the last half-decade of the 20th century, overall hurricane activity in the North Atlantic doubled, and the Caribbean experienced a five-fold increase (4). Hurricane intensity also may be associated with warmer temperatures (5,6).

## Vulnerable regions and groups

According to the IPCC, certain regions and populations are more vulnerable than others to the health impact of climate change (7). They include the following:

- Populations within or bordering regions with a high endemicity of climate-sensitive diseases (e.g., malaria)
- Regions with an observed association between epidemic disease and weather extremes (e.g., El Niño-linked epidemics)
- Locations at risk from combined climate impacts relevant to health (e.g., stress on food and water supplies or risk of coastal flooding)
- Areas at risk from concurrent environmental or socioeconomic stresses (e.g., local stresses from land-use practices or an impoverished or undeveloped health infrastructure) with little capacity to adapt

Climate change entails direct and indirect risks to human health, including risks from weather extremes (such as extreme heat and cold, storms and flooding, and drought-related wildfires); air pollution and aeroallergens; infectious diseases, particularly those that are waterborne, foodborne, or vector-borne; and malnutrition. Latin America has regions with specific vulnerabilities to these negative health impacts. Small islands in the Caribbean today are severely impacted by climate-related health events such as water-borne diseases and mortality from weather extremes (8). In addition to the potential flooding of Caribbean islands, Latin America's coastal areas will also be susceptible to a rise in sea level and flooding. Rapidly developing urban areas that give rise to slums in Latin America are often vulnerable to extreme weather events such as floods and landslides (9). Health problems associated with poorly sanitized water also affect urban slums. This chapter addresses these direct and indirect risks and follows with possible public health responses to climate change.

## ■ Weather extremes and health

Populations around the globe already suffer from extreme temperatures, severe storms, rising sea levels, and droughts. Before describing the most direct impacts below, however, it is important to recognize that some of the indirect effects of climatic stress on a region can have serious implications for human and health and well-being. For example, a 2013 meta-analysis of climate links to violent behavior showed surprisingly strong correlations (10). According to the authors, for every standard deviation change toward warmer temperatures or more extreme rainfall, the mean increased frequency of interpersonal violence rose by 4%, and for intergroup conflict the increase averaged 14%. This meta-analysis is but one example of why a cross-sector approach is required to comprehensively assess climate-change health risks. Nonetheless, more literature has been published on the direct threats that climate disruption poses to human health, as described below.

### Heat waves

The relationship between temperature and morbidity/mortality is J-shaped, with a steeper slope at higher temperatures (11). In the United States, heat waves kill more people than hurricanes, floods, and tornadoes combined. Heat-related illnesses range from heat exhaustion to kidney stones (which increase with dehydration) (12).

Excess deaths tend to occur during heat waves, defined by the World Meteorological Organization as periods of five or more days when temperatures exceed the average maximum (from 1961-1990) by 5°C (9°F). The 1995 Chicago heat wave took approximately 600 lives over the course of five days, and the 2003 European heat wave is estimated to have killed at least 40,000 people in just two weeks (13).

In urban areas, the “urban heat island effect” can intensify heat as a result of buildings, human and industrial activities, and other factors. Black asphalt and other dark surfaces (on roads, parking lots, and roofs) have a low albedo (reflectivity); they absorb and retain heat, reradiating it at night when a place would otherwise cool down. In addition, urban areas are relatively lacking in trees, so they receive less of the cooling effect associated with evapotranspiration. Global warming is expected to increase both heat and humidity, exacerbating the effect of heat islands and increasing heat stress on urban populations (14). Modeling studies project that by the end of the 21st century, the number of heat wave days could double in Los Angeles (15) and quadruple in Chicago (16) if emissions are not reduced. People in cities in developing countries may be especially vulnerable to morbidity and mortality during heat waves.

In theory, in a warmer world, the reduction of extreme cold could reduce the number of deaths caused by low temperatures. However, deaths in the winter season are not necessarily linked to a temperature effect (e.g., influenza). A study of daily mortality and weather data for 6.5 million deaths in 50 U.S. cities between 1989 and 2000 showed a marked difference between mortality from hot and cold temperatures. The researchers found that, on average, cold snaps increased death rates by 1.6%, while heat waves triggered a 5.7% increase in death rates. Relatively milder winters attributable to global warming are unlikely to offset the more severe health effects of summertime extremes (17).

**Table 11-1** Recent trends, assessment of human influence on the trend, and projections for extreme weather events for which there is an observed late-20th century trend.

<i>Likelihood of further changes</i>		
<b>Phenomenon and Direction of Trend</b>	<b>Early 21st Century</b>	<b>Late 21st Century</b>
Warmer and/or fewer cold days and nights over most land areas	<i>Likely</i>	<i>Virtually certain</i> <i>Virtually certain</i> <i>Virtually certain</i>
Warmer and/or more frequent hot days and nights over most land areas	<i>Likely</i>	<i>Virtually certain</i> <i>Virtually certain</i> <i>Virtually certain</i>
Warm spells/heat waves. Frequency and/or duration increases over most land areas	Not formally assessed	<i>Very likely</i> <i>Very likely</i> <i>Very likely</i>
Heavy precipitation events. Increase in the frequency, intensity, and/or amount of heavy precipitation	<i>Likely</i> over many land areas	<b>Very likely</b> over most of the mid-latitude land masses and over wet tropical regions <i>Likely</i> over many areas <i>Very likely</i> over most land areas
Increases in intensity and/or duration of drought	<i>Low confidence</i>	<b>Likely</b> ( <i>medium confidence</i> ) on a regional to global scale <i>Medium confidence</i> in some regions <i>Likely</i>
Increases in intense tropical cyclone activity	<i>Low confidence</i>	<b>More likely than not</b> in the Western North Pacific and North Atlantic <b>More likely than not</b> in some basins <i>Likely</i>
Increased incidence and/or magnitude of extreme high sea level	<i>Likely</i>	<b>Very likely</b> <i>Very likely</i> <i>Likely</i>

**Source:** Intergovernmental Panel on Climate Change. Climate change 2014: Impacts, adaptation, and vulnerability. Cambridge, United Kingdom: Cambridge University Press, 2014.

## Climate-related disasters

On average, disasters killed 123,000 people worldwide each year between 1972 and 1996. Africa currently suffers the highest rate of disaster-related deaths (18), although 80% of the people affected by natural disasters are in Asia. For every individual killed in a natural disaster, an estimated 1,000 people are affected (19), either physically, mentally, or through the loss of property or livelihood.

Post-traumatic stress disorder (PTSD) and other mental disorders may substantially affect populations, depending on the unexpectedness of the impact, the intensity of the experience, the degree of personal and community disruption, and long-term exposure to the visual signs of the disaster (20). Symptoms of PTSD have been found to be as high as 75% in refugee children and adolescents (21). In poor countries, disasters can trigger large-scale population displacement, often to jurisdictions ill-prepared to receive and care for them. Malnutrition and communicable diseases are pervasive in refugee populations. Overall, crude mortality rates in displaced populations may reach as high as 30 times the baseline, with much of the mortality occurring in children under 5 (22).

Even in the United States, system failures were evident in the aftermath of Hurricanes Katrina and Rita, when over 2,000 Americans were killed during that hurricane season—more than double the average number of lives lost to hurricanes in the United States (23). One study has shown that Hurricane Katrina survivors experienced twice the rate of mental illness as a similar population in New Orleans prior to that hurricane (24).

## Flooding

Globally, flooding accounted for the highest number (approximately 175 million) of natural disaster victims in 2010 (25). Floodplains and coastal zones are the locations most vulnerable to flooding. Degradation of the local environment can also contribute heavily to vulnerability. For example, Hurricane Mitch, the most deadly hurricane to strike the Western Hemisphere in the past two centuries, caused 11,000 deaths in Central America, with thousands of other people still recorded as missing. Many fatalities occurred during mudslides in deforested areas (26). In the United States, the amount of precipitation falling in the heaviest 1% of rain events has increased by 20% in the past century, while total precipitation has increased by 7%.

Heavy rains can lead to flooding, which can increase the risk of waterborne diseases such as cryptosporidium and giardia. Using 2.5 inches (6.4 cm) of daily precipitation as the threshold for initiating a combined sewer overflow (CSO) event, the frequency of these events in Chicago is expected to increase by 50% to 120% by the end of this century (27), posing an increased risk to drinking and recreational water quality.

## Climate effects on air quality

Ground-level ozone ( $O_3$ ) is an example of a pollutant whose concentration may increase with a warmer climate. Biogenic volatile organic compound (VOC) emissions are temperature-sensitive, and an increase of as little as 2°C could cause a 25% increase in these emissions (28). Under the right circumstances, higher levels of isoprenes result in higher levels of ozone. Particulate matter (PM) formation can also increase at higher temperatures, due to increased gas-phase reaction rates (29).

In the United States, the average number of days exceeding the health-based eight-hour ozone standard could increase by 68% by the 2050s because of global warming (30,31). In California, higher temperatures are projected to increase the frequency, intensity and duration of conditions conducive to air pollution formation, potentially increasing the number of days conducive to ozone air pollution formation in Los Angeles and the San Joaquin Valley by up to 85% (32). A study from Germany also shows increases in ozone concentrations under climate change scenarios, with daily maximum ozone increasing by 6%–10%, and subsequent ozone exceedance days increasing four-fold (33).

*Aeroallergens:* Airborne biological agents, such as pollen and molds, may increase with climate change. Higher levels of carbon dioxide promote growth and reproduction by many plants, including those that produce allergens. For example, ragweed plants experimentally exposed to high levels of carbon dioxide can increase their pollen production several-fold, which is perhaps part of the reason for rising ragweed pollen levels in recent decades (34,35). In a study comparing urban and rural parts of Baltimore, ragweed grew faster, flowered earlier, and produced more pollen in urban locations than in rural locations, presumably because air temperature and  $CO_2$  levels are significantly higher in urban areas (36).

## Infectious diseases

The diseases most sensitive to influences by climatic conditions are those spread not by person-to-person pathways but through direct means: water- and foodborne, as well as vector-borne, diseases.

### Water- and food-borne diseases

In freshwater systems, both water quantity and water quality can be affected by climate change. In marine waters, changes in temperature and salinity will affect coastal ecosystems in ways that may increase the risk of certain diseases. The impact of climate change on water *quantity* is relatively straightforward.

Regarding water *quality*, many community water systems are already overwhelmed by extreme rainfall events. Runoff can exceed the capacity of sewerage systems or treatment plants, and these systems are designed to discharge excess wastewater directly into surface water bodies (37,38). Urban watersheds sustain more than 60% of their annual contaminant loads during storm events (39). Turbidity also increases during storm events, and studies have linked turbidity and illness in many communities (40,41).

Waterborne disease outbreaks from all causes in the United States are distinctly seasonal, clustered in key watersheds, and associated with heavy precipitation (11). Similarly, in Walkerton, Ontario, Canada, heavy precipitation in May 2000, combined with failing infrastructure, contaminated drinking water with *E. coli* 0157:H7 and *Campylobacter jejuni*, resulting in an estimated 2,300 illnesses and 7 deaths (42).

Intense rainfall can also contaminate recreational waters and increase the risk of human illness (43) through higher bacterial counts. This association is strongest at the beaches closest to rivers (44).

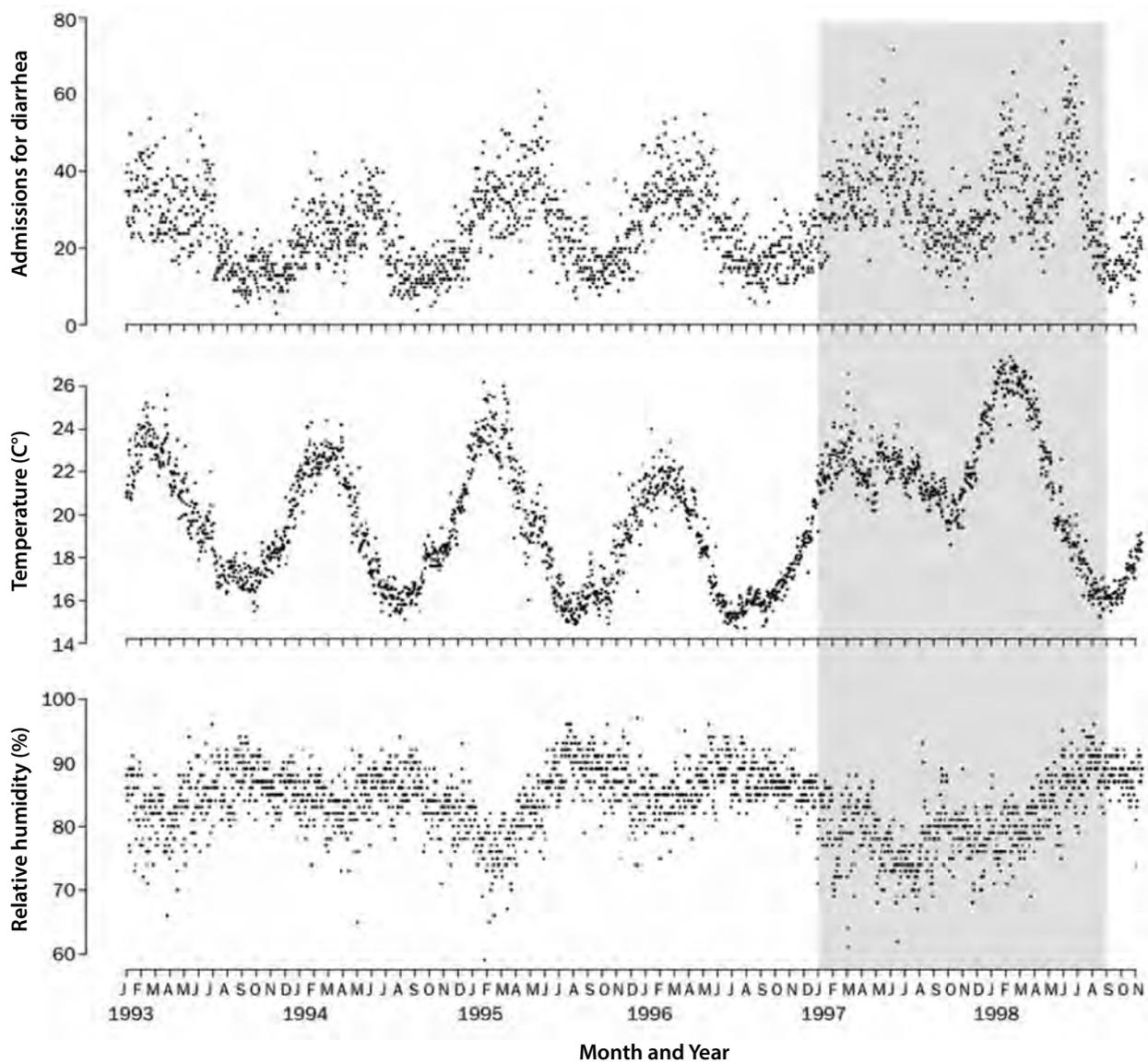
*Marine Environments:* Over the past three decades, the frequency and global distribution of harmful algal blooms (HABS) appear to have increased, and more human intoxication from algal sources has occurred (45). Modeling in the Netherlands predicts that by the year 2100, a 4°C increase in summer temperatures, in combination with water column stratification, will double the growth rates of several species of HABS in the North Sea (46). Biotoxins associated with warmer waters also include ciguatera (one of the most common causes of nonbacterial, fish-borne food poisoning), whose range could extend to higher latitudes. An association has been found between ciguatera poisoning and sea surface temperature in some Pacific Islands (47).

*Vibrio* species also proliferate in warm marine waters. Copepods (or zooplankton), which feed on algae, can serve as reservoirs for *Vibrio cholerae* and other enteric pathogens. For example, cholera in Bangladesh follows the seasonal warming of sea surface temperatures, which can enhance plankton blooms (48). Other *Vibrio* species have expanded in northern Atlantic waters in association with warm water (49). For example, in 2004, an outbreak of *V. parahaemolyticus* shellfish poisoning was reported from Prince William Sound in Alaska (48). Water temperatures during the 2004 shellfish harvest remained above 15°C, and mean water temperatures were significantly higher than in the previous six years (50). Such evidence suggests the potential for warming sea surface temperatures to increase the geographic range of shellfish poisoning and *Vibrio* infections into temperate and even arctic zones.

Other diarrheal diseases also display temperature sensitivity. During the 1997 and 1998 El Niño event, winter temperatures in Lima, Peru, increased by more than 5°C above normal, and the daily hospital admission rates for diarrhea more than tripled over the rates of the previous five years (51) (Figure 11-2). Long-term studies of the El Niño Southern Oscillation, or ENSO, have confirmed this pattern. ENSO refers to natural year-to-year variations in sea surface temperatures, surface air pressure, rainfall, and atmospheric circulation across the equatorial Pacific Ocean. This cycle provides a model for observing climate-related changes in many ecosystems. ENSO has had an increasing role in explaining cholera outbreaks in recent years, perhaps because of concurrent climate change (52). Overall, there is growing evidence that climate change can contribute to the risk of waterborne diseases in both marine and freshwater ecosystems.

*Foodborne diseases:* In the United Kingdom, researchers have found a strong relation between the incidence of foodborne disease and temperature in the month preceding the illness (53), suggesting food poisoning or spoilage. Reported cases of food poisoning across Australia, Western and Central Europe, and Canada follow a near linear relationship for each degree increase in weekly temperature (9). Temperatures contribute to an estimated 30% of salmonellosis cases in much of continental Europe, especially when they exceed a threshold of 6°C above average (54). Monthly incidence of food poisoning in Britain is most strongly associated with the temperatures of the previous 2 to 5 weeks (53). Other foodborne agents, such as campylobacter, are also seasonal but are not as strongly linked to temperature fluctuations. Food spoilage is temperature-dependent, as pest species, especially flies, rodents, and cockroaches, increase their contact with food at higher temperatures (55).

**Figure 11-2.** Daily time series between January 1, 1993, and November 15, 1998, for admissions for diarrhea, mean ambient temperature, and relative humidity in Lima, Peru (reprinted with permission from *The Lancet*).



**Source:** Checkley W *et al.* Effects of El Niño and ambient temperature on hospital admissions for diarrhoeal diseases in Peruvian Children. *Lancet* 2000; 355:442-450.

## Vector-borne diseases

Vector-borne diseases, transmitted by insect or rodent “vectors, are highly affected by ambient conditions. The incubation period of a vector-borne infective agent within its vector organism is typically very sensitive to changes in temperature and humidity (56) (Box 11-1).

*Mosquito-borne diseases:* Since insects are cold-blooded, climate change can shift the distribution of mosquito populations, affect mosquito biting rates and survival, and shorten or lengthen pathogen development time inside the mosquito, which ultimately determines infectivity.

According to the World Health Organization (1996) (57), malaria is the vector-borne disease most sensitive to long-term climate change. The incidence of malaria varies seasonally in highly endemic areas. In several regions, malaria has been shown to vary in response to weather disturbances. For example, in India’s Punjab region, excessive monsoon rainfall and the resulting high humidity have been recognized for years as major factors in the appearance of malaria epidemics. In that region, malaria epidemics have increased approximately fivefold during the year following an El Niño year (58).

Anophele mosquito populations can be exquisitely sensitive to warming; just a half a degree centigrade increase in temperature can translate into a 30%–100% increase in mosquito abundance, demonstrating a “biological amplification” of temperature effects. In the African highlands where mosquito populations are relatively small compared to lowland areas (59), such biological responses may be especially significant in determining the risk of malaria.

Global climate change effects will ultimately be realized on the ground at the local level. Therefore, local landscapes need to be included in the analyses. In the Amazon Basin, for example, malaria incidence fluctuates with rainfall levels. Yet, regional differences in the extent of wetlands and surface water modify the effect of rainfall so much that in upland locations with sparse wetlands, malaria increases with rainfall, whereas in areas with abundant wetlands, it decreases (60). In essence, climate effects must be analyzed in the context of local land cover data.

Climate also affects the arboviruses that cause dengue fever, West Nile virus, Chikungunya, and Rift Valley fever. Dengue fever is transmitted by the *Aedes aegypti* mosquito, and in laboratory studies, the rate of virus replication in the mosquito increases directly with temperature. Biological-based models have been developed to explore the influence of projected temperature change on the incidence of dengue fever. When linked to future climate change projections, these models suggest that, given viral introduction into a susceptible human population, relatively small temperature increases in temperate regions are likely to increase the potential for epidemics (61). Modeling of *Aedes* mosquito populations in relation to climate variation suggests a strong association, and when the model is applied retrospectively, these changes are strongly correlated with historic changes in dengue fever incidence (62).



### **BOX 11-1. SOME EFFECTS OF WEATHER AND CLIMATE ON VECTOR- AND RODENT-BORNE DISEASES.**

Vector-borne pathogens spend part of their life cycle in cold-blooded arthropods that are subject to many environmental factors. Changes in weather and climate that can affect transmission of vector-borne diseases include temperature, rainfall, wind, extreme flooding or drought, and sea-level rise. Rodent-

borne pathogens can be indirectly affected by the ecological determinants of food sources that affect rodent population size, and floods can displace and lead rodents to seek food and refuge. These effects are summarized below.

Temperature effects on selected vectors and vector-borne pathogens	
Vector	<ul style="list-style-type: none"> <li>• Survival can decrease or increase depending on the species</li> <li>• Some vectors have higher survival at higher latitudes and altitudes with higher temperatures</li> <li>• Changes in vector susceptibility to some pathogens (e.g., higher temperatures reduce the size of some vectors but reduce the activity of others)</li> <li>• Changes in the rate of vector population growth</li> <li>• Changes in feeding rate and host contact (which may alter the survival rate)</li> <li>• Changes in the seasonality of populations</li> </ul>
Pathogen	<ul style="list-style-type: none"> <li>• Decreased extrinsic incubation period in vector at higher temperatures</li> <li>• Changes in the transmission season</li> <li>• Changes in distribution</li> <li>• Decreased viral replication</li> </ul>
Effects of changes in precipitation on selected vector-borne pathogens	
Vector	<ul style="list-style-type: none"> <li>• Increased rain may increase larval habitat and vector population size by creating a new habitat</li> <li>• Excess rain or snowpack can eliminate habitat by flooding, thus decreasing vector population size</li> <li>• Low rainfall can create habitat by causing rivers to dry into pools (dry season malaria)</li> <li>• Decreased rain can increase container-breeding mosquitoes by forcing increased water storage</li> <li>• Epic rainfall events can synchronize vector host-seeking and virus transmission</li> <li>• Increased humidity increases vector survival; decreased humidity decreases vector survival</li> </ul>
Pathogen	<ul style="list-style-type: none"> <li>• Few direct effects but some data on humidity effects on malarial parasite development in the anopheline mosquito host</li> </ul>
Vertebrate host	<ul style="list-style-type: none"> <li>• Increased rain can increase vegetation, food availability, and population size</li> <li>• Increased rain can also cause flooding and decrease population size but increase contact with humans</li> <li>• Decreased rain can eliminate food and force rodents into housing areas, increasing human contact, but it can also decrease population size</li> </ul>
Higher sea level	<ul style="list-style-type: none"> <li>• Can alter estuary flow and change existing salt marshes and associated mosquito species, decreasing or eliminating selected mosquito breeding sites (e.g., reduced habitat for <i>Culiseta melanura</i>)</li> </ul>

West Nile virus (WNV) had its first reported outbreak in the United States in the summer of 1999, a likely result of international air transport. During the epidemic summers of 2002 to 2004, epicenters of West Nile virus occurred in locations experiencing either drought or above-average temperatures (63). During 2002, a more virulent strain of WNV emerged in the United States. Recent analyses indicate that this mutated strain responds strongly to higher temperatures, suggesting that greater risks from the disease may result from a future increase in the frequency of heat waves (64).

During a severe drought in East Africa in July 2004, an epidemic of Chikungunya virus erupted in Lamu, Kenya, where an estimated 13,500 people (75% of the population) were infected (65). Climate analysis showed that unseasonably warm and dry conditions, especially over coastal Kenya, occurred during May 2004 (66). Such conditions may have led to unsafe domestic water storage practices and infrequent changing of water storage. In addition, warm dry weather may have hastened viral development in the *Aedes* mosquito. The virus spread to islands of the western Indian Ocean, then to India, and, most recently, Italy during the summer of 2007. While the role of climate conditions in Italy is not clear, southern Europe was experiencing an unusually warm and dry summer (67).

## Rodent-borne diseases

Hantavirus occurs in the Americas and throughout the world. Infections are transmitted largely by exposure to infectious excreta from rodents and may cause serious disease and a high fatality rate in humans. For hantavirus pulmonary syndrome, which newly emerged in the southwest United States in 1993, weather conditions led to a growth in rodent populations and subsequent disease transmission followed by El Niño-driven heavy rainfall (68).

Extreme flooding or hurricanes can lead to outbreaks of leptospirosis. An epidemic of leptospirosis in Nicaragua followed heavy flooding in 1995. In one case-control study, a 15-fold risk of disease was associated with walking through flooded waters (69).

Plague is another climate-sensitive disease; it is carried by fleas and associated with populations of rodents, the primary reservoir hosts of the *Yersinia pestis* bacterium. Historically, according to tree-ring proxy climate data, during the major plague epidemics of the Black Death period (1280-1350), climatic conditions were becoming both warmer and wetter (70).

### Climate, food systems, and malnutrition risk

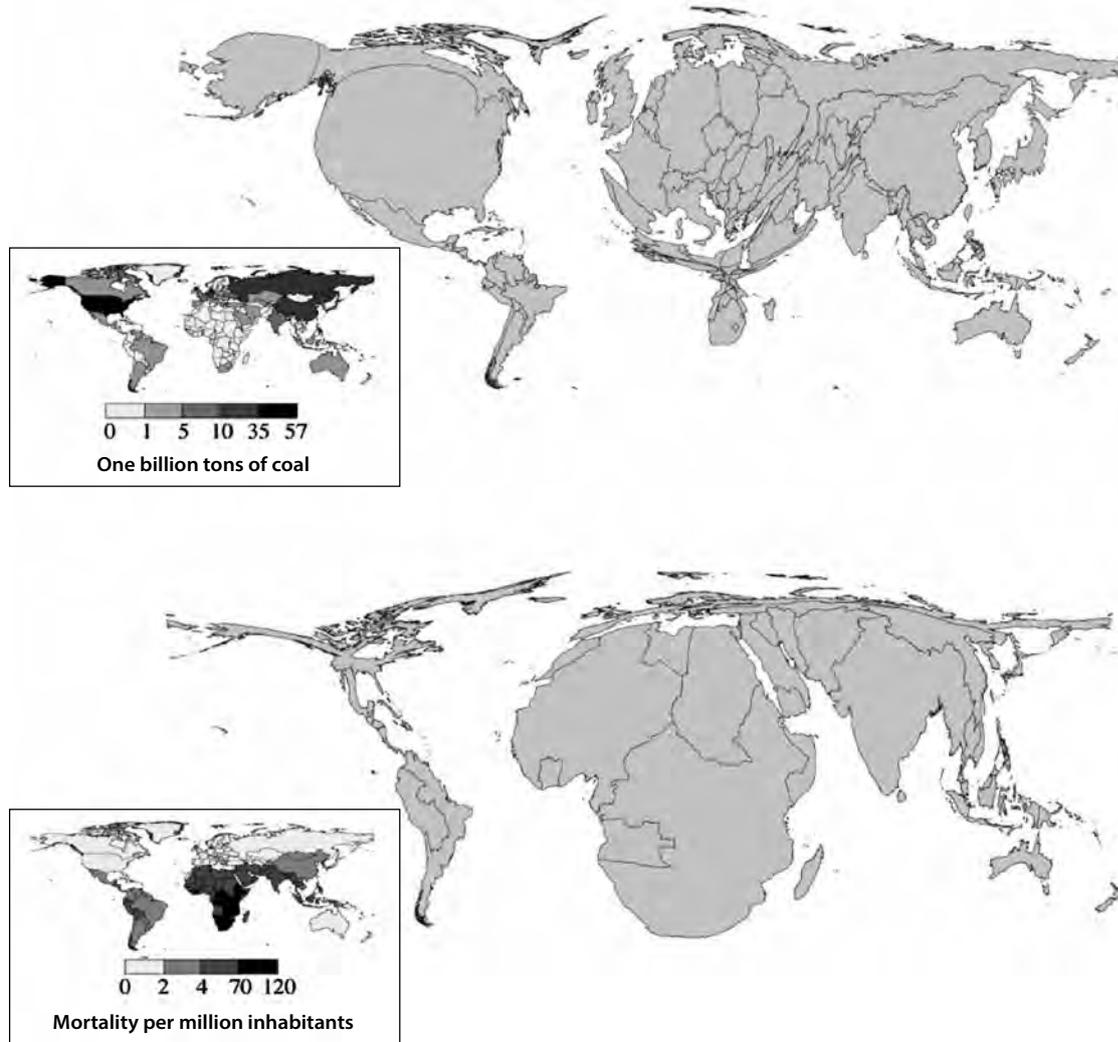
Crop and livestock production are clearly weather-sensitive and will thus be heavily impacted by climate change (71-73). Some changes will be positive and others negative, and the net impact on food production will likely vary from place to place. Changes in food production will depend on several key factors. First, are the direct effects of temperature, precipitation, CO<sub>2</sub> levels (related to, for example, the CO<sub>2</sub> fertilization effect), and extreme climate variability and sea-level rise (74). Next are the indirect effects of climate-induced changes in soil quality, the incidence of plant diseases, and weed and insect populations. Greater heat and humidity will also increase food spoilage (discussed in the infectious disease section below). The past two decades have witnessed the ongoing deterioration of food production in Africa, caused in part by persistent drought. For some foods, nutritional quality will diminish with climate change. Finally, the extent to which adaptive responses are available to farmers must be considered.

An estimated 800 million people are currently undernourished, and droughts will exacerbate this enormous health challenge (75). A study modeling climate change and undernutrition in children found that climate change will likely increase the rates of both moderate and severe stunting in 2050 (76) (Lloyd *et al.*, 2011). Furthermore, approximately 1.7 billion people, one-third of the world's population, currently live in water-stressed countries, and that number is projected to increase to 5 billion people (77) by the year 2025.

Currently, most crop cultivars are growing close to their thermal optimum. A recent study using data from 23 global climate models shows a high probability that by the end of the century, average growing season temperatures will exceed the hottest temperatures on record from 1900 to 2006 (Figure 11-3) (78). Lower yields are expected to occur throughout the tropics due to heat stress, and crops can be damaged from flooding, erosion, and wildfires. Climate change effects on global agricultural productivity will vary regionally, with reductions especially in sub-Saharan Africa and South Asia (79). Lower regional productivity could destabilize food security on a global scale (80). Estimates are that by the 2050s, climate change will increase the percentage of the world population at risk for hunger from the current 34% to a level of 64% to 72%, without adjustments for potential adaptive interventions (81).

An additional feature of crop growth under climate change pertains to nutritional value. With higher levels of CO<sub>2</sub>, some crops reduce their incorporation of nitrogen, resulting in lower protein levels. Studies of barley, wheat, rice, potatoes, and soybeans show reduced protein content when crops are grown under high-CO<sub>2</sub> conditions, and the magnitude of the effect varies with soil conditions, air quality, and other factors (82). For populations that depend on crops for their protein, this effect could further threaten nutritional status.

**Figure 11-3.** Cartogram comparison of undepleted cumulative carbon dioxide (CO<sub>2</sub>) emissions (by country) for 1950–2000\* versus the regional distribution of four climatesensitive health effects (malaria, malnutrition, diarrhea, and inland flood-related fatalities).



**Source:** Patz JA, Gibbs HK, Foley JA, Rogers JV, Smith KR. climate change and global health: quantifying a growing ethical crisis. *EcoHealth* 2007 4(4): 397-405.

- a) CO<sub>2</sub> emissions data source: Marland G, Boden TA, and Andres RJ. 2007. Global, Regional, and National Fossil Fuel CO<sub>2</sub> Emissions. In *Trends: A Compendium of Data on Global Change*. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A.
- b) The Intergovernmental Panel on Climate Change (IPCC). “Business as usual” greenhouse gas (GHG) emissions scenario, “IS92a” and the HadCM2 general circulation model (GCM) of the UK Hadley Centre were used to estimate climate changes relative to “baseline” 1961-1990 levels of GHGs and associated climatic conditions. Existing quantitative studies of climate-health relationships were used to estimate relative changes in diarrhea, malaria, inland and coastal flooding, and malnutrition for the years 2000–2030 (McMichael *et al.*, 2004). This is only a partial list of potential health outcomes, and there are significant uncertainties in all of the underlying models. These estimates should therefore be considered a conservative, approximate, estimate of the health burden of climate change.

\*In order to aggregate statistics for countries that changed boundaries during 1950–2000, two modifications were made, based on methods outlined in Smith, 1991 and 1996. First, for countries such as Germany that became unified during the period 1950–2000, the sums of the carbon emissions from the separate countries prior to unification were added to the cumulative carbon emissions after unification. Second, for countries that separated from a union such as those in the former USSR, carbon emissions that accumulated before the dissolution of the unified state were reapportioned to the member nations based on populations for the year 2000; the percentage of a country’s population relative to the sum of the populations of the other countries that broke from the union determined the weight of the carbon emissions delegated to that nation.

To fill gaps in the data for countries that maintained their boundary but did not collect emissions statistics for certain periods, data was extrapolated for missing years using regression methods outlined in Smith, 1996.

## ■ Fisheries, warming, and ocean acidification

The threat of ocean acidification from higher CO<sub>2</sub> levels in the atmosphere has been recognized relatively recently. Over the past 250 years, the uptake of anthropogenic carbon reduced ocean pH by 0.1 units, a trend that is continuing. IPCC scenarios predict a drop in global surface ocean pH of between 0.14 and 0.35 units over the 21st century. While the effects of ocean acidification are not fully understood, this process may threaten marine shell-forming organisms (e.g., corals) and their dependent species (83). Other aspects of climate change may also threaten fish populations. For example, the recent slowing of the North Atlantic Gulf Stream may reduce the abundance of plankton, a major source of food for many fish larvae (84). Declining larval fish populations will affect the capacity of overexploited fish stocks to recover.

Such threats to global fisheries, therefore, threaten coastal and island populations that rely on fish as their main source of protein. Worldwide, fish represent 16% of the animal protein consumed by people, with a higher proportion in some regions (e.g., 26% in Asia). Climate change, together with other pressures such as overfishing, may seriously threaten this source of nutrition.

### Case studies

Specific examples from Latin America highlight some ways in which climate change will impact health in the Latin American region.

#### Case study 11-1

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### DENGUE FEVER IN THE CARIBBEAN

According to WHO estimates, approximately 2.5 billion people are at risk of contracting dengue fever in the tropics and subtropics (85). Dengue fever is affected by temperature and rainfall, so climate change will likely affect the distribution of the disease vector and the length of season of the disease (86). According to the most recent IPCC report, the projected increase in temperature has implications for increased vector abundance and dengue fever (2007).

The number of dengue cases has been rising significantly in the Caribbean, and all four serotypes of dengue fever are present in the region (87). Barbados, Grenada, Guyana, Suriname, and Trinidad and Tobago are the countries in the Southern Caribbean region that have suffered the most from dengue in the past decade (88). Cuba had the largest outbreak of dengue in the region in 1981, with 344,203 reported cases and 158 deaths (89). More recently, Trinidad and Tobago has reported a significant number of cases: 6,314 in 2002 and 2,340 in 2003 (87). El Niño years can be drier in the second half of the year in the Caribbean (90), and these drought conditions cause people to store water in their homes, a behavior that provides breeding grounds for the vector, resulting in a subsequent increase in dengue transmission. A regional assessment of dengue fever in the Caribbean indicated that the 40-gallon barrels used for water storage were the main breeding grounds for the dengue vector (87).

#### Case study 11-2

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### FLOODING IN VENEZUELA

Although floods are infrequent events, when they do occur, large numbers of people are usually affected. For example, the 1999 flooding in Venezuela resulted in approximately 30,000 casualties. In addition to drowning deaths, the floods created a higher risk of malaria, dengue, cholera, leptospirosis, and yellow fever (91). To assess the impact of climate change on events such as floods, WHO estimated the relative risk of several health outcomes or health-related phenomena (i.e., diarrhea, coastal floods, malaria, and dengue) for the year 2030 and determined that flooding had the highest relative risk, where relative risk is the ratio of risk of disease or death among those exposed to the ratio among those not exposed (92). The 2007 IPCC report projects a rise in sea levels, which could cause flooding in coastal areas of Latin America.

## Case study 11-3

### VISCERAL LEISHMANIASIS IN BRAZIL

Approximately 350 million people are at risk of leishmaniasis in the 88 countries in which it is endemic (93). When untreated, the fatality rate of visceral leishmaniasis (VL) can be as high as 95% (94). In Brazil, 90% of the VL cases occur in the northeastern region of the country (95), where El Niño events have been linked to the disease (96). El Niño-induced droughts cause malnutrition and rural-to-urban migration, factors associated with VL cases (94). Malnutrition makes people, especially children, more susceptible to VL, and migration brings carriers of the parasite to populations without immunity (96).

## ■ Recommendations to decision-makers: Mitigation and adaptation

Because of the severity of climate change impacts on health, it is crucial to find strategies to lessen these impacts. Addressing climate change risks will demand a two-pronged approach. The first, known as *mitigation*, corresponds to primary prevention, and the second, known as *adaptation*, corresponds to secondary prevention.

Mitigation refers to efforts to stabilize or reduce the production of greenhouse gases (and perhaps to sequester those that are produced). This goal can be achieved through policies and technologies that result in more efficient energy production and lower energy demand. In a recent report by the U.S. Department of Energy, higher energy efficiency technologies were promoted in an effort to create a more climate-resilient energy sector (97) (DOE, 2013). Lower greenhouse gas emissions could also result from the implementation of transportation policies that encourage walking, bicycling, mass transit, and fuel-efficient automobiles.

Adaptation (or preparedness) refers to efforts to reduce the public health impact of climate change. Many of today's current challenges, such as deaths from heat waves, floods, and air pollution, will be exacerbated by climate change. If we anticipate severe weather events such as hurricanes, then preparation by emergency management authorities and medical facilities can minimize morbidity and mortality. Similarly, public health surveillance systems can detect outbreaks of infectious diseases in vulnerable areas, a prerequisite for early control. Additional strategies that can be adopted include strengthening public health education campaigns and providing adequate staff to implement these programs. Implementing adaptation programs across various scales such as the international level (i.e., the World Health Organization), the regional level (i.e., the ministries of health), and the individual level may help boost their effectiveness. Much of preparedness, thus, can build from analyses of the strengths and weaknesses of current prevention efforts and a rethinking of potential thresholds that may change in the future.

The IPCC report states that health problems from climate change will be greatest in poor countries (2007). Since low-income countries may lack the infrastructure or financial resources to implement adaptation efforts, cost-effective and sustainable policies are needed. Yet all countries, both rich and poor, may reap more near-term “co-benefits” from mitigating greenhouse gas emissions as well.

## ■ Health co-benefits and unintended consequences of mitigating greenhouse gas

While the steps needed to address climate change seem challenging, some will yield multiple benefits. For example, planting trees in cities helps reduce CO<sub>2</sub> levels, while at the same time reducing the urban heat island effect, reducing local energy demand, improving air quality, and providing an attractive venue for physical activity and social interaction (98). Another example is reducing the use of fossil fuels in power plants—a principal means of reducing greenhouse gas emissions, as well as a strategy to reduce air pollution (99). A third example is sustainable community design (100). In communities designed to facilitate active transport (walking and bicycling) and transit use, vehicular travel is reduced. This would increase physical activity and reduce air pollution and motor vehicle injuries and fatalities (101). Health professionals need to be alert to such opportunities.

However, the steps taken to address climate change can have unintended consequences as well. For example, biofuels, if made from food crops, could divert crops from use as food, creating scarcity and increasing food prices (102,103). This could affect the amount of humanitarian food aid available for extremely impoverished countries, as

shipments of food aid from the United States are inversely correlated to commodity prices (104). Demand for biofuels may also accelerate the conversion of forests to cropland, which could paradoxically increase carbon dioxide levels (105-107) and threaten biodiversity in sensitive areas (108). A full life cycle analysis (LCA) for biofuels quite surprisingly showed slightly higher particulate matter (PM) levels for corn-based ethanol compared to gasoline and cellulosic ethanol; growing corn for ethanol involves a great deal of fertilizer and farm machinery and may simply shift air pollution more to rural versus urban locations (109). Overall, the biofuel debate illustrates the potential for unintended consequences, especially for vulnerable populations, and the need for careful analysis of each major strategy adopted to address climate change (27).

## ■ The ethics of climate change and health

Ethics obviously enters into the assessment of climate change as it affects population health. First, on a global scale, the nations responsible for most of the carbon emissions to date account for but a small proportion of the world's population and are relatively resilient to the effects of climate change. In contrast, the large population of the global south—the poor countries—accounts for a relatively small share of cumulative carbon emissions and has a very low per capita emission rate (although total emissions from developing nations are growing rapidly, and China surpassed the United States in 2006). A recent paper by Smith *et al.* (110) examined the international natural debt (IND), and the combination of historical CO<sub>2</sub> and CH<sub>4</sub> emissions by country and found that wealthier countries impose a greater health burden on developing countries because of their INDs (2013). The United States, with 5% of the global population, produces 25% of total annual greenhouse gas emissions. This difference exemplifies the ethical implications of climate change on a global scale, shown graphically in Figure 11-3. Of course, if developing nations do not choose development pathways using more efficient energy technology, global climate change trends will intensify even as the equity imbalance decreases (111).

Even within countries, disparities exist, and poor and disadvantaged people will in many cases bear the brunt of climate change impacts, including health impacts. This was graphically demonstrated in the aftermath of Hurricane Katrina, a disaster typical of those expected to increase with climate change. Poorer individuals in New Orleans and the nearby Gulf region were disproportionately likely to fail to evacuate, suffer catastrophic disruptions following the storm, and be unable to recover (112-114).

Of course, another dimension of the inequities of climate change is that of intergenerational justice concerns (115). Many have argued that we in the present generation have a moral obligation to those who will follow and should therefore attempt to reverse climate change.

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# The deterioration of ecosystems and biodiversity: Consequences for human health

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## ■ Ecosystems and biodiversity: fundamentals and functions

Any assessment of the risks to human health from changes in the ecosystem must start with the premise that the structure and functioning of the world's ecosystems changed more rapidly in the second half of the 20th century than at any time in human history (1). In the light of these changes, the purpose of this chapter is to provide an overview of ecosystems, their current state in the Americas, and the impact of ecosystem degradation on human health.

One of the best references on the current state of ecosystems is the Millennium Ecosystem Assessment. This is a major UN-supported research project, launched in 2001, aimed at analyzing the changes that have occurred in ecosystems over the past few decades and forecasting future trends. Some of the key findings of this project are as follows (1-4):

- Around 60% of the services provided by world ecosystems have been degraded
- 15 of the 24 ecosystems evaluated have seriously deteriorated
- One fourth of the earth's surface is under cultivation
- Between 40% and 50% of all available freshwater is currently being used
- Over one quarter of the world's fish stock has been depleted
- Around 20% of the world's coral reefs have been lost in the past 20 years alone
- Nutrient pollution has caused eutrophication of waters and the loss of fishing grounds
- Species extinction rates have been accelerating and are currently 100-1,000 times the prehistoric rates
- The global environmental crisis is also threatening the survival of the human species.

### Definitions

The term "ecosystem" is hard to define and remains subject to debate. However, according to some authors, an ecosystem can be understood as a dynamic complex or system consisting of a natural community constantly interacting with its physical environment (5-8). This definition, however, fails to take certain key elements into account. The National Oceanic and Atmospheric Administration (NOAA) defines an ecosystem more broadly as "a geographically specified system of organisms (including humans), the environment and the processes that control its dynamics" (9), with the environment consisting of the "biological, chemical, physical and social conditions that

surround organisms.” Therefore, the term can be applied more specifically to the biological, chemical, physical, and/or social environment (9).

Inclusion of the social element reflects the fact that there is a close relationship between ecosystems and human populations. From drinking water to the food we eat, ecosystems are responsible for providing products and services without which it would be impossible for human beings to survive. Ecosystems make the world habitable by, among other vital functions, purifying air and water, maintaining biodiversity, and decomposing and recycling nutrients (10). The energy needed for an ecosystem to function is basically supplied by the sun. Solar energy is absorbed and converted into food by plants and other photosynthetic organisms at the base of the food chains. Furthermore, ecosystems depend on environmental cycles such as the continuous circulation of water, carbon, and other nutrients. Water is a critical element in ecosystems, since its quantity and quality, as well as temperature and the amount of solar energy, determine the types of animals, plants, and insects that will inhabit a given ecosystem and how it will be categorized. Ecosystems can be forests, grasslands, rivers, coasts, deep waters, islands, mountains, and even cities. More specific examples (11) are aquatic ecosystems, coral reefs, deserts, marine ecosystems, coastal areas, jungles, savannas, boreal forest (taiga), tundra, and urban ecosystems.

Far from being static, an ecosystem possesses a constant dynamic that generates its own random fluctuations. Among the elements that make it dynamic are reactions to natural disturbances and even competition for survival among species. Three basic factors are needed for an ecosystem to be kept in balance: the recycling of nutrients, the utilization of sunlight as a basic source of energy, and populations of a size that do not generate excessive consumption. A useful concept for understanding how ecosystems work is autopoiesis, defined as “a set of continuous biological energy processes involving the formation of carbon compounds by means of which living things can be maintained” (12). Autopoiesis decreases when ecosystems are degraded or when elements are introduced that cannot be integrated into biogeochemical cycles or recycled.

At this point it is worth revisiting the concept of ecosystem resilience, described as “the capacity of ecosystems to absorb disturbances without significantly altering their structure and functionality” (13) – in other words, the ability of an ecosystem to return to its original state after a disturbance. Given the complexity of communities and ecosystems, resilience is normally more pronounced when they have a larger number of self-regulating mechanisms. Without these mechanisms, communities and ecosystems are more vulnerable and less able to recover.

On the other hand, the concept of environmental services is invaluable for assessing and evaluating ecosystems. The term “environmental services” refers to the qualitative functions of the natural goods of the earth, water, air, and biota (14). Certain services are provided globally, such as biodiversity and atmospheric carbon storage in soils and plants. Other benefits are regional or local, such as flood and pest control and pollination. The Millennium Ecosystem Assessment (1) highlights four categories of services provided by ecosystems:

- Support services (e.g., the biogeochemical cycle of nutrients, soil formation, and primary production)
- Supply services (e.g., food production, fresh water, materials or fuels)
- Regulating services (e.g., climate regulation, pest and flood control, water purification, pollination)
- Cultural services (e.g., aesthetic and spiritual values, education, and leisure).

These services can be affected by factors such as climate change, desertification, deforestation, and urbanization. These factors, as well as their links to human health, will be examined in due course.

## ■ Ecosystems and biodiversity in the Americas

### Ecoregions of the Americas

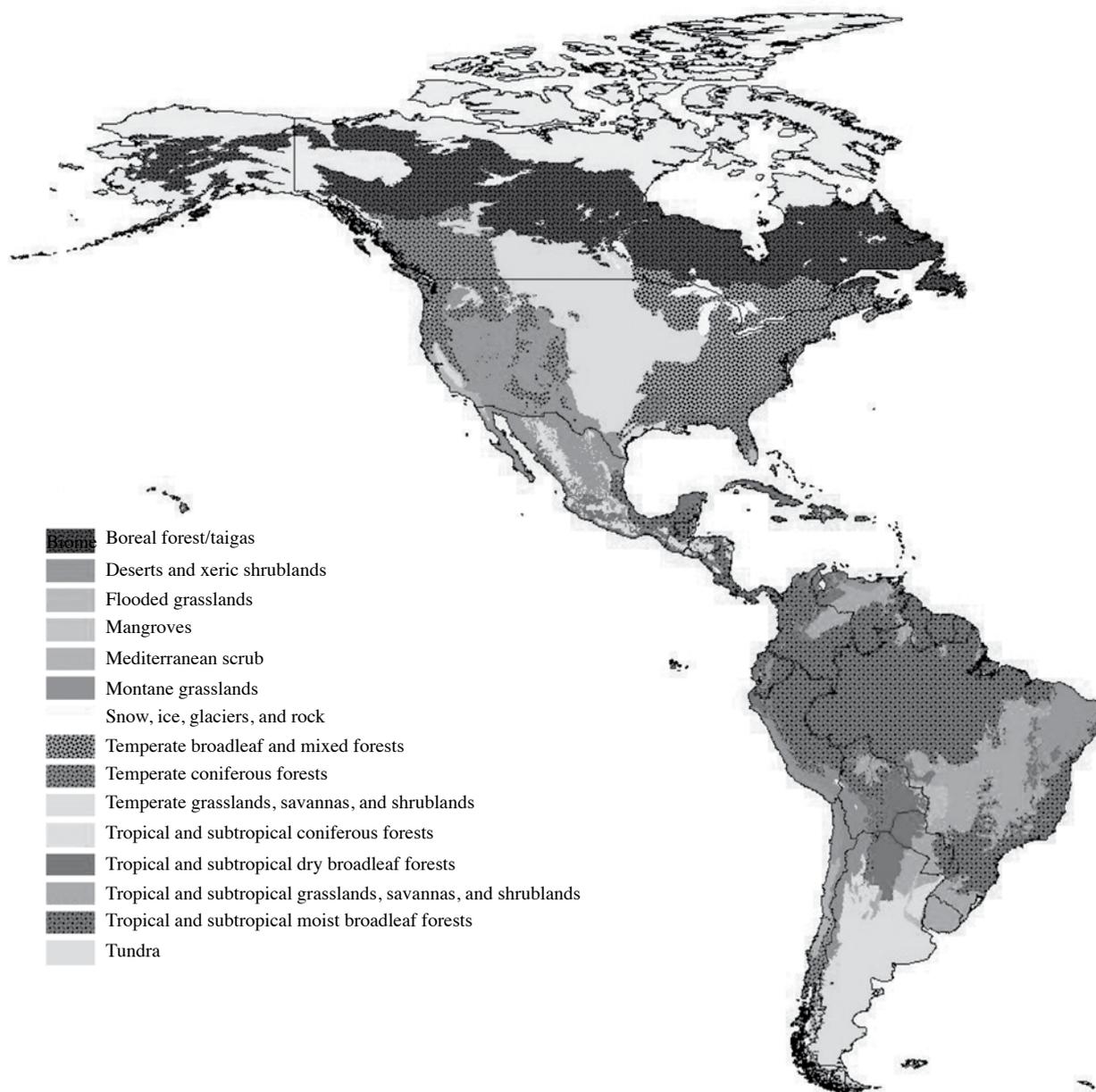
Olson’s (15) map (Figure 12-1) shows the different ecoregions of the Americas, stretching from the boreal forests (taigas) of Alaska and Canada down to the temperate grasslands of Argentina (15). Coniferous forests grow in northwestern Canada and the United States, while xeric shrublands (chaparral) and desert plains are common in northern Mexico, California, and parts of Chile. In the northeastern United States there are mixed and temperate forests as well as coniferous forests (also found in Chile).

Further south we find the tropical savannas of South America, mainly in Venezuela, Colombia, Uruguay, Paraguay, Argentina, and central Brazil. Tropical and humid subtropical forests cover large areas of Brazil, Colombia,

Venezuela, Guyana, Suriname, and French Guiana, as well as Panama and southeastern Mexico. Temperate grasslands are found in the central areas of the United States and Argentina.

It is also important to mention mangroves, which mark the transition between land and sea. Covering around 240,000 km<sup>2</sup>, mangroves occupy one quarter of the world's tropical coastlines and are a major ecological and forestry reserve. They can be found from the Mississippi River to the Florida Everglades, as well as in Caribbean countries. They also exist in northern and southern Ecuador and Colombia and in southern Mexico. Mangroves are estimated to cover around 60,000 km<sup>2</sup> of Latin America and the Caribbean (16), serving as a refuge for organisms both above and below water, from small organisms and fish to large creatures such as crocodiles. Mangroves also help prevent erosion thanks to their root systems, which retain sediments, and their foliage, which protects the land from tropical storms by resisting wind and waves. It is interesting that even when mangroves are damaged by storms, they always grow back, given their remarkable capacity for self-repair, which is better than any man-made barrier (17).

Figure 12-1. Biomes in America



Source: Olson, 2001 (15).

The countries of the hemisphere can be classified in terms of their biodiversity. Megadiverse countries are those that harbor the greatest number and diversity of plants and animals in the world (18). These are mainly tropical countries such as those in Southeast Asia and Latin America, which together contain over 70% of the world's biological diversity. According to the list of the Group of Like-minded Megadiverse Countries (LMMC), eight of the world's 17 megadiverse countries are in the Americas: Bolivia, Brazil, Colombia, Costa Rica, Ecuador, Mexico, Peru, and Venezuela (18).

### Urban and semiurban ecosystems

The population of the Latin American region doubled during the second half of the 20th century, from under 400 million in 1950 to over 800 million in 2000 (19).

The Latin American and Caribbean region is the most heavily urbanized region in the developing world, with urbanization levels similar to those of developed regions. According to projections, the region's urban population is likely to increase from 75% to 80% of the total population between 2000 and 2015. In Guyana and Saint Lucia, the urban population represents less than 28% of the total, while in Argentina, Puerto Rico, and Uruguay it exceeds 90% (20).

It is impossible to speak about urbanization without addressing the question of the size of cities. Small cities are those with less than 500,000 inhabitants (21), whereas intermediate or mid-sized cities have between 1 and 5 million. Meanwhile, megacities with over 10 million inhabitants will continue to absorb the bulk of the world's population now and in the future. An estimated 22% of the world's urban population lives in mid-sized cities, important from the standpoint of economic and social activities and often the prime destination for rural migrants (21).

The megacities in the Americas include Mexico City, with around 20 million inhabitants, followed by metropolitan New York-Newark, with 19,400,000; São Paulo, with 18,845,000; Buenos Aires, with 12,795,000; metropolitan Los Angeles-Long Beach-Santa Ana, with 12,500,000; and Rio de Janeiro, with just under 12 million (22). Demographic projections for 2015 estimate the following: São Paulo (21,300,000), Mexico City (20,078,000), New York-Newark (19,968,000), Buenos Aires (13,401,000), Los Angeles-Long Beach-Santa Ana (13,156,000), and Rio de Janeiro (12,404,000) (23).

Large cities occupy places where the ecosystems originally provided all the services needed by the population. However, rapid demographic growth has put enormous pressure on ecosystems, causing shortages of resources such as water. As a result, cities have been forced to obtain their resources from distant locations, with serious repercussions for the balance of the original ecosystems. As cities expand, areas previously devoted to agriculture are occupied and agricultural production shifts to less productive land, including forests, leading to erosion and desertification. Moreover, urbanization of coastal areas can lead to the destruction of essential humid zones and change critical habitats, such as beaches and coral reefs. Loss of both these habitats can cause seasonal flooding, landslides, losses in food production, and larger vector populations. The impact of urban development on the atmosphere (e.g., significantly altered air quality) is widely known (24).

### Rural ecosystems

It is common knowledge that agriculture and natural ecosystems increasingly compete with one another for often scarce water resources. At a conference in 2005, the United Nations Food and Agriculture Organization (FAO) assessed that world food production would have to increase by 60% by 2030 in order to feed 8.1 billion people and respond to changes in diet. It also anticipated that by 2030, water extraction for agricultural purposes would increase by about 14%. At the same conference, the FAO argued forcibly that the challenge for the next three decades is to produce more food while using less water and simultaneously safeguarding natural ecosystems. To do this, it would be necessary to maximize agricultural production by protecting and strengthening the many different services provided by ecosystems (25).

The main factors that influence the functioning of rural ecosystems are water use, the amount of land devoted to agriculture, and the use of pesticides. Argentina, Brazil, Ecuador, Chile, Mexico, and Nicaragua use over 60% of their water resources for agricultural purposes, while other countries in the hemisphere such as Canada which use under 12% (26). The United States, Brazil, Argentina, Mexico, and Canada are the countries in the hemisphere with the largest amount of land devoted to agriculture. The size of the agricultural areas is reflected in the quantities of pesticide used by these countries: the United States uses 428,189,000 tons, Brazil uses 151,678,000, tons hand

Argentina uses 123,760 tons. It is worth noting that Brazil has the hemisphere's largest percentage of monocultures, with 22.4% of its agricultural land devoted to them (27).

In the Central American countries and many other areas of Latin America, a significant proportion of the economically active population works in the agricultural sector. Half the population of Central America (around 35 million in 2002) lives in rural areas, particularly in Guatemala and Honduras. A large percentage (85-90%) of pesticides used annually in Central America are for agricultural purposes, often by communities with limited access to social security or health services (28).

The Central American countries are among the hemisphere's principal pesticide importers. According to WHO (29), this subregion imports an estimated 1.5 kg of pesticides per inhabitant per year—a figure three times higher than the world average. The potential damage to the population's health is significant, especially considering that around 35% of the pesticides imported into the region are for restricted use, even in the exporting countries (29). The quantities of imported pesticides give some idea of their potential for causing environmental damage. However, other factors should be taken into account when assessing the potential impact of pesticides on areas, such as health. In order to evaluate the potentially negative health impact, the term "pesticide load index" records information about the quantity of pesticides reported by each country, assuming that at least 80% of pesticides are used in the agricultural sector. According to data from the 2001 Report on the Project on the Occupational and Environmental Aspects of Exposure to Pesticides in the Central American Isthmus (PLAGSALUD), Costa Rica used 12 tons/100 ha, El Salvador 20 ton/100 ha, Guatemala 7 ton/100 ha, and Honduras 5 ton/ha. Nicaragua and Belize used far less (under 5 tons/100 ha) (29).

In terms of occupational exposure, an estimated 3% of agricultural workers experience an episode of pesticide poisoning each year. Over 50% of the poisonings occur in less industrialized countries despite the fact that the overall quantity of pesticides is smaller. These poisonings reflect poor hygiene and safety levels (28). Central American countries report 7,000 cases of pesticide poisoning per year. However, there is considerable underreporting, given the difficulties encountered by agricultural workers in accessing health services, as well as problems with misdiagnosis, registration, and reporting (28). According to the PLAGSALUD report, regional exposure indicator modeling shows that the incidence of pesticide poisoning increases by 9-11% for every 100 tons of imported pesticides per hectare of agricultural and non-agricultural land. On the other hand, there is no clear link between exposure figures and pesticide-related deaths (29). In 1992-2001, the Central American countries reported a total of 43,368 cases of acute pesticide poisoning, with 4,323 pesticide-related deaths.

## Coastal systems

Around half the world's population lives at a distance of 100 km or less from the coast (20). Approximately one third of the coastline of North and Central America and half of South America's coastline is moderately or critically threatened by the impacts of development. Urbanization, calculated by the number of people living in coastal systems, exceeded 85% throughout the hemisphere in 2000 (30).

Meanwhile, the region's oceans face a number of different threats, including eutrophication caused by pollution from land-based nutrients, uncontrolled urbanization, lack of wastewater treatment, salinization of estuaries caused by lower levels of fresh water, ballast water from ships, and invasive exotic species. These threats include the effects of climate change. Coastal zones are one of the ecosystems most directly threatened by the rise in sea levels caused by climate change. It is projected that over the next few years, certain areas of the hemisphere will suffer the impact of this phenomenon (31). According to the Intergovernmental Expert Group on Climate Change (IPCC), sea levels in southeastern South America have risen 2-3 mm per year over the past 20 years. Furthermore, it is anticipated that the rise in sea levels will lead to the salinization of estuaries and groundwater systems, reducing the availability of fresh water for human consumption in coastal zones (32).

One way of treating waste in the coastal zones of Latin America and the Caribbean is to install submarine outfalls for discharging liquid waste into the sea. According to the Pan American Center for Sanitary Engineering and Environmental Sciences (CEPIS) (33), marine outfalls are a viable alternative for disposing of wastewater from coastal zones. In 2000, Puerto Rico had 15 marine outfalls. Compared to the rest of the region, it has the highest per capita use of this disposal method, with outfalls built using the models and criteria of the U.S. Environmental Protection Agency (EPA). In Brazil, three of the five most heavily populated coastal cities (Rio de Janeiro, Salvador, and Fortaleza) are partially served by larger marine outfalls, although in these cities, the wastewater is not treated. Brazil has 12 marine outfalls (54 for industrial effluent), while Mexico had nine (two for industrial effluents) in 2000 (33).

## Demand for ecosystem services / pressure on natural resources

Since time immemorial, human beings have used and abused natural resources. Examples of abuse in the hemisphere include those committed by the Mayas (Maya Empire 2500 BC-900 AD, which is present-day Belize, Guatemala, Honduras, and Mexico), by the native inhabitants of North America (1800), and even by the United States and Canada (1900). In all these cases, soil erosion caused by overexploitation and species lost through over-hunting have left a heavy imprint on these territories (19).

Human beings are by and large responsible for the virtually irreversible changes in the diversity of life on Earth. The majority of these changes, usually to accommodate a drastic increase in the demand for food, water, and fuel, represent a loss of biodiversity. The following paragraphs paint a picture of the type and magnitude of these changes caused by factors that have led to the deterioration of the ecosystems: deforestation, desertification, water stress, effects on the atmosphere and air quality, the impact of solid waste, and sanitation.

### Deforestation

Tropical rainforests are home to a wide diversity of species and provide important environmental services both globally and locally. Their habitats and species, however, are under threat from pressures such as deforestation. An example of this is the changes induced by the loss of woodlands in the hemisphere. The countries that have experienced the greatest changes since 1990 are Ecuador, El Salvador, Honduras, and Nicaragua, with a percentage loss of approximately 1.3%. On the other hand, in Argentina, Brazil, Costa Rica, Guatemala, Mexico, Paraguay, and Venezuela, these losses have been slightly over 1%. It is worth noting, however, that the percentage changes in all these countries do not reflect the true scale of loss that has occurred, for example, in Brazil, which has the hemisphere's largest forest area and where over 50,000 km<sup>2</sup> (27) of forest has disappeared since 1990, practically equivalent to the loss of the total forested area of Nicaragua or Honduras. Between 2000 and 2005 alone, Brazil's primary forest disappeared at a rate of some 3.5 million hectares per year (34).

The foregoing represent highly significant losses, since as a result of deforestation, the carbon stored in biomass is removed as products or discharged by combustion into the atmosphere through microbial decomposition. Deforestation also accelerates wood and underground organic carbon decay. Local climate and soil conditions determine the speed of decomposition, with most of the remaining biomass decomposing in around 10 years in humid tropical areas (35). While forests provide the basis for the integrated management of water resources, the specific effects of deforestation vary with the characteristics of each area (36). The relationship between forests and water quality is complex and subject to debate, as forests provide services to the ecosystem while ensuring a constant supply of goodquality water. The loss of forest cover and changes in soil use can obviously affect water sources and threaten the survival of millions of people, as well as damaging the environment (37).

The combination of environmental degradation, changes in soil use, and alterations in the global climate has a disruptive effect on ecosystems and increases the transmission of parasitic diseases? (2). Deforestation affects the entire ecosystem. Changes in vegetation, the introduction of farm animals, the development of human settlements, and losses of biodiversity all impact vector-borne diseases (38). Forestry activities such as logging have been linked to increased exposure to yellow fever, malaria, and leishmaniasis vectors (39), as exemplified by the yellow fever outbreaks in Brazil (40) and Paraguay (41).

### Desertification

Desertification, or the degradation of land in arid ecosystems, is considered a threat to human development. Degradation leads to the loss of primary production and is generally caused by soil erosion and changes in vegetation, as well as by processes such as salinization (34). The combination of the current low levels of well-being (high poverty and infant mortality rates, low GDP, etc.), a large and growing rural population, highly variable environmental conditions in the arid zones, and the dependence of local populations on ecosystem services means that continuing soil degradation could have even worse negative impacts on the well-being of a very large number of people.

The environmental impacts of desertification can be felt on a regional and global scale, affecting even areas far from where they occur. For example, sandstorms in China can impact air quality as far away as North America (3). The reduction of plant cover that accompanies desertification intensifies dust and aerosol formation. Phenomena

such as cloud formation and rain patterns can also be affected, as well as the global carbon cycle and plant and animal biodiversity.

Arid and semi-arid zones currently occupy around two fifths of the world's total land area and are home to over 1 billion people. The arid zones of over 110 countries are threatened by desertification, particularly in Africa, Asia, and Latin America (42). Around 25% of the land area of Latin America and the Caribbean consists of deserts and arid zones (3).

### **Water stress and safe water sources for human consumption and sanitation**

#### *Water scarcity and access to safe sources*

Some 87% of the population of the world's population uses drinking water from improved sources: 54% have piped water in the home, plot, or backyard, while 33% use other improved sources of drinking water (4). In 2006, 92% of the Latin American and Caribbean population had access to drinking water services, either piped into their homes or from an easily accessible public source (4). Meanwhile, 47 million people (8%) had no access to any type of reliable non-health-threatening drinking water, and 25% of those living in the rural areas of the region depended on other non-piped improved water sources (4).

As for the effects on health and sustainable development, it is essential to protect natural water resources. It is not enough simply to provide the necessary amounts of water; it must be ensured that water is fit for different uses (e.g., drinking water, irrigation and recreational uses), can be accessed in a practical and economical manner, and does not cause adverse effects on health. There is a direct connection between protecting water resources and basic environmental sanitation.

#### *Case study: Water in Mexico city*

For historical and political reasons, Mexico is a highly centralized country. This means that government services and industrial development are concentrated in Mexico City (43), which is home to 47% of the country's chemical industry and which generates 20% of GNP. The city is one of the most densely populated areas in the country, with 5,877 inhabitants per square kilometer (10 times more than the national average of 53 inhabitants per km<sup>2</sup>) (44). Together with its metropolitan area, Mexico City is the second largest mega-city in the world, with a population of around 20 million (22). The valley in which the city is located (Mexico Valley) occupies the southern part of the Mexico basin, approximately 2,400 m above sea level and surrounded by mountains of volcanic origin with elevations of over 5,000 m.

Mexico City occupies hydrologic region XIII of the Mexico Valley, located on the upper basin of the Pánuco River and formed by two sub-basins—that of the Mexico Valley and the Tula River (see map in Figure 12-2) (45). The Cutzamala System supplies the Mexico Valley with approximately one fourth of the water consumed in this area—16 m<sup>3</sup> per second—from the rainwater captured in seven reservoirs in the states of Mexico and Michoacán (46). The remainder of the drinking water comes from 14 aquifers located in the valley itself. These are overexploited and under substantial pressure (46). One of the first signs of a fall in the underground water level was the drying up of the natural watersheds in the 1930s, which coincided with the heavy exploitation of the main aquifer through wells 100-200 m deep (43). Estimates up to 2007 showed that this aquifer presented a negative hydraulic balance of 30%, meaning that every cubic meter extracted was replaced by only 300 liters (47).

**Figure 12-2.** Hydrologic regions of Mexico.

*Source:* Espacio Digital Geográfico (ESDIG) SEMARNAT (48).

The earth in the various clayey areas of the city is sinking at a rate of between 6 cm/year and 30 cm/year. In the past 60 years, the city center has sunken by approximately 10 m. The resulting costs are unquantifiable and involve the construction of deep drainage, the installation of pumping systems, the deterioration of every type of public and private infrastructure, etc. The drop in the static level of the aquifer is a dual burden in water-supply terms: on the one hand, water needs to be pumped from increasingly deep levels while water quality worsens, thus increasing operational and water treatment costs. A full 35% of all the water distributed is lost to leakage in the system, partly due to aging pipes (47).

Mexico City's entire water supply system is now at a critical point. At present, due to lower rainfall in the watersheds that supply the reservoirs, the lowest level in the past 16 years has been reached (378,000,000 m<sup>3</sup>). The alternatives proposed by the Mexico City government to minimize the negative effects include suspension of the Cutzamala System on certain days of the month (49). In a press release of 21 July 2009, the Mexico City Water Authority (SACM) and the National Water Commission (CONAGUA) announced that the water supply from this system would be reduced for an entire week rather than on certain days. Jointly with the Mexico Valley Watershed Agency (OCAVM), SACM, and the State of Mexico Water Commission (CMEA), CONAGUA therefore ordered reductions in the water supplied by the Cutzamala System to the Mexico Valley Metropolitan Area (ZMVM)—aimed at saving the resources through preventive action before the 2010 dry season. This new approach to water supply reduction was expected to produce a saving of 6.68 million m<sup>3</sup> per month (3.5% of all the water consumed in the ZMVM) (50).

A further serious problem, whose solution has followed the lead of the water supply solution, although in this case the answer has been to use water from the Mexico Valley, is sewage management. Since the valley is an enclosed basin, costly works have been constructed to divert rainwater and wastewater through a common drainage system. Originally, all the stormwater runoff ended up in the valley's lakes, but as these were gradually overtaken by urban

development, it was necessary to dispose of both stormwater and wastewater elsewhere to prevent flooding. Currently 40 m<sup>3</sup>/s of the wastewater generated in the Federal District and State of Mexico is removed from the Mexico Valley. A further problem, in addition to the amounts of wastewater, is that of its quality: in Mexico City only 2.50 m<sup>3</sup>/s is treated (47).

Despite the gravity of the situation and growing awareness of the environmental, social, economic, and health problems caused by poor water management in Mexico City, irrational use of water persists and is widespread. Large amounts are lost through leaks in broken supply and drainage networks, which must be repaired; recycling of treated wastewater continues to be minimal; and the massive overexploitation of the aquifer means that large quantities of water must be piped from neighboring watersheds despite the management problems involved. Worse still, the wastewater pumped out of the Mexico Valley contains pollutants from untreated domestic and industrial sources, with the consequent negative environmental impacts (47).

All this paints a picture of the city's impact on the ecosystem as the result of the growing demand for water services, which far exceeds the available resources. There can be no doubt that the water issue should be made a top social and political priority.

### *Changes in the quality of marine water*

Specific threats to the marine waters of the region include the following (20):

- 86% of all wastewater is discharged untreated into the rivers and oceans (80-90% in the Caribbean)
- Oil pollution from the refineries in the Caribbean and Gulf of Mexico and offshore oil wells in the Gulf of Mexico and near the Brazilian coast. Oil spills are a particularly serious problem in the Gulf of Mexico
- Agrochemical runoff is a major problem. Highly toxic concentrations have been found in estuaries in the Caribbean, Colombia, and Costa Rica
- Hazardous waste, including radioactive materials from other regions, is transported in ships around South America or through the Panama Canal, and heavy metals pollute the Gulf of Mexico.

The degradation of the coastal systems poses a human health hazard. Cholera and other waterborne diseases are increasing in coastal areas, often linked to deteriorating water quality, climate change, and harmful algal blooms encouraged by eutrophication (20). Cholera has seriously affected the economies of Latin America and the health of its population. The cholera epidemic that broke out in Peru in January 1991 rapidly spread to other countries through water, contaminated food, and infected individuals. Cholera has traditionally been associated with the pollution of aquatic ecosystems. In Peru's coastal and tropical areas, where over 10,000 cases were reported in a six-month period (January-July 1991), high concentrations of *V. cholerae* were found in marine water, fresh water, and plankton samples. High concentrations of the infectious agent were also found in the Rimac River, Lima's main source of drinking water, and in coastal waters near the contaminated sites (51). Pollution, combined with other unhealthy conditions, poor water hygiene, and faulty management of water treatment and distribution systems, caused the epidemic to spread (52).

### *Sanitation*

In Latin America and the Caribbean, only 241.311 million people (48.61% of the total population) have connections to conventional sewerage systems, with 151.921 million people (30.60% of the population) using "on-site" sanitation systems such as latrines, septic tanks, etc. (19). An estimated 103.237 million people (20.79% of the region's population) have no wastewater or sewerage systems, 37,054 million (10.15%) of them living in urban areas and 66.183 million (50.41%) in rural areas. Lack of wastewater treatment remains one of the region's most pressing health problems, mainly in the Caribbean (19).

The importance of access to safe water and sanitation is reflected in the fact that around 3 million people in developing countries die prematurely from water-related causes. The highest proportion of deaths occurs among women and children from poor families with no access to safe water sources and proper sanitation (42). It is now generally acknowledged that access to safe water and sanitation is essential for preventing diarrheal diseases and other infections. It also contributes to eradicating global poverty, as proposed in the Millennium Development

Goals (53). Half the urban population in Latin America and the Caribbean suffers from one or more diseases associated with unsuitable water and sanitation (54).

Ensuring proper sanitation and access to safe water is an effective public health measure. Improving sanitation and hygiene has become one of the most effective interventions with the greatest cost-benefit for reducing the high rates of disease in developing countries (53). This is mirrored in the results of sanitation improvement programs, which have had a marked effect on the health status of the population. For example, epidemiological studies in Brazil (including two by Moraes *et al.* in 2003) to analyze the impact of sanitation programs on intestinal and diarrheal diseases suggest that adequate drainage and sanitation systems in communities significantly reduce diarrheal and parasitic diseases (55,56). A more recent study, also in Brazil, shows that a sanitation program led to a 22% reduction in the longitudinal prevalence of diarrhea among city populations and a 43% reduction in the areas where the baseline prevalence of diarrhea was highest (53).

### **Impact on the atmosphere and air quality**

In the countries of the Americas, there are two major problems related to air quality: pollution in major cities and household pollution resulting from the burning of biomass (20,57). The burning of fossil fuels and biomass (especially firewood), both of which cause environmental degradation, is a concern addressed in the Millennium Development Goals, especially MDG 7, Target 9 (57). The pollutants generated by burning biomass consist of particulate matter, nitrous oxides, sulfur oxides, and carbon monoxide, all of which have a serious impact on health, causing respiratory infections, chronic obstructive pulmonary disease (COPD), increased mortality (from cardiovascular diseases), lung cancer, etc. (58). On a global level, pneumonia and other acute respiratory infections are the leading causes of death among children under 5. Exposure to household pollution doubles the risk of pneumonia, which causes over 900,000 of the 2 million deaths per year (59).

In a literature review on the effects of air pollution on health (1994-2004), we found 85 studies in the scientific journals published by countries in the Americas (60). Most of these articles focused on the urban populations of countries such as Brazil, Chile, Cuba, Mexico, Peru, and Venezuela. The findings of the short-term studies of the region were similar to those in the international literature. The short-term effects of air pollution include increases in daily mortality rates, hospital admissions of people with respiratory and cardiovascular diseases, emergency and medical consultations for respiratory and cardiovascular disorders, reduced working days, absenteeism from work and school, and the appearance of acute symptoms (wheezing, coughing, phlegm production, respiratory infections) (61). Longer-term effects include death from respiratory and cardiovascular disease, the incidence and prevalence of chronic respiratory diseases (asthma, COPD), chronic changes in physiological functions, and lung cancer (61).

### **Impact of solid waste**

There has been a substantial increase in the solid waste produced in cities and rural areas. This has had a major impact on ecosystems through both air and water circulation. The cumulative environmental effects have been widely studied, highlighting the presence of groundwater-polluting leachates, soil pollution that results in lower food production, the proliferation of pathogens and harmful fauna that transmit infectious and parasitic diseases, and chemical agents that contribute to neurological and systemic damage, including cell damage.

Products generated by the accumulation of solid waste can be as harmful to people as the original products (62), since they circulate in the environment, carried by water, air, and soils. Populations living near waste dumps (especially those closer than 5 km) are at particular risk of increased health problems.

The amount of solid waste that cannot be processed by ecosystems has substantially increased. In the United States, the amount of solid waste increased from 269 million tons/year in 1989 to 413,014,732 tons/year in 2006 (63), although this figure fell to 389 million tons in 2008 (64). Waste collection by municipal authorities in the countries of the hemisphere ranged from 100% in the United States to 34.4% in Paraguay (27), while the amount of waste production ranged from 0.40 kg/inhabitant/day in cities such as Sucre, Bolivia, to 1.99 kg/inhabitant/day in São Paulo, Brazil (65). Table 12-1 indicates some of the environmental problems related to solid waste management.

**Table 12-1.** Major environmental impacts related to solid waste management (62).

Activity	Water	Air	Soil	Landscape and climate
<b>1. Landfill</b>	Leachates (heavy metals, synthetic organic compounds)	CO <sub>2</sub> , CH <sub>4</sub> , odor, noise, CoV	Heavy metals, synthetic organic compounds	Visual effects, harmful fauna. Worst option for GHG emissions.
<b>2. Incineration</b>	Discharge of air pollutants	O <sub>2</sub> , NO, N <sub>2</sub> O, HCl, HF, CO, CO <sub>2</sub> , dioxins, furans, HAP, COV, odor, noise	Ash, rubble	Visual effect. GHG.
<b>3. Composting</b>	Leachates	CO <sub>2</sub> , CH <sub>4</sub> , CO, powder, odor, bioaerosols	Lesser impact	Some visual effects. Low emission of GHG period
<b>4. Disposal on soil</b>	Bacteria, viruses, heavy metals	Bioaerosols, dust, odor	Bacteria, viruses, heavy metals, PAH, PCB	Harmful fauna, insects. Low emission of GHG.
<b>5. Recycling</b>	Wastewater	Dust, noise	Waste landfill	Lower emissions
<b>6. Waste transport</b>	Spills	CO <sub>2</sub> , SO <sub>2</sub> , NOT, dust, odors, noise, spills	Spills	High levels of CO <sub>2</sub>

CO<sub>2</sub> = carbon dioxide; CH<sub>4</sub> = methane; CoV = volatile organic compounds; SO<sub>2</sub> = sulfur dioxide; NO = nitrous oxides N<sub>2</sub>O = nitrous oxide; HCl = hydrochloric acid; HF = hydrofluoric acid, CO = carbon monoxide; and PAH = polycyclic aromatic hydrocarbons.

Reported health effects of solid waste management include:

1. Landfills: WHO has reported that the evidence associating sanitary landfills and incineration with health hazards (especially cancer, reproductive effects, and mortality) is weak or insufficient (66,67). Although links have been found between the risk of birth defects/low birthweight and living near sanitary landfills (68), this remains unproven due to a series of confounding factors (62).
2. Incineration: Studies on incinerators have focused particularly on dioxins. Non-Hodgkin's lymphoma and soft tissue sarcomas have received the most attention from researchers. The National Research Council of the United States concludes that epidemiological studies have failed to detect any significant effect on health. However, most of the studies included in the 2001 review by Hu and Shy (69) show higher concentrations of heavy metals and organic compounds among the populations occupying areas close to incinerators.
3. Composting: Links have been described between contamination by bioaerosols generated by open-air composting facilities and irritation and respiratory symptoms among the residents of nearby areas (62). The review conducted by Domingo *et al.* (70) focuses on the chemical and biological risks to workers in composting facilities and on the potential impact on local residents.
4. Disposal on soil: A study in El Salvador identified nonspecific refuse bins, plastic storage containers, and infested containers as constituting a dengue risk (71).
5. Recycling: The recycling process has a number of disadvantages, including the generation of emissions. While there is little information about the problems caused by exposure to recycling (72), Poulsen *et al.* (73) list a series of key factors that could cause health problems among people working in waste-sorting and recycling plants.

## ■ Vulnerability factors

Vulnerability can heighten risk in the presence of a threat or hazard. It can be defined as “a function of exposure and susceptibility to impacts and the inability to cope with or recover from them” (20). People can be exposed to

hazards such as drought and poor, socioeconomic, institutional, and environmental conditions. Impacts depend not only on the degree of exposure, but also on the susceptibility of a threat to which a community (a river basin, an island, a house, a village, a city, or a country) is exposed and on the ability to cope with and adapt to such threats (20). Vulnerability studies need to consider the fact that vulnerability is multidimensional and requires a multidisciplinary approach as well as multisectoral interventions.

There are substantial causal links between the state of the environment, human well-being, and vulnerability (20). Ecosystem changes generate human health hazards, but these risks vary with the social and environmental vulnerability of each group. The main vulnerability factors addressed in this chapter include:

## Poverty and inequity

Social inequity is widespread in the countries of the hemisphere. The Gini index is one way to measure how evenly income (or wealth) is distributed throughout a country. According to this indicator, indexes nearer to 0 mean that inequity is lower, while those closer to 100 mean that inequity is greater. According to the 2008 Human Development Report (74) some of the figures for Latin America (e.g., a Gini index of 60.1 for Bolivia and 59.2 for Haiti) were exceeded only by those of certain African countries. Meanwhile, Brazil and Panama, with Ginis of 57 and 56.1, respectively, are almost comparable to South Africa. In contrast, Mexico, the United States, and Canada have the hemisphere's lowest Gini indexes (46.1, 40.8, and 32.6, respectively) (74).

In addition to inequity, the poorest social groups are more vulnerable to the effects of ecosystem disturbance, given that:

1. **Their health is more precarious (e.g., higher levels of malnutrition or undernourishment).** In countries with a low HDI, people live shorter lives because their health is undermined by hunger (20).
2. **They have less access to environmental services such as drinking water.** Despite improved access to water and sanitation, the poorest suffer from greater water shortages due to where they live, poorly maintained infrastructure, and limited economic resources (20). Poorer populations often live in environments that make them more susceptible to infectious and other diseases. Limited access to material goods at the household level (money, food, drinking water, housing, clothing, electricity, natural and financial resources) and on a community level (physical infrastructure and services) is part of the cycle of poverty, vulnerability, and environmental change (20).
3. **They are less able to cope with disasters and other events.** One of the main causes of greater vulnerability to hazards is global environment change. Natural hazards, such as earthquakes, floods, droughts, storms, cyclones and hurricanes, forest fires, tsunamis, volcanic eruptions, and landslides, are a danger to everyone, but poorer people suffer disproportionately more from their effects (20).
4. **Their productivity and employment in activities that depend directly on the ecosystem is lower.** Poor people are more vulnerable to the adverse health effects of local and global ecosystem changes. The link between ecosystems and economies is very close, as ecosystems are a major source of employment, especially in middle- and low-income countries (19). This is true, for example, in Latin America, where jobs in fishing, agriculture, and forestry play a key role in the economies (37).

While diminished human well-being tends to increase immediate dependence on ecosystem services, the resulting additional pressures can undermine the future capacity of ecosystems to continue providing essential services (19). Any deterioration in human well-being goes hand-in-hand with a corresponding reduction in the options available for people to regulate the use of natural resources at sustainable levels. This in turn heightens the pressure on ecosystem services, creating a spiral of increasing poverty and ecosystem degradation (19).

## Migration for environmental reasons

The unbridled growth of large and small cities has had a number of undesirable effects on ecosystems and has led to different phenomena, such as people migrating for environmental reasons, degradation of natural resources, sanitation issues, etc.

The report produced by the expert seminar of the International Organization for Migration (IOM) (75) argues that **environmental migrants** are “persons or groups of persons who, for compelling reasons of sudden or progressive changes in the environment that adversely affect their lives or living conditions, are obliged to have to

leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their territory or abroad.” This report also mentions that environment-induced migration can be the result of:

- “Extreme environmental events,” which include any disaster that may affect a large population over a wide region and whose effects can be immediately felt in neighboring communities. Examples are hurricanes, cyclones, tsunamis, coastal and fluvial flooding, earthquakes, and volcanic eruptions
- Gradual changes, such as desertification, soil degradation, and deforestation.

Although extreme environmental events such as natural or industrial disasters often cause massive and sudden population displacement, the above-mentioned seminar concluded that a much larger contingent of people worldwide emigrate due to the gradual effects of man-made environmental degradation. Gradual environmental changes, such as desertification, soil degradation, and deforestation, generally include changes produced slowly over a lengthy period as small but cumulative processes. In certain cases, thresholds are reached beyond which the phenomena become irreversible. In Latin America, most migration is due to desertification. For example, in northeastern Brazil and Argentina, people have moved mainly to the capitals and to the south and central areas. Meanwhile, in Bolivia, Chile, Ecuador, Haiti, Mexico, Peru, and the Dominican Republic, many migrants have shifted from degraded areas to urban centers, including the national, state, and provincial capitals (75).

These population movements have effects on both the places of origin and destination. Urbanization plays a major role in encouraging people to move from their places of origin. Many of the migrants from environmentally degraded areas in Latin America and elsewhere tend to move to urban centers, since these are important national, state, or provincial capitals. In Bolivia, around 1.5 million rural dwellers have fled from desertification and now make up virtually the entire population of the city of El Alto. If not managed properly, mass human migration can also accelerate environmental degradation. One example is the massive population shift that occurred as a result of the 1985 earthquake in Mexico, when people evacuated from the center of Mexico City headed for the outskirts of the city, where services such as sanitation systems and piped water were totally lacking. The subsequent changes in land use resulting from these new migrants contributed to significant environmental deterioration over the next decade and led to the massive flooding of previously dry areas (75). As for the effects of migration on places of origin, outgoing migration can reduce demographic pressures and help certain areas recover from environmental degradation, thus making it possible for emigrants to return. However, in situations of very serious degradation, such as fallow land deterioration, recovery will take many years (75).

### Environmental vulnerability by geographical region and specific characteristics

While some of the effects of ecosystem degradation have already been mentioned, it is also important to emphasize that their magnitude can vary, depending on the geographical region where such changes occur. The Environmental Vulnerability Index (EVI) is useful for measuring environmental vulnerability in a specific geographic context. This indicator was created by the South Pacific Applied Geoscience Commission (SOPAC) and the United Nations Environment Program (UNEP) to rate the degree of impact of the different types of environmental problems on countries (76). Consisting of a five-point scale (from the most resistant to the most vulnerable countries), the EVI reveals substantial differences between countries in the hemisphere. For example, Trinidad and Tobago and Jamaica are rated as “extremely vulnerable” (77) and Cuba, Guatemala, and Costa Rica as, “very vulnerable,” while Chile, the United States, and Mexico are classified as “vulnerable.” Paraguay, Uruguay, Canada, and Panama are rated as “at risk” (53).

While this method is used for rating environmental vulnerability, other indicators rate countries’ sustainability. This is the case for the Environmental Sustainability Index (ESI), which calculates the capacity of countries to protect the environment over the coming decades. The ESI index collates different datasets to calculate current and past pollution levels, environmental management efforts, and the capacity of a society to improve the functioning of its environmental systems (78). The ESI also makes it possible to compare countries in terms of the reduction of environmental stress and of human vulnerability to environmental disturbances and the social and institutional capacity to respond to environmental challenges. As for sustainability, a higher ESI value means a better prognosis for a country to maintain favorable future environmental conditions. In the hemisphere, Uruguay ranks first in the world, with an ESI of 71.8, followed by Canada in sixth place (64.4) and Brazil (62.2) in eleventh place. In contrast, El Salvador, Trinidad and Tobago, and Haiti are in 118th, 139th, and 141st place, with ESI values of 43.8, 34.8, and 36.3, respectively (55).

## ■ Risks and health impact of ecosystem degradation

From the foregoing we can see that ecosystems throughout the world are suffering intense degradation. This is also true of the Americas, where the phenomenon has its own particular characteristics. Degradation can generate health hazards, which are always mediated by social and environmental vulnerability factors.

The following are some of the phenomena arising from ecosystem degradation that can affect population health and generate acute and chronic effects:

- Changes in local temperature regimes (e.g., average temperature or its degree of variability)
- Changes in the water cycle (duration, intensity, and spatial distribution of precipitation)
- Habitat destruction, fragmentation, or conversion (e.g., caused by deforestation)
- Changes in the distribution and availability of surface water (e.g., construction of dams or irrigation systems)
- The use of agricultural land for intensive crop growing and livestock production (e.g., intensive cattle ranching and monocultures)
- Changes resulting from the use of chemical pollutants, including pesticides and excessive nutrients
- The effects of urbanization.

### Disability-adjusted life-years (DALYs) attributable to environmental causes

It is estimated that 24% of global morbidity and 23% of all deaths can be attributed to environmental factors (19), while 25% of mortality in developing countries and 17% in developed countries is attributable to environmental causes.

Over 10% of all DALYs lost in Latin America are attributable directly to environmental and occupational risk factors arising from poor water and sanitation, and 5.5% to urban air pollution, chemical substances, agroindustrial waste, and indoor air pollution. These figures mask profound differences between and within the countries (Annex, Table 12-3).

However the DALY method for evaluating disease levels needs to be used carefully, given the ongoing debate between the economic and epidemiological research communities. Criticisms about the global burden of disease (GBD) can be grouped into three categories. First, concern exists over the consequences of extrapolating from population health figures in cases where data is limited, inaccurate, or missing. Second, issues have arisen regarding the way in which the DALY approach groups together both fatal and nonfatal health consequences. Third, some reputable economists argue that GBD analyses may be irrelevant or ambiguous when used for setting priorities in health (79).

According to information in the Environmental Health Report issued by WHO and UNEP (76) the main environmental risk factors with quantifiable impacts on disease include the following:

- **Water from unsafe sources and poor hygiene:** This environmental risk, resulting from a series of diseases (including diarrheal diseases) caused by polluted water, is estimated to cause 1.7 million deaths annually (76).
- **Indoor air pollution:** This is linked to the use of fossil fuels, mainly in developing countries. At the global level, 1.5 million people died in 2002 from diseases caused by this type of pollution (76).
- **Ambient air pollution:** It is calculated that around 800,000 people die annually from air pollution. The levels of airborne fine particulate matter, usually generated by vehicles and industrial and energy generation plants, are linked to increased daily and premature mortality from cardiopulmonary diseases, acute respiratory infections, and cancer (76).
- **Climate change:** Extreme climatic events such as heat waves, flooding, and droughts cause an estimated 150,000 deaths per year in addition to injuries. Climate change also negatively impacts local food production and causes changes in vector-borne disease transmission, as well as other infectious diseases (76).
- **Lead exposure:** This contributes to mental retardation in children and cardiovascular diseases associated with hypertension. Lead exposure causes around 13 million DALYS per year (around 1% of

GDB) (76), while the burden of disease due to exposure to other metals such as mercury, arsenic, and manganese (all of which can cause subclinical effects in children and other susceptible people) has not yet been fully established (80).

## Reemerging diseases

Vector-borne diseases are unique in that they are largely dependent on the environment. The ecological changes that directly or indirectly affect pathogen, vector, and nonhuman host populations can produce epidemiological alterations in these diseases (38).

Ecosystem and biodiversity changes undoubtedly heighten the risk of transmission of many diseases to humans. Changes in ecosystems (e.g., logging activities, dam and canal construction) can alter the habitats, and therefore the populations, of disease-bearing vectors. However, major vector-borne infectious diseases such as malaria cannot be described as completely dependent on ecosystems but, rather, result from human interaction with ecosystem services. It follows that improved ecosystem services management, public education programs, chemical and medical interventions, and poverty alleviation could play a major role in reducing—and in certain cases eliminating—the transmission of reemerging diseases (34).

## Zoonoses

The Joint Report of the World Health Organization (WHO), United Nations Food and Agriculture Organization (FAO), and World Organization for Animal Health (OIE) of 2004 defines emerging zoonoses as infectious diseases in animals that are transmissible to human beings. Without referring to past prevalence of zoonoses, the report points to increased incidence from a geographical, host, or vector standpoint (81). Examples include avian flu and bovine spongiform encephalopathy. Other less well-known diseases linked to animals are brucellosis, rabies, and parasitic diseases such as cysticercosis and taeniasis.

Zoonoses are recognized as a potentially serious global and regional problem with a negative impact on human health and economies. While the problem is likely to worsen, it is difficult to forecast which zoonoses will emerge in the future because of their multifaceted nature and the constant evolution of different factors. Anthropogenic factors such as agricultural expansion and intensification to meet the growing demand for animal protein, the trade in domestic and exotic species, urbanization, and the destruction of habitats are some of the main factors related to the emergence of these diseases. Environmental changes, human and animal demographics, and changes in pathogenic microorganisms and livestock-raising practices also contribute to their increase (82).

A recent example of the impact of zoonoses was the outbreak of severe acute respiratory syndrome (SARS) in Canada, caused by a coronavirus that probably originated in southeastern China in November 2002 (83). The disease spread rapidly, infecting some 8,400 people and killing 800 worldwide. In Toronto alone, 375 infected patients were reported and 44 deaths were attributed to the disease. SARS is of animal origin, the result of massive ecological and social changes in China. The outbreak in Canada was not directly caused by any disturbance in the local ecosystem but was imported by an infected traveler, which shows that local ecosystems can also affect global ecosystems (83).

## Neglected diseases

Most neglected diseases are tropical infectious diseases that are most prevalent among poor populations living in marginal areas. Incapacitating diseases such as lymphatic filariasis, schistosomiasis, soil-transmitted helminth infection, Chagas disease, leishmaniasis, leprosy, and trachoma continue to cause disability and even death. Although the term “neglected tropical diseases” is often used for countries in the Americas, “neglected diseases” is more appropriate given that some diseases, such as leptospirosis, are not confined to tropical and subtropical areas. Although these diseases are varied, they share characteristics that enable them to persist among low-income populations as a result of unsafe water and poor sanitation, which foster transmission cycles and the proliferation of disease-bearing vectors (84). However, these are not the only determinants of these diseases in Latin America and the Caribbean. Additional factors combine to propagate neglected diseases: poverty, ethnic and gender inequity, age, and a series of ecological niches that can create relevant hot spots from an epidemiological standpoint (85).

Some 33 million people are currently living with HIV. In 2007, 2.7 million more people were infected with the virus and a further 2 million died from AIDS. On the other hand, neglected tropical diseases, generally associated with poverty and the lack of health services, affect around 1.2 billion people worldwide (86), causing impairments

and disability. The global prevalence of leprosy in early 2008, however, was 212,802 reported cases (down from 5.2 million in 1985). A total of 2,854 cases of leprosy were reported in the Americas in 2007 (86).

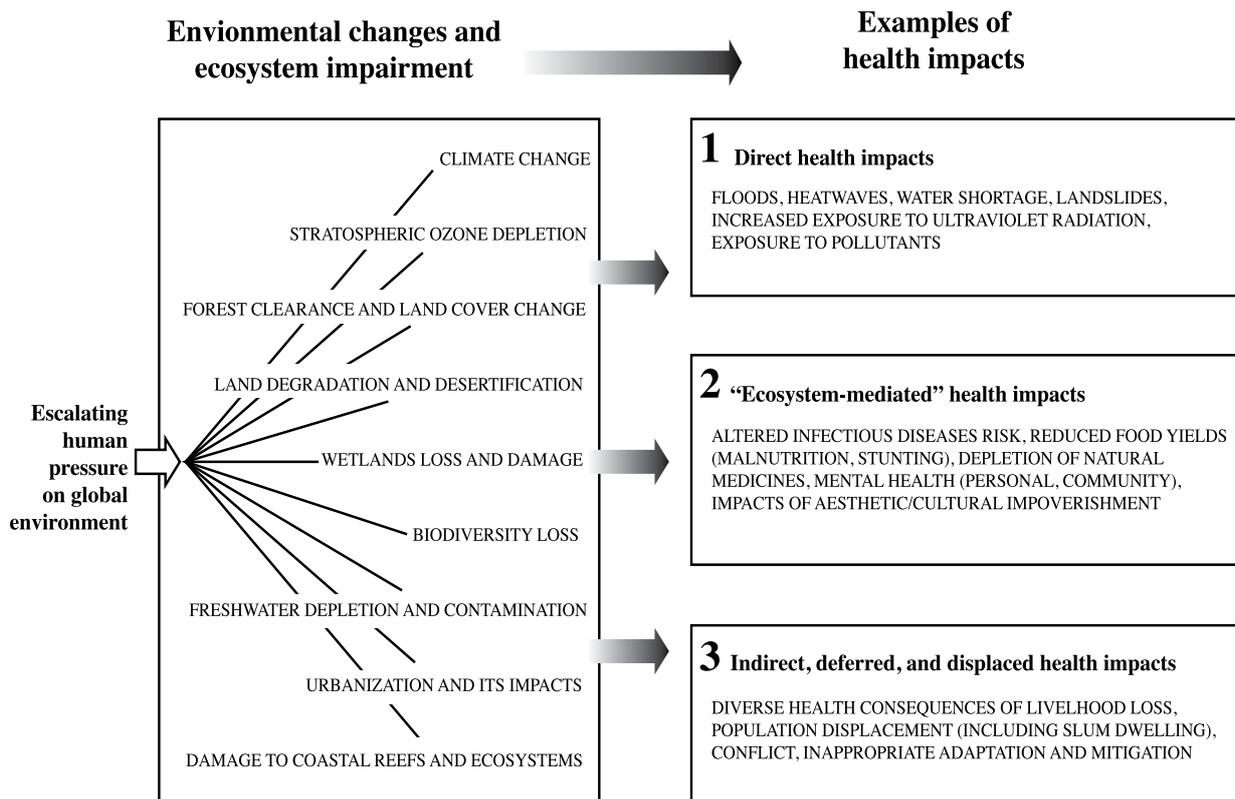
Diseases such as schistosomiasis and Chagas disease affect between 1.8 and 9 million people in Latin America and the Caribbean, respectively, while up to 90 million people in the region may be at risk (85). Public health policies need to give priority to tackling the problem of neglected diseases, which significantly contribute to morbidity and drastic reductions in the earnings of poor families and communities throughout the region, even though they do not directly cause high mortality rates.

## ■ Driving forces and decision-making

There is a clear link between ecosystem changes and their effects on population health. These changes can contribute to an increase in infectious diseases and the appearance of emerging and reemerging diseases and are responsible for chronic illnesses resulting from exposure to toxic substances.

It is equally clear that development models, particularly policies related to the use of natural resources, are to some extent responsible for the changes in ecosystems. The scheme proposed by WHO in the chart below gives an idea of the adverse effects of ecosystem degradation on health.

Figure 12-3. Adverse effects on health caused by the degradation of ecosystems (34)



This topic will be analyzed in more detail in Chapter 4 (Environmental Health Governance in Latin America and the Caribbean), but for the moment we at least have a conceptual framework for understanding, managing, and tackling these driving forces.

## Driving forces on ecosystems

The Millennium Ecosystems Evaluation project contained four scenarios for analyzing credible future changes in driving forces, ecosystems, ecosystem services, and human well-being (54):

- *Global orchestration*: development patterns focused on global economic growth, social responsibility, and access to public goods
- *Order from strength*: guiding development at the regional level, with emphasis on national security and economic growth
- *Adapting mosaic*: regionalized development, with emphasis on local adaptation and flexible governance
- *TechnoGarden*: global development patterns emphasizing scientific innovation and environmentally sound technologies

The above scenarios should not be regarded as accurate forecasts, and it is important to realize that other scenarios could develop in more optimistic or more pessimistic contexts. Two basic forces are responsible for exploiting and pressuring ecosystems: population growth and increased consumption.

The Millennium Ecosystems Evaluation (54) defines a driving force as any natural or man-made factor that causes direct or indirect change in an ecosystem. The direct type of change might include changes that influence ecosystem processes, the use of nutrients, land use changes, diseases, and invasive species. Indirect changes (e.g., demographic, economic, sociopolitical, scientific, technological, cultural, and religious changes) are widely responsible for changing one or more of the direct factors.

Growing populations and economies are linked to increases in consumption and greater pressure on ecosystems. The extent of this pressure depends on a series of human factors and factors germane to the ecosystem. Human factors include demographics, technology, behavior, policies, and culture. However, the level of pressure is essentially related to the resilience of an ecosystem. Conservation measures can sometimes reduce human pressure on ecosystems. On the other hand, a moderate increase in pressure could produce an adverse, nonlinear, unexpected response by the ecosystem (e.g., the collapse of a coral reef or a marine system).

The direct driving forces vary from place to place. The major forces at present are climate change, land use, invasive species, fishing, river modification, excessive water use, and pollution.

## ■ Remediation strategies

Following a review of the current state of ecosystems in the Americas and the impact on human health, potential remediation strategies need to be considered. Remediation in the present context can be seen as a pathway to restoring and stabilizing ecosystems. Another way of looking at the situation is to talk about ecosystem management; since human intervention in ecosystems has been negative up to now, our societies are responsible for devising alternatives for restoring them on the assumption that this will reduce health risks. In any case, the main point is that rather than providing palliative solutions for reducing these risks, positive steps must be taken to change ecosystems for the better. A number of examples can be provided of how a significant reduction in the incidence of certain diseases can be obtained through ecosystem management. The malaria reduction program in Mexico and Central America is a case in point.

### Case study: Regional program of action and demonstration of sustainable alternatives to DDT for malaria vector control in Mexico and Central America (2004-2008)

*Ángel F. Betanzos Reyes, Mario Henry Rodríguez and Emilio Ramírez Pinto*

In Mexico and Central America, environmental conditions that favor the presence and breeding of malaria vectors exist in around 6% of the ecologically favorable area for transmission of the disease. In the subregion, over 15 million people (10.2% of the population) are at risk of contracting malaria (87, 88). In these endemic areas, the lack of education for preventing and controlling malaria in the most affected groups and the poor technical training

of local health workers have made it difficult to control transmission. All the countries in this area nevertheless have national control projects that include a vector control component. Before 2002 this consisted simply of spraying dwellings with insecticides that have a residual effect, mainly DDT (89).

In 1999, the Commission for Environmental Cooperation of North America (CEC) (also known as the North American Free Trade Agreement [NAFTA] Commission for Environmental Cooperation), together with Central American ministries/secretariats of health and PAHO/WHO, implemented the “Regional Program of Action and Demonstration of Sustainable Alternatives to DDT for Malaria Vector Control in Mexico and Central America (2004-2008),” with resources from the Global Environment Facility (GEF/GEF) (90). This project consisted of four components: 1) demonstration projects; 2) the strengthening of countries’ institutional capacity for controlling malaria without the use of DDT; 3) elimination of DDT stockpiles; and 4) project management and coordination. A total of 202 demonstration areas (experimental group) and 51 control localities (non-intervention group) were selected in the participating countries (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, and Panama). The strategic objective was to take action exclusively in the demonstration areas to target and control malaria breeding sites without the use of DDT, based on the Mexican experience, tailoring it to local vector transmission and control conditions.

The interventions brought together stakeholders from communities and local governments and were carried out using an intercultural approach that included a specific component for the participating indigenous communities (91). Municipal governments played a key role in identifying and training the community leaders responsible for coordinating and organizing local activities focused on individual, family, and community health care, improvement of surrounding areas, environmental preservation, and the promotion of community organization through meetings, discussions, and home visits. Local populations were involved in the different stages of the project through the transfer of knowledge, practices, and innovative techniques for controlling malaria vectors, their participation by representatives in local health committees, and the use of educational techniques (e.g., puppet shows, community manuals, and contests). The only countries that used chemical products were El Salvador, where larval control measures were used in 71.4% of the demonstration areas, and Panama, where at the start of the project, organophosphates (fenitrothion) were sprayed on one occasion in people’s homes in an effort to control a reemerging epidemic.

A substantial reduction in the number of malaria cases and indexes was observed after the interventions in the demonstration and control areas. A total of 7,434 cases were reported in the demonstration areas during the four years of the project—from 2,439 cases in 2004 down to 914 in 2007—representing a 62.5% reduction in the absolute number of cases. The data collected during the interventions were inadequate to show a reduction in malaria incidence in the demonstration areas versus the control areas, due to the selection of localities that were not comparable and their contamination with similar activities during the work process. However, significant differences were noted between the outcomes in some countries such as Belize and Costa Rica. El Salvador has continued its sustained malaria control activities over a number of years, and, like Mexico, is considered a priority candidate by WHO for participating in the malaria elimination initiative (92). The main point is that, with the exception of Mexico, malaria reduction rates in the demonstration areas were higher than the overall national rates in the Central American countries.

**Table 12-2.** Percentage reduction in malaria cases in countries and demonstration sites. UNEP/DDT/GEG/PAHO Project. Central America, 2004, 2007

Country	Cases in the country	Cases in the demonstration sites	% reduction	2004	2007	% reduction
	2004	2006-7				
Belize	1,057	844	20	376	128	66
Costa Rica*	1,289	1,223	5	99	112	-13
El Salvador	76	49	36	26	0	100
Guatemala	35,349	31,093	12	265	92	65
Honduras	14,813	11,561	22	521	105	80
Mexico	6,861	2,514	63	902	456	49
Nicaragua*	5,095	2,514	51	94	16	83
Panama*	3,406	1,281	62	156	5	97
Total	67,946	51,079	25	2439	914	63

## ■ Research requirements and policy recommendations

As elsewhere in the world, the Hemisphere has undergone rapid ecosystem degradation, especially since the 1970s. This has posed increasing risks to human health. Acknowledgment of the situation has led to a number of key initiatives on biodiversity and human health which, when applied to the countries in question, could lay the foundations for future sustainability policies (93). Recommendations for understanding, mitigating, and remedying the situation include a research component, as well as the need to formulate multisectoral policies.

More accurate research data is essential for calculating the damage to the region's ecosystems and its link to health problems. Thus, research projects should be designed to link social, environmental, and health disciplines at the hemispheric, country, and regional level. There is no doubt that boosting environmental epidemiology research continues to be fundamental. However, it is also necessary to adopt approaches with a wider, more comprehensive view, such as the Ecosystem Approach to Human Health (ECOSALUD), which seeks to:

- Generate new knowledge by studying the interplay between the social, environmental, and biological determinants of health
- Use this knowledge for proper management of the dynamics of ecosystems (socioeconomic and bio-physical environment) associated with the health condition studied.

The four methodological pillars of this approach are:

- Training of cross-disciplinary teams
- The social and gender equity perspective
- Stakeholder participation
- Research directed towards decision-making, which includes management plans and policy-making

The key research recommendations for the Hemisphere include the following:

- Establish a specific inventory of the state of ecosystems at the hemispheric and regional (Latin America and the Caribbean) level, including a permanent monitoring system. This inventory should contain detailed information on the link between health and environmental conditions. We also propose the creation of an “Interactive Regional Population Health Risk Atlas” whose main input would be a diagnosis of ecosystems that includes an assessment of different future scenarios. This instrument could be used by planners and society in general to develop improvement, monitoring, and, eventually, adaptation programs. It would also include assessments of the short- and long-term social and economic costs to health of the overexploitation of the ecosystems. Such an assessment should be conducted by researchers from social, environmental, and health disciplines.
- As for rural ecosystems, we propose an updating of the data on the importation and use of agrochemical products in reports such as that of PLAGSALUD, which could be expanded to other countries in the hemisphere. Better notification systems should also be introduced for recording cases of acute and chronic poisoning from pesticides exposure.
- Conduct studies on the health impacts of different solid waste treatment methods. The current data is based on studies done in Europe and Asia and, to our knowledge, the effects of open air garbage dumps, recycling plants, incineration, waste collection, and solid waste transport have not been studied in depth in the Latin American and Caribbean region, where economic and social conditions are radically different from those in Europe and Asia, as are the types of waste to which the population is exposed.
- Improve access to data about the treatment of wastewaters that are currently discharged into the sea through submarine outfalls. In this respect, we recommend that the statistics be updated prior to the preparation of a report on the situation in the hemisphere. Notification systems for diseases contracted as a result of contact with polluted water at beaches and in other recreational areas also need improvement.
- Conduct more studies on the effects of climate change on regional ecosystems and their consequences for health. Although climate change is a global phenomenon, its regional effects vary with social and

- environmental conditions. These effects are mediated by effects on the ecosystems.
- Study the effects of damage to ecosystems by vector-borne diseases such as dengue, Chagas disease, etc., prior to drafting intervention proposals.
  - Conduct studies on urban ecosystems (in large and medium-sized cities) with a view to designing management proposals, important in view of the growth of cities in the region.
  - Intensify research with an ecosystems approach to zoonoses and reemerging and neglected diseases to obtain information on their current prevalence and future incidence.

Finally, a further key point is the need to scale up research capabilities and regional cooperation in the hemisphere, where employment opportunities in knowledge creation differ substantially from country to country. Given that environmental problems stretch beyond the borders of each country, there is a very clear need to promote research through South-South and North-South cooperation.

### Policy recommendations

Health problems are the result of the complex relationships between ecosystems and human societies. Solutions must not only embrace the health sector but extend beyond it. This will require the participation of other sectors, such as those related to the environment and to manufacturing processes. The following recommendations may help provide a solution to the problems highlighted in this chapter:

1. Countries should strengthen links between the environmental and health sectors at all levels, building on the successful outcomes of the various Meetings of Health and Environment Ministers (e.g., the Meeting of Ministers of Health and Environment of the Americas, held in Mar del Plata, Argentina, in 2005). The key topics in this respect are climate change, air pollution, solid and toxic waste, water management and use, environmental surveillance, and health indicators.
2. Environmental health surveillance systems need strengthening. This involves an ongoing exchange of information between the environmental and health sectors. Given the growing problems of water availability and pollution, water quality and air quality monitoring information needs to be incorporated in the epidemiological surveillance systems. More programs and greater investment are needed to improve the capture, treatment, and recycling of water.
3. More investment is also needed to control sources of air pollution. Sources include both indoor pollution (e.g., through programs for improved stoves) and outdoor pollution (through better industrial production processes, vehicle replacement, and improved public transportation and fuels). Improvements in monitoring systems are also needed, particularly in Latin America's major cities. Despite the continued growth of the cities, some countries still have no regulations or surveillance systems to protect the population. In this respect, North-South exchange of technology and experience would be useful.
4. As for solid waste, the health sector needs to make efforts to reduce the generation of highly polluting and persistent disposable items with probable or proven health effects. Their production, marketing, and final disposal must be analyzed from the health standpoint, evaluating the effects of these items on health over the short and long term.
5. Greater collaboration between countries is needed, especially between those in a region that are signatories to environmental agreements and programs. One example of this is the Commission for Environmental Cooperation of North America (CEC). A spinoff of NAFTA, this body deals with regional research on the existence and transport of chemical substances with potential repercussions for health. These agreements and programs are part of the framework of broader agreements such as the Stockholm Convention on Persistent Organic Pollutants.
6. The region needs to increase capacity-building and human resources training with regard to health and the environment. The areas of opportunity range from the technical and operational levels to the highest management levels of the region's health systems. Specialization and graduate training programs should be included, so that developing countries in particular will not suffer from a shortage of experts to study the effects of ecosystem degradation on health.

In conclusion, it is vital to study in depth the link between the deteriorating state of the ecosystems and health and sanitary issues, both within countries and at the watershed level. Better understanding will make it possible

to formulate policies, programs, and projects at the local level to maintain and create healthy environments. This presupposes that local environmental and social vulnerability will also be taken into account, as well as the views of the stakeholders involved. We therefore recommend promoting the creation of multidisciplinary research groups in which decision makers will also be involved. The link between research and decision-making is a priority in view of the environmental crisis in the Hemisphere. Immediate decisions based on the best scientific knowledge available are needed.

## Annex

Table 12-3. Burden of disease by environmental factors (94)

Country	Population (000)	Drinking water and sanitation				Air pollution			
		Access to improved water sources (%)	Access to better sanitation (%)	Deaths from diarrhea per year	Diarrhea DALY/1,000 per capita per year	* Annual PM10 [mg/m <sup>3</sup> ]	** Urban population (%)	Deaths per year	DALY/1,000 per capita per year
Antigua and Barbuda	82	91	95	-	1.0	26	33	-	0.2
Argentina	38,372	96	91	300	1.0	78	74	13,100	2
Bahamas	319	97	100	-	1.1	18	72	-	-
Barbados	291	100	100	-	0.6	95	4	-	0.1
Belize	269	91	47	-	2.5	12	25	-	-
Bolivia	9,009	85	46	-	13	72	45	1,000	1.2
Brazil	184,318	90	75	3,400	5	35	45	13,600	0.6
Canada	31,955	100	100	25,100	-	21	79	2,700	0.4
Chile	16,124	95	91	-	0.2	62	57	2,400	0.8
Colombia	44,317	93	86	200	1.0	42	41	2,600	0.4
Costa Rica	4,253	97	92	2,100	2.3	40	46	200	0.3
Cuba	11,247	91	98	100	1.3	38	39	1,800	0.9
Dominica	68	97	84	200	0.9	34	22	-	0.2
Dominican Republic	9,325	95	78	-	1.0	36	43	800	0.7
Ecuador	12,917	94	89	1,300	5	34	48	500	0.3
El Salvador	6,576	84	62	1,100	4	48	27	300	0.3
Grenada	105	95	96	700	4	49	n/a	-	-
Guatemala	12,397	95	86	-	1.7	60	23	500	0.3
Guyana	739	83	70	3,900	10	13	28	-	-
Haiti	9,149	54	30	200	7	47	31	600	0.7
Honduras	6,702	87	69	5,700	22	69	31	600	0.6
Jamaica	2,665	93	80	1,200	6	43	27	200	0.4
Mexico	103,338	97	79	200	2.8	49	56	9,300	0.6
Nicaragua	5,394	79	47	4,500	2.0	32	26	100	0.2
Panama	3,175	90	73	900	6	58	29	200	0.4
Paraguay	5,793	86	80	200	3	103	25	500	0.6
Peru	26,959	83	63	500	4	62	53	3,200	0.8
Saint Kitts and Nevis	49	99	95	2,500	4	33	29	-	0.4
Saint Lucia	159	98	89	-	2.3	74	n/a	-	-
Saint Vincent and the Grenadines	118	n/a	n/a	-	1.1	56	19	<10	0.4
Suriname	450	92	94	-	-	13	55	-	-
Trinidad and Tobago	1,319	91	100	<100	4	22	4	<10	0.0
United States of America	296,844	100	100	-	1.2	24	72	40,600	0.7
Uruguay	3,324	100	100	-	0.2	154	44	1,400	2
Venezuela	26,260	83	68	-	0.7	16	62	-	-
				1,600	2.4				

n/a Not available

\* Weighted average per population of particulate matter of less than 10 microns in diameter [ $\mu\text{g}/\text{m}^3$ ] (estimates or monitored, where available)

\*\* Percentage of the urban population living in cities >100,000 and national capitals

- Zero, not applicable, or estimation method not sensitive

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# Environmental health and genetic susceptibility

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## ■ Introduction

Environmental policy researchers and decision makers have been concerned for many years about the effect of the environment on public health. In order to ensure the health of entire populations, it has become critical to identify the risk factors of their vulnerable subgroups. Children, older persons, pregnant women, and the chronically ill are considered vulnerable because of their physical condition; however, social, environmental, and genetic factors are also determinants of susceptibility (1).

The environment is closely connected to human morbidity and mortality. Exposure to infectious microorganisms, chemical agents, pesticides, radiation, and toxic metals has been associated with acute and chronic disease, disability, and even death. In 2006, it was estimated that 24% of the global burden of disease was caused by preventable environmental exposures (2).

The environment and lifestyles have been modified by population growth, industrial development, and other factors inherent to modernization (1). Economic growth and urbanization have been accompanied by high concentrations of environmental contaminants, unhealthy eating habits, little or no physical activity, and an increase in alcohol and tobacco use (3).

Formally, environmental health addresses all the physical, chemical, and biological factors external to an individual (4). However, given the importance that lifestyle is now seen to have in human health, the definition of environmental exposure is frequently expanded to include lifestyle among the exogenous factors responsible for many illnesses (5). All human beings are affected one way or another by exposure to the environment. Most exposures are involuntary and beyond an individual's control, and they can originate in different settings in both open and enclosed spaces. Lifestyle-related factors, in contrast, depend largely on the individual.

It has been observed, however, that people exposed to similar levels of contaminants or who have equivalent lifestyles do not necessarily contract the same illnesses. In 1775, English physician Percivall Pott noticed a high incidence of scrotal cancer among chimney sweeps exposed to coal tar, leading him to establish an association between occupational exposure and the disease. However, not all exposed workers developed this cancer (5). That is, other factors are in play in the origin of diseases such as cancer.

It is now known that the effect of exposure on a person's health depends on his or her genetic susceptibility. It has also been recognized that multiple genes and various environmental agents (including lifestyle) influence the etiology of many diseases and that these genes and agents interact among themselves. Consequently, these diseases are known as complex diseases, examples of which are cancer, diabetes, and asthma.

As the population grows, urbanization and exposure change rapidly, while genotypes change very slowly over many generations (6). This combination is disadvantageous to human health, since potential endogenous protection cannot be activated when and how it may be needed.

Epidemiological studies have been critical in charting the health effects of exposure to physical and chemical agents. However, many findings are still controversial because of their lack of replicability in different human populations. While it is true that differences among studies' results may be due to differences in a large number of variables, such as case definition criteria, study design, or accuracy of exposure measurement, they may also stem from genetic diversity among populations.

With the demonstration of the influence of genetic variations on responses to environmental exposure, in 1987 the National Research Council of the National Academy of Sciences in the United States adopted a definition for biomarkers of susceptibility. These include markers that reflect genetic differences in the ability of cells to repair DNA damage caused by environmental factors and damage related to certain inherited genetic traits that increase the risk of certain diseases (7). To evaluate the effect of genetic markers on the risk of developing a given disorder, for several years studies were conducted with genes that were biologically identified as candidates, but little was known about the human genome as a whole.

In 1990, the human genome project was launched with the objective of sequencing DNA and identifying and locating the different genes physically and functionally. In February 2001, the first draft of the sequence was published (8). The complete sequence of the human genome consists of an estimated 3.3 billion base pairs and includes 30,000 to 40,000 genes encoding different proteins (9). Today, technology makes it possible to identify regions of genetic susceptibility using genome-wide association studies (GWAS). Knowledge of the sequence and location of genes has opened many doors to analysis of the genetic determinants of different diseases. However, much work remains to identify the genes involved in specific diseases, the potential genetic variability among populations, and the way that genes interact among themselves and with the environment (10).

In recent years, evaluation of the interaction between genes and the environment has been gaining momentum. There has been a gradual increase in the number of studies that combine genetic and environmental information to study the mechanisms that drive complex diseases. However, problems in drawing definitive conclusions persist, making it necessary to redouble efforts to more clearly understand the etiology of these diseases, and hence, be able to devise preventive health policies and improve treatment regimens.

The first part of this chapter discusses complex diseases and the need for developing biological hypotheses that take the combined involvement of the environment and genetic susceptibility into account. The second part discusses the difficulties and offers suggestions for the design of studies on gene-environment interactions. Given the breadth of this subject, to illustrate the impact of this research on human health, this section describes important findings related to breast cancer, lung cancer, type 2 diabetes, and asthma.

The third part of the chapter discusses current genetic and genomic approaches and analyzes the need to increase the participation of the Latin American population in these scientific and technological developments. It then discusses Latin American genetic diversity and underscores the importance of this population to research on the interaction between genes and the environment. The chapter ends with a summary and offers suggestions on methodology and health policy improvements.

## ■ Complex diseases

Mendel's laws are a set of basic rules governing the biological transmission of traits from parents to offspring. These laws explain and predict how the physical characteristics of a new organism will appear based on the traits of the parents (11). However, many complex hereditary diseases do not follow a classical heredity pattern consistent with Mendel's laws. Diseases of the parents are not necessarily transmitted biologically to the children, while children can suffer from diseases that their parents did not have. An individual may inherit polymorphisms that confer susceptibility to a certain disease and even so, die without developing it. On the other hand, a person who does not have a genotype that puts him or her at risk of contracting a certain disease can likewise develop it.

It is now known that the combined effects of multiple genes and various environmental factors, including lifestyle, are involved in the origin of complex diseases. Predisposition to illness may also depend on sex and may vary with age and whether the person has a concomitant condition.

Watson and Crick's (12) discovery of the structure of DNA in 1953 and the sequencing of the chemical base pairs that make up the human genome in 2001 have contributed a wealth of invaluable information for the study of a vast number of diseases. However, contrary to expectations, the etiology of many of them is still unclear (13).

To date, it has not been accurately determined how many—and which—genes mediate in the course of a complex disease, nor how many—and which—environmental agents are involved. It is known that the direction and extent of the clinical effect of a genetic variant on a disease can change if the environment changes (6). Identifying all the main players and their contribution to the development of the disease is not easy, because the individual effect of any factor may be confounded or interact with the effect of other factors (14).

A line of research that has become increasingly important in the past 20 years focuses on including the gene-environment interaction as a strategy for unraveling the causes of complex diseases, making it possible to develop preventive health policies and improve treatment strategies.

## ■ The gene-environment interaction

Insight into the interaction between genes and the environment is not entirely new. In the early 20th century, Archibald Garrod (1857-1936) suggested that variation in patient response to treatment could be due to genetic differences and that the influence of diet may in turn alter the genetic effect (15).

Nevertheless, for a long time, epidemiological and laboratory studies to evaluate the effects of exposure to different contaminants did not take the influence of genetic susceptibility into account. The study of the distribution and environmental determinants of complex diseases continues to be an important source of clues about the causes of these disorders.

Moreover, many genetic studies pay no attention to environmental aspects; however, important signs have also been observed in different regions of the genome that determine a propensity for some diseases. Fortunately, studies that include both environmental and genetic information and analyze the gene-environment interaction from the standpoint of biological plausibility beyond a mere statistical outcome are becoming more frequent. As a result, major progress has been made in our knowledge of the causes of many diseases, although the challenge of elucidating the complexity of these interactions remains.

Analysis of the interaction between genes and the environment has been fraught with serious difficulties. Genetic effects on the risk of developing complex diseases can be very small when genes are studied in isolation. Furthermore, if exposure is measured inaccurately, its effects on health responses may be underestimated. These and other limitations, such as lack of an accurate diagnosis of the disease and small sample size, have caused much confusion by leading to contradictory results (16).

Alternatives for improving the evaluation of interactions include the creation of collaborative consortia to collect larger samples and increase the power of statistical tests. To this end, obtaining high-quality information on the exposure of interest is critical.

Exposure levels are often not constant over time. For example, air pollutant concentrations can vary from day to day depending on temperature or wind speed and direction. The evaluation of acute effects on some health responses can yield extremely valuable information for understanding the biological processes that cause complex diseases. Cohort studies that repeatedly measure both exposure and health response are an alternative worth considering (16). Although monitoring subjects does require more economic and human resources than cross-sectional or case-control studies, a cost-benefit payoff is seen in population health.

Ambiguity in the definition and diagnosis of complex diseases can be overcome by determining intermediate quantitative phenotypes. For example, quantifying decreases in lung function over time using repeated spirometry can yield information on the pathogenesis of chronic obstructive pulmonary disease or asthma (17).

In evaluating the gene-environment interaction, it is essential to bear in mind that ancestry can act as a confounding factor in the association between genes and health response. In recently admixed populations (as will be seen below, this is the case with Latin America's population), ancestry can be simultaneously associated with genotype and health response (phenotype). That is, ancestry may itself be a risk factor for developing the disease, but it can also influence prevalence of the polymorphism of interest. Failure to consider this situation in the analysis can result in a false association or masking of a true association (17). The role of gene-gene interaction and epigenetic mechanisms should also be considered alongside the study of gene-environment interaction.

Cancer, diabetes, and asthma are some of the most common complex diseases and have been the focus of studies to analyze environmental and genetic effects and their interaction. The following section presents the findings of different research groups on these disorders.

## Cancer

Worldwide mortality from cancer is higher than that of HIV, tuberculosis, and malaria combined (18). According to figures from the GLOBOCAN project, in 2012 there were 14.1 million new cases and 8.2 million deaths from cancer worldwide. Contrary to the popular belief that cancer is a disease of developed countries, it has also become a growing public health problem in developing countries. Neoplasms of the breast, prostate, lung, colon, and rectum account for half of total incidence in developed countries, while neoplasms of the lung, breast, stomach, colon, rectum, liver, and cervix account for 54% of total incidence in less developed countries (19).

Exogenous cancer risk factors include alcohol consumption, active or passive smoking, sedentary lifestyle, obstetric history, obesity, and exposure to certain infectious agents, chemical products, and radiation. The American Cancer Society estimates that in 2013, around 174,100 cancer deaths in the United States will be related to tobacco use. The World Cancer Research Fund, in turn, estimates that some one-quarter to one-third of new cases in the United States will be related to poor nutrition and physical inactivity (20). In Latin America, alcohol consumption is a more important environmental risk factor than smoking (21). Obesity is also a very important factor; in Latin America, an estimated 2% ( $n = 10,009$ ) of all cancers, in the case of men, and 6.4% ( $n = 33,687$ ), in the case of women, are obesity related (22). Furthermore, it is anticipated that by 2030, 50% of men and 60% of women will be overweight or obese (23) and, accordingly, that the proportion of related neoplasms will be even higher. Tumors of the cervix, liver, or stomach caused by infections are more common in developing countries than in developed countries (24).

In 2012, the age-standardized rate of new cancer cases in Latin America and the Caribbean (177 per 100,000) was lower than that of the United States (318 per 100,000) and Europe (253.6 per 100,000), but the respective mortality rates were not that different: 94.9, 105.8, and 113.1 (25).

Different studies agree that cancer incidence can decline dramatically with the modification of related external factors (26, 27). An estimated 75% to 80% of cancer cases in the United States are due to environmental factors (27).

With regard to genetic susceptibility, studies conducted in the white population have found genes associated with different neoplasms. Knowledge of cancer genetics in the Latino population is still very limited, and most of the published studies have been conducted among Latinos living in the United States who, as a result, are exposed to an environment and lifestyle different from those of their countries of origin.

At the global level, the leading causes of cancer deaths are breast cancer in women and lung cancer in men.

## Breast cancer

Breast cancer is the most common cancer in women worldwide. Although our picture of breast cancer incidence and mortality in Latin America is still incomplete because not all Latin American countries have studied it (28), it is estimated that breast cancer mortality has increased over the past 20 years and that breast cancer has become the leading cause of cancer death in this population (3). Factors associated with incidence include overweight and obesity, alcohol consumption, diet, age, obstetric history, menopause, and genetic susceptibility.

### *Environment*

The influence of lifestyle on cancer has been demonstrated in various epidemiological studies and was recently reviewed by the World Cancer Research Fund (29). Several systematic reviews indicate the protective effect of physical activity (30,31). According to the results of the studies included, women who engage in three to four hours a week of moderate or vigorous physical activity have up to a 30% lower risk of breast cancer. A study in Colombia determined that 14.2% of breast cancer deaths in women aged >45 years are due to physical inactivity. In a sample of post-menopausal Mexican women, every additional hour per week of moderate physical activity had an odds ratio (OR)<sup>1</sup> of 0.91 (significant) with a 95% confidence interval of 0.85-0.97. That is, women who exercise one hour more reduce the possibility of contracting breast cancer by 10% compared to women who exercise one hour less.

The effect was not significant in premenopausal women (OR = 0.99; with a CI of 0.94-1.05) (32). The protective effect of physical activity may be related to changes in the levels of estrogens and hormones such as insulin (26, 30) and adipokines.<sup>2</sup> (33)

With regard to anthropometric factors, a clear association has been reported between breast cancer and overweight or obesity in post-menopausal women (34). However, results related to premenopausal women remain controversial. A systematic review of articles published from 1997 to February 2012 concluded that after menopause, both body mass index (BMI) and waist-to-hip ratio bear a positive relationship to breast cancer risk and that before menopause, the risk decreases in women with greater BMI but increases in women with central obesity as calculated using waist-to-hip ratio (35). A positive relationship between breast cancer and BMI has been reported in Colombia and Mexico, but the association in premenopausal women was negative in Brazil. In Argentina, increased waist-to-hip ratio was associated with increased breast cancer risk (28).

With regard to hypotheses on biological mechanisms that explain the influence of anthropometric factors on breast cancer risk, Coyle posits that high concentrations of androgens in adipose tissue increase circulating estrogens, which in turn increase production of insulin-like growth factors (IGF-I), promoting proliferation of cancerous cells (26).

Various epidemiological studies indicate that breast cancer risk increases with alcohol intake. Estimated relative risk and dose may vary from study to study; however, a meta-analysis concluded that women who consume about 12 g of alcohol daily may see a 10% increase in breast cancer risk compared to women who do not drink (36). This increase is observed in all breast cancer phenotypes with a significant dose-response; furthermore, alcohol consumption before first pregnancy seems to be more harmful than after first pregnancy.(37)

Several foods and nutrients have been associated with breast cancer in women—in particular carbohydrates and foods with a high glycemic load, as well as low folate and vitamin B12 intake (38).

Exposure to organochlorine pesticides is also a risk factor for breast cancer. Currently, these substances are only used in agriculture or programs to eradicate or control malaria-transmitting mosquitoes. A study of Mexican women found a positive association between levels of the DDT metabolite (p-chlorophenyl) ethylene in blood and breast cancer risk, especially in post-menopausal women (39). However, a meta-analysis did not yield conclusive results (40).

### **Genes**

Twins and family aggregation studies have demonstrated the genetic contribution to the development of breast cancer (41). Only a small fraction of breast cancer has been associated with genetic inheritance (26,42). Among white women, heritability<sup>3</sup> is estimated at 27%, with a 95% confidence interval of 4% to 41% (43).

The massive search for genetic signs with GWAS analyses has increased the number of variants associated with this disease. In the European population, at least 68 genetic regions involved in breast cancer risk (44) have been identified. Some variants that have been systematically indicated as being associated with this cancer are found in the *BRCA1* and *BRCA2* genes.<sup>4</sup> It has been reported that 60% of Jewish women who have inherited a mutation in these tumor suppressor genes will develop breast cancer (45). In Latin America, it is estimated that the prevalence of *BRCA1* and *BRCA2* mutations among women with breast cancer is 41% in Bahamas, 30.9% in the U.S. Hispanic population, 15.6% in Chile, 13% in Brazil, 10.2% in Mexico, and 4.5% in Costa Rica. The prevalence of mutations in Latino women may be explained in part by Jewish migration to Latin America from the 15th to 17th centuries (3).

### **Gene-environment**

Insight into the modifying effect that the environment can have on the risk of developing the disease is grounded in the results of migrant studies: while breast cancer incidence rates are higher in Western white women than in Asian women, these studies show that while the incidence is considerably higher in non-white migrant women in the United States than in their countries of origin (46), rates in migrant white women rise to the level of those in first-generation native white women (47).

A study has found that physical activity and absence of obesity in adolescents can delay the age that breast cancer appears in women with *BRCA1* and *BRCA2* gene mutations (48). However, it is still necessary to understand the modifying effect that environmental factors can have on the risk of developing the disease in female carriers of this mutation (49).

The interaction between alcohol and antioxidant genes was described by Park *et al.* (50) Women with deletions<sup>5</sup> in the *GSTM1* or *GSTT1*<sup>6</sup> genes had a 5.3 times higher risk than those without mutations in the genes that encode for the corresponding enzymes. These results lead to the belief that a lack of antioxidant enzymes diminishes antitoxic capacity against alcohol. A biological hypothesis proposes that the combination of alcohol and a diet low in antioxidant folates can cause an imbalance in the DNA repair process and favor growth of cancerous cells (26).

Nickels *et al.* studied the interaction between 23 polymorphisms<sup>7</sup> and 10 risk factors (age of menarche, number of deliveries, breastfeeding, body mass index, height, alcohol consumption, smoking, hormone replacement therapy, oral contraceptives, and physical activity). They looked at data from 24 studies by the Breast Cancer Association Consortium and analyzed a total of 75,892 European women: 34,793 cases and 41,099 controls. They found that the association between breast cancer and the *LSP1*-rs3817198<sup>8</sup> polymorphism may depend on the number of deliveries: a positive association was found in nulliparous women and in women with four or more children, but no significant association was found between the polymorphism and breast cancer in uniparas. However, they did not find an association between breast cancer and 1p11.2-rs11249433<sup>9</sup> in nulliparous women but did in women who had given birth. With regard to alcohol intake, the association between breast cancer and the *CASP8*-rs17468277<sup>10</sup> polymorphism was significant in women who consume 20 g daily or more, unlike those who consume less than 20 g (51). These results and many others show that the association between breast cancer and some frequent genetic polymorphisms can vary in relation to different environmental factors.

## Lung cancer

Lung cancer has the highest incidence of any neoplasm in the world, with 1.2 million new cases each year (52). It can be a prolonged disease that progresses slowly. The median time from smoking onset to death from lung cancer is 50 years (53). Among Latinos, it is the leading cause of cancer death in men, and the second leading cause in women (after breast cancer) (54).

### Environment

Based on several scientific and interdisciplinary studies, the International Agency for Research on Cancer (IARC) has developed a list of carcinogenic agents and divided them into five categories according to the degree of certainty about the harm they cause. Group 1 includes substances that are proven to produce cancer in humans; these include arsenic, asbestos, beryllium, cadmium, chromium, radon, silica, and tobacco smoke. This information is updated periodically and is available to the public in IARC monographs (55).

Exposure to tobacco smoke, either actively or passively, is the number one risk factor for lung cancer. Over 60 carcinogens have been found in tobacco smoke. An estimated 90% of lung cancer cases in the United States are caused by tobacco smoke (56). While the prevalence of smokers in developed countries has been dropping, the trend in developing countries has been moving upward, particularly among women (52).

Radon, produced by the decay of radium, is a highly radioactive gas and is considered the second leading cause of lung cancer. Found in the air, its concentration depends on the uranium content of the soil. Due to dilution in the air, radon levels in open spaces tend to be lower than in enclosed spaces, especially basements, mines, caves, and water treatment plants, which means that it has been a major source of occupational exposure. However, in the home, the gas passes through small pores, cracks in cement floors, or wall junctions. In countries such as Argentina, Brazil, Ecuador, Mexico, Peru, and Venezuela, average exposure to indoor radon is lower than 100 becquerels<sup>11</sup> per cubic meter (100 Bq/m<sup>3</sup>) (57). The World Health Organization recommends introducing provisions in building codes to reduce radon in homes. The national reference concentration has been set at 100 Bq/m<sup>3</sup>, but if this level cannot be reached under the prevailing country-specific conditions, it is recommended that the level not exceed 300 Bq/m<sup>3</sup> (58). However, a combined analysis of seven case-control studies in the United States discovered that prolonged residential exposure (from 5 to 30 years) to radon is related to a higher risk of lung cancer (59). This contrast suggests the need to review the existing standard.

Arsenic exposure has also been associated with various adverse health effects, including lung cancer, bladder cancer, skin lesions, diabetes, and cardiovascular diseases. In countries such as Bangladesh, Thailand, Taiwan, India, Argentina, and Chile, high concentrations of this metalloid have been found in drinking water. In Chile, lung and bladder cancer mortality from 1992 to 1994 were 153 men and 50 women per 100,000 in a region with high concentrations of arsenic in water, in comparison with 54 and 19 per 100,000, respectively, in a region where the water was not contaminated (60). In the United States, an association has been observed between exposure to low concentra-

tions of arsenic and an increase in lung cancer incidence (61). This association is even more marked in cities with a higher prevalence of smokers, making it possible to state that people exposed to both arsenic and tobacco smoke may be at even greater risk for lung cancer (61).

Inhalation of asbestos fibers is another risk factor for lung cancer. This substance is found naturally in low concentrations in the air and drinking water, which means that we are all exposed. However, exposure can reach dangerous levels in the workplace for individuals working directly with the material or if there are items in the home made with asbestos that are damaged. Damaged materials release tiny fibers that, when breathed in, can become a health hazard (62). In 2000 and 2001, Brazil banned the use of asbestos in four states, reducing the national market for asbestos by 70%. In 2001, Chile also banned it by decree. In 2004, Honduras, in turn, banned the importation, manufacture, distribution, marketing, transportation, storage, and use of products with asbestos, with the exception of fire-retardant clothing and thermal, electrical, and electronic insulation (63). In early 2006, 39 European and Middle Eastern countries, plus the United States and Australia, prohibited the use of asbestos (52), exporting this industry to other countries. In 2002, China, India, Indonesia, Japan, and South Korea were among the top 10 asbestos consumers, and in 2010, Mexico and Colombia were among the countries that used more than 10,000 tons (64). A Mexican case-control study of malignant pleural mesothelioma with 119 cases and 353 controls found that 80.6% of cases and 31.5% of controls had been exposed to asbestos in the workplace. After adjusting for sex, age, and exposure category, the population attributable risk was 44%, while in the group with occupational exposure it was 82.3%. The authors state that the relationship among all industrial uses of asbestos is generating an increase in mesothelioma-related diseases and deaths among Mexican workers (65). Worldwide, some 5% to 7% of all types of lung cancer are attributable to occupational exposure to asbestos (66).

Beryllium is a material used in the manufacture of electronic and high-tech components. Although occupational exposure to high concentrations of beryllium is rare in the world, a large number of workers are exposed every day to low levels in the nuclear, aerospace, and electronics industries. Although the IARC and the American Conference of Governmental Industrial Hygienists (ACGIH) classify beryllium as an occupational carcinogen, the U.S. Environmental Protection Agency (EPA) classifies it as a probable carcinogen and the European Union has stated that it can cause cancer if inhaled (52). Data from epidemiological studies have not been conclusive.

### **Genes**

Although lung cancer is primarily environmental in origin, studies using genetic segregation or linkage analysis and twin studies have demonstrated the involvement of genetic susceptibility (67). Many of the polymorphisms identified as being associated with lung cancer susceptibility are genes that encode proteins associated with metabolism of the carcinogens contained in tobacco smoke or that have activity related to suppression of mutations caused by these carcinogens. Three polymorphisms associated with nicotine dependence have been found in region q25 of chromosome 15.<sup>12</sup> Region 5p15.33 has been associated with a risk of adenocarcinoma. Regions 6q23-25 and 13q31.3 have also been associated with a risk of lung cancer in nonsmokers, although their contribution appears to be small. There are different molecular routes for developing lung adenocarcinoma, but the influence of environmental factors is still unclear, especially in the case of nonsmokers (68).

### **Gene-environment**

It has been observed that region 15q24 is associated with lung cancer, but whether this association is direct or indirect is still a matter of debate. That is, it is not clear whether there is a gene in this region that causes lung cancer or whether what the gene causes is addiction to tobacco, which would be the reason why it increases susceptibility to lung cancer (69). The biological hypothesis holds that the effect of the carcinogens in tobacco smoke and their metabolically active forms create DNA adducts,<sup>13</sup> causing disruption of the cell cycle and inducing genetic instability that predisposes to development of malignant tumors (26).

Studies of genetic susceptibility to occupational exposure to asbestos have found interactions between exposure and some antioxidant genes. Smith *et al.* showed that carpenters with zero copies of the *GSTM1* gene had a greater risk of developing pulmonary diseases than those who had one or two copies (70). Another study indicates that, with cumulative exposure, the TT genotype<sup>14</sup> in the gene for catalase (CAT-262 C>T),<sup>15</sup> an antioxidant enzyme, can confer greater risk of asbestosis than the other genotypes. Although an interaction was not found, exposure

was considered a confounder in the association between the gene and asbestosis (71). Other genes that have been studied are *GSTM1*, *GSTT1*, *NAT2*, and *CYP1A1*, but more research is needed in this regard (72).

Occupational exposure to beryllium can cause a chronic disease called berylliosis. Susceptibility to this disease has been positively associated with the HLA-DPBI\*0201 allele,<sup>16</sup> incorporating a glutamic acid substitution (73). A later study found that 14 of 20 patients with berylliosis had an altered glutamic acid allele.

With regard to the interaction between genes and arsenic exposure, two polymorphisms that alter the effect of arsenic metabolism were detected in a population exposed to contaminated drinking water in Bangladesh. Individuals lacking a polymorphism (SNP<sup>17</sup> rs4925) of the *GSTO1* gene had greater concentrations of arsenic metabolites in urine, while those without a polymorphism at rs11191439 of the *AS3MT* gene (associated with rapid arsenic excretion) had lower levels (74). A protective haplotype<sup>18</sup> has been found in the *AS3MT* gene in an indigenous population in the Argentine Andes that had had prolonged exposure to high concentrations of arsenic; interestingly, frequency of the haplotype was higher than in other groups in the region with less prolonged exposure. The results point to a possible adaptation to arsenic exposure through positive genetic selection (75).

Given the evidence of interaction between exposure and genetic polymorphisms, a reduction in environmental exposure, especially in the workplace, could substantially reduce prevalence and mortality from lung cancer and other related diseases.

## Diabetes

Diabetes is a chronic disease that is not curable but can be controlled. Type 2 diabetes comprises a number of metabolic disorders and, as a result, includes a group of diseases. It is characterized by elevated blood glucose caused by defects in insulin production, insulin action, or both. Over time, hyperglycemia can damage many organs and cause severe complications and premature death.

Type 2 diabetes is the most common type in adults, but is now also appearing in children with obesity (76). Type 2 accounts for at least 90% of all diabetes cases (77).

According to figures from the International Diabetes Federation, over 371 million people worldwide had diabetes in 2012. Brazil, with 13.6 million, and Mexico, with 10.6 million, were among the 10 countries with the most cases in people aged 20 to 70. It is estimated that there will be 552 million diabetics by 2030 (78). The more moderate projections for Latin America estimate that a 148% increase in the number of cases will occur from 2000 to 2030, assuming that obesity and physical inactivity rates remain constant. However, since obesity is also increasing, the number may be underestimated (78).

Because of the metabolic changes characteristic of pregnancy, blood glucose can increase during that time, and what is known as gestational diabetes can develop. This occurs in one out of 25 pregnancies and tends to disappear when gestation ends; however, both mother and child run a greater risk of type 2 diabetes in the future, compared to general population risk. Nearly half of women with a history of gestational diabetes end up becoming diabetic five to 10 years after delivery.

## Environment

Modifiable risk factors include overweight, unhealthy diet, physical inactivity, and hypertension. Non-modifiable factors are age, a family history of diabetes, and, in women, a family history of type 2 diabetes and a history of gestational diabetes.

## Genes

Among risk factors, the ethnic component is of particular importance. In the United States, age-adjusted prevalence of type 2 diabetes mellitus (DM2) in adults varies with ethnicity. In individuals of Asian origin, it ranges from 4.3% to 8.2%; in those of European origin, it is 7.6%; in African-Americans, it is 14.9%; and in Hispanics, it ranges from 10.9% to 15.6%. Based on twin and family studies, it has been calculated that 22% to 73% of variability in susceptibility to diabetes is due to a genetic component (heritability) (79).

Through studies with candidate genes, variants have been identified in genes such as *PPARG* and *KCNJ11*, associated with response to hypoglycemic drugs used for treatment of DM2. It has been reported that the *HNF1A* and *HNF4A* variants, among others, are causal of maturity-onset diabetes of the young (MODY), corresponding to Mendelian forms of DM2 (occurring in all generations). Some variants of transcription factor<sup>19</sup> 7-like 2 (TCF7L2)

have repeatedly been observed in white and Asian populations; these variants are thought to act through regulation of proglucagon gene expression in enteroendocrine cells (80).

Association analyses using genome-wide marker data (GWAS) have increased the number of variants associated with DM2; almost all act through  $\beta$ -cell defects, and few have been related to defects in insulin action (79). Today, at least 90 variants have been identified, but it is thought that, even taken together, they explain a very small proportion of the genetic variance associated with diabetes, so the search continues (81).

Since most studies have been conducted with white populations, there is little data on other populations. A study of the genetic effects of European risk variants in a Mexican mestizo population found that only eight of the 21 variants were also associated with risk in mestizos (82). A study of the Mexican genome found a susceptibility haplotype that had a frequency of 28% in Mexican mestizos but was very rare in Europeans (frequency <2%). The activity of this haplotype is related to triglyceride metabolism (83).

### *Gene-environment*

The imported effect of lifestyle on the development of type 2 diabetes was demonstrated in a study that compared diabetes prevalence in Pima Indians living in different conditions. The Pima Indians are an indigenous people living on both sides of the border between Mexico (Sonora) and the United States (Arizona). It is a particularly endogamous ethnic group and, as a result, is considered genetically to have maintained its New World origin. The Mexican Pima engage in more moderate to intense physical activity and eat a lower-calorie diet. Prevalence of DM2 in the Mexican Pima is 6.9%, while in the United States Pima it is 38% (84).

A recent study in the United States evaluated the interaction between 18 recognized susceptibility polymorphisms and five environmental factors identified in serum samples and associated with type 2 diabetes (nutrients: cis- $\beta$ -carotene, trans- $\beta$ -carotene, and  $\gamma$ -tocopherol; markers of contaminant exposure: PCB199 and heptachlor epoxide). The only significant interaction found was between rs13266634 (SLC30A8) and trans- $\beta$ -carotene. In high concentrations, this nutrient (>1 standard deviation from the mean) seems to have a protective effect. Interaction with other risk factors, such as body mass index, physical activity and energy use, carbohydrates, and fat, was also studied; however, effects that were nominally significant lost significance when corrected for multiple comparisons (85). These results underscore the importance of having an exposure assessment that is as accurate as possible and the need to design studies with larger samples to confer sufficient statistical power to the tests.

## **Asthma**

Asthma is a respiratory disease characterized by chronic inflammation of the airways that produces reversible obstruction and hyperresponsiveness. It tends to appear in infancy, and more than 75% of children who exhibit symptoms before the age of 7 stop experiencing them after the age of 16 (86). Today, asthma is a global public health problem, and its prevalence in children and adults is growing. In the United States, it is the leading cause of child morbidity. In 2011, 235 million people in the world had asthma, but the number is expected to rise to 400 million by 2025 (87).

### *Environment*

Despite decades of research on risk factors, the causes of asthma are still not entirely clear. The most frequently studied environmental factors include tobacco smoke and air pollutants, such as ozone and particulates.

Ambient ozone is formed from reactions by gasoline vapors, chemical solvents, nitrogen oxides, carbon monoxide, and volatile organic compounds produced by vehicles and burning seasons (88).

Particulates arise from natural or anthropogenic activities (89). They vary widely in size, shape, and chemical composition. Natural sources include sea water evaporation, pollen, and volcanic ash. Furthermore, incomplete combustion of oil, gasoline, diesel fuel, and other hydrocarbons generates small soot particles, for the most part carbon crystals. Burning of refuse, firewood, and tobacco also produces particulate matter.

Both ozone and particulates are powerful oxidants that, when inhaled, cause an imbalance between endogenous oxidants and antioxidants, leading to what is known as oxidative stress.

Moreover, socioeconomic status and ethnic structure may partly explain the variability in developing asthma (90). In the United States, asthma prevalence is higher among Puerto Ricans, African-Americans, Hawaiians, and

Filipinos than among Mexicans and Koreans. In Latin America, asthma prevalence varies widely, ranging respectively from 23.0% and 22.8% in Cuba and Puerto Rico to 14.4% and 13.2% in Central America and Mexico (91).

### **Genes**

Genetic susceptibility has been an important research subject since the last decade. Hundreds of association studies with candidate genes have been conducted in different populations (92). It is believed that genetics contributes greatly to asthma and that heritability ranges from 35% to 95% (93).

### **Gene-environment**

Several epidemiological studies confirm the protective action of antioxidant intake in people exposed to large amounts of air pollutants (94). Research has been done on the combined effect of vitamin C intake and antioxidant gene activity in asthmatic children exposed to high ozone concentrations in Mexico City. A clinical trial with antioxidant vitamins (vitamins C and E) showed that children who had a *GSTM1* gene deletion were more sensitive to the effect of ozone unless they were protected by the addition of antioxidants (95). An extension of this study found that vitamin C intake in the daily diet may be sufficient to achieve this protective effect (96).

Several observations on susceptibility polymorphisms continue to be the focus of debate. Alleles classified as conferring risk in some populations appear to confer protection in others. This divergence may be related to the fact that environmental factors associated with asthma vary by ethnic group and social class. For example, smoking habits vary among different ethnic groups and even among Latinos, depending on place of birth, educational level, and socioeconomic status (90). It is evident, then, that asthma is caused by a complex interaction between susceptibility genes and assorted environmental factors.

## ■ Genetic and genomic strategies for identification of risk genes for common diseases

Before publication of the first draft of the human genome sequence, genetic susceptibility studies were conducted with a limited number of candidate genes. That is, based on a biological hypothesis, the focus would be on a polymorphism in a gene that was part of the metabolic pathway of the disease of interest, and genotyping of that site would be done in a group of individuals following a particular study design (case-control, case-only, or family design). This practice is still used, especially in replication studies. Among other advantages, it is much more economical than analyzing the complete genome and allows for easy evaluation of interactions with environmental characteristics; however, the picture of the etiology of the disorder remains limited to that polymorphism.

GWAS analyses consist of identifying a large number of genetic variants in a relatively large number of people (thousands of individuals). The technology now exists to determine up to 5 million single-nucleotide polymorphisms per person. This approach does not need a prior biological hypothesis on the association between a gene and the disease; instead, susceptibility regions are sought throughout the entire genome. The significant variant or variants will be analyzed in detail to identify the metabolic pathway to which they belong and determine their functional activity.

With the sequencing of the human genome, it became evident that, in addition to identifying and locating hundreds of genetic variants and susceptibility regions, an understanding of the molecular bases of cellular operation was needed. This discovery, and the technology advances that have facilitated the analysis of large quantities of data, have cleared the way for other strategies, such as mass sequencing of the part of the DNA responsible for encoding proteins (exome) and epigenomics.

### **Exome sequencing**

The exome is the part of the genome formed by exons. Exons contain the information for producing the protein encoded by the gene. Since changes in protein encoding regions are responsible for 85% of genetic diseases, exome sequencing is a powerful tool for identifying rare variants that have a significant effect on the development of complex diseases.

In Mexico, as a result of exome sequencing of Mexican and Vietnamese women, *CBFB* mutations and *RUNX1* deletions associated with breast cancer risk were discovered, in addition to confirmed variants such as *PIK3CA*, *TP53*, *AKT1*, *GATA3*, and *MAP3K1* (97).

## Epigenomics

Epigenomics deals with the study of gene-environment interactions that occur in the body and produce heritable changes in gene function without producing changes in the sequence of DNA bases. Using the genetic or genomic approach, genetic susceptibility is detected through people's genotype. However, genotype does not directly contribute information on gene expression. Epigenomics has shown that human health does not depend only on information contained in genes at birth, but rather that genes are subject to biochemical changes, related to the environment and other stimuli, that enable or prevent expression of certain genes (98).

DNA methylation is the inclusion of a methyl group in a gene and is one of the main signaling mechanisms for gene expression. Environmental effects are one way the degree of methylation is controlled. Certain substances ingested with food, such as folic acid, methionine, and choline, have the function of adding methyl groups. In general, methylation mainly occurs in gene promoter regions. An imbalance in the methylation rate can trigger diseases. Recent studies have shown that hypomethylation affects cancer-related biological functions, as in the case of neuroblastoma. On the other hand, hypermethylation is associated with alterations in gene promoter regions involved in cell cycle development and regulation (99).

With regard to occupational exposure, it has been confirmed that arsenic, asbestos, and radon can induce epigenetic changes that entail methylation in the promoter region of tumor-suppressor genes and deregulation of microRNA.<sup>20</sup> These conditions are implicated in various human diseases, including lung cancer (52).

With regard to breast cancer, a wide range of gene expression profiles has been found that indicate that transcription control is critical to development of the disease. This underscores the need for studies on nutrients that affect epigenetic transcription mechanisms, such as DNA methylation and post-transcriptional histone<sup>21</sup> modifications (100).

A group of Spanish scientists combined genome and epigenome analysis to identify DNA regions that, when activated, promote development of tumors and cells that give rise to chronic lymphocytic leukemia. The study found that lymphocytic leukemia subtypes exhibit different DNA methylation patterns, which may depend on the normal cells from which they come, thus modifying the biological characteristics and clinical course of the disease (101).

Other scientific disciplines are gaining traction in research on complex disease pathogenesis: metabolomics, which is the study of endogenous and exogenous metabolites in a cell, tissue, or bodily fluid; proteomics, which characterizes each protein expressed by its respective genes; nutrigenomics, which explores the effects of nutrients on the genome; and toxicogenomics, which studies the genome's response to toxic agents (102).

## ■ Latin American diversity

The Latin American population is the result of a recent mixture of ancestral groups. This mixture mainly consists of the European conquerors, the African slaves that traveled with them, and the original inhabitants of the Western hemisphere, called Native Americans (3). Given the variability of the genetic structure of the pre-Columbian populations distributed throughout Latin America, racial mixture proportions vary substantially within and among the different Latino subgroups. In a sample of children in Mexico City, individual proportions of indigenous ancestry range from 33% to 99%, and the average is 70.9% (93). Native American ancestry in Brazil, Costa Rica, and Colombia averages an estimated 20%, while in northwestern Argentina it can reach 70% (103). In a sample of Puerto Ricans, another study found an average of 66% European, 16% African, and 18% Native American ancestry, while in the sample of Mexican-Americans, the respective percentages were 45%, 3%, and 52% (104).

This diverse ancestry may affect the propensity for developing diseases. The highest rates of asthma prevalence and morbidity and mortality in the United States are among Puerto Ricans, while the lowest rates are in people of Mexican origin. Furthermore, among Mexicans, Native American ancestry is associated with mild asthma, while European ancestry is associated with more serious forms (105). Greater susceptibility to developing breast cancer has also been observed in Latinas in the United States with a greater proportion of European ancestry (106), while

among Puerto Ricans based in Boston, a negative relationship was found between African ancestry and type 2 diabetes and cardiovascular diseases, but a positive relationship was found with hypertension (107).

Even though Latinos are considered a single ethnic group, they actually represent a wide range of subgroups with widely different cultural, socioeconomic, and biological heritages. Such diversity makes Latinos an interesting and important resource for elucidating the genetic, environmental, and social underpinnings of complex diseases (108). Evaluation of the effect of ancestry, environment (including socioeconomic status), and the interaction between the two on the health of the Latin American population will provide a better understanding of the biological mechanisms of complex diseases (107).

Studies of the association between genetic variants and diseases that affect recently admixed populations should take into account the confusion that ancestry can introduce, since otherwise, associations may appear that lack a biological justification or real associations may remain hidden. For these purposes, strategies have been designed to estimate the proportion of individual ancestry from genetic markers or ancestry informative markers (AIM) (109).

Despite the importance of the mestizo population to elucidating the causes of many diseases, most studies are conducted in white populations. The economic advantages of developed countries put them at the immediate forefront of science and technology. Thus, platforms for determining genotypes use the white population, either from Europe or the United States, as a reference. Nonetheless, studies with Latin Americans use those same platforms, even though the reference should not be the same. However, they are the only platforms available.

Important tools have been used in genomic analysis, such as the haplotype map (HapMap) and a database containing information on the complete sequence of 1,092 human genomes, as references in genomic studies of mestizo populations, although the Latin American population is underrepresented (110).

Developed countries are strong not only economically but organizationally. Given the need for large samples to analyze and to replicate results, they have formed major consortia to share information and save resources.

The individual efforts of Latin American countries to keep from falling behind on this winding road of modern science must be combined to quicken the pace and obtain results for the different mestizo populations in Latin America. That way, current and future databases can become more representative, making possible regional results and the formulation of public policies on health and protection tailored to the particular needs and situation of this population.

## Summary

Complex diseases are those whose etiology is related to multiple genes, environmental factors, lifestyles, and their interactions. Many of these factors and their interrelationships have not yet been completely clarified.

Much of the research to identify risk factors and vulnerable populations is conducted in white populations that do not represent the genetic diversity of mestizo populations such as those of Latin America. Much remains to be done to understand the complex interactions between genes and the environment in order to adopt preventive health policies and identify the best treatments for mestizo populations, but it is also important to preserve the health of indigenous groups.

Genetic association studies of complex diseases in the Latin American population living in the United States may not reflect the susceptibility of the general population in the country of origin. Socioeconomic status and lifestyle, on the one hand, and environmental exposure, on the other, can substantially modify health effects.

Obtaining high-quality information on environmental exposure and lifestyle and correctly identifying genetic variants in large groups of individuals are critical for evaluating gene-environment interaction.

Different studies concur that changing lifestyles toward a healthy diet and physical activity can substantially improve the health of populations. Reducing occupational exposure through better protection of workers can also lead to a marked reduction in morbidity and mortality.

Although we still have very limited information on individual susceptibility to developing complex diseases due to endogenous factors, the dissemination and implementation of modifiable factors among populations is, by far, the best preventive health strategy.

## Recommendations

### Methodological issues

Since correct identification of environmental determinants is critical to uncovering the etiology of diseases, measurement of exposures should be done as accurately as possible. Though very useful, direct measurement of

pollutant concentrations in the air, water, or soil is not always feasible. Therefore, the use of validated questionnaires on diet or environmental or occupational exposures is recommended. Chemical and molecular analysis of blood or urine samples can improve accuracy in the determination of individual exposure (5).

Longitudinal studies to assess the relationship between health responses and exposures that change over time can yield important information on the phenomenon.

Consideration of quantitative phenotypes prevents the problem of ambiguity in disease definition and diagnosis.

The formation of large consortia is paramount, not only to increase sample size and acquire sufficient statistical power, but also to join forces economically and academically. The fruitfulness of the exchange of opinions and experiences is also a benefit.

Insofar as possible, assessment of the gene-environment interaction should be accompanied by evaluation of gene-gene interaction and epigenomic mechanisms. This can provide a closer view of what actually happens in these still mysterious biological mechanisms.

Technological advances and new scientific approaches brought massive quantities of information on polymorphisms and mutations to the table, triggering the need for new analytical methods and interdisciplinary efforts. Geneticists, epidemiologists, physicians, biologists, chemists, bioinformaticians, and statisticians have joined forces to better understand the origin of complex diseases. There is an urgent need to train specialists in these areas to further research and the formation of high-quality working groups.

### Health policies

Since it is impossible to change the genetic susceptibility of populations, the best alternative is to educate and inform people about what can be changed. Efforts to promote education in preventive health and environmental preservation should be bolstered with due responsibility, seriousness, and commitment.

Increasing the health sector's human and financial resources is an investment that will pay off in the medium and long term. Complex disease prevention will lengthen the healthy productive lifetime of many people, and timely and appropriate apportionment of treatment for sick people will considerably reduce spending on hospitalization, when needed, or disability. In the workplace, standards that regulate the control of risk factors, including shared employee-employer responsibility for the use of protective equipment, should be supported and enforced.

Efforts must also be made to improve national disease registries. In the case of cancer, only 6% of the Latin American population is included in national registries, compared to 96% in the United States and 32% in Europe (3).

Increased economic resources for bio-health research will enable Latin American countries to become active participants in this new era. Identifying the genetic and environmental susceptibility characteristic of our populations is urgently needed if we are to propose solutions tailored to our situation. A healthy population is a productive population.

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## ■ Notes

- 1 Odds ratio (OR): measure of association between exposure and disease in case-control studies. An OR <1 indicates a protective effect of the exposure. In this case, physical activity represents the exposure.
- 2 Proteins secreted by adipose tissue.
- 3 Proportion of genetic variance with regard to total variance observed in the trait (phenotype) of interest. [www.dorak.info/epi/glosge.html](http://www.dorak.info/epi/glosge.html)
- 4 *BRCA1* and *BRCA2*: genes that belong to the family of tumor suppressor genes. The proteins encoded by the two genes are essential in DNA repair.
- 5 Heritable mutation involving the loss of a fragment or a complete gene.
- 6 *GSTM1* and *GSTT1* are genes in the glutathione family. They have been associated with antioxidant activity.
- 7 Variation in the DNA sequence in a given position. The frequency of a polymorphic variant should be greater than 1% in the general population. If the frequency is lower, the variant is considered a mutation.
- 8 When referring to a genetic variant, it is common to indicate the name of the gene where it is found followed by the reference number assigned to the variant: *LSPI*-rs3817198 refers to the variant identified as rs3817198 located in gene *LSPI*. This gene is found in chromosome 11 and encodes for a protein that is expressed in immune system cells.
- 9 Another way of referring to the variant is to indicate its position within the genome. There are 23 chromosome pairs; each chromosome has a region called the centromere, which divides it into two arms: a short one (p for petit) and a long one (q for queue). Thus, 1p11.2-rs11249433 refers to variant rs11249433 located in band 11.2 of the short arm of chromosome 1.
- 10 Localized variant rs17468277 in the *CASP8* gene.
- 11 Unit of the International System of Units that measures radioactive activity.
- 12 Band 25 of the long arm of chromosome 15.
- 13 A chemical adduct is a product formed by the direct union of two molecules.
- 14 The combination of two alleles (alternative forms of a gene that differ in sequence) that every individual carries. If the two alleles are the same, the genotype is said to be homozygous; if they are different, it is called heterozygous.
- 15 This is another way to represent a variant. In the catalase gene, a nitrogen-base change was found in codon 262. This notation has gradually fallen into disuse.
- 16 A specific allele combination of the major histocompatibility system or HLA.
- 17 SNP (single-nucleotide polymorphism): polymorphism in a single nitrogenous base. The most common type and variant in the human genome.
- 18 Combination of alleles from different sites on a gene or chromosome that are inherited together.
- 19 Protein that functions as a transcription factor. Transcription is the process whereby information contained in the DNA sequence is transferred to formation of the protein.
- 20 An RNA (ribonucleic acid) fragment of 21 to 25 nucleotides in length with the capacity to regulate the expression of other genes.
- 21 Basic proteins that form chromatin together with DNA. Chromatin is involved in DNA growth.

# Emerging infectious diseases and the environment

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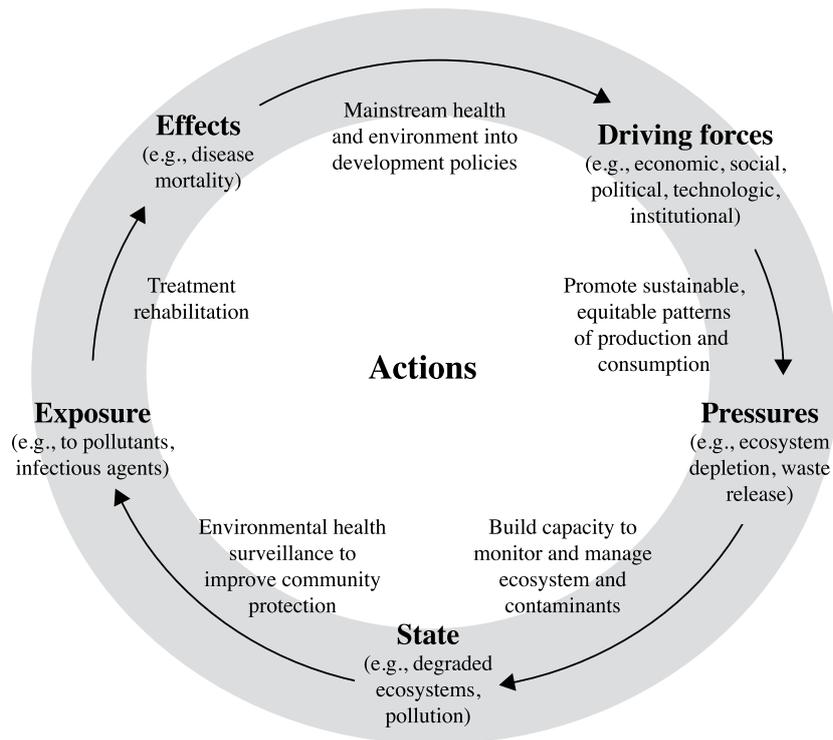
## ■ Introduction

### The environment and infectious disease

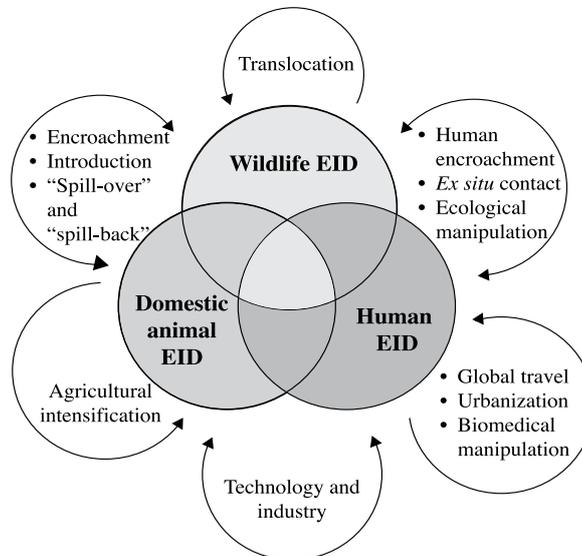
The Greek physician Hippocrates commented, “You will find, as a general rule, that the constitutions and the habits of a people follow the nature of the land where they live.” Throughout history, the impact of environmental conditions on human health has been a consideration of medical practitioners. As the environment affects human health, humans also affect the environments in which they live. In this chapter, we will use the World Health Organization (WHO) DPSEEA (driving force, pressure, state, exposure, effects, and action) model to focus our discussion on anthropogenic changes to the environment that influence the emergence of infectious disease within the environmental context (1-3). The model then will be used to frame a discussion of recommended actions to reduce the impacts of these changes.

In the DPSEEA model, the *driving forces* of economic, political, institutional, and social decision-making processes lead to *pressures* on the local level that act on both ecosystems and host populations –including humans and other hosts (Figure 14-1). These pressures contribute to *state* changes, such as degraded ecosystems and population movements, which may result in increased *exposures* and subsequent *effects*, including disease occurrence and transmission. In this chapter, the events of particular concern are the growth and movement of populations (including the globalization of trade and travel), the exploitation of natural resources, the demand for food, and human interactions with wildlife. Through these events, the dynamics of disease emergence, transmission, and spread are intricately linked to the environment. The movement of pathogens among reservoirs, vectors, and hosts occurs within ecosystems that can be defined physically, chemically, biologically, and sociologically (4). Within this context, environmental changes are highly relevant to infectious disease dynamics, and human activities can profoundly influence and be influenced by these changes. Disease emergence and transmission are driven by the external factors of population movement, agricultural intensification, and other changes in the cycling of pathogens among humans, domestic animals, and wild animals (Figure 14-2) (5). A recent systematic review found “several examples of zoonotic disease emergence at the wildlife–livestock–human interface that were associated with varying combinations of agricultural intensification and environmental change, such as habitat fragmentation and ecotones, reduced biodiversity, agricultural changes, and increasing human density in ecosystems” (6).

**Figure 14-1.** The WHO DPSEEA model. This schematic, reproduced from (1) with permission, illustrates the dynamics of events related to human health as a cyclical pathway of driving forces, pressures, state changes, exposures, and effects. Actions anywhere in the cyclical pathway can impact disease burden.



**Figure 14-2.** The host-parasite ecological continuum. This figure, reproduced from (5) with permission, illustrates the connections between emerging infectious diseases (EID) in humans and diseases in wild and domestic animals, highlighting the importance of a strategy that incorporates a landscape approach that brings together aspects of veterinary and human epidemiology within shared and overlapping environments while encompassing components from Figure 14-1 within a cross-disciplinary framework. Figure 14-2 includes elements of the DPSEEA concepts in which the fundamental relationships among hosts (human, wildlife, and domestic animals) are influenced by a range of pressures (indicated by the arrows).



The environmental drivers of disease emergence have complex interrelationships and interact with changes in technology and the breakdown of public health and political systems. Events at the global scale, such as climate change (discussed in Chapter 11), depletion of the ozone layer, and transboundary pollution, impact and transcend local public health systems, underscoring the need for a more global approach to policy, surveillance, and control efforts. The magnitude of these factors has recently increased in many regions of the world, including the Americas, often more rapidly than the actions or response capabilities of regional political and health systems.

Infectious diseases continue to emerge in industrialized countries, developing countries, tropical zones, and temperate zones. There have been increases in and a heightened recognition of infectious disease morbidity and mortality from reemerging and novel pathogens, as well as from the expansion of transmission pathways (4,7,8). The emergence of HIV/AIDS in the United States contributed to an approximately 40% increase in the age-adjusted mortality from infectious diseases in the 12-year period from 1980 to 1992 (4). More recently, the 2014 outbreak of Ebola virus in West Africa has claimed thousands of lives and is the largest Ebola outbreak yet.

Bacterial pathogens also continue to reemerge as public health threats due to a decline in the efficacy of available antimicrobial therapies. Pervasive antimicrobial resistance present in both pathogenic and nonpathogenic bacteria results in the formation of an *environmental resistome*, or a pool of readily available transmissible genetic material, capable of inducing and spreading multidrug resistance (9).

Emerging infectious diseases pose a complex challenge for existing public health infrastructures. Emerging diseases may present as more virulent strains of old diseases, antimicrobial-resistant strains that defy existing treatment options, or diseases previously unknown to humans, such as the recently discovered Lujo virus, a viral hemorrhagic fever caused by a novel arenavirus (10). The pandemic potential of influenza A virus, as seen in the emergence of avian influenza A (H7N9) in humans for the first time in China in 2013, and the dramatic increases in the range and severity of dengue fever and other existing diseases exemplify the need for continued attention from national and international health organizations to prevent and mitigate emerging infections.

## The landscape perspective

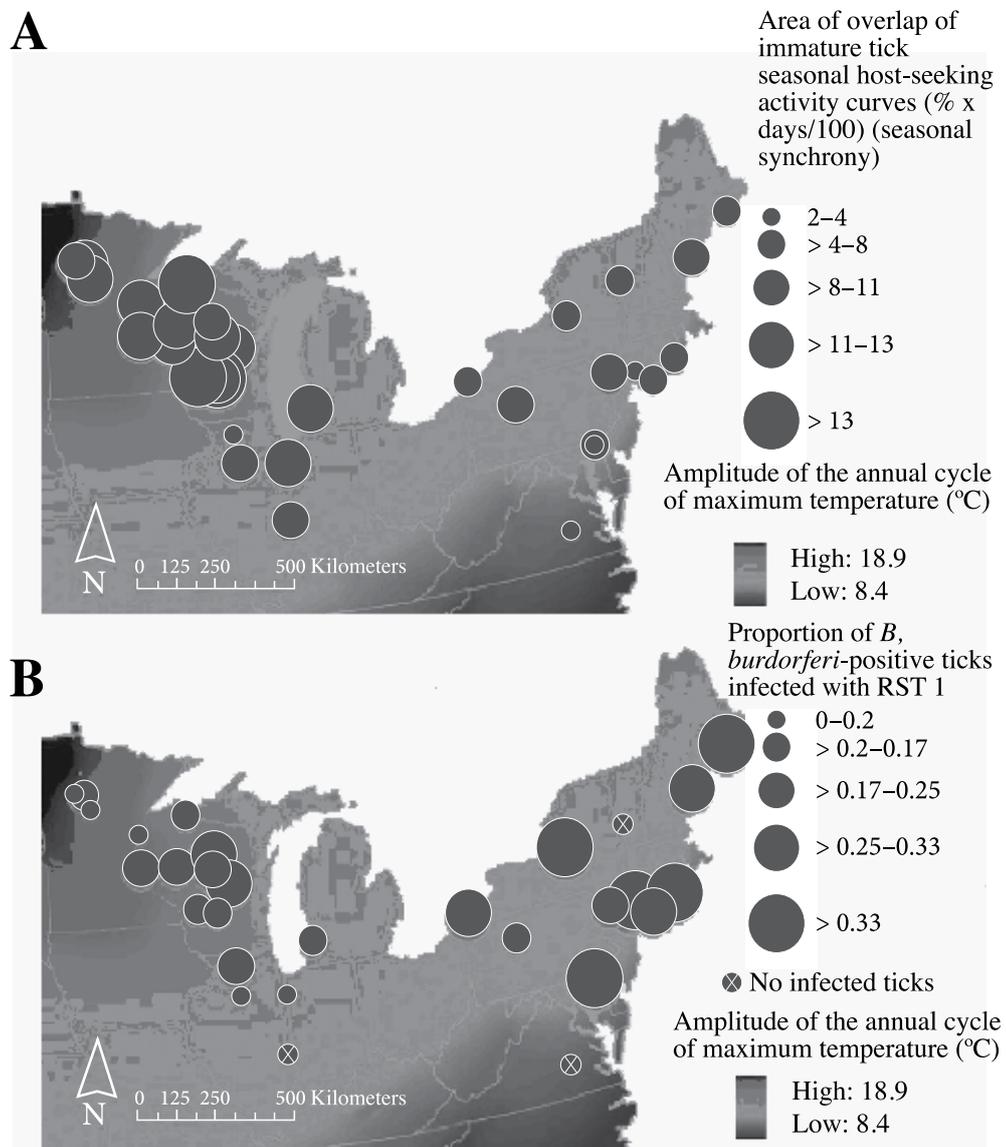
Environmental drivers of disease vary in time and space; therefore, emerging pathogens should be considered from a landscape perspective, incorporating spatial, temporal, and ecological considerations. The incorporation of a spatial-temporal component in research on emerging infectious diseases is relevant to understanding events in specific, distinct environments, as well as the spread of disease among populations and regions over time. Pathogens can be transported in a variety of ways, including via water, air, and fomites, and these pathways can include long distance movement (discussed below). Proximity plays a major role in the transmission of pathogens (the successful spread of an organism from one host to the next), and the probability of transmission increases as the distance between an infected and susceptible host decreases (11), demanding the incorporation of spatial terms when creating realistic models for disease transmission. As populations move and goods are transported further and faster, there is a growing need for realistic models that enable timely and accurate prediction of and response to the emergence of disease. The field of landscape ecology has informed studies of emerging infectious disease, providing the mechanism and framework for identifying and studying environmental drivers of disease from an ecological perspective. Spatial epidemiology and landscape epidemiology are two related fields that combine landscape ecology, geography, epidemiology, and statistics. The former field focuses on spatial variation in disease risk, and the latter on identifying associations between ecological changes and risk factors for human and animal disease. Environmental data, human population data, and the distribution of pathogens or vectors in a given area are used to characterize, predict, and prevent the spread of emerging infectious diseases. For example, regional particulate matter concentrations, goat density, and proximity of infected farms were identified as predictors of human Q-fever illnesses in the Netherlands (12).

Ecological characteristics are relevant to emerging infectious diseases. Measurement of these characteristics allows for the generation of integrated risk maps, incorporating variation over time and space while accounting for specific landscape or habitat factors. Habitat fragmentation is one such characteristic, which can result in separated habitat islands as well as in an overall decrease of total habitat area and a changing boundary, or edge, between adjacent habitats. This is an important state change, driven by the pressures of expanding cities, population movement, resource exploitation, deforestation, road building, increased demand for food, and expansion of crop monoculture. The causes of wildlife habitat fragmentation are frequently coupled with shifts in human habitation patterns, bringing human populations into closer contact with wildlife-endemic pathogens, resulting in the exposure of naïve human populations to new diseases. Meteorological characteristics also influence the spatial-temporal distribution

of disease risks. Changes in humidity, rainfall, and temperature may result in shifts in pathogen or vector range and survival (see Chapter 11).

All of these parameters can be indexed by spatial location and integrated into models, either as direct field measurements or as indirect proxies for measurements taken from satellite imagery. An example of the use of this analysis method is shown in Figure 14-3, which maps the spatial distribution of associations between Lyme disease vector behavior (A) and disease strain (B) as a function of the geographic variation in amplitude of the annual temperature cycle. Socioeconomic and other demographic variables can also be mapped and integrated into studies of the distribution of diseases (13). These layers of information can be relevant to developing actions and evaluating efficacy. Box 14-1 highlights three general tools used by researchers to analyze emerging infections. Kitron (1998) discusses these concepts in detail (14).

**Figure 14-3.** Maps of temperature amplitude and (A) seasonal synchrony of tick activity and (B) *Borrelia burgdorferi* RST 1 strain prevalence in ticks in the northeastern United States, reproduced from (15) with permission.





### BOX 14-1. TOOLS

1. **REMOTE SENSING:** Satellite remote sensing has enabled landscape ecologists and epidemiologists to map areas of interest for a variety of pathogens/diseases such as Hantavirus, malaria, dengue, and Lyme disease. Satellite remote sensing enables researchers to have access to large spatial datasets that are longitudinally “followed,” as satellites provide repeated snapshots of areas at regular intervals, allowing researchers to look at spatial-temporal trends in disease. Analyzing satellite remote sensing data is inexpensive in comparison to repeatedly collecting large quantities of data. Free user-friendly programs such as Google Earth provide open access to maps and visualize the epidemiology of emerging diseases.
2. **GEOGRAPHIC INFORMATION SYSTEMS (GIS):** The storage, manipulation, mapping, and analysis of data have enabled researchers to visualize patterns of exposure and disease through computer-based mapping and spatial analysis programs. In these GIS, data layers can be overlaid to analyze associations among the layers, or merely for visualization purposes. GIS are used widely for the mapping of various types of data, from demographics and land cover datasets to information on sources of pollution and the populations surrounding them. In the context of emerging disease, GIS have been used to incorporate landscape, animal, and human data for analysis of areas of elevated risk of exposure or disease. Downloadable free software programs permit everyone with a computer to access this tool.
3. **SPATIAL STATISTICS:** Spatial heterogeneity is often observed in both exposures to pathogens and patterns of disease incidence. Many techniques such as cluster analysis and the assessment of spatial variation in risk can be useful in the study of emerging diseases, because disease data are often spatially dependent.

## ■ Environmental drivers and pressures of emerging infectious diseases

### Growth and movement of populations

Population growth affects emerging infectious diseases through three main pressures: increases in numbers and changes in the distribution of populations within regions, an increasing proportion of populations within cities, and the increasing demands upon natural systems to supply required water, energy, food, and resources. The global human population continues to grow and is expected to surpass 9 billion by 2050 (16). Since 2005, most of the world's population has lived in cities, and the population size of many cities has increased (Figure 14-4). The pressures of growth and urbanization result in several state changes; the expansion of cities into peri-urban and exurban areas increases opportunities for contact between humans and wildlife species that are reservoirs, amplifiers, and vectors of pathogens (17). The increasing incidence of Lyme disease in urban and exurban communities is a key example of transmission due to this state change (15).

Explosive urban growth has occurred in several areas —e.g., Mexico City, Mexico; São Paulo, Brazil; Puerto Maldonado, Peru; Ulaanbaatar, Mongolia; and Quanzhou, China – that may lack concomitant development of infrastructures and social services. These population pressures create state changes, such as changes to regional aquatic systems due to contamination with waste. Human and animal waste that contaminates surface waters that are used for drinking and cooking can increase exposure to pathogens such as *Cryptosporidium*. The greater frequency and severity of dengue fever outbreaks in urban and peri-urban areas provides another example of the health effects associated with population pressures (18). Population growth also puts pressure on the health and sanitation infrastructure in industrialized countries. An outbreak of *Cryptosporidium* in the U.S. city of Milwaukee in 1993 is estimated to have sickened more than 400,000 people, with over 100 deaths (19).

In addition to population growth, voluntary and involuntary population movement has increased in the past half-century. Population movement links environments that would otherwise be isolated and expands social contact between infected and naïve persons. War, natural disasters, and livelihood-seeking are major political and socioeconomic drivers of population movement. For example, the devastating earthquake of 2010 displaced individuals within Haiti and brought an influx of foreign aid workers into the country, which is believed to have contributed to the introduction of a Nepalese strain of *Vibrio cholera* and the spread of a cholera outbreak in Haiti (20,21). Population encroachments may be massive and sudden, resulting in expropriation of land, exploitation of

natural resources, habitat fragmentation, and the movement of nonimmune persons into areas of endemic disease, with little or no access to health care or other social services. Livelihood-seeking is associated with less-sudden population movement. This pressure, along with other social behaviors, has been a major driver of the emergence and spread of HIV/AIDS, as well as other diseases (22,23).

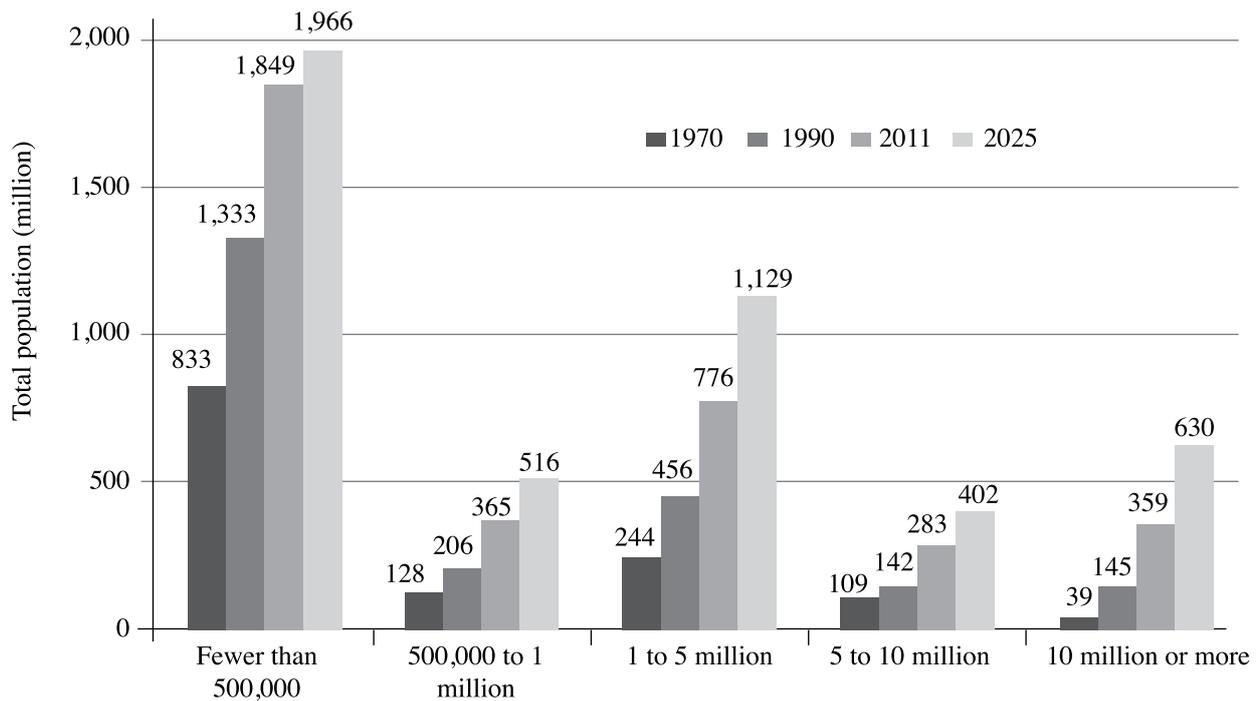
Sporadic and extensive population movements are associated with social connections, employment, and trade. Land travel across the border between Guinea, Liberia, and Sierra Leone contributed to the spread of Ebola in 2014 (24). Air travel has recently increased the long-range mobility of millions of people (Figure 14-5), dramatically affecting the dynamics of disease emergence, as illustrated by several outbreaks and epidemics. Global travel facilitated the transmission of HIV. The emergence and spread of severe acute respiratory syndrome (SARS) from Asia to North America was also facilitated by air travel (25). Furthermore, outbreaks of dengue have been associated with increases in regional travel in Asia and Latin America (26).

## Exploitation of natural resources

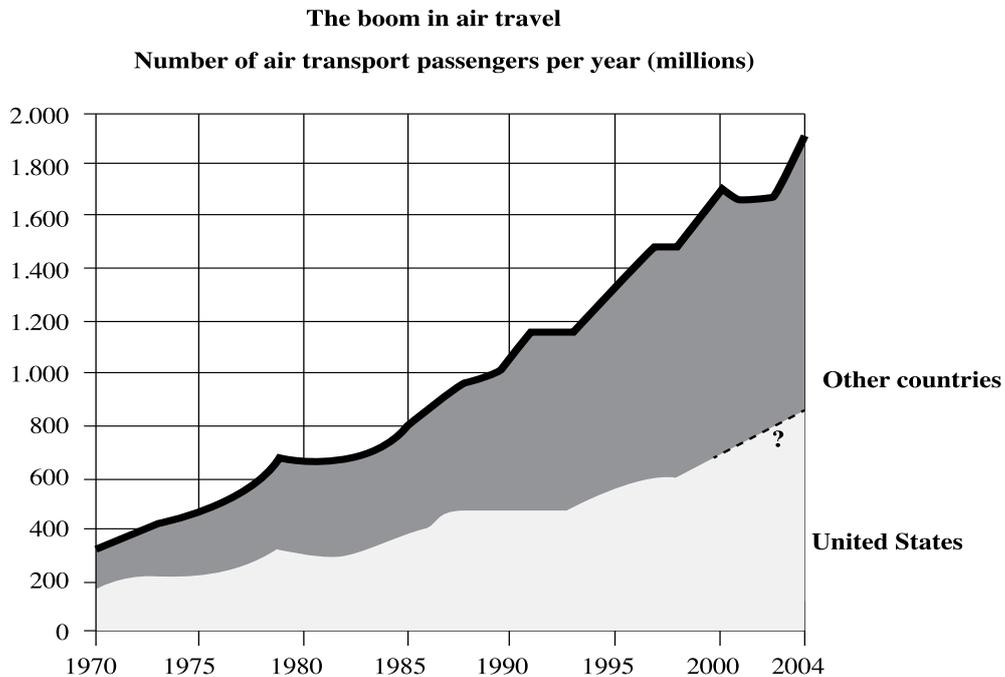
The demand for natural resources, including water, metals, fossil fuels, wood, and gemstones, is another pressure related to population growth, as well as to social, political, and economic driving forces. Together, these pressures in turn fuel many of the state changes that occur in natural systems and the movement of populations into unexploited areas for resource extraction and processing. Human activities —such as dam construction, logging, mining, and fossil fuel extraction – increase habitat fragmentation and affect emerging infectious disease rates. Some of the strongest evidence connecting the exploitation of natural resources to the emergence of infectious disease exists in the interactions between gold mining, tuberculosis, and HIV (27) and in higher incidences of clinically apparent malaria infection in gold mining populations (28,29). Associations between gold extraction and malaria incidence have been demonstrated using spatial statistical methods (30). As shown in Figure 14-6, an analysis of incident malaria cases in Brazil demonstrated that most cases diagnosed outside of Amazonia were associated with direct or secondary contact with gold mining regions in Amazonia. Small-scale gold mining alters landscapes by disrupting aquatic systems and expanding suitable vector habitats. The state of at-risk populations is further changed by introducing mercury into these systems, as well as by attracting nonimmune and economically vulnerable persons seeking employment into malaria-endemic regions with little access to health systems. These events may interact biologically, because mercury exposure reduces the acquisition of host immunity to *Plasmodium spp.* (28).

Construction of river dams for power generation or agriculture is a pervasive activity (more than 40,000 large dams and approximately 20 times as many small dams have been constructed globally) (31), which creates impoundments that are hospitable to intermediate host species and vectors and may also kill species such as *Gambusia* (mosquito fish), which naturally prey on vectors. Dam construction can alter malaria vector dynamics and transmission patterns (31) and has also been associated with an increased prevalence of schistosomiasis in many parts of the world (32). Other stresses on natural resources, including wood cutting and agricultural development, can have other effects such as increases in the rate and geographic extent of desertification in certain regions, which can increase the potential for global dissemination of clouds of desert dust that can carry pathogens across the oceans (33) (Figure 14-7).

**Figure 14-4.** Total population in millions by city size class. This figure, reproduced from (34) with permission, shows the growth of cities and megacities and UN predicted growth for 2025.



**Figure 14-5.** Increases in air travel, by millions of passengers per year, reproduced from (35) with permission.



**Sources:** World Development Indicators, World Bank online database, 2007; International Civil Aviation Organization, 2006.

**Figure 14-6.** Malaria and contact with gold mining. This map, reproduced from (36) with permission, shows the association between incident malaria cases in regions outside of Amazonia (place of diagnosis indicated by arrowhead) and contact with gold mining regions in the Amazonian state of Para. Over 80% of cases were associated with direct or indirect contact with gold mining.



**Figure 14-7.** Atmospheric pathways of desert dust movements, reproduced from (33) with permission. The two major intercontinental pathways of dust transport extend from desert regions in Africa to the Americas and from Central Asia to North America. These dust clouds play an important role in the global transport of pathogens.



### The demand for food

Population growth and change increase the demand for natural resources, in turn driving many of the changes observed in natural systems. The demand for food is a special case of resource exploitation associated with distinct pressures and impacts, resulting from population growth, demographic transitions from rural to urban environments, increases in per capita income, and changes in dietary patterns—notably the greater preference for a meat-based diet. As incomes increase, dietary patterns change as more individuals have the means to purchase meat products for consumption. Pressures on the food system have increased the exploitation of wildlife, driven the expansion of crop production and crop monoculture, intensified competition for scarce resources such as water, and altered methods of raising animals for food.

### Exploitation of wildlife

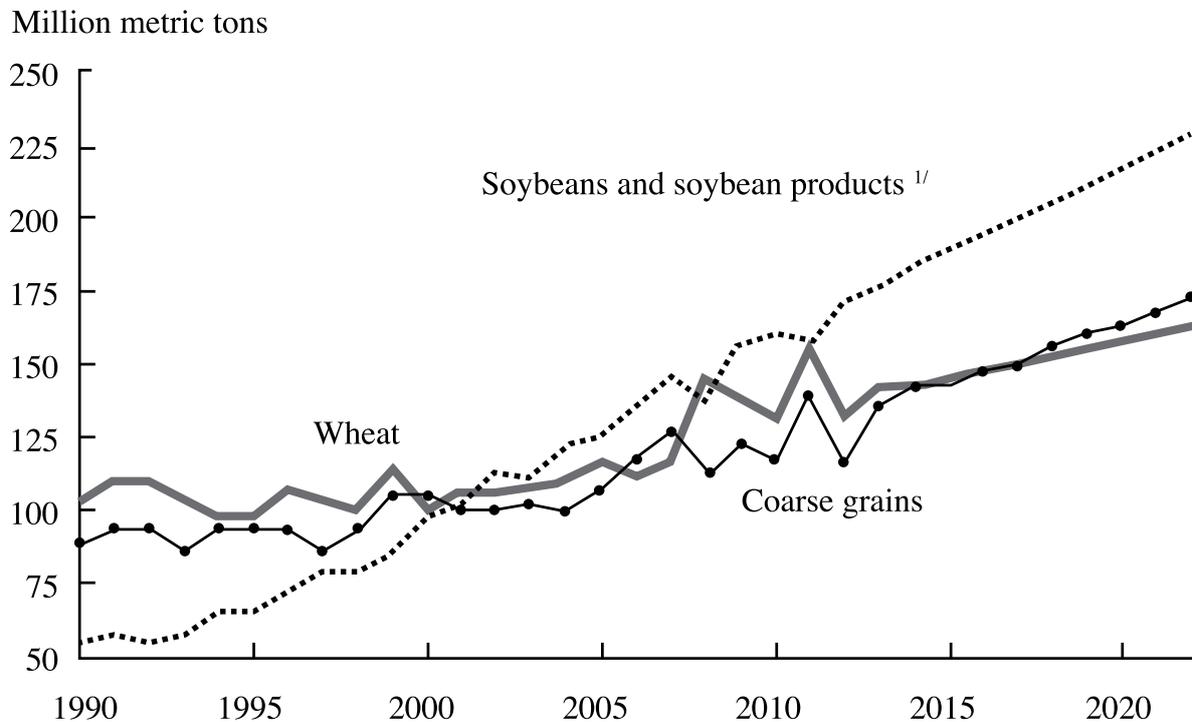
Wild animals comprise a significant portion of the protein source for human populations in some regions of the world. Direct interactions between humans and wildlife may occur through bushmeat hunting or at live animal markets (“wet markets”), where wild animals are sold. At wet markets, live animals including domesticated animals as well as wildlife such as birds, primates, bats, reptiles, and snakes are held in small stalls in close proximity to each other, enhancing opportunities for pathogen transfer between wild animals, domesticated animals, and humans. Wild civet cats sold at a wet market in Guangzhou, China, were identified as the reservoir species in the SARS outbreak of 2003. SARS entered the general population via workers and customers of this market (25). For subsistence hunters, contact with wild animals can involve the exchange of blood during kills and the handling of inner organs during butchering, which may result in exposure to a range of novel pathogens, including retroviruses. The hunting and consumption of fruit bats was linked to an Ebola outbreak in the Democratic Republic of the Congo in 2007 (37). The large Ebola outbreak of 2014 in West Africa appears to have begun with an infection in a 2-year-old with probable exposure to bats in Meliandou, Guinea (24).

### Monoculture and expanding crop production

The pressure of increased demand for animal protein has also resulted in expanded crop production. Intensive food animal production, particularly of poultry and swine, uses massive quantities of manufactured feed consisting

primarily of corn and soybeans. As shown in Figure 14-8, the global production of soybeans, wheat, and coarse grains, including corn, has increased substantially over the past 20 years. In some regions, this trend has resulted in major changes in the landscape, such as the conversion of large tracts of land to monoculture and the adoption of genetically modified strains of major feedstock plants such as corn and soybeans. According to Hecht (38), the increasing allocation of land to soybean cultivation to produce poultry feed is a more intensive driver of landscape change in Amazonian Brazil than road building, logging, and mining combined.

**Figure 14-8.** Global trade in wheat, coarse grains (including corn), and soybean products, reproduced from (39) with permission.



<sup>1/</sup>total of soybeans, soybean meal, and soybean oil.

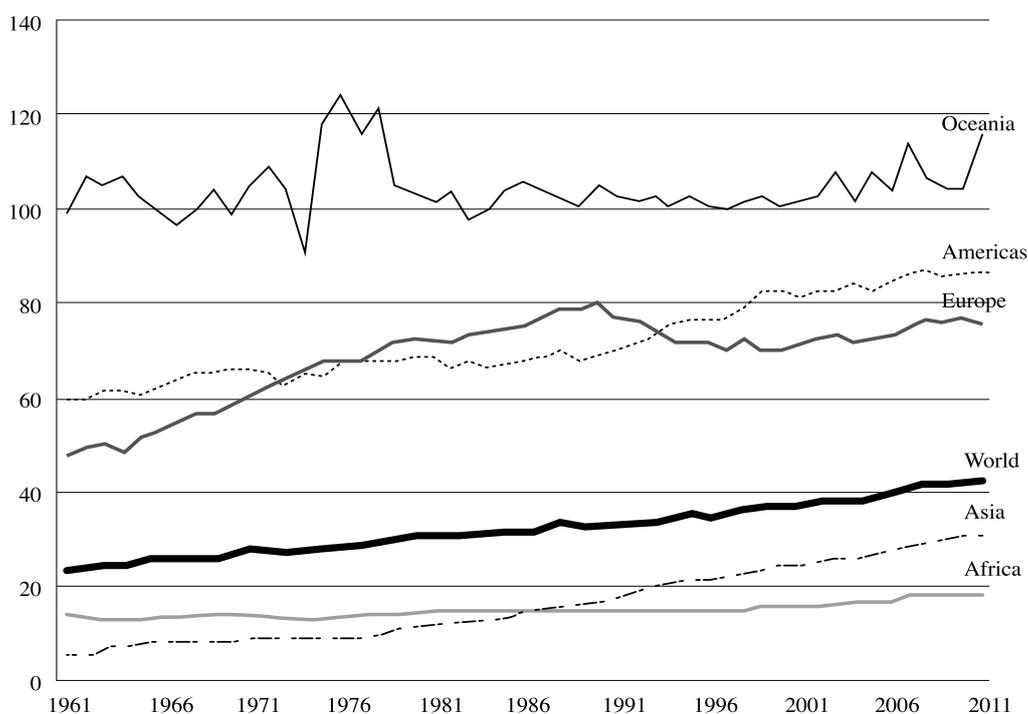
The global food marketplace also contributes to ecological change through the intensive production of non-native plant species as high-value trade products, such as strawberries in Central America. In these settings, plant cultivation is accompanied by the heavy use of pesticides, which can reduce species diversity, kill natural vector controllers, and select for vector resistance. Widespread pesticide resistance in malaria vectors in Southeast Asia has been directly related to agricultural overuse of DDT (40).

### Industrial food animal production

The global demand for animal protein has resulted in increased production of domesticated animals for human consumption. Globally, per capita meat and poultry consumption has increased dramatically during the past several decades (Figure 14-9). This demand has transformed the way that food animals are raised, shifting from small-scale family farms and community cooperatives to large-scale animal production units. Increased production, in turn, has led to greater availability of cheap fast-food products, which can facilitate a feedback loop of increased demand and increased production. The industrial model of food animal production results in selection pressures for emerging pathogens and increases the risks of zoonotic disease transmission from animal populations to humans. A recent systematic review reported that there is “strong evidence that modern farming practices and intensified systems can be linked to disease emergence and amplification (6).” Numerous animals are confined in small areas

in industrial food animal production. For example, the median number of broiler chickens per farm in the United States is approximately 160,000 (41). Animal confinement is associated with many state changes that influence infectious disease emergence. Confinement of thousands of animals in unhygienic conditions greatly increases the prevalence of pathogen carriage by animal populations, creating selection pressures for microbial evolution (42). Livestock-commensal organisms such as *Enterococci* and poultry-commensal organisms such as *Campylobacter* can cause disease in humans through both food and nonfood pathways. Direct contact between humans and animals occurs during the raising, transportation, and slaughter of animals. Indirect environmental exposures may occur through bioaerosols, overflow or leaching from farm waste holdings, and land disposal of waste (42). Industrial-scale farms can produce more waste and demand more resources than is sustainable by local ecosystems (41). This unsustainability results in global sourcing of animal feed, global dissemination of animal byproducts, and regional distribution of manure (41). These practices may promote the dissemination of pathogens and may also spread antimicrobial resistance genes and impact the environmental resistome locally, regionally, or globally.

**Figure 14-9.** Per capita meat consumption. This figure was produced using data from (43).



### Food animal production methods, pathogen evolution, and dissemination

The use of antimicrobials in animal feed is widespread in food animal production worldwide, with reports from Asia, Africa, the Middle East, Europe, and the Americas (9). This practice contributes to selection pressures favoring antimicrobial resistance genes, leading to resistant strains of pathogens. The association between the use of antimicrobials as feed additives and increased prevalence of pathogen resistance to important human therapeutic drugs has been demonstrated in several scenarios, such as fluoroquinolone resistance in *Campylobacter*, vancomycin resistance in *Enterococci*, and livestock-associated strains of methicillin-resistant *Staphylococcus aureus* (MRSA) (9,44). In the latter case, genetic comparisons of these livestock MRSA strains revealed that they had originated in people as methicillin-susceptible *S. aureus* and that use of tetracyclines in livestock feed may have driven selection for methicillin resistance in the animals, ultimately resulting in spill-back of these MRSA strains into human populations (44).

In addition to increasing selection for resistance, industrial food animal production (IFAP) methods also drive pathogen evolution, as has been observed for swine influenzas (45). Intense host-host contact between domestica-

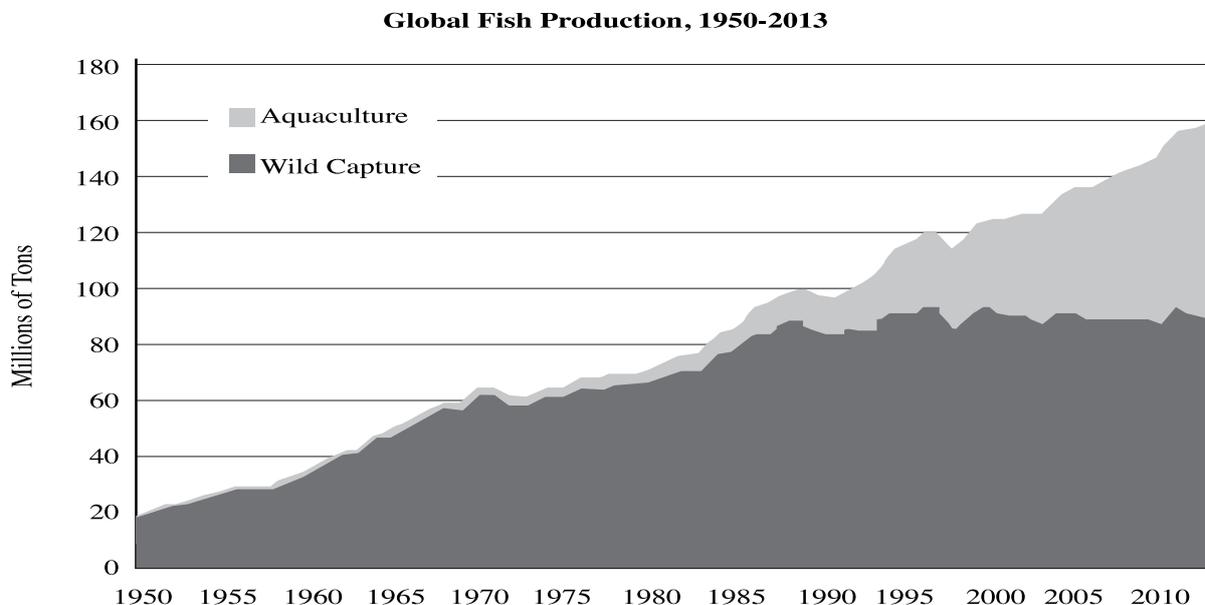
ted animals has the potential to hasten the pace of influenza A virus reassortment, with subsequent development of increased virulence and potential to adapt to new hosts. The industrial food animal environment, in which thousands of genetically similar animals are raised in close contact, may favor selection of virulence characteristics in animal or zoonotic disease agents, greater pathogen shedding, and more rapid spread of pathogens between animals (46). Food animal workers bear a significant exposure burden and often form a “bridge” between food animals and the general human population. The lack of effective and adequate protective equipment for workers contributes to zoonotic pathogen exposures. Thus, food animal workers are a high-risk population at the animal-human interface. Recent studies of the industrial animal workforce emphasize that occupational risks for zoonotic infections and sequelae may previously have been unrecognized or underestimated (9,47-49).

IFAP practices also result in increased geographic spread of pathogens. IFAP facilities are not biosecure (42). Massive ventilation systems are required to prevent heat stress, allowing the venting of air and dust from these facilities. Some uses of animal wastes result in a direct transfer of the domestic animal ecosystem into natural systems—for example, the use of poultry-house wastes for feed in aquaculture impoundments, as discussed below. Additionally, this so-called integrated system of poultry and fish production creates artificial wetlands that are frequented by wild species, enhancing the potential for cross-species pathogen transmission. Influenzas carried by wild birds have been shown to mix with influenzas in the wastes of domestic species in these settings (50). In addition, nitrogen and phosphorous from agricultural runoff have contributed to the eutrophication of many bodies of water. This ecosystem disruption has consequences, including increases in algal toxins, some of which are harmful to both humans and fish (51). In some regions, higher levels of organic nitrogen in surface water have been associated with a greater abundance of certain species of mosquito larvae, including those that transmit malaria and West Nile virus (52). Drinking water and seafood can become contaminated with pathogens from the improper management of livestock and human waste. Several pathogens that originate in animal waste, such as *Cryptosporidium* and *Giardia*, are associated with waterborne diseases. The lack of consistent access to safe drinking water is a major public health problem in many regions of the world. Finfish and shellfish also contribute to foodborne bacterial-, viral-, toxin-, and parasite-associated disease transmission. While different pathogens are adapted to different environmental conditions, alterations in aquatic ecosystems may lead to conditions that increase or shift the range of pathogens and change the dynamics of pathogen and host interaction, contributing to the potential for disease emergence.

### Aquaculture: Animal protein from fish and shellfish

The demand for animal protein has changed the terrestrial landscape, and this pressure has changed the aquatic landscape as well, primarily in freshwater and coastal ecosystems. Intensive aquaculture production, or finfish and shellfish farming, has increased dramatically during the past 25 years, as shown in Figure 14-10 (53,54).

**Figure 14-10.** Global increase in aquaculture production, reproduced from (53) with permission.



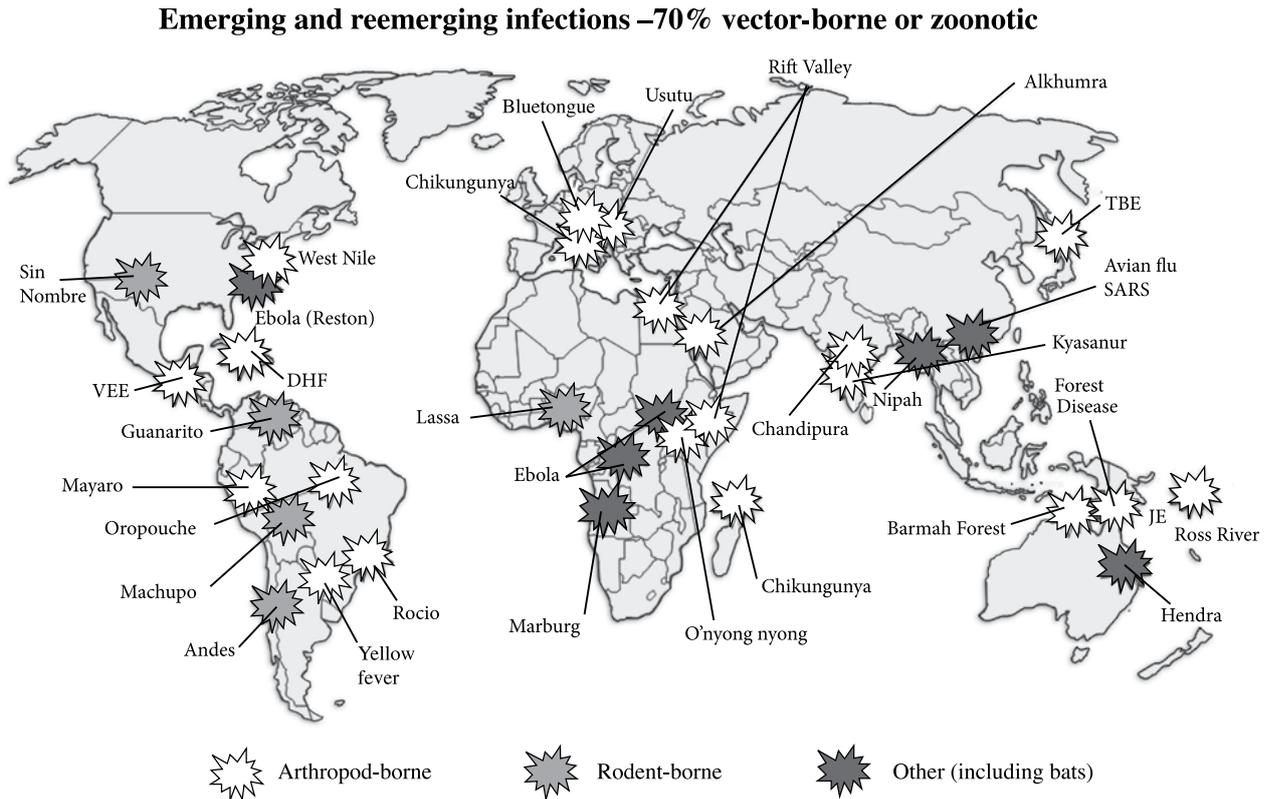
The impacts on pathogen dynamics and evolution associated with aquaculture are similar to those of industrial farming of terrestrial animals because of similar practices such as monoculture, ad libitum feeding, and crowding. In several regions, animal wastes are introduced into fish ponds to provide nutrients, linking aquaculture and agriculture (51,52,54). In addition, the use of antibiotics in aquaculture feed, as in livestock and poultry feed, is widespread (54,55). Chile used more than 450 tons of antimicrobials in salmon production in 2013 (56). Antimicrobials used in Chilean aquaculture include oxolinic acid and flumequine, which are members of the quinolone class of antibiotics and are particularly important in human medicine, as well as amoxicillin, erythromycin, and oxytetracycline, all of which are used in human medicine, and florfenicol, a veterinary antibiotic in the amphenicol family (56,57). Although amphenicol antibiotics generally are not firstline treatments in humans because of their association with adverse side effects, the use of these antibiotics in aquaculture may contribute to selection for multidrug-resistant bacteria (58). Antibiotic-resistant bacteria have been found in aquaculture environments and on farm-raised fish, and there is evidence of the exchange of resistance genes between bacteria in aquaculture environments and terrestrial environments (54,55). Ultimately, practices such as feeding antimicrobial drugs and animal waste to fish may pollute waterways, enhance the spread of antimicrobial resistance determinants from mammalian-sourced organisms to those found in fish, and promote the persistence of human pathogens such as *Cryptosporidium* in aquatic environments (54,59).

### The one health concept: Interactions between domestic animals, wildlife, and humans

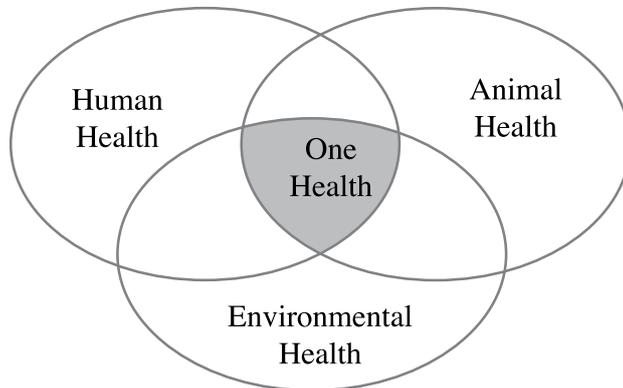
Throughout this chapter, we have highlighted environmental factors leading to increased interactions between humans, wildlife, and domestic animals that are important to the emergence of infectious disease threats to humans from zoonoses. The “One Health Initiative” recognizes these interactions and aims to foster interdisciplinary collaborations to improve human, animal, and ecosystem health (60). As shown in the One Health map in Figure 14-11, more than 70% of emerging infectious diseases are of wildlife origin, and the number of these diseases has been rapidly growing since the 1940s (60,61). Zoonotic diseases emerge from wildlife reservoirs at the interface between traditional wildlife habitats and areas of human activity, including livestock production. Small-holder and cooperative food animal production have been implicated in the transmission of zoonotic diseases among wild animals, domestic animals, and humans because of the frequent opportunities for direct contact between wildlife and domesticated animals raised out in the open. Smaller-scale operations were identified as secondary sources in the outbreaks of Nipah virus in Indonesia and Bangladesh (62) and avian influenza (including H5N1) in many parts of the world (50). Pressures from interactions are intensified in areas of urban or agricultural expansion into previously undeveloped areas (63) and through the acclimatization of wildlife populations to suburban and urban habitats. Deforestation and habitat loss can drive animal migration and thus enhance the potential for pathogen spread (64). Climate change and natural disasters also play a role in the translocation of humans and wildlife, establishing novel contacts between wildlife, livestock, and human communities (65). Zoonotic pathogen transmission is also facilitated by the growth of ecotourism and the rise of trade in wildlife and exotic animals (65,66). In addition to enhancing pathogen transmission, these factors may also promote the global movement of antimicrobial-resistance genes. For example, travel to Greece or Africa and pet ownership independently predicted colonization with ESBL-producing *E. coli* in attendees at an infection surveillance conference in Germany (67).

Focusing solely on the anthropogenic drivers of disease emergence within the environmental context is not sufficient to understand and begin to control this complex web of human-animal, animal-animal, and vector interactions. A key tenet of the global “One Health Initiative” is that emphasis on the interconnectedness of human and animal health is needed for joint efforts from all health disciplines to better understand, control, and prevent cross-species disease transmission. This perspective modulates the concepts of DPSEEA as applied to the environmental perspective on emerging infectious disease (Figure 14-1) to emphasize the equal importance of human and animal health in understanding the cycles of events in the DPSEEA model (68). The “One Health” perspective is illustrated in Figure 14-12.

**Figure 14-11.** World map of recent emerging and reemerging infections, reproduced from (60) with permission.



**Figure 14-12.** A One Health perspective. Species and pathogens interact on a global scale, requiring collaboration to address emerging diseases on the human, animal, and environmental health scales (5,60).



The public health implications of interactions between humans, wildlife, and domesticated animals stem from the opportunities for pathogen evolution related to interspecies transmission (45). Contacts among species can lead to an increase in pathogen host range and can increase the dissemination of both human and animal disease. Migratory species transmit pathogens over intercontinental distances and can rapidly shift zoonotic diseases from a local to a regional or global scale. Likewise, trade in food animal products and wildlife may have similar effects,

although it is harder to predict or anticipate the impacts of the latter because much of the wildlife trade is illegal. Emergence of disease from wild animal populations often relies on the presence of domestic animal “amplifier” hosts, or animals that can replicate on a large scale and transmit pathogens from sylvatic reservoirs into human communities (69). During the Nipah virus outbreak in Malaysia in 1998-99, the presence of an amplifier host (pigs) converged with environmental factors to facilitate the emergence of this novel virus (63,70). Priming for persistence of an emerging pathogen can allow for enzootic circulation of an emerging disease that may not otherwise persist within the farm; this priming may have contributed to the emergence of Nipah virus in Malaysia (63). Mature mango trees near pigsties in Malaysia led to the initial transmission of Nipah virus from fruit bats (flying foxes) to pigs. However, emergence in humans beyond sporadic cases associated with a direct bat-pig-human chain required persistent circulation within pig populations, which appears to have occurred as a result of intensification of livestock production (63).

The role of insects and rodents as vectors —among humans, wildlife, and domesticated animals— is well understood for many infectious diseases, notably malaria, Lyme disease, plague, and West Nile virus. Insects such as flies also mechanically transport pathogens in and around food animal facilities without serving as a part of the pathogen life cycle (42). Human activity that degrades natural habitats for certain species of insects and rodents may drive these populations into greater contact with humans and domesticated animals in both urban centers and industrial food animal facilities. Biosecurity measures in land-based industrial food production systems attempt to reduce contact between food animals and large land mammals; however, small rodents and insects that live inside and around animal operations can easily bridge these systems and link domesticated animal and wildlife populations.

In most parts of the world, human populations have more contact with domesticated animals than with wildlife, including in cities where households raise chickens and other domestic species (as in Cairo, Egypt, and Ulaanbaatar, Mongolia). In these settings, pathogen adaptation to domesticated species, including swine, increases the risk of human infection by zoonotic pathogens such as swine and avian influenzas (45,50). Close contact, including shared housing, has been implicated in the transmission of zoonotic tuberculosis (*Mycobacterium bovis*, or bTB) between cattle and humans in Africa (70). Recognizing the points of contact between wild animals, domesticated animals, and humans, as well as the multiple pathways of pathogen transmission among these populations, is a critical step in designing surveillance and control efforts at the shifting interface of these populations.

## ■ Recommended actions

This chapter argues that environmental factors are critically important to understanding the emergence of infectious disease. From this premise, we conclude with the overall recommendation that actions should be taken to address the anthropogenic drivers of environmental change that influence infectious disease emergence, identify potentially emerging diseases, and prevent their spread. Moreover, as many events enhance the rapid international spread of infectious diseases by trade, travel, and atmospheric dispersion, collaboration of the international community is essential to recognizing and controlling disease emergence.

The DPSEEA model illustrates five points in a cyclical pathway at which actions can be taken to reduce the effects of disease and mortality (Figure 14-1), and actions at any point on the pathway from driving forces to effects can be effective in reducing the burden of disease. From a public health standpoint, preventive measures are preferred: that is, actions performed further upstream from the outcomes of disease and mortality will often be more efficient. Thus, taking action to promote sustainable methods of livelihood, food production, and resource consumption can reduce state changes in critical ecosystems and alleviate many of the pressures that currently fuel the emergence of disease. While this is the ultimate goal of sustainable environmental and health policies, we recognize that responses at subsequent points on the DPSEEA pathway can at times be more feasible actions to reduce the burden of emerging disease. We recommend the following strategies:

### Responses to driving forces

#### Natural resource exploitation

**Incorporate the assessment of potential impacts on infectious disease risks into natural resource development and land use planning.** Anthropogenic drivers that change ecosystem states have major impacts on vector distribution and control. In planning activities related to resource exploitation, human settlements, and food pro-

duction, including aquaculture, specific consideration should be given to the potential for ecosystem disruption and vector habitat expansion as factors in emerging infectious diseases. These factors must be addressed, particularly in evaluating proposals for development activities such as mining and construction of roads and dams. These considerations should be explicitly incorporated into environmental or health impact assessment requirements by national and international institutions.

### Demand for food

**Improve conditions in food animal production operations.** Current farming practices, particularly in industrial food animal production facilities, may promote disease emergence. In Resolution 66/28, the United Nations (UN) General Assembly endorsed the outcome document of the 2012 UN Conference on Sustainable Development, entitled *The Future We Want* (71), which noted the need for more sustainable agriculture and aquaculture and stressed the importance of preventing “the spread of animal diseases, recognizing that the livelihoods of farmers, including pastoralists, and the health of livestock are intertwined (72).” Policies and economic incentives should specifically address such issues as the crowded confinement of animals and improper management of animal waste. Protecting the health of farmers, farm workers, and food processing workers is imperative to preventing the emergence of zoonotic disease (48,49). Policies should require occupational exposure assessment and the implementation of control measures to prevent the spread of disease to farm workers. Policies that reduce the upstream potential for disease emergence and transmission within animal populations would be more successful in protecting agricultural workers as well as consumers.

**Protect the effectiveness of antimicrobial drugs.** Antimicrobial agents are critical tools for stopping the spread of new bacterial pathogens and reducing disease morbidity and mortality. However, the effectiveness of these drugs is jeopardized by overuse in intensive food production systems. Nontherapeutic use of antimicrobials in animal feed has been associated with the emergence of drug-resistant strains of bacterial pathogens. This practice is spreading as industrial methods of food animal production are adopted in developing countries to feed their own populations and to produce items for trade. National authorities should implement the recommendations of WHO, FAO, and OIE to prohibit the use of antimicrobials as feed additives for food animals, as implemented in the European Union.

**Enforce and extend guidelines and regulations covering trade in wild and domestic animals and animal products and harmonize food safety regulations internationally.** The transportation of animals and animal products is an important pathway for the transmission of diseases between animals and from animals to people (50). As animals and animal products cross borders, they may carry zoonoses that pose a risk to human populations. International standards for food safety and the transportation of animal products may reduce the burden of such incidental pathogen transport. These standards should address the potential for pathogen growth and transmission at all stages of food production, from the farm (or wild habitat) to the table.

### Responses to pressures and state

**Increase international collaboration, communication, and capacity building to improve public health systems and global tracking.** Successful disease prevention strategies require the integration of human and technological resources. In some regions, capacity building and infrastructure development will be necessary to achieve sustainable monitoring and disease prevention programs. International collaboration, including the sharing of information and resources, will promote the common goal of preventing disease emergence. A commitment to open and accessible disclosure of information will facilitate a more rapid response to disease threats.

A “One Health” approach that acknowledges the links between human and veterinary medicine and includes interdisciplinary collaboration across the globe will promote an integrated mechanism for addressing emerging disease (49,60,73). Better collaboration and communication among epidemiologists, physicians, veterinarians, wildlife ecologists, and related professionals is critical to improving current surveillance, monitoring, and control efforts for unusual or unexpected disease in both animals and humans. This kind of collaboration played an important role in controlling the Nipah virus outbreak in Malaysia (70).

Active disease surveillance and environmental monitoring are key to identifying where diseases may emerge. The techniques and concepts of spatial epidemiology should be incorporated into disease monitoring efforts. Many pathways link wildlife, domestic animals, and human communities, and the recognition of points of contact at this shifting interface is critical to identifying surveillance priorities while targeting multiple routes of transmission.

Given the interconnections between diseases in domestic animals, wildlife, and humans, surveillance should be conducted in all three of these populations.

Surveillance for disease in human populations should include coordination of reporting at the local, national, and international levels. Investigation of disease outbreaks and timely reporting of investigation results can help to identify the source of disease outbreaks and thus prevent their spread. While disease surveillance in human populations is important, less attention has been devoted to disease surveillance in animals. Surveillance of disease in wild and domesticated animals may provide information that will permit the implementation of preventive measures further upstream in the disease emergence process.

Wildlife surveillance should be improved and coordinated. Important steps in this area have been taken in avian influenza planning, but programs need to build on this framework and extend their reach to other emerging pathogens. Monitoring amplifying species and insects that serve as vectors for disease is an important component of effective surveillance strategies. Expanded surveillance of wildlife in regions of high biodiversity may require increased laboratory infrastructure or international collaboration and the sharing of laboratory resources, as illustrated by the global response to pandemic influenza risks.

Surveillance of domestic animals should include testing for pathogens on the farm as well as at marketplaces and on food products, examining the entire pathway from the farm to the table. A successful surveillance program requires timely reporting of potential threats. A combination of regulation and economic incentives may be necessary to encourage rapid and timely disease reporting and prevent the introduction of diseased animals onto other farms or into the marketplace.

**Improve research efforts that integrate environmental health and infectious disease epidemiology.** Increased financial and political support for international research and training efforts integrating the fields of environmental health sciences and infectious disease epidemiology (in both human and veterinary medicine) will help identify factors that increase the likelihood of disease emergence. The development of tools such as rapid or real-time tests for pathogens and improved genotyping techniques can facilitate the tracking and tracing of the emergence and dissemination of pathogens. Further incorporation of spatial techniques such as satellite remote sensing into research and surveillance efforts, as appropriate, would improve disease monitoring and evaluation in cost effective ways with international sharing of technological resources.

## Responses to exposure

**Develop preparedness plans.** A rapid response to disease threats can prevent primary infections from turning into outbreaks, outbreaks from turning into epidemics, and epidemics from turning into pandemics. Governments should develop preparedness plans that include procedures for responding to sentinel events, preventing disease transmission, and allocating resources for disease prophylaxis and treatment. Effective risk communication strategies should be incorporated as essential components of response plans. These needs are not limited to pandemic preparedness, but are also relevant to diseases such as dengue.

## ■ Conclusions

Hippocrates also wrote, “Extreme remedies are very appropriate for extreme diseases.” Because the public health burden of emerging infectious diseases can be extreme, identifying and addressing the environmental context of these diseases is critically important. Because of its sensitivity to both natural and anthropogenic pressures, the environment is an important integrating focus in the emergence of pathogens into human communities. Many factors—including human population growth and movement, stress on natural resources, demand for food, and human interactions with domestic and wild animals through agriculture, hunting, and other activities—affect disease dynamics. The complex nature of the relationships among these driving forces and pressures demands global and comprehensive responses. Effectively addressing these factors involves many points of intervention, including efforts to reduce the driving forces behind disease emergence, greater international collaboration, enhanced surveillance efforts across the disciplines of human, animal, and environmental health, and improved research efforts that include the use of models to evaluate spatial variation in risk. Recognizing and addressing anthropogenic changes to the environment that promote infectious disease emergence—particularly with regard to population movement, agricultural expansion, land use, and trade practices—is of critical importance to preventing the emergence, transmission, and establishment of infectious diseases.

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# Risk communication in Latin America

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*If we have not gotten our message across, then we should assume that the fault is not with our audience.*  
Fischhoff, 1985 (1)

## ■ Environmental and health problems in Latin America and the Caribbean and the importance of risk communication

The past 20 years have seen increasingly frequent threats to societal health and security that are unlike the classic epidemics of the past. Today's world faces constant risks from global warming, ozone depletion, mad cow disease, avian influenza, radioactive waste, genetically modified crops, nuclear weapons, and technological disasters. At the same time, a range of human activities and lifestyles that have so far defied solution are causing environmental and health problems such as air pollution and harmful exposure to heavy metals and pesticides stemming from industrialization, urban expansion, and production processes in both urban and rural settings. These environmental factors impact a variety of ecosystem services and, consequently, human health, while industrial processes can pose growing risks to human and animal health (including zoonoses associated with the raising of livestock for food production). This complex panorama of threats poses challenges for biosecurity and biocontainment (2) in Latin America.

When a population is seriously affected by environmental change, the crisis almost immediately sparks criticism from the general public and media alike, with accusations flying that information is being withheld or that special interests (economic, political, industrial, or other) are prevailing over the health and welfare of citizens. Under these circumstances, risk communication can help people understand the potential health problems resulting from chronic or acute exposure to toxic agents or harmful environmental and biological processes.

As one element in the field of public health, risk communication has become important in the broader area of environmental health and can be defined as the process of interaction and information sharing among individuals, groups, and institutions, viewed from three perspectives (3):

- As an independent phenomenon in institutions, stakeholder groups, or the communication flows inherent in social organization.
- As a strategic activity for administering external and internal communication to ensure consistency with the objective of an intervention program.
- As a tool for capacity building in the intervention's target group or the affected population.

According to Morgan *et al.* (4), this process ensures that lay people have the information they need to form independent judgments and, based on information about risks to health, safety, and the environment, take the necessary action. Thus, communication can be a useful tool for concern, consensus, or crisis. Greater knowledge encourages active community participation in tackling and solving environmental problems, making the community the actor rather than the object acted upon and ensuring a dialogue between the community and those responsible for risk management.

Risk assessment is a process for learning about the potential dangers from given agents, identifying the channels of exposure that make human populations vulnerable, and describing the health effects of such exposure. Developed by diverse interdisciplinary groups, this methodology is the starting point for gaining perspective on the risks to a population and taking steps to manage those risks.

Risk assessment methodology necessarily involves uncertainty, a fact that is difficult to communicate to audiences and can lead to politicizing risk. Covello (5) has stated that when uncertainty arises, the facts should be promptly shared, accompanied by an explanation of what is known, unknown, likely, and unlikely, along with an indication of what can be done to reduce the uncertainty. The public should be cautioned that current thinking may prove to be mistaken.

Risk communication is an excellent context for sharing information on risk management. Thus, it is a decision-making process used for policy-making and informing the public both about the dangers identified through risk assessment and their public health implications. In risk management, monitoring, management, and technological, financial, and regulatory factors are considered, making it a vitally important tool.

Figure 15-1 shows the role of risk communication in the different phases of risk assessment and management. It is an ongoing interactive process in which all stakeholders, including the community, participate.

**Figure 15-1.** The risk management cycle



Source: (6, page 319)

Some traditional methods of communicating risk —generally, those with a technical perspective or based on a factual information model— are no longer considered the sole mechanisms for public policy making with respect to risks. Authorities at every level now recognize that genuinely thoughtful and interactive citizen participation makes risk management more effective. This requires governments to change how they interact with the public.

In line with this new awareness, the countries of Latin America and the Caribbean (LAC) are transitioning to a culture of citizen participation, in which public institutions must inform the various sectors of society about their activities and results through transparent accountability mechanisms and participatory activities.

Although the participatory approach in risk communication can foster greater consensus, it cannot guarantee complete harmony. From the policymakers' standpoint, communicating information about risks through transparent, participatory action shows respect for the public and its right to know, while recognizing the limitations of government response.

There is no doubt that the higher levels of education and technological development of the population are increasing access to information in most urban areas through the Internet and newspapers, and in rural areas through radio and television. Local governments are facing new pressures now that the public has access to information; at the same time, the promotion of democratic processes is offering society greater opportunities for participation and action. A more educated and better informed public is less likely to accept without question government dictates about matters that affect daily life.

Governments are also facing the challenge of clearly distinguishing between communication techniques that the public considers propaganda and those designed to provide technical information, promote health, educate, or change attitudes. This challenge is accentuated when the government takes on the functions of both communicator and regulator.

The crisis of a lack of trust in public institutions, more widespread than ever, poses a constant challenge, particularly in Latin American societies. Restoring trust is a goal that every government should embrace as a medium- and long-term process. Credibility, security, and trust are the foundations of a democratic society and are essential in any successful attempt at communicating risk.

When risks are well understood, predictable, and quantifiable, risk communication can be clear and direct. However, governments are increasingly faced with having to inform citizens about little known, unpredictable risks on which experts disagree. Bier (7) has emphasized that the public should always come first, that information should be approached proactively, and that policymakers should work to predict potential public reactions to the decisions under consideration. Balch and Sutton (8) recommend that risk communicators promise only what they can deliver, and deliver what they promise, to avoid losing credibility. Sandman and Lanard (9) insist that the public be informed before a crisis arises, so that it can be emotionally and intellectually prepared. The public must also understand the need for logistical preparedness, and the relevant information should be communicated to all stakeholders in a transparent manner. One of the problems facing risk communication in LAC is the sectorized nature of government operations, which impedes the effective assignment of responsibility for informing communities about the environmental risks to which they are exposed while hindering resource allocation for a corresponding plan. In the case of industrial risks that affect marginalized populations, risk communication tends to be very limited and generally occurs only after media pressure on industries (e.g., productive and extractive industries such as mining) and local government to assess the situation and disclose the information about where exposure has occurred, any effects it has had, and the steps taken to address the problem. Examples of such situations can be found in Mexico (10), Ecuador (11), Peru (12), and other countries.

A sampling of the various reports of risk communication experiences in LAC shows two main lines of action. The first, and most important, is risk communication in disasters, a scenario that has been well planned for and evaluated in nearly every country in the region. Climate change scenarios and the increased frequency and intensity of hydrometeorological phenomena have made this issue a priority. The second line of action involves response plans for an influenza pandemic. This is a scenario for which communication has been well designed and carefully structured through an initiative spearheaded by PAHO that has been executed in many countries in the region. A series of training exercises have been conducted in the region —some with a particular theme, such as pesticides or the containment of toxic waste, others to familiarize people with the subject and methodology involved.<sup>1</sup>

Another experience was reported by Zepeda (13), who conducted a survey on the communication of phytosanitary risks in Argentina, Bolivia, Canada, Chile, Colombia, Costa Rica, Cuba, the Dominican Republic, Guatemala, Mexico, Paraguay, Peru, Trinidad and Tobago, the United States, and Venezuela.<sup>2</sup>

Finally, an online search was conducted for evaluations of plans other than disaster plans; however, no evaluation of risk communication efforts was found. This could be because, even if such efforts had been undertaken, the

findings were not published, or, alternatively, because they were simply academic exercises that are hard to find; this makes it difficult to learn from past experience and optimize current plans.

## Social determinants and risk communication

Communication activities designed to put the social determinants approach on the public health administration agenda can be targeted to two different audiences: the general public and professionals in health and related sectors. The media and social networks can be used to transmit health recommendations with a view to changing behaviors. To improve knowledge about social determinants among civil servants and health workers in general, it is important to improve dissemination of the evidence with respect to those determinants and ensure compliance with the mandate issued by supranational bodies such as the Commission on Social Determinants of Health.

Differences in exposure to social determinants, which define the degree of vulnerability and consequences, are also opportunities to formulate specific messages with a greater impact on target audiences. Different risk communication activities can be proposed depending on the types of determinants involved.

*Structural determinants:* Access to health resources is determined by income and socioeconomic status, schooling, and occupation. In addition, access varies as a function of gender, race, and ethnicity. These latter variables play an important role in life and, in extreme cases, are associated with greater health risks.

In terms of access to health services, over the past several decades some Latin American countries have attempted to implement measures and reforms leading to universal health care (14-19), with particular emphasis on vulnerable populations. Others, such as Argentina, have social welfare systems that give a large proportion of the population access to health service. In Chile, this occurs through public- and private-sector mechanisms, and in Cuba, through a State-based model. In all cases, the right to *health for all* can be a key message to emphasize to the general public.

Access to a good education makes it possible to exercise another human right that is often not respected, with major repercussions. The links between the two rights (health and a good education) can be used to advantage; for example, more schooling and higher educational levels for women have a positive impact on the nutritional status of their future children (20).

An adult's occupation and income throughout working life also have an impact on health. Although legislation in most Latin American countries already includes health protections for workers and progress has recently been made in certain communities in the region, substandard working conditions are still a reality for thousands of people. Much of the progress in this regard has been achieved through messages effectively transmitted through social networks, shining a spotlight on clear violations of human rights.

*Intermediate determinants:* Housing conditions, which determine people's immediate environment from birth onward, can be altered, and regulations have been issued to protect individual health and family safety in the home (21). The content of such regulations must be translated and tailored to the different cultures in the region to facilitate their assimilation by families and communities.

Behaviors, habits, and lifestyles are the social determinants that have been the target of risk communication activities. The greatest challenge is how to effect changes in these determinants through strategies that encourage the target public to become better informed and adopt behaviors to protect it against specific health risks or to promote good health, fostering prevention at various levels.

Transmitting and assimilating information is the obligatory starting point for changing behavior. Processes designed to achieve this must consider current recommendations on creating messages and devote the necessary time and resources to this activity. Care must also be taken to evaluate the effectiveness of the messages in order to optimize these efforts.

As a process that facilitates community participation, risk communication can strengthen consensus-based decision-making by allowing the voices of all stakeholders to be heard, particularly those of the most vulnerable groups, such as migrants, informal workers, indigenous peoples, and the residents of disadvantaged neighborhoods. This process can be a tool for addressing the intermediate social determinants, especially if *health for all* is the goal (22).

## ■ Risk perception and risk communication: Inseparable components

Risk perception is the ability to perceive threats based on previous experience and personal and societal beliefs. According to Wiedemann (23), risk perception is "the ability of an individual to interpret a situation potentially

prejudicial to himself or to the health or life of third parties, based on previous experiences and their extrapolation to a future point in time. This skill ranges from a vague opinion to a firm conviction.” Using this definition, the author posits that risk perception is based primarily on perceptions and beliefs, and only to a lesser extent on previous personal experience.

Studies on risk perception emerged in the 1970s and 1980s, particularly in the United States and some European countries, as an alternative to utilitarian and technical risk analysis grounded in engineering, toxicology, economics, and the actuarial sciences, which ignore the beliefs, fears, and questions of the communities involved. These studies intensified and now constitute a scientific discipline whose aim is to understand the negative reactions of lay people when confronted with new technologies.

The first step in a risk perception study is to identify the differences between the views of a lay person and an expert about a given danger (24). A “lay” person here is someone who in the course of his or her lifetime has not acquired formal knowledge about the subject at hand. The risk perceptions of lay people tend to be markedly different from those of experts, particularly scientists (25). Lay people’s interpretations of risks are based primarily on their beliefs and convictions rather than on scientific data, while technical personnel and scientists rely principally on scientific data.

In LAC, risk perception studies in academia began to increase in the second half of the 1990s, especially in connection with HIV/AIDS (some studies on this topic were already available in the early 1990s). Work in this area increased significantly after the turn of this century, revealing the potential for adopting risk perception strategies in Latin America (Table 15-1), especially in relation to the assessment and management of risk. Although most of the findings in this area still come from research on sexually transmitted infections or HIV/AIDS, some research on environmental health has been conducted, especially in the past five years, in which risk perception strategies have played a key role in linking research with action.

Within LAC, Brazil reports the greatest number of studies on risk perception, with HIV/AIDS being a major focus. Several years ago, many studies began presenting information on risk perception initiatives associated with environmental health research, highlighting the potential use of such research to better understand how vulnerable population groups deal with the risks to which they are exposed. One example, from a comprehensive study of Brazilian agricultural workers (25), indicates that the workers only considered the effects of direct exposure to pesticides to be a threat, particularly those related to symptoms of acute poisoning (Case Study 15-1). This buttresses the hypothesis that previous experience is important in workers’ perception of risks. Thus, among the workers interviewed, risks were perceived to exist when the effects were manifested or visible; thus, when exposure had no visible effects, the perception was that no risk existed.

**Table 15-1.** Published Latin American research on risk perception (Medline/PubMed records from 2000-2012 and JCR Science and Social Science, 2011 edition)

<i>Author(s)</i>	<i>Country</i>	<i>Year</i>	<i>Subject of Risk Perception</i>
Cezar-Vaz <i>et al.</i>	Brazil	2012	Work-related injuries
Coronado Salas <i>et al.</i>	Mexico	2012	Assessment of risk communication strategy
Peres <i>et al.</i>	Brazil	2012	Exposure to pesticides in rural work
Cezar-Vaz <i>et al.</i>	Brazil	2012	Work-related injuries
Da Silva <i>et al.</i>	Brazil	2012	Exposure to pesticides in rural work
Catalán-Vásquez <i>et al.</i>	Mexico	2012	Exposure to manganese in mining
Banegas <i>et al.</i>	Chile	2012	Cancer prevention
Torres Nerio <i>et al.</i>	Mexico	2011	Environmental exposure in children
Valencia <i>et al.</i>	Colombia	2011	Air pollution
Barraza <i>et al.</i>	Costa Rica	2011	Exposure to pesticides in rural work
Santos <i>et al.</i>	Brazil	2011	Cancer prevention
Blanco-Muñoz & Lacasaña	Mexico	2011	Exposure to pesticides in rural work
Lopez-Quintero & Neumark	Colombia	2010	Substance (ab)use among young people
Sampaio-Filho <i>et al.</i>	Brazil	2010	Alcohol (ab)use among young people
Oliveira & Foccacia	Brazil	2010	Work-related injuries
Catalán-Vásquez <i>et al.</i>	Mexico	2010	Exposure to manganese in mining
Dearborn <i>et al.</i>	Ecuador	2010	HIV/AIDS
Cezar-Vaz <i>et al.</i>	Brazil	2009	Work-related injuries
Neves & Mello	Brazil	2009	Violence and work-related injuries

<i>Author(s)</i>	<i>Country</i>	<i>Year</i>	<i>Subject of Risk Perception</i>
Dinelli <i>et al.</i>	Brazil	2009	Vaccination of health workers
Olivi <i>et al.</i>	Brazil	2008	Sexually transmitted diseases
Nathan	Bolivia	2008	Accidents among mountianside residents
Katagiri, <i>et al.</i>	Brazil	2008	Zoonotic infections among dog owners
Gil, <i>et al.</i>	Peru	2008	Drug use by students
Ferreira	Brazil	2008	HIV/AIDS
Recena, <i>et al.</i>	Brazil	2008	Exposure to pesticides in rural work
Thielen, <i>et al.</i>	Brazil	2008	Speeding/automobile accidents
Trujillo, <i>et al.</i>	Colombia	2007	Substance (ab)use among young people
Kendall, <i>et al.</i>	Mexico	2007	HIV/AIDS
Fonseca, <i>et al.</i>	Brazil	2007	Exposure to pesticides in rural work
Bird, <i>et al.</i>	Mexico	2007	Exposure to tobacco smoke among students
Castillo-Arriaga, <i>et al.</i>	Mexico	2007	Diabetes
Peres, <i>et al.</i>	Brazil	2007	Exposure to pesticides in rural work
Salazar, <i>et al.</i>	Peru	2007	HIV/AIDS
Maia, <i>et al.</i>	Brazil	2006	Hormone treatment for menopause
Peres, <i>et al.</i>	Brazil	2005	Exposure to pesticides in rural work
Baltazar Reyes, <i>et al.</i>	Mexico	2005	Prevalence of sexually transmitted diseases
Filipe, <i>et al.</i>	Brazil	2005	HIV/AIDS
Peres, <i>et al.</i>	Brazil	2004	Exposure to pesticides in rural work
Dias, <i>et al.</i>	Brazil	2004	C-sections
Ferreira	Brazil	2003	HIV/AIDS
Tate, <i>et al.</i>	Cuba	2003	Health and sanitation
Bronfman, <i>et al.</i>	Chile	2003	Environmental and health risks
Praça, <i>et al.</i>	Brazil	2003	HIV/AIDS
Segurado	Brazil	2003	HIV/AIDS
Peres, <i>et al.</i>	Brazil	2003	HIV/AIDS
Antunes, <i>et al.</i>	Brazil	2002	HIV/AIDS
Alves, <i>et al.</i>	Brazil	2002	HIV/AIDS
Tunala	Brazil	2002	HIV/AIDS
Santos, <i>et al.</i>	Brazil	2002	HIV/AIDS
Iriart, <i>et al.</i>	Brazil	2002	Bodybuilding and use of steroids
Cordeiro	Brazil	2002	Work-related injuries
Castor	Trinidad & Tobago	2002	Gonorrhoea infection
Vieira, <i>et al.</i>	Brazil	2001	STDs and sexual behavior
Ventura-Filipe, <i>et al.</i>	Brazil	2000	HIV/AIDS
Fernandez, <i>et al.</i>	Cuba	2000	Health and sanitation

Elaine Vaughan's pioneering research (26) yielded similar findings on risk perception and self-protective behavior related to chronic pesticide exposure.

A number of assessments of different risk communication experiences with Latin American migrant populations in the United States have found that the ways these populations perceive risk, and their responses, depend on the particular danger involved. Among Mexican-Americans, for example, social networks (friends, relatives, neighbors, and fellow workers) are considered the most credible sources of information on the more common types of dangers such as seasonal floods, as opposed to events such as a nitric acid spill. Next in credibility (a prerequisite for the development of risk perceptions) are the media, followed by opinion makers and, last, government spokespersons. It has also been found that once members of this particular minority group receive information about a threat, they make efforts to verify, reject, or add to the information, seeking information from a range of sources (27).

Experience, information, and cultural background form an inseparable triad shaping risk perception, although these are not the only variables related to risk perception in the general population or specific groups.

The three most common approaches used in the study of risk perception are (a) psychological or psychometric, (b) cultural or anthropological, and (c) sociological.



## CASE STUDY 15-1. PESTICIDE RISK COMMUNICATION IN BRAZIL

The São Lourenço Valley is one of the most productive agricultural areas in the Brazilian state of Rio de Janeiro. It produces more cauliflower than any other area in the country (an estimated 600 tons per year), and is one of the largest sources of tomatoes (1,750 tons per year). Both of these crops require major pesticide use. Production comes from small family farms of roughly two hectares each that grow multiple crops. Given the characteristics of the climate and the crop rotation techniques used, agricultural activity continues year-round, thus increasing the exposure of families to pesticides and environmental pollution. Previous studies have indicated that approximately eight tons of pesticides per year are used in 128 family farms, or 56 kg per worker per year.

A risk perception survey was conducted in this area using semi-structured interviews. The findings revealed some important aspects of risk perception among local workers. Most of the women interviewed did not clearly understand the potential harm of pesticides; the channels of exposure, in particular, were not well understood. The invisibility of the risks was clearly evident in their handling rubber hoses and washing of clothes and equipment. Based on these results, a risk communication strategy was designed with a focus on women's participation in the work. Using data from the interviews, a script was written about a fictitious episode in which a rural woman worker was contaminated. The script was used to produce

a *fotonovela* (a pamphlet with photos and dialogue bubbles) entitled *Menina Veneno*, which in Portuguese means both "poisoned girl" and "rash girl."

The *fotonovela* was analyzed in discussion groups, where the material was favorably received. The story's narrator was a typical woman worker, and the dialogue was taken from the statements of women interviewed in the risk perception survey. No recommendation was made in the *fotonovela*, which simply presented the narrator's impressions of her own experience as it unfolded in her home with her family.

Approximately 97% of the participants in the discussion group ( $n = 83$ ) said that the story had been easy to read and understand. The other two participants found the text boring and the *fotonovela* too long (24 pages). The message was understood even in a group of five semi-literate women, thanks to the association between the images and certain key words in the text. Recognizing themselves in the *fotonovela's* characters, the women workers in the rural São Lourenço Valley were able to discuss various environmental health issues, especially those related to their participation in rural work and the use of agricultural pesticides.

This experience reinforces the idea that risk perception studies are important to the development of educational and risk communication campaigns, serving as an effective bridge between research and action.

*Source:* Peres *et al* (28).

The psychological approach examines how people express their opinions in response to specific questions about risks. This is also known as the "psychometric" approach, since the main way of collecting data is through standardized psychometric questionnaires that ask informants to assign points in response to questions on trustworthiness, fear, safety, satisfaction, and risk acceptance. The factors that raise people's anxiety about specific risks are: (a) involuntary exposure to risks arising from situations in which they did not participate in the decisions that led to the exposure; (b) a tendency to associate health problems with recent exposure; (c) lack of awareness of environmental health risks, combined with the inability of science to provide adequate explanations about a given problem; (d) lack of participation in the development of risk management strategies; and (e) lack of awareness of most of the risks from exposure.

The cultural or anthropological approach is based on the premise that different societies or population groups will react differently to the same risk. Under this premise, individual perception of risk develops over the course of a lifetime and is strongly influenced by the shared cultural values of the respective social groups or society. Experience also shapes risk perceptions, and each cultural value acquired throughout life is part of that experience. Thus, in the cultural or anthropological approach, addressing the risk perceptions of a particular group requires an understanding of how people have acquired their experience, as well as how the culture has influenced their beliefs, fears, hopes, etc.

Finally, the sociological approach views social experience as the basis for risk perceptions. From this vantage point, a person cannot be considered an "isolated entity" (which is possible in the psychological approach, and perhaps in some very limited cases, in the cultural approach), but, rather, a social actor. A particular risk or technology must not be taken out of context but viewed as part of the "social experience" in which population groups interact

within the group and with the factors that cause the threats. Thus, when using a cultural approach to the analysis of risk perceptions, it may be necessary to focus on determinants of a social order, such as societal organization, socioeconomic determinants, etc.

According to Vaughan (26), cultural beliefs can influence the perception of disease, the filtering of information about risks, and the tendency to react to potential health threats. This supports the proposition that risk perception and risk communication are inseparable components of the complex scenario in which environmental health relationships play out.

Three elements are essential to understanding this close relationship between risk perception and risk communication. First, risk communication involves dialogue (i.e., it is a two-way process). Communication transcends the transmission of information, as it is the result of interactions among all of the participants in a decision-making process. Technical personnel and the community are at once informants and receivers of information; the process involves dialogue, vertically transected by multidimensional elements, which may be associated with both the technical aspects of the communication process (such as material, technical content, the tool or medium selected, etc.) and sociocultural factors (such as culture, life course, linguistic modalities, etc.).

Second, risk communication is also education, and education is transformation through knowledge. According to Paulo Freire (29), the educational process requires reaching an “agreement on meaning.” Freire believes that **“for the act of communication to be effective, it is essential that there be agreement on meaning among citizens as reciprocal communicators. In other words, the verbal expression of one individual must be perceived by the other as an image with a common meaning. If this agreement on meaning does not exist, the communication process is invalidated as an expression of the object signified.”** Thus, if communicators do not understand the universe in which they are working, they will tend to transmit knowledge produced in the context of their own specific (academic) reality for a highly differentiated population group, leading to the failure of educational practices and the violation and devaluation of local or traditional cultural norms.

Finally, genuine risk communication will take place only in a climate of trust and credibility. According to Peters *et al.* (30), trust and credibility are a function of three sets of determinants (1): knowledge and expertise; (2) openness and honesty; and (3) concern and care. These authors tested six hypotheses regarding the determinants of trust and credibility in the context of risk communication and found that perceptions of trust and credibility as they relate to a risk communication strategy depend on different factors. According to the authors: **“(a) for industry, an increase in public perceptions of concern and care results in a larger increase in perceptions of trust and credibility than any other variable considered; (b) for government, an increase in public perceptions of commitment results in a larger increase in perceptions of trust and credibility than any other variable considered; (c) for citizen groups involved in environmental problems, an increase in public perceptions of knowledge and expertise results in a larger increase in perceptions of trust and credibility than any other variable considered; and (d) for society as a whole, the determinants of trust and credibility are not monolithically invariant across organizations and institutions.”**

Effective use of intervention strategies to deal with complex environmental health issues, such as pesticide exposure, urban air pollution, and problems associated with climate change, requires an interdisciplinary approach in which experts from many fields are exposed to the basic principles and contributions of the other disciplines. Thus, each must understand the science, methods, education, and language of the others. Greater emphasis must be placed on the beliefs of target communities, even if, at first glance, they appear to be irrelevant.

A key aspect of risk communication is the need to get all segments of the target population involved and actively participating, including children and adolescents, who in many cases are the ones most affected. An initial step in this direction is learning about the perceptions of these segments of the population. In San Luis Potosí (Mexico), risk perception studies have been conducted among children in different locations, focusing primarily on areas with pollution issues and marginalized urban and rural communities (31).

When using risk communication in the interests of concern and care with a view to modifying individual or group behaviors, the initiatives must be linked to cultural research, particularly studies on risk perceptions. Such research, as noted, yields knowledge about people’s beliefs, fears, and feelings about the content communicated and can help make risk communication appropriately responsive and effective. We believe that just as changes in attitude cannot be dissociated from individual and collective subjective factors, it is impossible to dissociate risk perception from risk communication.

In conclusion, a case study has been presented that examines the possibility of linking scientific research data with action, combining risk perception with risk communication. A risk perception study was conducted in a major rural area in the Brazilian state of Rio de Janeiro and, employing a participatory community-based approach, a risk

communication initiative was designed and implemented that helped a group of women gain better knowledge of the risks involved in their work.

This case study reinforces the idea that risk communication strategies cannot be dissociated from public perceptions of risks and highlights a real challenge for professionals in the field, as well as regulatory bodies, researchers, and the representatives of specific population groups throughout Latin America, bearing in mind the following: (a) the multicultural identity of the region's population (even within countries, as in Mexico and Brazil); (b) the lack of interest displayed by experts in some academic disciplines in integrating the knowledge of social scientists into environmental health projects and risk assessment initiatives; (c) the inexperience of some government sectors with public participation in decision-making and the corresponding failure to value such participation; and (d) the lack of understanding of risk communication's role as a powerful mechanism for dialogue—one that is much more effective than a mere channel of information. Overcoming and removing these barriers are a way to improve environmental health in our region.

## ■ Creating the message in risk communication plans

Formulating messages is fundamental to any communication strategy for managing environmental health risks. This involves shaping the information to be shared with a target audience for the express purpose of preventing an environmental risk to its health in a context that is never independent.

The message can be described as a means of communicating, as creatively as possible, why the change being promoted is advantageous (32), even when the goal is to reinforce existing practices or behaviors. Often, the act of summarizing the objectives of a risk communication plan in a written or oral message helps clarify the path to follow and makes it possible to anticipate part of the desired effect. Creating the message, especially its content, structure, and dissemination plan, has been key to developing risk communication plans in many of the experiences described in the literature (33).

If, as noted, risk communication is a two-way process, or dialogue, then freedom (or the appearance of freedom) is an important variable in the process. There tends to be an intrinsic asymmetry in this dialogue, since information is transmitted from those who know (the experts) to those who do not, or who know less (lay people), and the analysis and process generally ignore the beliefs and social factors that influence risk perception in the target community. If risk communication is also education, then, according to Freire (34), it is implicitly liberating if conducted in freedom without coercion, assuming that agreement has been reached on the meaning of what is being communicated.

Generally, the target audience that the message seeks to protect has formed expectations about what it wants to know about a particular risk, especially when the risk has not suddenly appeared. These expectations do not always coincide with the intent of the risk communication strategy—a problem must be addressed and, insofar as possible, remedied, since it can jeopardize the process and hinder achievement of the expected results.

Today, in creating environmental health messages, consideration must be given to the significant technological development observed over the past few decades and the fact that the public is better informed, with nearly real-time access to current information—a fact that significantly influences its expectations. Communication channels, or media, many of which are controlled by the State or private transnational monopolies, are more efficient and reach a wider audience than ever before, making them important players in this scenario. This is especially true of the Internet. Di Giulio (35) has described how the influence of the media can reinforce myths, misconceptions, and stigma regarding particular people and places.

The message in communicating environmental health risks is usually aimed at preventing an effect by encouraging a change in individual or social behavior, even when an acute adverse event, such as a disaster, an epidemic, or an air pollution alert, has already occurred. The change is generally presented in connection with a promised benefit. In other words, it is assumed that knowledge alone does not produce change and that the benefit to be obtained and the path to obtain it must be clear. In designing a message it is therefore important to back up the promise with evidence of the prospective benefit. Both the promise and the evidence, as well as the strategy itself, must be based on a jointly constructed relationship arising from a genuine and horizontal dialogue between the transmitters and receivers of the message.

A message should be based on a thorough knowledge of the target audience's perceptions of the risk at hand; those perceptions can only be understood by embracing a horizontal, nonpaternalistic approach—not only because it will lead to the desired social empowerment, but also because it is more effective. The process should be open to

the target public, with special attention paid to the beliefs of its members and to the cultural and social factors that influence them, especially in Latin America, with its complex multicultural composition, where an interdisciplinary approach is crucial.

Consideration should be given to the credibility of the source of the message, as judged by the target population. Lindell and Perry, who described some of these judgments, emphasize that the population's perception of the source's credibility is critical to ensuring the effectiveness of the message, even when credibility is already high; for example, attention to the message can wane if the population believes that it is no longer relevant or that the risk is not that high (27).

The main message, which is usually accompanied by several secondary messages, should be in formats understandable to the target audience, paying particular attention to the educational level of the audience, its access to specific media and sources, and the frequency with which they are used. A message will be successful if it convinces the target public to interpret as dangerous a situation that is recognized as such by the "experts" and impels it to take the necessary action.

The message should summarize the main aspects of the risk—that is, it should describe the problem, indicate who will be affected, and identify ways of mitigating its effects. It should also emphasize the importance of taking precautionary action, while highlighting the fact that certain facilities that pose potential environmental threats may also be providing benefits (e.g., gas distribution plants, which pose a danger but also provide needed gas). In constructing the message, the extent to which its success will rely on repetition should be assessed. Table 15-2 shows the information that should be included in a written message as part of a risk communication strategy.

Creativity in formulating the message, which largely determines its appeal, is based on identifying the particularities of the target audience. Many health communication programs have failed because they were geared to a general, undifferentiated population (34) and failed to take into account such factors as its composition, the prevalence of biases and prejudices, and the influence of communication patterns on social practices.

Today, thanks to the target public's greater access to communication platforms, it is possible to design risk communication plans that simultaneously validate both the medium and the message. Such validation is key to the success of risk management through the communication strategy, ensuring that technical or academic language is adapted and made understandable to the target audience and that the medium selected effectively serves the intended purpose.

Fundamental to risk communication is the principle that people under stress generally (a) find it difficult to hear, understand, and remember information and (b) want to know that the spokesperson is more interested in them than in his or her own knowledge. Covello has designed "message maps" to help create messages and foster empathy with the audience, especially in times of crisis when attention is focused on ways of approaching the problem, clearing up questions, determining whether the authorities are doing the right thing, and ascertaining whether someone is firmly in control (5). Table 15-3 presents the example of the avian flu pandemic.

**Table 15-2.** Information that should be included in a written risk communication message

<p>Goals and content of the informative material.</p> <p>Nature of the risk.</p> <p>Alternatives to the action that is generating the risk and any risks associated with those alternatives.</p> <p>Uncertainties in the risk assessment.</p> <p>How the risk will be managed.</p> <p>Benefits associated with the risk.</p> <p>Action that the public can take to mitigate or manage exposure to the risk.</p> <p>Contact point.</p> <p>Glossary.</p> <p>Conversion table.</p> <p>Useful advice.</p> <p>Table of contents.</p> <p>List of related information.</p>
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Source: Lundgren and McMakin, 2004, p. 196 (36).

**Table 15-3.** Message map preceding a risk communication event associated with the influenza pandemic

<i>Key message 1:</i>	<i>Key message 2:</i>	<i>Key message 3:</i>
The influenza pandemic is caused by an influenza virus new to human beings.	It is hard to predict when an influenza pandemic will occur.	Influenza pandemics tend to be more serious than seasonal influenzas.
<i>Supporting fact 1-1:</i>	<i>Supporting fact 2-1:</i>	<i>Supporting fact 3-1:</i>
Seasonal influenza is caused by viruses that are already being transmitted among humans.	Seasonal influenza occurs every year, generally in the winter.	Influenza pandemics tend to affect more people than seasonal influenzas.
<i>Supporting fact 1-2:</i>	<i>Supporting fact 2-2:</i>	<i>Supporting fact 3-2:</i>
An influenza pandemic can start with an existing influenza virus that has mutated.	Influenza pandemics have occurred approximately 30 times in recorded history.	Influenza pandemics can seriously affect a larger portion of the population (including young adults) than do seasonal influenzas.
<i>Supporting fact 1-3:</i>	<i>Supporting fact 2-3:</i>	<i>Supporting fact 3-3:</i>
Fewer people will be immune to a new influenza virus.	An influenza pandemic could last beyond the usual flu season.	A serious pandemic could change everyday life for an extended period of time and involve restrictions on travel and public gatherings.

Source: Covello, 2008, p. 3 (5).

Message maps contain detailed information, vertically organized in blocks of three, designed to answer foreseeable questions or concerns and providing a visual overview of the messages to be transmitted. Message maps enable risk communicators to formulate messages in advance; once formulated, they can be tested in focus groups or through other empirical research.

When using risk communication to safeguard health and encourage individual or societal changes in behavior, the efforts must be linked to cultural studies —specifically, studies of risk perceptions. During the process of risk communication, knowledge of people’s beliefs, fears, and feelings can be gained, making it possible to properly calibrate the response and maximize the effectiveness of the communication. Since it is impossible to dissociate changes in attitude from individual or collective subjective factors, it is also important not to dissociate risk perception from risk communication.

It is as important to know what message to communicate as to stratify the information. Thus, it is essential to know what *can* be communicated, whether there is an accurate understanding of what the community wishes to know, and what it is that the community needs to know. The main messages must be selected and prioritized according to their expected impact and the nature of the risk, all within the framework of the meaning agreed upon with the target audience. Since environmental health risks are of a different nature, the challenge is to make the messages clear whatever the format used. Given the potential impact of the information on the public, appropriate steps must be taken in advance to provide support and deal with reactions.

One way of making a message appealing is to clearly differentiate the components of its target audience, since there is no such thing as the “general public.” Validation of the message is essential if it is to be successful. Today, it is possible to simultaneously validate both the message and the medium used to communicate it, using computer software to facilitate the process.

In summary, creating a message requires reaching a prior agreement with the target audience about the meaning of what is being communicated. Environmental health messages are usually designed to effect change and should therefore include evidence of the expected benefit, a description of that benefit, and the basic characteristics of the risk. This means describing the nature of the problem, indicating who will be affected, presenting alternatives to mitigate the effects, indicating how to take the necessary precautions, and stressing the importance of doing so. Participatory formulation of the message, including the definition of the promised benefit and the evidence to back up that promise, is vital if the message is to become the focus of a two-way communication strategy involving a

dialogue between experts and lay people. This process will be legitimate and effective if it is carried out under conditions of freedom, without coercion.



Community participation was fundamental in the activity described below, carried out in the Amazon region of Peru (Case Study 15-2).

## **CASE STUDY 15-2. BELÉN FESTIVAL: ART AND COMMUNITY CLOWNING HELP ADDRESS HEALTH AND DEVELOPMENT PROBLEMS IN AN EXTREMELY POOR URBAN AREA IN THE AMAZON REGION OF PERU**

### **Introduction**

Despite the efforts of countries and international cooperation agencies to achieve the Millennium Development Goals (MDGs), the challenge of bridging the gaps between and within countries persists. The Belén Network, which coordinates citizens, organizations, and authorities in the flood-prone lowlands of the Belén District of Loreto, Peru, promotes a comprehensive approach to the social determinants of local health, undertaking different art-related initiatives with an emphasis on community clowning.

The Belén Festival is the network's most important activity, held each August since 2005. The festival was consolidated two years later, when the Representative Office of the Pan American Health Organization (PAHO/WHO) in Peru answered the call of two volunteer clowning organizations (the Bolaroja Association of Peru and the Gesundheit! Institute of the United States of America) and provided support for the implementation of a local development project in some of the poorest and most stigmatized areas of the country. The objective was and continues to be the medium-term improvement of living conditions among the people of Lower Belén, using a highly participatory process in which art brings together and mobilizes people, based on the ties forged through the sustained intervention of community clowns working with local partners.

For six consecutive years, the Belén Festival has used community art (façades and murals) as a tool to create ties, while leaving behind a tangible product. During the 10 days of the festival every August, the aforementioned organizations and local authorities have implemented some 30 educational, recreational, and health care-related activities, always starting and ending with a festive parade. The presence of hundreds of community clowns is powerful because their activity bears witness to a shared reality that surpasses the

relationships of power and forms of censorship found in every human group and historical period.

In the 2012, 2013, and 2014 editions of the Belén Festival, there was a change in methodology: instead of painting façades, the community clowns visited the homes of families in critical situations, offering educational messages on disease prevention and health promotion, such as hand washing, water disinfection, waste disposal, cleaning of utensils, nutrition, sexual and reproductive health, and specific measures against diseases such as leptospirosis, which are exacerbated by poor living conditions. The messages, presented to families by clowns, were supported by street theater and a pre-recorded jingle played from a specially equipped motorbike provided by the Regional Health Directorate of Loreto.

### **Methods**

In August 2007, based on previous interventions by community clowns, the first workshop was held on participatory local planning. Local authorities and representatives of grassroots organizations, local NGOs, educational establishments, health services, cooperating agencies, and other interested institutions all attended. The main social and health problems affecting the district were identified and a set of actions was proposed to address these problems. Also, the Belén Network was formed to further the joint implementation of these solutions and to strengthen the coordination of activities between different sectors and stakeholders.

In August 2008, the name "Festival de Belén" was used for the first time. Between November of that year and early 2009, PAHO/WHO and the School of Public Health of Cayetano Heredia University (Peru) conducted a study on the social determinants of health in the Pueblo Libre area (home to approximately one third of the 15,000 people living in Lower Belén). The quantitative component of this study was carried out by citizens chosen by neighborhood councils and trained to work on a census of this kind.

A diagnostic study of the La Restinga Association (co-organizer of the festival) found that 42% of children in one section of Pueblo Libre are malnourished. Since 2009, the organizations in the network have been making great efforts to build a community activity center and begin operations on land acquired through a contribution made by the Gesundheit! Institute. The

community center will be a place where the people of Lower Belén can build their dreams using tools that can help make these dreams come true, in close collaboration with the services already offered by the Peruvian government. The activities and lessons learned could then serve as an inspiration for other communities.

### Results

Numerous activities have been carried out to consolidate the Belén Festival, including: 1) periodic follow-up meetings; 2) organization of the 2008, 2009, 2010, 2011, 2012, 2013, and 2014 editions of the Belén Festival; 3) the population and housing census of the Pueblo Libre areas, described above; and 4) efforts to mobilize technical and financial resources from different national and international entities. The achievements of the Belén Festival during this period include: colorfully painting over 900 exterior home façades and nine murals in the neighborhoods of Pueblo Libre, Venecia, Sachachorro, and San Francisco, located in Lower Belén; visits to deliver health messages to the homes of more than 700 people; and the ongoing implementation of dozens of art and health activities on behalf of thousands of people in the area. The efforts of the volunteers (transported by the Peruvian Air Force and Navy) have helped strengthen the capabilities of hundreds of children and others who organize the festival every year and participate in its activities. Some of them can be expected to commit themselves to the collective development and well-being of their neighborhood and the families and people living there.

### Discussion and conclusions

When the river rises from December to June every year in Lower Belén, water floods the bottom floors of the wooden and palm dwellings, seriously impacting domestic, economic, and social activity. Most of the homes in the area lack access to drainage systems or a safe water supply, but receive fetid discharge from the rest of the city. There are also critical levels of social violence in the district. This complex scenario requires a comprehensive approach and the commitment of every stakeholder, especially the local population.

The initial connection with the local community was made on its healthy side, like the connection between a clown and a patient in a hospital: what Bolaroja calls community clowning. A human community, despite living in conditions of severe oppression and inequity, still longs to live healthily, even when the media and social focus is usually negative. The community clown project connects with that healthy side of the community, the same way a hospital clown connects with the healthy side of a patient. And based on that link—which in itself sends a message similar to community painting in Belén—more human and more efficient participatory public health processes and development initiatives can begin. It also is clear that the Belén Festival helps reduce the stigmatization of the neighborhood by attracting the rest of the city to attend concerts, performances, and other activities.

The messages of the Belén project are developed through dialogue with the community, in a back-and-forth process using recreational and artistic tools that touch people's souls and that seek their participation in social change. In terms of public health, the project shows that community clowning is a valuable resource for building community ties that facilitate honest, genuine communication, and that empower populations in extremely vulnerable situations. Based

on recent experience, the organizers of the festival know that clowns are also effective when they work door-to-door, lifting the community spirit as they transmit concrete messages for disease prevention and health promotion. Integrating the impact of art into the framework of participatory and community processes is without a doubt a powerful public health tool that can help improve primary health care. The promise of change in Lower Belén is based on working in a network in which, every August, people celebrate with color and health.

Source: Guerra (33)

## ■ Communications media, health risks, and environmental risks

The World Health Organization (WHO) recognized in 2007 that “the mass media have a powerful influence on people's perceptions of risks, whether from a new disease epidemic, deliberate attacks or natural catastrophes. The Internet, television, radio, newspapers and magazines are the most influential sources of everyday information on risks to health... In covering health issues, the media perform two major functions: they explain and report scientific information and government policies for the public and at the same time, reflect the concerns of the general public (38).” Even before that, WHO had published a handbook on communicating effectively through the media during public health emergencies (39), pointing out its importance in transmitting information about outbreaks (40) and highlighting its role in influenza-pandemic preparedness and response (41).

Risk communication uses the media to inform the public about environmental threats to health, mitigation measures, and other means of controlling pollution, as well as real or supposed medical advances, new pharmaceutical products, and health programs.

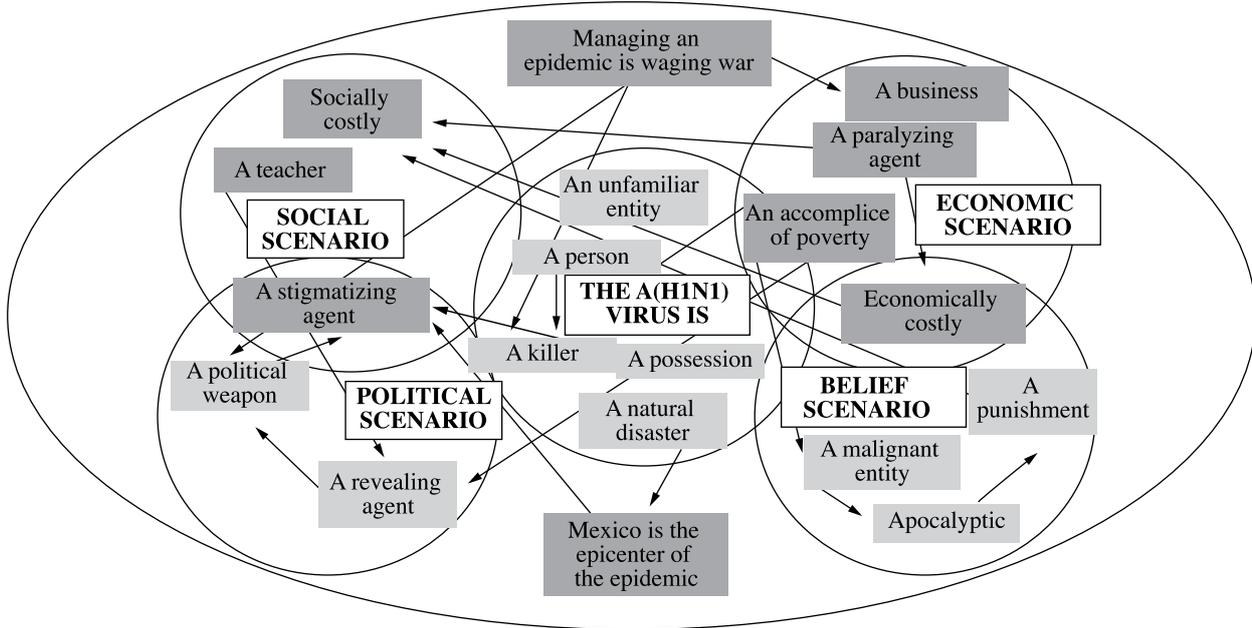
In the case of the influenza A(H1N1) epidemic in Mexico, the Secretariat of Health issued an alert; the immediate response was designed to protect health and lives, and, insofar as possible, maintain the country's socioeconomic dynamic. During the emergency, the precautionary principle was adopted and applied to deal with the health threat, and action centered on three strategies: risk communication initiatives, promoting healthy environments, and forging ties with a range of public and private institutions and civil society organizations. The risk communication strategy was based on two main health measures: proper hand washing and the correct technique for covering the mouth and nose when coughing or sneezing. As the situation developed, however, it became necessary to communicate other promotion and prevention measures so as to prevent and reduce infection among the population. With the support and participation of all forms of media, the necessary information was promptly conveyed to the different segments of the population in the manner stipulated. The risk perception study that PAHO and the Secretariat of Health conducted among men and women aged 15 to 75 in May of that year revealed that the basic prevention measures transmitted had generally been absorbed by the public. The need to cover one's mouth was familiar to all, and the public also recognized that symptoms of respiratory infection should trigger a visit to a health facility. At the same time, large restaurants instituted the established hygienic measures (42).

One interesting experience with respect to the role of the media is described in a study by González *et al.* (37), which assessed the response of Mexican society to the information about the influenza A(H1N1) virus published in two national newspapers. The research highlighted the metaphors that the messages employed to raise awareness among readers and achieve a particular effect, including informing, persuading, obscuring, clarifying, and promoting an understanding of complex issues. The authors stated that the media reports created a national panic about the threat of contagion. The resulting fear led to countless imaginative metaphors in public discourse that facilitated people's understanding of a complex situation, since the metaphors explained what was happening in familiar terms. The authors found that, faced with the unknown, people were pondering the origin, workings, and potential harm of the virus and its impact on their lives. This imaginative capacity was reflected in people's use of metaphors to clarify or simplify abstract concepts. Finally, the authors concluded that it would have been impossible to adequately instill an understanding of the presence and impact of the influenza A(H1N1) virus in Mexico without journalistic recourse to a holistic use of metaphor, rooted in the various symbolic representations present in the social, economic, political, and belief scenarios (see Figure 15-2).

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**Figure 15-2.** General semantic web, by scenarios

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Sources: (37, page 116).



In today's society, the media (television, radio, newspapers, magazines, and the Internet) are the main source of information, keeping citizens abreast of what is happening day to day, both nationally and internationally, and enabling them to form opinions about events.

In recent decades, environmental information has increased due to the growing interest among news outlets in reporting on environmental quality and public health. At the same time, the scientific world is fortunately taking an increasingly active role in elucidating health risks, though less committedly than might be

hoped. Moreover, public and private universities and research institutions are generating scientific and technical information that puts risks in greater perspective.

This increased interest in the environment and its problems led to the creation of the Environmental Communication Network of Latin America and the Caribbean (REDCALC) in 2000. Consisting of 145 communicators in 15 countries, its purpose is to improve the way in which the region's media report on environmental issues and to sponsor exchanges and professional training on these issues. Major items on the network's agenda include water, climate change, biodiversity, waste, environmental education, and environmental communication. The network is connected with other entities and networks through its members in the various countries of the region.<sup>3</sup> It also maintains relations with other Latin American networks.<sup>4</sup> The Network and international organizations such as UNEP, national environmental organizations such as PRONATURA, Foro Boliviano de Medio Ambiente y Desarrollo, Foro Ecológico del Perú y Desarrollo, Centro Latinoamericano de Ecología Social, Instituto de Ecología Política, Programa Chile Sustentable, Agencia Periodística del MERCOSUR, Conservación Ambiental, and ECOLOQUIA, along with specific projects such as Tierramérica (a UNEP/UNDP initiative that serves as the main platform for multimedia communication on the environment and development in Latin America and the Caribbean) disseminate environmental information through electronic bulletins. The topics covered include climate change, ecological news, "South" energy issues, the environment, bioregionalism, legal and environmental studies, biodiversity in Latin America and the Caribbean, environmental communication, Green Year, and ECOPORTAL. A further effort in the region has been the creation, in 2007, of the Latin American Union of Environmental Journa-

lists (Unión de Periodistas Ambientales de Latinoamérica), whose objective is to support this specialized area and inspire new journalists to join the effort, while encouraging the sharing of experiences and defending journalists in the exercise of their profession.

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### **BOX 15-1. ENVIRONMENTAL COMMUNICATION IN THE CONTEXT OF RISK COMMUNICATION**

*Environmental communication* is devoted to providing information on environmental quality, damage to ecosystems, flora and fauna, and pollution problems in general; measures that improve the quality of the environment; and environmental education. It often involves the expression of public outrage, alerting citizens or relevant officials to problems.

*Risk communication* focuses on the impact that environmental changes could have on human health and safety, with the aim of reducing exposure to specific environmental hazards. This is a two-way process.

All these efforts have led to greater citizen awareness about specific environmental problems, as well as more general issues, although the degree of this increased awareness varies across the region and within individual populations. Thus, there is still much to be done in this regard.

As indicated above, environmental communication is not synonymous with risk communication (see Box 15-1).

Much of the information on risks that is disseminated is based on citizen complaints or interviews with health professionals and researchers, whose opinions are not always based on technical assessments of health risks for particular places or populations.

In communicating information about risks, managers, technical personnel, health professionals, and communications experts often have to contend with the fact that, in practice, it is the mass media that are the purveyors, analysts, and guardians of information (43).

The media and the accuracy and timeliness of media reporting play an essential role in communicating information about risk. They can be an important mechanism for disseminating information about risk communication plans to inform the public about: the ways in which the health, environment, and other sectors are dealing with a situation involving health risks; the direction and magnitude of changes; and how citizens can participate. Media coverage of an issue depends on the particular situations involved. In the case of disasters and the resulting social upheaval, for example, coverage may extend over several weeks, depending on the impact of the crisis. González (43) has lamented that there continue to be “biased focuses and approaches that fail to transmit significant information on the vast complexity of environmental realities, help people form opinions about the information, increase social participation in conservation programs, or support risk prevention efforts.”

The media often approach environmental problems from a catastrophic, apocalyptic perspective that leads to indifference, apathy, and resistance to taking action to address problems. González also states that the media tend to sensationalize certain aspects of new problems, while ignoring others that, although more serious, are no longer considered newsworthy because of the frequency with which they occur.

The ideal would be to have absolute independence between the source and the journalist (or communication channel), ensuring a healthy distance between the person providing the original information and the person reporting it. However, this is difficult to accomplish, given the number of different interests and actors involved.

The communication channel is often indistinguishable from the source (when reading news on the Internet, for example, this risk is usually implicit). This can have serious consequences, especially in situations involving social shock, when a false report presented as valid news can spread far more rapidly than a message to correct the information. In addition, time pressures and news organizations themselves (newspapers, magazines, radio, television) tend to limit the number of sources consulted, preventing more in-depth reporting and limiting the range of views presented.

When scientific information is involved, quality is not the only important factor; the design of the communication strategy is equally important. The necessary information must be communicated without distortions or biases and must successfully reach the target audiences. This need for effective targeting is the starting point for selecting which media to use, for if the selection process is flawed, not only will the problems not be solved, but there will be psychological resistance to the information transmitted.

To increase the effectiveness of the media, journalists must be trained and brought up to date on environmental and health issues. Although work along these lines has been under way since the late 1980s, it has been inadequate (44), and greater efforts at professionalization are necessary.

The better the working relationship between media organizations and risk communicators (channel and source), the greater the possibility of achieving accurate and balanced coverage. Scientists and policymakers sometimes have an overly simplistic, imprecise, and sensationalistic view of media coverage. However, the answers that scientists give to journalists and reporters are sometimes hard to translate into news items, since the language and format of journalism may be incompatible with the material. To improve the coverage of health issues and risks, the media should:

1. Provide information that is understandable and balanced, including differing opinions about problems and their causes and consequences in language that is understandable to the majority of the population, without sacrificing scientific rigor.
2. Analyze environmental problems from an economic, political, social, and cultural standpoint.
3. Facilitate public access to the greatest possible quantity of high-quality data available on each socially important environmental issue or subject, so that citizens have information on which to base their own opinions and actions.
4. In selecting information sources, include professionals and scientists from different environmental areas, and build relations of trust and mutual benefit with them.

As mentioned above, in supporting efforts to communicate with the public about outbreaks, the World Health Organization (40) has published a handbook for journalists and communicators, explaining: the state of knowledge about a potential influenza outbreak; the significance of such an outbreak for the society in question; existing uncertainties; and the possibility of a pandemic and how to manage it and its potential impact. Such efforts are important in transmitting knowledge about a potential global event of major public health concern in a simple, fact-based way to communicators and other relevant audiences.

## ■ Creating risk communication plans

One important element to consider in planning risk communication is interaction with the people involved and the institutions capable of working together to meet the desired objective. Communities can provide valuable information for determining the health impact of potential exposure to hazardous agents. Professionals involved in transmitting information on risks must understand the community's needs and be capable of facilitating dialogue on technical issues related to health risks, bearing in mind the community's psychological, political, social, economic, and health needs.

In *The Future We Want* (2012) (45), the United Nations stressed the importance of participation by all sectors of society. In this document it argues that sustainable development requires the genuine interest and active participation of the various authorities, as well as women, children and young people, indigenous peoples, nongovernmental organizations, local authorities, workers and unions, business and industry, the science and technology community, farmers, local communities, volunteer groups, foundations, migrants, families, older persons, and people with disabilities.

Facilitating this interaction requires:

- Recognizing the importance of the community's contribution.
- Including the community in the decision-making process.
- Identifying and responding to the needs of different groups within the community.
- Holding public hearings, sometimes in the form of smaller, informal meetings.
- Recognizing that people's values and feelings are a legitimate aspect of environmental health problems.

## ■ Planning risk communication

Planning is vital to success. The first step is to define the objective of the communication and the expected results, so that the process can be evaluated. It is essential to know the nature and situation of the target audience and to understand what it needs to know, how it wishes to receive the information, and what can be done to overcome existing constraints (3).

In planning, the need for financial resources, personnel, and equipment must also be borne in mind. Risk communication is a relatively new phenomenon in Latin America and the Caribbean; thus, a great deal of work lies ahead to convince policymakers of its importance.

## ■ Steps in a risk communication plan

The eight items below are proposed as basic steps for devising a risk communication plan. They come from a systematic review of the literature conducted by Baker on persuasive communication (44).

1. **Assessing the health risk:** According to PAHO (1999), health risk assessments have three objectives. The first is to determine the probability of a harmful effect from exposure to hazardous agents. If the probability is high, the second step is to try to identify the channels through which the recipient population comes in contact with the hazardous agents. The third and final objective is to implement intervention or management programs that foster necessary changes in behavior to reduce the risk to the exposed population. Risk communication should also cover matters related to the need for measures to respond to floods, droughts, water shortages, and communicable and noncommunicable diseases. With regard to communicable diseases, redoubling efforts to combat HIV/AIDS, malaria, tuberculosis, influenza, poliomyelitis, and other communicable diseases remains a high priority, since they are still a major global concern (46,47). Risk communication is also important in preventing noncommunicable diseases, especially cancer, cardiovascular diseases, chronic respiratory diseases, and diabetes, many of which are caused by social determinants of health.
2. **Defining objectives:** Establishing objectives for a risk communication plan is fundamental. If objectives are not well-defined and effectively formulated, the plan is unlikely to be effective. The objectives can range from raising people's awareness about a risk to changing behavior to reduce it. As a methodological strategy, risk communication can help improve the quality of education at the various levels by fostering community education tailored to the specific context, with the aim of improving children's environmental health and training teachers.
3. **Evaluating of target audiences:** The initial step in creating messages about risks is to ascertain the public's perceptions and knowledge about the risk.
4. **Evaluating of the sociocultural and demographic context:** The population's vulnerability to a particular risk is determined by extrinsic factors associated with sociodemographic realities, including inequity, poverty, customs, educational level, risks from exposure to hazardous agents, problems caused by climate change, lifestyles, diet, etc. Thus, certain populations, such as indigenous and marginalized urban communities, are particularly vulnerable. Latin America has more than 670 indigenous cultures; thus, in designing an effective plan, it is of paramount importance to know and understand a target community's culture. To evaluate the audience, information can be obtained from indirect sources such as health institutions, environmental organizations, and other relevant sectors, as well as from epidemiological and demographic databases. This information should be supplemented with the evaluation conducted by the risk communication group based on direct sources. When children or adolescents are the most heavily affected group, they should be the target audience, along with their parents and teachers. A number of strategies can be used to analyze a population's perceptions and knowledge about a risk to which it is exposed.

## ■ Strategies for the adult population

- a) *Observation.* A visit should be made to the community to observe its lifestyle, habits, behaviors, customs, and other conditions.
- b) *Questionnaires.* These are recommended for gathering identification data and data on housing, diet, occupation, local resources, and behaviors in a particular group, as well as more general information.
- c) *Focus groups.* The objective of this method is to elicit statements from the participants about the main

problems affecting the general population. It is advisable for groups to have seven to 10 participants to ensure that everyone participates.

- d) *In-depth interviews.* These are repeated, face-to-face meetings between researchers and informants, designed to gain an understanding of the interviewees' outlook on their lives, experiences, and situations, as stated in their own words, using a model involving conversation between equals, rather than a formal question-and-answer format.

## ■ Strategies for child and adolescent populations

- a) *Drawing.* Some studies in Mexico highlight children's drawings as a useful way of assessing opinions and perceptions of the environment (47).
- b) *The Dilemma approach.* This is a type of focus group that involves using questions drawn from a guide designed to encourage children's participation to learn about their perceptions of their environment and health. The activity is conducted in small groups of seven to ten children in which they are asked questions such as "What would happen if...?" The analysis of their perceptions is then based on their responses (48). These tools have been used with children living in different situations of risk in urban areas, as well as in rural indigenous communities (49,50).
5. **Selecting the approach:** This phase of the work should draw on the evaluation of the target audience, since the choice of approach will depend on whether or not the population perceives the risk, and on the concerns that people have expressed (health, safety, economic realities, environment, esthetic issues, political factors, etc.) (44).
6. **Constructing the communications:** In formulating a risk communication plan, the factors that should be considered from a communicational perspective include the following minimum elements (51):
- **The source:** The person or persons who convey the message or information. A risk communicator must be a person whom the public will trust —someone who is technically competent, credible, and widely accepted by the population.
  - **The target audience:** The social group to whom the message is directed.
  - **The message:** What one wishes to communicate.
  - **Communication channels:** Since these are the mechanisms through which the message reaches the public, it is important to choose the most appropriate one. Notable in this regard are risk communication experiences in Mexico (49,52) at contaminated sites in San Luis Potosí, where interventions centered on communicating to children, who are generally the most affected. These activities in Mexico also used analysis of risk perception as a strategy for evaluating the intervention. There have been communication initiatives designed to reduce disaster risks in the Caribbean, while initiatives in the Dominican Republic (53), Barbados, Dominica, Granada, and Saint Lucia have employed risk communication plans to deal with public health emergencies (54).

## Tools for the adult population

- a) *Written messages.* Brochures, manuals, newspaper articles, posters, pamphlets, scientific articles, etc. A large amount of information can be included in these messages at a modest cost, though some people will find them difficult to understand.
- b) *Oral messages.* Talks, radio interviews, presentations, etc., provide opportunities to interact with the public; however, they offer no physical material for the population to retain for future reference.
- c) *Visual messages.* Posters, "wall newspapers," guided visits, videos, television, etc. These messages are easy to remember, can be placed where people will see them, and are eye-catching. However, they contain little information, do not provide an opportunity for interacting with the public, and are usually expensive.
- d) *Interaction with the population.* Focus groups, advisory committees, and formal hearings encourage community participation but can be costly; care should be taken when covering any social or political issues that could create obstacles to the process.

## Tools for the child population

- a) *Theater*. For children, acting is an activity that stimulates the imagination and promotes solutions for everyday problems and situations.
- b) *Puppet shows*. This is a very valuable teaching strategy for encouraging behaviors that promote self-care and community health.
- c) *Didactic experiments*. These help children develop their potential for feeling, perceiving, speaking, reflecting, imagining, and building.
- d) *Video*. This tool permits the use of three types of language: words, sounds, and imagery, which can generate far more information than a single mode of expression can.
- e) *Stories*. Stories motivate children and help them learn about life. They stimulate children's imaginations, enrich their vocabularies, and develop their ability to express what they are feeling and thinking.
- f) *Play*. Play contributes to children's physical and social development, improves their ability to concentrate, perceive, and remember, and serves as an educational tool to help them cope with real-life situations.

When communicating a message about risks, any audience will be made up of a variety of groups with different degrees of knowledge about the risk and varying interest in and exposure to it. Because of this, no single channel of communication can satisfy all of the public's needs. The channel best suited to each group must therefore be found. One good strategy is to have the target group itself decide on the best channels for communicating the messages. There have been experiences using these tools with children living at polluted sites (49,52).

7. **Implementing the risk communication plan:** Activities for this operation must be coordinated. Thus, it is helpful to design an activities schedule, indicating the human and financial resources and infrastructure needed for each activity. For the plan to be effective, the activities must be socially and culturally relevant to the intended audience, so that rather than leading to decontextualized memories or information retention, the information received results in conceptual changes among the receivers that can serve as a foundation for their habits and behaviors in the face of health threats.
8. **Evaluating effects:** Once a risk communication plan has been implemented, it should be evaluated to determine its real impact (55). One way of doing this is by identifying changes in thinking and behavior. If the effects are not evaluated, it is impossible to say whether the plan worked for the target group (i.e., whether it reached the target group, effectively communicated its messages, and fostered a change in behavior and in the perception of the problem).

The techniques described in the step involving evaluation of the target population can be repeated once the plan has been implemented to gauge the increase in knowledge and any behavioral changes. If relevant, the evaluation can also examine exposure to a toxic agent. Strategies may draw on qualitative or quantitative research. The best advice is to use both—an approach known as mixed research. Another basic aspect of evaluation is to triangulate the information obtained from different strategies. This yields more reliable, higher-quality findings.

As indicated in the discussion of risk communication planning, the type of evaluation should be considered from the outset. The factors to be evaluated will depend on the case in question. Table 15-4 shows the factors to be considered, based on the type of risk communication involved.

One important aspect of risk communication (as indicated in the section on the importance of risk communication) is the approach taken to deal with outbreaks, epidemics, and environmental accidents. Professionals in many Latin American countries have received training in this regard. Experience with the influenza A (H1N1) virus in Mexico, however, underscores the need to improve risk communication with different audiences (policymakers, the media, the general public, business groups, etc.) to reduce alarm among citizens, foster acceptance of contingency measures, and ensure an appropriate and timely response to protect the public's health.

**Table 15-4.** Evaluation issues to consider in communicating for concern, consensus, and crisis

<i>Communication for concern</i>	<i>Communication for consensus</i>	<i>Communication during a crisis</i>
Did the public engage in less dangerous behavior?	Were all segments of the public represented, so as to reach a consensus?	Have all members of the public been alerted to the risk?
How long did the modified behavior last?	Does the public understand enough about the risk for informed decision-making?	Does the public understand enough about the risk for informed decision-making?



Have all members of the public been warned about the risk?

Was there a public consensus regarding the decision?

Did the public engage in less dangerous behavior?

Does the public understand enough about the risk for informed decision-making?

Can the decision be implemented? *temperature with the dynamics of Aedes aegypti (L.) development in household vessels, which shows how changes in certain human behaviors reduce vector populations*

Was the information provided consistent with the risk?

Source: Lundgren and McMakin, 2004. p. 379 (36).

Effective crisis communication can help people make informed decisions, reduce anxiety, apathy, or anger, and minimize adverse effects on the economy and societal functioning, ultimately alleviating suffering and saving lives.

In this type of communication, the individual acting as spokesperson becomes a fundamental element in the success or failure of the communication process. That individual must not only be trained to successfully do the job but must also possess personal attributes suited to performing the job. This includes enjoying the recognition and trust of the citizenry; having credibility, empathy, scientific knowledge, and the ability to put that knowledge into simple words; having self-confidence; and having good oral communication skills and appropriate body language.

Several risk communication planning initiatives are currently under way in Latin America, among them projects implemented by Mexico's National Public Health Institute, entitled *Formación de una red de promotores en el distrito magnesífero de Molango, Hidalgo* (56). Since 2004, Central America and the Dominican Republic have been the sites of a project proposed by the ministries of public health, entitled *Estrategia de gestión integrada de prevención y control del dengue*. Colombia's National Health Institute, with support from the country's universities and the University of Florida (United States), implemented in 2007 the project *Interactions of*

*temperature with the dynamics of Aedes aegypti (L.) development in household vessels, which shows how changes in certain human behaviors reduce vector populations* (57). Other past and present work at the Universidad Autónoma de San Luis Potosí (UASLP) in Mexico has included implementing risk communication plans at several sites: a metallurgical area; a site where water was contaminated with fluoride; a mining area in Villa de la Paz-Matehuala (Case Study 15-3);<sup>5</sup> and an indigenous area of the Huasteca Potosina region, where wood-burning stoves are still used for cooking, putting women and children at high risk for respiratory illnesses from exposure to the compounds released when biomass is burned. Links have recently been established among Mexico's Secretariat of Social Development, the National System for Comprehensive Family Development, and UASLP, with a view to executing a joint project to introduce eco-friendly cook stoves in this region. A risk communication plan, designed to gain the community's acceptance, is to be implemented to support the initiative.

### CASE STUDY 15-3. USE OF RISK COMMUNICATION TO REDUCE CHILDREN'S EXPOSURE TO LEAD AND ARSENIC IN THE POLLUTED AREA OF VILLA DE LA PAZ-MATEHUALA, SAN LUIS POTOSÍ, MEXICO

The mining area of Villa de la Paz-Matehuala in San Luis Potosí, Mexico, was the subject of an environmental impact assessment by the Environmental Toxicology Laboratory of the Universidad Autónoma de San Luis Potosí. Mineral concentrations in soils and sediments

were found to range from 19 mg/kg to 17,384 mg/kg for arsenic, 15 mg/kg to 7,200 mg/kg for copper, 31 mg/kg to 3,450 mg/kg for lead, and 26 mg/kg to 6,270 mg/kg for zinc. The study concluded that the soil was the principal source of exposure and that children were most at risk from the exposure. Based on this, a risk communication plan was developed to encourage children to change their habits and behaviors in the face of this environmental problem, so as to reduce their exposure to lead (Pb) and arsenic (As). The plan involved using different media to reach children. Theater, didactic experiments, educational videos, puppet shows, talks, and children's story sessions were organized. Between September 2003 and October 2005, the initiative reached 142 children from five schools in the area. Talks and workshops were also held with parents and teachers from the participating schools. The evaluation of the plan examined knowledge acquisition and behavioral changes through children's drawings and the use of questionnaires. Serum Pb levels and urine As levels were also measured. The evaluation was conducted before and after implementation of the plan. One of the criteria for inclusion in the evaluation was that parents sign an informed consent permitting blood and urine samples to be taken; thus, not all the children involved participated in the evaluation.

An evaluation of the questionnaire found that the children had indeed acquired knowledge from the information provided, indicating that both the message and the media adequately met the objective. The children's drawings

showed that they had acquired knowledge about the source of Pb and As exposure, while the questionnaires administered to parents indicated that the children had made changes in their behavior and habits. Among the behavioral changes were improved hygiene, including cleaning their rooms and toys, no longer eating dirt, and not sucking on their pencils.

In terms of the biological monitoring, urinary As measurements were quantified in 67 children in September 2003, June 2004, and June 2005, and creatinine averages were 16.65, 16.86, and 19.03  $\mu\text{g/g}$ , respectively. The mean levels found in the three samplings were below the threshold level of 50  $\mu\text{g/g}$  of creatinine, while 3% of the children were above the threshold level. No changes in the urinary concentrations of As were detected between the three samplings (before, during, and at the conclusion of plan implementation), perhaps because levels were not high to begin with.

Serum Pb measurements for 60 children in the area in September 2003 and June 2005 were 10.91  $\mu\text{g/dL}$  and 7.97  $\mu\text{g/dL}$ , respectively. In a comparison of the Pb concentration in the blood of each child before and at the conclusion of plan implementation, a paired t-test showed a statistically significant reduction of  $p < 0.001$ , indicating a reduction in each child's exposure to Pb. These results are attributable to the effectiveness of the plan, given that the findings are consistent with changes in the children's habits and behaviors.

This study also revealed that the air, as well as the soil, may be a source of exposure, since it can carry contaminated dust. A new plan has therefore been proposed to address all of the sources and factors. This should be formulated in parallel with other interventions, such as action to stabilize tailings dams.

**Sources:** Coronado Salas, *et al* (58).

*Project supported by Fondos Mixtos CONACYT-San Luis Potosí (FMSLP-2002-4266).*

## ■ Risk communication and social media

Social media are technology-based communication channels used to promote social interaction among people (59). They include a wide range of tools that help people come together online and share information and opinions through chat rooms, instant message applications, blogs, forums, networking websites, etc.

According to eMarketer (60), the number of social network users was expected to increase to 1.43 billion in 2012, representing a 19.2% increase over 2011. Based on this estimate, one out of five people in the world were expected to have used a social network by the end of 2012. Public health practitioners and risk communication experts are just beginning to understand the various impacts of social media on behavioral change and risk prevention, as people only began interacting with these platforms in such large numbers a little over a decade ago.

Recent events, such as the Fukushima nuclear crisis, highlighted how important social media can be for risk communication. Analyzing the role of social media during the 2011 Japanese tsunami and nuclear crisis in Fukushima province, Ng and Lean (61) pointed out that several social media tools such as Facebook, Twitter, and WhatsApp were heavily used for exchanging risk messages and warnings during the crisis. According to these authors, however, such channels were not fully tapped, particularly due to the reluctance of official agencies to use social media for crisis control (they relied more on traditional communication channels such as television and radio to disseminate risk messages). While official agents and public relations officers used the traditional mass media channels to keep the public informed, the general population was using social media intensively to contact parents and friends living in the region, disseminate risk messages from official channels, and share information about the crisis. This communications "mismatch" created a situation of undue stress and distrust of authorities. According to the authors, "while the use of social media in this crisis could have altered significantly the level of trust in authorities and others, two additional points should be considered. One point is the use of plain language versus scientific language in order to reach a wider audience. The other is an urgent need to improve public information especially in the event of a nuclear emergency and to enhance educational efforts and action by improving radiological protection communication from regulatory bodies and international agencies".

Rowel *et al.* (62) posit that low-income populations and other minorities are the most vulnerable groups in a natural disaster. According to the authors, a major determinant of this vulnerability is that traditional (expert-oriented) risk communication systems are ineffective in reaching these population groups, since many are distrustful of government agencies and of those who typically communicate risk messages. A possible explanation is that traditional risk communication initiatives are not based on the social networks and social media normally

used by disadvantaged populations –platforms that are more important for information dissemination than formal channels in these communities.

In our times, social media cannot be overlooked as strategic risk communication tools for specific population groups. These media should increasingly be used for sharing risk messages; bringing risk experts, authorities, and the general population together; and reducing distrust of authorities.

## ■ Conclusions and recommendations

Risk communication is one of the most difficult phases of the risk analysis and management process to successfully implement. Effective communication does not happen by itself but demands dedication and effort.

In order to elicit people's thoughts and opinions about the environmental hazards they face, risk perception studies must be conducted to identify the elements for building a positive relationship with the target audience, while at the same time ensuring the public's participation in developing the messages and in successfully designing the strategies to use in the risk communication plan. This approach fosters the active participation of society in decision-making about risk assessment and risk management and helps strengthen the environment and health sectors.

Fundamental to the process is clearly defining the purpose of the message to be transmitted, particularly in relation to the context and target audience, and making that message the central element of the plan. The message will be successful if it causes the target audience to grasp a danger and take corresponding action to protect its health. The message should be based on a candid, horizontal dialogue between the transmitters and receivers of the message.

It is inconceivable in the present era of information, globalization, and other contemporary phenomena that people lack information about situations that pose a risk to their health and safety. Regional efforts must be launched to promote and support training for journalists interested in covering the environment as a specialized branch of communications work. Moreover, academic institutions that train journalists and communicators should cover environmental issues, with emphasis on environmental health impacts. Furthermore, those charged with developing risk communication plans should draw on the professionals from the various media to improve the process. Lack of adequate, reliable information leads people to seek information from sources whose credibility and professionalism may be doubtful.

The formulation of a risk communication plan should be overseen by policymakers in the environment and health sectors, as well as the agriculture, labor, transportation, and energy sectors. It is essential that these officials continue to communicate and have a clear commitment to the work, which includes participation by the target audience and skilled personnel and the negotiation of funding. The work should be both inter- and intrasectoral, with support from academia to ensure its consistency, viability, and impact. In addition to empowering the population by providing information and promoting action to protect its health, these plans should help restore and/or maintain confidence in institutions and authorities.

Training human resources is vital to developing this area of work in health and the environment. It ensures a supply of trained professionals in this field while increasing the number of work options for graduates. Training outside academia should also be promoted.

Significant attention should be given to understanding how the current and ever-increasing access to direct, immediate, and simultaneous information is shaping approaches to risk communication and health education. The goal of these efforts is not only to predict the potential effects of such information availability on actors in the field of communications but to take full advantage of the situation in designing communication strategies.

The information and knowledge produced about the relationships between health and nature should be made freely available to all in an accessible, simple, and reliable manner –especially to those responsible for safeguarding public well-being.

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## ■ Notes

- 1 In some cases, risk communication in general is involved and is promoted by universities or the private sector in the form of continuing education, master’s degree programs, or programs for government personnel.
- 2 Some 71% of the countries indicated that the communication took place at the outset of the risk assessment process; 14% conducted it once the risk assessment had been completed; and another 14% did so while drafting regulations.
- 3 Argentina, Colombia, Ecuador, Guyana, and Paraguay, in addition to groups in Bolivia, Brazil, Chile,

El Salvador, Guatemala, Mexico, Panama, Peru, Uruguay, and Venezuela.

- 4 For example, the Rede Brasileira de Jornalismo Ambiental (the oldest, with over 300 members), the Red Mesoamericana, the Society of Environmental Journalists/Sociedad de Periodistas Ambientales, Red Mexicana de Periodistas Ambientales (PAL-NET), Asociación Argentina de Periodistas Ambientales, Asociación Paraguaya de Periodistas Ambientales, Jornalismo Ambiental, O Eco Planeta Azul, and Red de Periodistas Ambientales de Costa Rica.
- 5 All of these projects have obtained support from Mexico's National Science and Technology Council (CONACYT).

# Consumer health protection: A basic civil right

Ana Evelyn Jacir de Lovo  
Neilton Araújo de Oliveira

## ■ Introduction

This chapter outlines the challenges currently faced by providers, consumers, academia, consumer protection agencies, health authorities, and public policymakers in general in strengthening and guaranteeing consumer health protection.

It describes how human health is affected by the quantity and quality of goods and services that consumers acquire in the marketplace, highlighting the need to coordinate international and interinstitutional efforts to effectively protect consumer rights, particularly their right to health and safety.

Special attention is given to the changes wrought in recent decades by the globalization of production, trade, and consumption, as well as the advent of new technologies that transform and complicate the task of guaranteeing consumer health.

Through the exploration of these issues, it outlines some of the major consumer health risks in areas ranging from food, nutrition, and medicines to advertising, product labeling, and the safety of non-food products, proposing important public policy measures that should be adopted at the national and hemispheric level to minimize or prevent the negative impacts of these risks on consumer health.

## ■ Safe consumption: A social, cultural, and economic determinant of health

Health is the basic right of every human being. Since it is increasingly understood as the product of multiple social, political, economic, environmental, and cultural determinants, a multisectoral health care approach is required to effectively safeguard it (1).

In March 2005, the World Health Organization (WHO) created the Commission on the Social Determinants of Health, declaring that the “structural determinants and conditions of daily life [are] responsible for a major part of health inequities between and within countries. They include the distribution of power, income, goods and services, and the circumstances of people’s lives, such as their access to health care, schools and education; their conditions of work and leisure; and the state of their housing and physical environment. The term ‘social determinants’ is thus shorthand for the social, political, economic, environmental and cultural factors that greatly affect health status” (2).

The Commission issued three main recommendations: “a) improve daily living conditions; b) tackle the inequitable distribution of power, money and resources; and c) measure and understand the problem and assess the impact of action.”

This approach was reaffirmed in the Rio Political Declaration on the Social Determinants of Health, in which the WHO Member States expressed their “determination to achieve social and health equity through action on the social determinants of health and well-being through a comprehensive intersectoral approach” (3). The Declaration emphasized that health equity is a shared responsibility and requires the engagement of all sectors of government and society and all members of the international community in “health for all” global action.

The Declaration contains five critical priorities for combating health inequity:

- i. *Adopt better governance for health and development;*
- ii. *Promote participation in policy-making and implementation;*
- iii. *Further reorient the health sector toward reducing health inequities;*
- iv. *Strengthen global governance and collaboration;*
- v. *Monitor progress and increase accountability.*

Within this framework, a fundamental health determinant is safe consumption: consumer’s lives may be at risk if the goods and services on the market are unsafe. In the United States, for example, an estimated 36 million consumer accidents occur annually, with a cost to society of US\$1 billion and some 34,500 deaths.

Increasing globalization and dematerialization of the markets, intensified by ecommerce, makes it difficult to know the origin of a particular product or service and the conditions under which it is produced. It is now more necessary than ever to pursue the complex task of overseeing and monitoring the safety of products in the market.

Moreover, modern lifestyles characterized by growing levels of stress, eating disorders, and lack of physical exercise, combined with globalized consumption patterns, economic determinants of consumption (e.g., price, quality, income), cultural patterns, personal identity, social contexts, and the influence of advertising, are creating new health problems such as chronic diseases, obesity, and hypertension. We now know for sure that the eating habits acquired during childhood can trigger these diseases in adulthood, as does the consumption of foods high in salt, sugar, and fats.

As Sara Busdiecker notes, food is a source of energy and biological nutrients for human beings and is also an economic good and a social and religious symbol. Due to its multiple roles, it should be studied from the standpoint of the sociocultural, biological, and economic-political environment. In examining the role of food, multiple socioeconomic and cultural variables, over and above the purely biological aspects, need to be assessed (4). It follows that since food is an important health determinant, as well as a circulating economic good, its behavior in the markets must be explored –a conclusion that is equally valid for all consumer goods and services.

The market is the principal mechanism for accessing goods and services. While it can be argued that large numbers of people living in poverty do not have enough income to meet their needs, many nevertheless obtain at least some of the products they need in the market.

In line with the above-mentioned criteria and considering how the concept has evolved, it can be concluded that “safe consumption” is definitely a social determinant of health, since health is determined by the quantity and quality of the goods and services that people consume and use, and especially by their food, lifestyles, and consumption patterns.

Since most people purchase consumer goods and services in the markets, consumer product safety monitoring is essential for protecting consumer health.

In addition to their impact on people’s health, consumption patterns linked to lifestyles have direct implications for the sustainability of development because of their impact on the environment. The Organisation for Economic Co-operation and Development (OECD) defines sustainable consumption as “the use of goods and services that respond to basic needs and bring a better quality of life, while minimising the use of natural resources and toxic materials and emissions of waste and pollutants over the life-cycle, so as not to jeopardize the needs of future generations” (5). When designing consumer health policies, therefore, the focus should be on promoting sustainable consumption, preventing negative impacts on natural resources, and ensuring the raw materials and food supply for future generations.

While suppliers must ensure clean production using more ecologically efficient methods, consumers must also give preference in their purchasing decisions to “green” products and to goods and services that do not harm

the environment. This trend can be observed, for example, in the current U.S. government's efforts to promote the manufacture and use of more efficient, less polluting vehicles.

UN General Assembly Resolution 66/288, entitled *The future that we want* (6), adopted at the Río+20 Conference, reaffirmed this by recalling to the Member States the commitments made in the Rio Declaration, Agenda 21, and the Johannesburg World Summit Implementation Plan in regard to sustainable production and consumption, and by acknowledging that in order to achieve global sustainable development, fundamental changes in the way societies produce and consume are essential.

## ■ Actors responsible for consumer protection

Although suppliers are responsible for ensuring that the products they offer meet minimum safety standards, it is the State's role to ensure that the goods and services circulating in the market do not endanger consumer health.

Most consumer protection legislation stipulates that suppliers (i.e., those involved in the production, manufacture, importation, supply, construction, distribution, rental, facilitation, transformation, storage, transportation, marketing, or contracting of goods, and in the delivery of services to consumers) have at least three responsibilities:

- To guarantee that the goods and services marketed to consumers do not pose a risk to their lives, health, or safety, or to the environment.
- To report risks to health, safety, and the environment that the use of the products could pose.
- To ensure that the accompanying instructions for use contain the necessary warnings, indications, and annexes to ensure that consumers have as much information as possible on the safety of a given product.

Some legislation states that once a product has been put on the market, if it is found that its use may pose a health hazard or risk, the supplier must inform the competent authority and the public, recall the product, and accept returns.

In view of these provisions, it is important for governments, businesses, and consumer organizations to develop effective monitoring and control systems with rapid alert mechanisms based on information systems and analyses of the risks posed by the consumption of certain goods and services.

Since the 1970s, suppliers, consumers, civil society organizations, and governments have launched initiatives to create mechanisms for differentiating products through voluntary environmental and quality certifications issued by third parties with the aim of promoting good manufacturing practices. The most important certifications are the "green" or "eco" seals or badges, which are issued to products that reduce negative health effects during the manufacturing or production stage and their useful life at the moment of consumption, and that also minimize the generation of waste. These quality seals, together with certifications such as "ISO," guarantee that the products that display them meet the legal and technical standards established for their production.

In addition to the aforementioned self-regulation mechanisms, it is also necessary to strengthen market surveillance. The market is not perfect. Although trade is as old as humankind and benefits everyone (by enabling consumers to obtain the goods and services that they need without actually producing them), private incentives are not always in alignment with social costs and benefits. In other words, the pursuit of personal interests does not necessarily result in the well-being of society as a whole (7).

## ■ Imbalances of power and new challenges in consumer relations

Empirical evidence and economic theory point to market inefficiencies caused, *inter alia*, by the way in which businesses are structured (monopoly, oligopoly, etc.), externalities, and the globalization of trade and production. Other contributing factors are cross-border trade and telemarketing driven by the new technologies, the ethical behavior of market agents, transaction costs, and inequalities stemming from lack of access to information.

George Akerlof, Michael Spence, and Joseph Stiglitz shared the 2001 Nobel Prize for Economics for their studies on the consequences of asymmetric information on market operations. The prize was an acknowledgment that markets do not function efficiently if the sellers of a product know more than the buyers. This market defect was illustrated in Akerlof's celebrated article on the used car market, "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism" (8).

In this same vein, Greenewald and Stiglitz (9) also highlighted the existence of significant defects in market operations, especially in the developing economies, where information is imperfect and the markets are incomplete. Stiglitz (10) argues that government intervention is needed to correct marketing defects (especially unsatisfactory product instructions) that can cause immediate harm to consumers. The two key issues are: consumer health hazards arising from deficient product information, and the failure of some service providers and producers of food, drugs, and certain other manufactured products to meet technical standards and requirements.

Institutional and regulatory frameworks emphasize that consumers have a basic right to safe goods and services that do not endanger their health and lives. This right, however, is not automatically guaranteed. Doing so requires the health authorities, consumer protection agencies, and other bodies responsible for market regulation to join forces to ensure that the market functions properly. This is precisely what obliges government authorities and consumers to be vigilant in identifying, preventing, and combating business practices that can endanger consumer health.

On 15 March 1962, then U.S. President John F. Kennedy sent a message to Congress in which he said that consumers “are the largest economic group in the economy, affecting and affected by every public and private economic decision... But they are the only important group in the economy whose views are often not heard.” Kennedy also mentioned four basic consumer rights: the right to safety –to be protected against the marketing of goods and services hazardous to health; the right to be informed; the right to choose, and the right to be heard (11). Based on this declaration and the rights added by the consumer movement, headed by *Consumers International* (known at the time as the *International Organization of Consumers Unions*–IOCU), the United Nations General Assembly institutionalized these rights by approving the Consumer Protection Guidelines in 1985.

The UN Guidelines, updated in 1999, recognize that consumers often face imbalances in economic terms, educational levels, and bargaining power. Governments should therefore guarantee them the right of access to non-hazardous products. The first guideline guarantees the physical safety of consumers, stating that appropriate measures need to be adopted to ensure that products are safe and that consumers are provided with instructions for their proper use and any information about potential hazards (12).

The first guideline states that “in advancing consumer interests, particularly in developing countries, Governments should, where appropriate, give priority to areas of essential concern for the health of the consumer, such as food, water and pharmaceuticals. Policies should be adopted or maintained for product quality control, adequate and secure distribution facilities, standardized international labelling and information, as well as education and research programmes in these areas” (9).

Despite this regulatory progress, the task of guaranteeing product safety and legal equity, certainty, and security for suppliers and consumers has become increasingly complex for a number of reasons, especially the following:

- *The globalization of production and trade*, which alters frameworks and consumption patterns and tends to supplant traditional national consumption habits. For example, the consumption of corn and beans is gradually giving way to food with high salt, sugar, and fat content. Global production and consumption of such products make it more difficult for States to ensure that they are safe for consumers.
- *The new information technology (e.g., telematics)*, which dematerializes trade and consumer relations. With the advent of e-commerce, it is no longer necessary to go to a bank to pay a bill or to visit a shopping center or market to buy something. Products can be seen and bought in real time over the Internet, with no physical contact at all with the supplier.
- *Biotechnology*, which boosts productivity and adapts “natural” products to the needs of consumers and suppliers. For example, biotechnology increases the production of chicken breasts by reducing poultry fattening time. Furthermore, additional research and information is required on the production and consumption of transgenics and their potential negative health impact.

## ■ The need for national and international cooperation

In this increasingly complex globalized scenario, it is hard for individual States in isolation to successfully combat poor practices and threats to consumer health and safety. Cross-border efforts must therefore be scaled up to prevent and address real or potential risks to consumer health.

Sharing information, experiences, and institutional capacities is essential for safeguarding consumer health and safety. This joint approach is doubly important in the developing countries, with their weaker institutions and more limited resources.

At the national level, there are various institutional mechanisms for monitoring the safety of products circulating in the national, regional, or global market. The countries have health, agricultural, and other specialized authorities (e.g., food, water, energy), as well as consumer protection agencies and bodies that set and enforce product quality standards.

However, interinstitutional coordination and the creation of synergies are hindered by the fact that responsibilities are divided among a plethora of institutions and different levels of authority.

Aware of this challenge, the OAS and PAHO are working together at the inter-American level to promote an integrated approach to consumer health protection and safety, based on the premise that any initiative in this area must be an interinstitutional effort involving many State agents, civil society, and international organizations. The first step, in 2009, was to hold a regional workshop for experts from government consumer protection agencies, health authorities, Consumers International, and other consumer organizations (13) to identify the main challenges to consumer health. This workshop yielded a series of recommendations covering the minimum requirements and action modalities needed in a program for the prevention and control of risks to consumer health and safety, with at least three basic objectives:

- To guarantee the safety of goods and services available in the market.
- To improve consumer information and education to boost consumer decision-making capacity.
- To raise awareness among the authorities and coordinate their activities both nationally and regionally.

The following section outlines the ideas and concerns expressed during the workshop. However, the authors are solely responsible for the line of argument.

## ■ Areas of consumption that pose the main threats to health

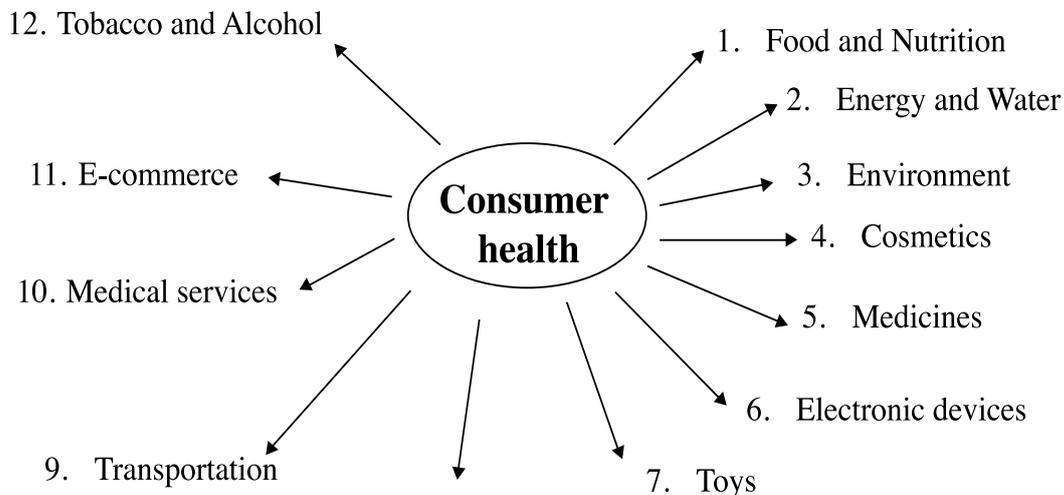
The wide range of consumer products, limited resources, and the breadth of consumer rights (from protection against economic loss to the protection of life and health) mean that the intervention areas need to be ranked in order of priority.

The main priority is to focus on activities that constitute imminent and irreparable threats to consumer health, as well as those that affect large populations or potentially vulnerable groups such as children, the elderly, or persons with disabilities.

The product areas that entail greater health risks to consumers include food and nutrition, drugs, cosmetics, children's articles (toys, clothing, and personal care items), electrical appliances, vehicles, and health services.

It is important to point out that the safety of goods and services is not guaranteed solely by the quality of the item for sale. Other factors are involved, among them the amount consumed, the context in which the item is consumed, and the use to which it is put, as well as the age and health status of the consumer (Figure 16-1).

Figure 16-1



Despite the need for priorities with objective and quantifiable parameters, few countries have the methodologies for determining them. The majority of them set priorities on the basis of institutional experience and/or the record of accidents caused by the use of goods and services.

A wide range of health problems can be caused by unsafe products, poor consumer decision-making, market imperfections, and/or the lack of market oversight by the competent government authorities.

The following are examples of these consumer health risks. In all the cases indicated, the authorities and consumer protection organizations play a key role in informing and educating consumers, thus helping to prevent and combat the growing number of cases of chronic disease and/or risks to the health and lives of consumers.

## Food and nutrition

Health authorities and consumer protection organizations and agencies agree that while malnutrition has devastating effects, especially among children under 5, poor nutrition (excess sugar, salt, and fats) is leading to obesity and a higher incidence of chronic diseases. An unhealthy diet is one of the main causes of heart disease, diabetes, and certain cancers, all of which are on the rise, even in low- and middle-income countries. This consensus has broadened and become clear in the Pan American Forum for Action on NCDs, recently created by PAHO (14) to promote the adoption of appropriate measures in widely diverse countries in the Hemisphere.

This Forum estimates that 250 million people are living with chronic diseases in the Americas: “Every year chronic diseases cause the deaths of 4.5 million people, representing 77% of total deaths in the Region. The number of deaths is expected to increase by 53% by the year 2030. Human suffering and financial costs will be enormous, but these deaths are almost totally preventable.”

Cardiovascular diseases in the United States alone incur an estimated annual cost of \$448.5 billion, while the direct and indirect costs of diabetes in Latin America and the Caribbean represent an estimated \$65 billion. These figures are supported by PAHO (see Table 16-1).

**Table 16-1.** Chronic diseases

Chronic disease is now the overall major health challenge facing the countries of the Americas when measured in terms of premature loss of life and avoidable health costs. Examples include:

- a. A total of \$448.5 billion spent on cardiovascular diseases (CVDs) in the United States in 2008.
- b. In Chile, \$200 million spent annually on dialysis, due mostly to diabetes and hypertension.
- c. In Central America, catastrophic diseases account for the largest share of health expenses.
- d. An estimated \$65 billion spent annually, in direct and indirect costs, on diabetes in Latin America and the Caribbean.
- e. In the United States, cardiovascular disease costs more than 300 billion dollars a year.
- f. In the Caribbean, studies commissioned by the special CARICOM Heads of Government Summit on chronic diseases estimate the economic impact of diabetes and hypertension alone to be at 5-8% of GDP.

**Source:** PAHO, PAHO, Fact Sheet: Chronic Diseases in the Region of the Americas, 30 November 2009.

Mention was made in the Forum about the quality and cost of health care, and the lack of access to health care by people with no health insurance. As healthcare costs rise, preventing chronic diseases becomes increasingly important and can yield substantial social and individual benefits. Effective consumer education and information can play a key role in disease prevention.

Some 80% of the Latin American and Caribbean population currently lives in urban areas, which has led to major changes in people’s diets (15). For example, “traditional” food is being supplanted, especially among city-dwelling children and adolescents, by junk food with a high sugar, fat, and salt content. One striking example is

Mexico, where the population has the highest calorie intake in the world due to excessive consumption of high-calorie nonalcoholic beverages (16).

Another consequence of growing urbanization is the higher demand for processed foods (pre-prepared, pre-cut, and pre-cooked with a long shelf-life) and greater consumption of foods that are modified, fortified, and contain additives and even foods for special diets with reduced fat, salt, calories, and sugar. An external PAHO study suggests a further explanation for these changes in diet: the nearly 40% increase in the gross price of fresh fruits and vegetables in the United States since 1985, coupled with lower prices for sweets, fats, oils, and soft drinks. This has led to greater consumption of many high-calorie products and lower fruit and vegetable consumption, particularly among low-income population groups (17).

Another important factor that an intersectoral consumer health protection program needs to address is the use of hormones, antibiotics, pesticides, and other chemicals in livestock production and agriculture in general. These substances can have adverse health effects. For example, their excessive use, abuse, and misuse can leave traces in food for human consumption, causing acute poisoning and chronic effects such as endocrine disorders, cancers, liver necrosis, congenital deformities, and peripheral neuropathies. Some pesticides can have cumulative long-term effects because their biotransformation is very slow. Health authorities are responsible for setting appropriate standards to ensure the safety of such products.

## Drugs

Access to drugs is as important as their safety and efficacy. The pharmaceuticals market differs from other markets because of the way its stakeholders make decisions. The people who use medications are not those who decide what they should take and sometimes are not those who actually pay for them. Furthermore, the agencies that finance these purchases (government, social security, and private insurance) are not in a position to decide what should or should not be taken.

Pharmaceutical use is therefore mediated by the prescriber (physician or dentist) at the time a prescription is written. Since this practice differentiates drugs from other products on the market, advertising, although designed to reach a wider public, mainly targets physicians.

From a strategic standpoint, there is a need to explore specific measures to help prescribing physicians recommend drugs that are safer, more effective, and have a better cost-benefit ratio. Efforts should also be made to stress the need for drug prescribers and dispensers to provide consumers (i.e., patients) with all the necessary information about how to use the drugs, their side effects, and any contraindications and restrictions.

The pharmaceutical industry is one of the most information-asymmetric sectors. This asymmetry mainly involves brand names and trademarks registered for products manufactured with the same active ingredients. This creates considerable confusion among prescribers and consumers alike. While the industry usually possesses all the data about a product, the prescribers or consumers must often rely solely on the information that the drug companies choose to provide (18).

While it is important to promote strategies to improve access to drugs, there is also a need for drug policies under which States are responsible for guaranteeing access to good quality essential drugs and ensuring their rational use. Consumer lobbying groups can play a key role in ensuring that such policies are explicit and enforced. Two key challenges are prioritizing essential drugs and developing strategies to foster the use of generics.

PAHO has acknowledged the importance of promoting access to basic medical products and ensuring their permanent availability to reduce mortality and morbidity in the Region, noting that it is necessary to develop transparent mechanisms to evaluate and disseminate information on drug pricing in the countries, whether in a competitive or exclusive context, to reduce the existing information asymmetries.

Transparency in the drug market is also vital for ensuring that the consumer is informed and in a position to make better decisions. Consumer organizations can play a key role in this initiative. Coordinating efforts in this area will multiply institutional capacities without infringing on powers. Consumers should actively participate in this initiative to ensure greater transparency and relevance in management of the PAHO Strategic Fund (see Table 16-2).

**Table 16-2** PAHO Strategic Fund.

The PAHO Strategic Fund is designed to provide added value for countries in three important ways:

- Concentrating technical support for countries in the planning of procurement, distribution, and anticipation of future demand for essential medicines and basic products for public health;
- Ensuring the procurement and supply of basic, quality products for public health through the implementation of quality assurance standards
- Facilitating communication and coordination between suppliers and participating countries in order to increase the availability and accessibility of these products

*Source:* PAHO, Fact Sheet: Chronic Diseases in the Region of the Americas, 30 November 2009.

Another important goal is to provide consumers with relevant information about the adverse reactions (ADR) that certain biological products and medicinal and traditional plants can produce to prevent potential harm. Users of these products must be encouraged to report any adverse symptoms associated with their use of a particular product. Consumers and consumer organizations can play a strategic role in the early detection of adverse reactions or side effects, thereby helping to create an ADR reporting culture.

Timely and effective surveillance of adverse drug effects requires institutionalized channels and skillful coordination between the relevant authorities.

The trade in over-the counter medicines, encouraged by aggressive and sometimes misleading advertising campaigns, encourages the use of drugs of dubious quality, for which adequate information about their composition and potential effects is not available.

An example of this with fatal consequences is worth mentioning. In Panama, a cough syrup and toothpaste, both containing diethylene glycol (DEG), caused the poisoning deaths of over 100 people. In the case of the cough syrup, the Panamanian health authorities were believed to have purchased DEG under the mistaken impression that it was glycerin and used it in the manufacture of medications and syrups. DEG is in fact a solvent used for automotive equipment and as a cleaning agent, and is normally used as a cheap substitute for glycerin in products such as soap and toothpaste. A number of Latin American countries (Colombia, Costa Rica, Nicaragua, Panama, and the Dominican Republic) have reported imports of toothpaste contaminated with DEG (19).

## Advertising

The mass media affect all areas and lifestyles and especially consumer behavior. The number of hours that individuals, particularly children, spend each day watching television and using other communication devices, and the power of the images and explicit or subliminal messages that appear on the screen, influence conscious and unconscious purchasing decisions.

Advertising is an important resource for persuading consumers. One example is the advertising of food supplements, cosmetics and other so-called natural or medicinal products that, according to the ads, are miraculous, almost magical products for instantaneously improving a person's health or physical appearance. This type of advertising is so effective that it occupies much of the space on television, the Internet, radio, and in the press. In the food area, advertising has resulted in a shift from traditional foods to processed products that often contain high levels of salt, sugar, and fat.

Advertising aimed at children is particularly dangerous. Children are more vulnerable to advertising because they are less capable than adults of understanding that the goal is not to inform but simply to persuade people to buy products or services. Advertising aimed at children tends to promote foods and beverages that can for the most part be classified as junk food. Advertisers are occasionally guilty of conveying misleading messages about "healthy" lifestyles.

## Labeling

Labels are a means of communicating basic information about goods and services. Consumers can use this information to select the product they want for taste, convenience, or health reasons. Manufacturers use labels to

provide consumers with information about their products and to distinguish their products and brand names from those of their competitors.

The label that accompanies a product should be clear and understandable so as not to mislead or leave any doubt about a product's nature, identity, quality, composition, quantity, shelf-life, origin, provenance, or method of manufacture. The label must be prominently placed and be indelible and unalterable.

Cosmetics, for example, may appear to be in good condition for years but can deteriorate or be contaminated by microorganisms, which can cause irritation or allergies. To address this problem, many countries are requiring that cosmetics labels indicate the maximum period of use once the product has been opened. Unlike with food products, no expiration date is indicated, only the period in months or years from the date the product is opened.

Labeling standards are extremely important for ensuring safety in the food, cosmetics, and pharmaceuticals market, since lack of appropriate information can have detrimental effects on health. Thus, it is important for suppliers to comply with the relevant technical standards and regulations and that compliance be overseen by the competent authorities (see Table 16-3).

**Table 16-3**

In accordance with MERCOSUR technical regulations on the nutritional labeling of packaged foods (MERCOSUR/GMC/RES. No. 46/03):

Unless otherwise indicated in this technical regulation or in a specific technical regulation, the labeling of packaged foods must include the following information:

- Sales description of the food
- List of ingredients
- Net contents
- Place of origin
- Company name and importer's address (for imported foods)
- Batch identification number
- Expiration date
- Instructions for preparation and use of the food, where appropriate.

### Non-food products: Electrical equipment, electronics, and toys

Manufactured goods capable of endangering consumer health and safety should be subject to strict controls and surveillance conducted either through verification tests done in specialized laboratories or quality studies. An example of this was the discovery of lead-based paint in certain toys being sold around the world. The suppliers themselves eventually withdrew the toys from the market and issued a recall (20).

It is important for consumer protection agencies to develop their own investigative and research capacities. It is also vital to promote cooperation agreements at the national, regional, and global levels among counterparts, academia, the private sector, and specialized international organizations. The purpose of this cooperative effort would be to avoid repeating mistakes and to put the proper controls in place before any harm is done, with the competent authorities sharing relevant information about the health hazards of a product so that they can take appropriate action without delay. This information exchange is greatly facilitated today by worldwide connectivity and the globalization of production and trade.

It is necessary to maintain up-to-date databases of the scientific findings in connection with specific products and to disseminate these findings to consumer protection agencies and health authorities. One example of this approach is the research on the health risks of low-frequency electromagnetic fields (21).

Another important way of increasing the safety of goods and services is to create a statistical database on accidents caused by consumer products. The NEISS (*National Electronic Injury Surveillance System*) in the United States, for example, has proven useful in this respect. Operating under the Consumer Product Safety Commission (CPSC), the NEISS makes it possible to calculate the total number of injuries associated with a specific product

and, armed with the relevant information, the CPSC can work with suppliers to reduce the risk of injury. The data collected by the NEISS is also used for conducting studies, organizing public awareness campaigns, and setting product safety standards (22).

## ■ Tools for action: Rapid alert systems for consumer product safety

Rapid alert systems are used by the competent authorities to share information about harmful consumer products both within and among countries, as a prelude to adopting effective, coordinated, and proactive measures for recalling such products from the market or prohibiting their entry, thus avoiding or minimizing potential threats to consumer health and safety.

This type of system requires coordination among the health authorities, consumer protection agencies, metrology and quality assurance institutes, customs authorities, and other State agencies, so that risks can be detected and joint action quickly taken.

Rapid alert systems are particularly important in an increasingly globalized market, especially in developing countries or island nations that import most of the products consumed.

The European system is the most advanced regional rapid alert system. According to the European Commission, the European Union guarantees consumer safety with a system that alerts the public to hazardous products. EU legislation guarantees that the products for sale are safe and produced under fair conditions. The Commission has a rapid alert system (RAPEX) to track all products hazardous to consumers, except for food, pharmaceuticals, and medical devices. If a product is considered hazardous, RAPEX rapidly circulates the information to the 30 participating countries so that they can halt or restrict its distribution (23).

Meanwhile, in the Americas, Hemisphere-wide cooperation and institutional strengthening have resulted in the launch of a regional rapid alert system within the framework of the *OAS Consumer Safety and Health Network (CSHN)*, in partnership with PAHO.

Within this framework, the OAS Member States have begun to design and implement national interinstitutional product safety surveillance and alert systems. The systems are now in various stages of development in Brazil, Canada, Ecuador, El Salvador, Mexico, Peru, and the United States (see Annex 16-1). Regional developments are described in greater detail below.

## ■ The Inter-American experience

### *The Consumer Safety and Health Network (CSHN)*

In an increasingly globalized, dynamic, and complex market, where it is hard to determine the origin of products and where suppliers often have no direct contact with the products they sell, there is an urgent need to improve the ability to identify products that could pose risks to consumers and recall them from the market. This is becoming increasingly urgent since, as the more developed economies of the world heighten their surveillance and enforcement of consumer product safety, unscrupulous suppliers are likely to divert hazardous products to regions with lower levels of protection, less coordination among national agencies, and less cooperation among jurisdictions.

Countries must therefore develop interinstitutional responses involving the agencies and institutions charged with market surveillance. Moreover, parallel measures must be coordinated at the regional level, so that an alert about an unsafe product in one country can quickly be communicated to the other countries through a neutral agency. In this way, steps can quickly be taken to keep the product from entering the market or to take it out of circulation if it has already done so.

Through an interdisciplinary dialogue launched in 2009, the OAS Member States concluded that consumer protection involves much more than economic factors and calls for a comprehensive approach to protect rights and promote the full exercise of citizenship. At the same time, acknowledging that consumption is a social determinant of health, the OAS formed a partnership with PAHO.

In the light of the above, the OAS General Assembly adopted successive resolutions (24) that led to the creation and implementation of the Consumer Safety and Health Network and collaboration among the Hemisphere's consumer product safety authorities.

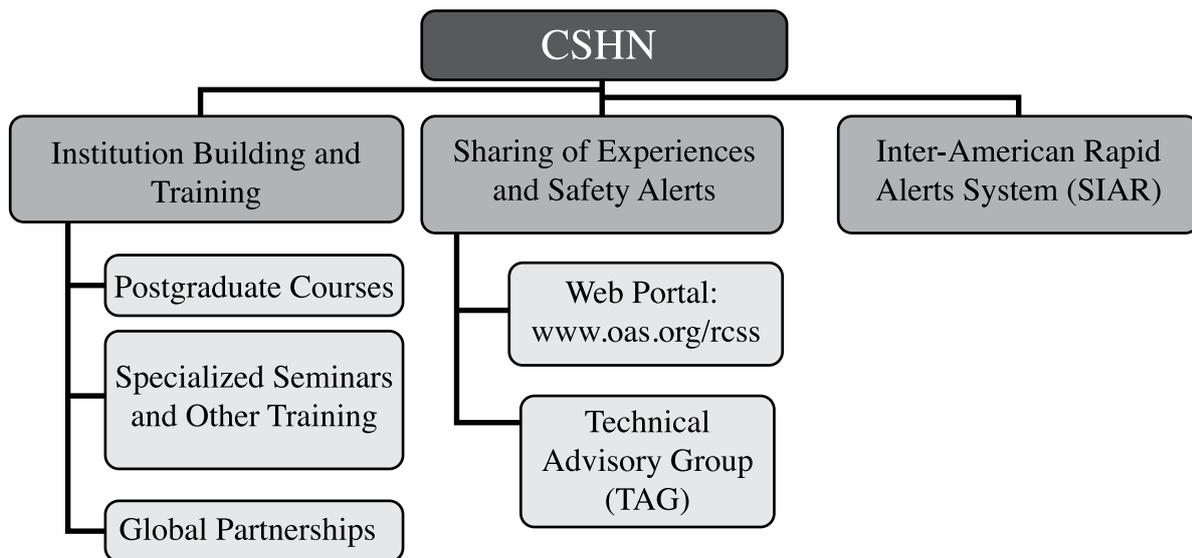
The CSHN gives concrete expression to the desire of the OAS Member States to create a framework for cooperation in product safety to guarantee consumer health and well-being by strengthening market surveillance capacities at the national and hemispheric level.

The Member States' strategy is to consolidate the sharing of experiences, training, institutional strengthening, and the region's international profile through the CSHN to ensure that consumer health and safety become priorities on the public policy agenda. A further goal is to gradually create a common language to harmonize product safety criteria, thereby contributing to more predictable, transparent, and competitive trade relations within the Hemisphere.

The CSHN has three strategic lines of action:

- 1) Institution building through consumer health and safety education and training for agents.
- 2) Dissemination and promotion of information exchange on consumer health and safety, with an Internet portal to receive and disseminate safety alerts.
- 3) Establishment of an Inter-American Rapid Alerts System for Product Safety (SIAR).

**Chart: Components of the CSHN**



The CSHN provides countries with a regional technical cooperation mechanism to combat the circulation of unsafe products in their markets. The CSHN has, *inter alia*, promoted and supported the creation and/or strengthening of national market surveillance systems for consumer product safety, trained hundreds of experts and officials, and administers the only existing Internet portal for regional safety alerts in the Americas.

In June 2014, Resolution AG/RES. 2830 (XLIV-O/14) of the OAS General Assembly established a management structure for the CSHN that responds to the mandates and guidelines established by the General Assembly and is accountable to the appropriate OAS political bodies. This resolution also established a Plenary, a Management Committee, and a Technical Secretariat as technical bodies.

The Plenary is the supreme authority of the CSHN. Participation in Plenary meetings is open to all competent national agencies. However, each Member State must exercise its vote and interact with the CSHN through a "Representative Authority" appointed by each government. The Management Committee, elected to exercise permanent leadership of the CSHN, consists of a chair, two vice-chairs, and two member delegates and endeavors to reflect and respect the principle of equitable geographic representation. The General Secretariat of the OAS (SG/OAS), in partnership with PAHO, serves as the Technical Secretariat.

The CSHN has supported the creation and consolidation of national efforts to improve consumer health and safety. Countries that up to a few years ago had neglected this area have now made it a priority. Brazil, for example, currently has a CSHN that operates at the federal, state, and local levels through an agreement between the Ministries of Health, Justice, and Industry; Chile and Colombia have established a national consumer health and safety working group; Ecuador, El Salvador, and Mexico have created modern alert systems for defective products, while Costa Rica, Panama, Peru, and Uruguay are making progress in that direction; and the Dominican Republic has established a Quality Observatory within the framework of the CSHN. Meanwhile, Brazil, Chile, Colombia, the Dominican Republic, Ecuador, and Peru have introduced legislative and institutional changes to boost their capacity to monitor product safety in their markets.

The CSHN has been developing rapidly, especially since the launch of the rapid alerts portal on the OAS website ([www.oas.org/rcss](http://www.oas.org/rcss)) in November 2010. It has furthered national capacity building and regional cooperation on product safety and is now considered a key player in specialized regional and global forums.

Thus, the Region has gained greater visibility and insertion in the global economy through the strategic partnerships formed both internally and externally: OAS-PAHO, the European Commission, the Organisation for Economic Co-operation and Development (OECD), the Caribbean Community (CARICOM), the Central American Council for Consumer Protection (CONCADECO), MERCOSUR, and the United Nations Conference on Trade and Development (UNCTAD). In addition, the CSHN is increasingly active in specialized regional and global forums such as the International Consumer Product Health and Safety Organization (ICPHSO), the International Consumer Protection and Enforcement Network (ICPEN), the Ibero-American Forum of Government Consumer Protection Agencies (FIAGC), and the International Consumer Product Safety Caucus (ICPSC).

### *The Inter-American Rapid Alerts System*

The core instrument for the CSHN's hemispheric cooperation is the Inter-American Rapid Alerts System (SIAR), the first integrated hemispheric system for the rapid and secure generation, management, and sharing of information on consumer product alerts, based on shared principles, general concepts, and relevant terminology.

The SIAR is supported by an advanced IT platform with an open access module for the public and a restricted, secure access module for duly authorized government authorities (25). CSHN member states are currently implementing the first stage of the SIAR.

This secure exchange of information enables countries in the Americas to adopt more effective and proactive measures to prevent hazardous products from entering their markets. It also provides a framework for working with suppliers to promote a voluntary culture of consumer product safety alerts and measures.

## ■ Looking ahead: Main challenges and issues

The globalization of production and trade, together with the dematerialization of trade relations fueled by the new technologies, are the main challenges for guaranteeing the right to safe and informed consumption.

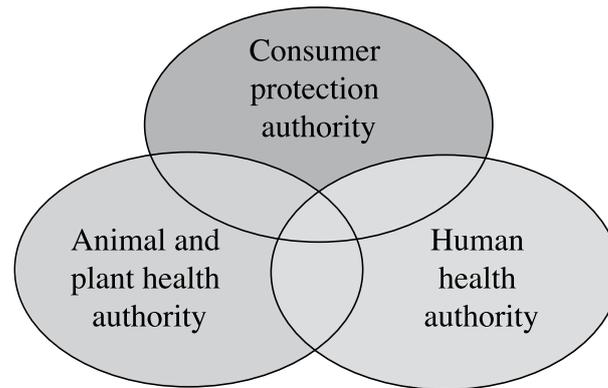
In order to respond to these developments, it will be necessary to strengthen institutions and harmonize, update, and/or create regulatory frameworks capable of protecting consumers, while encouraging market players to participate in the development of a new economic culture.

### **Institution building and interinstitutional coordination**

It is clear from the examples in this chapter that the wide range of health risks must be addressed not only by the competent authorities but by consumers, consumer organizations, and business.

Given the intersectoral nature of these risks, effective interinstitutional coordination, at least among the sanitary authorities, official consumer protection agencies, and consumer organizations, is essential. For example, to produce and distribute safe food, the health authorities, animal and plant health surveillance agencies, and consumer protection associations must coordinate their efforts –e.g., poultry plants producing vacuum-packed chicken for sale to the public must be inspected by the animal health authority; health authorities must ensure good production practices; and consumer protection agencies must verify the exact weight of the packages, as well as their “use-by” dates. The main thrust of these intersectoral procedures is to ensure that the food sold to consumers is safe for human consumption.

Figure 16-2. Interface between the competent authorities



Studies (26) point out that certain key institutional capacities of the consumer protection agencies and health authorities need strengthening to ensure effective consumer protection. Most countries possess competent government agencies with the power to settle disputes, inform and educate consumers, inspect and define supplier responsibilities, and even hold accountable any suppliers that have caused harm with a defective product or service at any point in the chain of production. However, these capacities must be buttressed with appropriate political and budgetary support to make consumer protection a sustainable State policy with sufficient human, institutional, and financial resources to ensure its effectiveness.

While institutional and regulatory frameworks need improvement, proper regulatory enforcement remains the main problem. Institutional market surveillance capacities must be strengthened and standardized. Moreover, agencies must be provided with the appropriate mechanisms and tools for enforcing current laws and regulations, thus improving surveillance through an interinstitutional partnership consisting of the competent agencies in each sector.

Consumer protection is a delegated State function in each country, and even in regional trade agreements. With very few exceptions, this function has not been raised to the ministerial or secretariat level and is most often found at the directorate or division level –often under the ministry of economy or an underfunded autonomous government agency.

One way of gaining robust support for consumer protection will be to work with other authorities with political clout, including those at the highest level.

One example of this is the partnership between Brazil's National Consumer Affairs Secretariat (SENACON), under the Ministry of Justice; the National Health Surveillance Agency (ANVISA), under the Ministry of Health; and the National Institute of Metrology, Quality, and Technology (INMETRO), under the Ministry of Industry and Trade –all of which are engaged in the surveillance of, and imposition of sanctions on, suppliers that fail to comply with consumer product regulations. Cooperation among these agencies guarantees the protection of consumer health and safety. The creation of the CSHN-WG Brazil, comprised of the above-mentioned agencies, is expected to result in a new, more integrated approach to preventing and redressing health hazards to Brazilian consumers –an approach that makes State policies more efficient and effective, prevents duplication of efforts and conflicting measures, and strengthens and enhances procedures to benefit consumer health.

In the case of Brazil, it is worth noting the jointly produced fact sheets and alert bulletins (*Consumption and Health* and *Health and Safety Alert*), as well as the training provided to technical personnel on consumer health and protection. Another major priority is the creation of a damage indemnification system to encourage market agents to adopt more responsible harm prevention measures (*Institutional Notice by the Consumer Protection Department and ANVISA, Brazil, 2009*) (27).

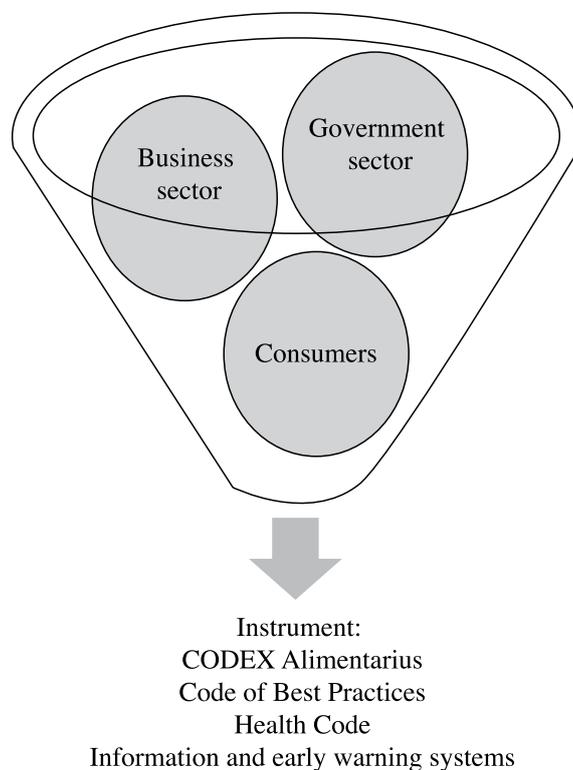
El Salvador also presents an interesting example of effective coordination between the health authorities and consumer protection agencies, with the creation of the National Food Safety Commission (CNIA) within the framework of the National Consumer Protection System. The CNIA's goal is to guarantee the basic right of consumers to purchase safe, good-quality food. The CNIA has succeeded in coordinating material, financial, and human resources from the Ministries of Agriculture and Livestock, Public Health and Social Welfare, Environment and Natural Resources, and the Consumer Protection Agency (*Defensoría del Consumidor*). Its responsibilities include

coordinating interinstitutional efforts and adopting policies to ensure compliance with the regulations governing the sanitary conditions, production quality and safety, processing, transport, distribution, warehousing, and marketing of food, as well as overall consumer protection (28).

Institutional strengthening requires partnerships, not only within government institutions (as stipulated by law in El Salvador, which has created the *National Consumer Protection System*) (14), but also with consumers and their organizations, as well as responsible, ethical suppliers. These partnerships must have effective tools, information and early warning systems, good practice codes, and be thoroughly familiar with relevant standards and regulations to ensure that consumers are kept from potentially harmful goods and services.

The above are but a few examples of joint cooperation initiatives. In recent years substantial progress has also been made in other countries of the region, among them Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador, Mexico, and Peru.

**Figure 16-3** Institutional Strengthening



### ***Civil society participation***

In terms of civil society participation (Figure 16-3), consumer protection organizations must become more actively involved in setting standards, disseminating information, and organizing joint activities in defense of consumer rights. They also need to pursue opportunities to support consumer protection policies and robust surveillance. Within the framework of the CSHN, a strong partnership has been forged with the consumer movement, through Consumers International, which has drawn up an action plan for bolstering civil society participation in the regional initiative.

### **Improving consumer protection in international trade and trade blocs**

The liberalization of trade within the framework of the World Trade Organization (WTO) and bilateral and regional agreements has yielded progress but also challenges that need to be addressed. The opening of new external markets through trade agreements requires countries to meet quality standards that are often stricter than

those established for domestic markets. Compliance with stringent export standards can have a positive impact on national consumers if exporters use the same standards for products geared to the domestic market.

On the other hand, opening domestic markets to imports means scaling up import controls, including sanitary controls for protecting human and animal health and phytosanitary controls for protecting plant health. One example of lax control was the harm caused by contaminated milk in September 2008, when over 54,000 children in several countries had to receive medical treatment after drinking powdered formula contaminated with melamine. While melamine by itself has low toxicity, animal studies have revealed the existence of kidney problems when it is combined with cyanuric acid (an impurity contained in melamine). In this case, the melamine level detected in the contaminated formula was much higher than the tolerance level (29). The Food and Agriculture Organization (FAO) and WHO reported that the contaminated products could have entered the market through formal or informal imports of milk and other products made with contaminated milk.

Trade agreements permit the application of sanitary and phytosanitary controls to protect the health of domestic consumers. For example, with the creation of the WTO in 1995, the *Agreement on Sanitary and Phytosanitary Measures* (SPS) was approved, recognizing the sovereign right of governments to protect health while ensuring that the measures adopted would not be used to restrict international trade (30).

All countries have measures in place to ensure that food is safe for consumers and prevent the spread of pests or diseases among animals and plants. These sanitary and phytosanitary measures can take many forms, such as requiring products to come from a disease-free area, product inspection, specific treatment or processing of products, the setting of allowable maximum thresholds for pesticide residues, or the banning of harmful food additives. Temporary application of the sanitary and phytosanitary measures is permitted under the safeguard clauses.

The WTO Sanitary and Phytosanitary agreement serves as a reference for all trade agreements but does not specify the standards that can be applied. The SPS agreement also encourages governments to adopt national measures consistent with international standards and guidelines and recommends that domestically produced goods be subject to the same requirements as products for export to the international market. The WTO also recommends acceptance of the regulations contained in the *Codex Alimentarius* (31), administered by the Joint FAO/WHO Commission.

Another international instrument that contributes to consumer protection is the *International Health Regulations* (IHR), amended in 2005, which entered into force in 2007 (32). The IHR's aim is to safeguard global health security by preventing and controlling the spread of diseases within and beyond country borders. The IHR requires countries to report every case that may constitute a public health emergency of international concern to WHO within 24 hours of its assessment; this guarantees, for example, that a safety alert regarding a particular product or service will lead to the adoption of timely measures.

With respect to food, the principle of "traceability" makes it possible to reconstruct the history of a particular food item throughout the food chain, including its production, processing, transport, distribution, and consumption. Food can be altered or contaminated during its harvesting or capture, transport, production, processing, distribution, or storage and cause disease. Health surveillance must therefore be comprehensive and coordinated at the national and international levels.

In the case of regional and subregional trade blocs in the Americas, a recent study (33) concluded that none of the countries in the Region expected to approve supranational consumer protection laws that would supersede current domestic legislation. However, all the regional plans analyzed recognized consumer protection as one of the basic principles of free trade and had made some progress toward harmonizing sanitary standards and regulations for consumer products.

This study also noted that the regional trade blocs closely follow the WTO system, which, as indicated earlier, allows temporary safeguards and exceptions to the principle of free trade for sanitary and phytosanitary reasons to protect human, animal, and plant health. The goal is "basic harmonization," as practiced in CARICOM and the European Union, that would enable Member States to maintain a higher level of consumer protection than currently exists at the regional level (25).

The national consumer protection authorities of the governments participating in the Central American integration process have shown a great deal of interest in conducting a comparative analysis of national legislation to facilitate the sharing of experiences and mutual learning.

While there are no prospects of the Central American region approving supranational legislation to replace current domestic laws, the Central American Integration System (SICA) established the Central American Consumer Protection Council (CONCADECO) (19) as a regional agency. The aim of the Council is to strengthen horizontal cooperation among consumer protection agencies and facilitate joint measures for effective protection

of the Central American population's consumer rights. Steps have even been taken toward creating a special service for handling transborder complaints.

As Elizabeth Villalta, a member of the Inter-American Juridical Committee (IAJC), points out, consumer protection has become a priority issue in the Central American Integration System, since to consolidate the rule of law and democratic governance, effective consumer rights protection is needed. This has made it possible to strengthen institutional aspects of government consumer protection agencies and to draft regional consumer protection policies (25).

Central America's experience is probably unique in the Hemisphere, as the countries have conducted regular joint activities, harmonizing methodologies to ensure simultaneous monitoring of the prices of gasoline and essential generic and brand-name drugs. Identification of the latter was based on the methodology used by WHO and PAHO and the subregion's epidemiological profile (34).

### Creation of a new economic culture

The general conclusion from the foregoing observations is that there is a need for a new economic culture in which consumers drive the market and not the other way around. Given the current imbalance of power between suppliers and consumers, this new approach requires the State to step in with effective regulations to ensure equity, certainty, and legal protection in trade relations, as well as full protection of consumer rights, especially the right to safe products and services.

The ideal approach would be to adopt the right kind of incentives to promote responsible, ethical behavior on the part of the stakeholders involved so as to increase self-regulation, trust, and social cohesion, as well as the legitimacy of today's prevailing market system. In this new economic culture, consumption must be sustainable and responsible and not threaten environmental sustainability and democratic governance. As noted at the Johannesburg Summit in 2002, 15% of the world's population living in the high-income countries is responsible for 56% of total global consumption, while the poorest 40% of the population in the low-income countries is responsible for only 11% of consumption (35). With this concentration of consumption comes the responsibility to conserve natural resources and the quality of life for future generations and to minimize the threat to global peace arising from consumption inequity.

Economic and demographic growth increases consumption. The OECD estimates that global GDP will increase by 75% over the next 20 years (with two-thirds of that increase corresponding to the OECD countries) and that the global population will grow by 1 to 2 billion people (mainly in the non-OECD member countries). This is expected to exacerbate the inequality between high-consumption and developing countries.

During the United Nations Conference on Climate Change (Copenhagen, 2009), the Heads of State and Government, together with a large number of national delegations and representatives of international and civil society organizations, acknowledged the urgency of reducing human interference in the global climate and lessening the direct and indirect impact of climate change on human health and well-being. However, deep disagreements among the countries made it impossible to reach a consensus on maximum targets for greenhouse gas emissions and mitigation measures for stabilizing and reducing the degradation of ecosystems.

These differences of opinion are, by and large, based on each country's own interpretations and expectations with respect to its lifestyles and present and future consumption patterns. The absence of viable agreements will unquestionably continue to dampen the prospects for more equitable development that is fully in balance with nature.

## ■ Conclusions and considerations for action

At least four conclusions can be drawn from the above:

- Safe consumption is a very important social determinant of health.
- In terms of the protection of consumer rights, the market is not automatically self-regulating due to the imperfections in its operations.
- The right to safe goods and services is a transborder issue, since trade and consumption are global. Regional and subregional cooperation, along with integration efforts, are needed to guarantee this right.
- Effective protection of consumer health is an interinstitutional challenge and a strategic opportunity for pursuing joint public policies, since consumer protection is a shared and complementary area of responsibility involving relevant government authorities, business, and consumers and their organizations.

Joint planning is therefore essential for enabling each entity to take appropriate steps in keeping with its own competencies and capacities.

### Promotion of specialized cooperation

Health regulations will be effective only if they are complemented with information, research, education, and consumer protection activities. It is important to promote opportunities for national and regional dialogue and interaction and to create and improve mechanisms for the health authorities, consumer protection agencies, other authorities, and civil society to share information, coordinate efforts, and introduce joint measures. These partnerships must be expanded and maintained by ensuring that other entities, academia, think tanks, the private sector, and consumer organizations subscribe to a joint program that involves them all.

This effort to develop joint and/or coordinated measures calls for more specific attention to the risks, goals, basic content, and steps that need to be taken in the priority areas as a prerequisite for State policies created by consensus among the health authorities, official consumer protection agencies, consumer organizations, the private sector, and academia in areas such as:

a. Food and nutrition

Since this is a very broad area, concentrating efforts on the food-related areas with greatest health impact is vital, especially where large populations and/or vulnerable groups are concerned. Three such areas are children's food, pollution by chemicals and organic products, and food advertising. In the children's food area, it is necessary to analyze the standards for preventing risks to their health (maximum levels of salt, sugar, and total and trans fats) and review and systematize best practices and the principal national measures for strengthening horizontal cooperation. As for chemical pollution (pesticides, antibiotics, heavy metals, veterinary drugs), it is vital to stress the health risks of trace substances and promote debate and research on public policies to promote organic farming. Meanwhile, best practices must be followed in food and food supplement advertising, and national monitoring and surveillance measures must be put in place to guarantee that the information conveyed is clear, truthful, sufficient, timely, and unlikely to mislead.

For good decision-making about food and nutrition, in addition to educating and informing consumers, it is important to have a rapid alert system that is national, regional, and international in scope to prevent harm to the public from unsafe food products.

b. Drugs

Here, there are four key considerations for consumer health and protection: *a*) regulation and surveillance of drug advertising to prevent misleading ads and other unethical practices; *b*) affordability and monitoring of drug prices; *c*) the safety, efficacy, and quality of drugs (drug surveillance and counterfeiting); and *d*) consumer education to enable people to make sound decisions about the rational use of drugs, avoid self-medication, and promote the use of generic drugs.

Meanwhile, the consumer sector must support governments in the effective implementation of pharmaceutical policies that promote access to good-quality essential drugs and their rational use, along with educational and informational activities to help consumers understand and support the concept of essential drugs and increase acceptance of generic drugs among prescribers and consumers.

Some studies show that many members of the medical community take a dim view of generic drug laws. Interinstitutional measures are therefore needed to bring physicians on board and comply with good prescribing practices.

c. Health care services

Users of private health care services face numerous problems in terms of the quality of care, respect for their rights, legal liability in health care delivery, information, advertising, fraud and contractual noncompliance, affordability, safety and quality standards, and the labeling of the drugs provided by these services.

d. Safety of non-food products

Compliance with existing rules, standards, and technical and legal regulations is extremely important for the safety of non-food products, especially in an era of growing globalization. Compliance can be facilitated through network-based information on risks and accidents, compliance assessments, and quality seals to prove that technical standards have been met. All these are essential for developing rapid alert systems for unsafe products.

In the Americas it is vital to promote, strengthen, and consolidate CSHN efforts under the OAS and PAHO to construct an integrated consumer products safety system. The Rapid Alerts System can contribute substantially to consumers' enjoyment of the basic right to health and safety.

The CSHN and its SIAR support instrument together constitute a rapid, accessible, reliable, and efficient mechanism for information exchange among the competent authorities. Over the long term, they will also be an excellent source of information on technical regulations and requirements, product safety standards, market surveillance practices, studies and research, and products withdrawn from the market, along with recall criteria and procedures.

SIAR is a learning opportunity that will make it possible to set criteria and establish procedures for issuing rapid alerts on potentially dangerous products in our countries. There is an urgent need for the competent national agencies in this area to coordinate and integrate their efforts in this respect.

e. Legislation

With input from their legal advisers, the consumer protection agencies and health authorities in each country must determine the positive and negative aspects of their regulatory framework. They must also identify best practices among consumers and consumer organizations in the formulation of technical standards. Universities and research centers are key players in identifying best practices and regulatory gaps so that remedial action can be taken.

The *Consumer Safety and Health Atlas* for the Americas is one example of a successful joint effort. This atlas, prepared with information supplied by the 21 member countries of the CSHN, was coordinated by a research team from Brazil's Getulio Vargas Foundation under Professor Ricardo Morishita and the CSHN Technical Secretariat in the OAS General Secretariat.

f. Corporate responsibility and self-regulation

To improve consumer health it is important to seek opportunities for dialogue with business on corporate responsibility, codes of ethics and good practices, quality systems, and the adaptation and preparation of technical standards and regulations. A good example of this type of initiative is the Pan American Forum for Action on NCDs.

This dialogue could have immediate effects, strengthening the institutional capacity of participating States to apply the regulations and providing opportunities to learn from shared experiences, knowledge, and mutual support activities and exchanges about relevant public policies.

The OAS is working on these initiatives with Consumers International, an institution that plays a key role in promoting dialogue and civil society participation at the international level.

## Creation of a regional observatory

Since it is hard to work effectively without information or knowledge, it is important to set up a regional observatory on consumer health protection to disseminate information on current regulations, technical standards, successful experiences, policies, and action programs in the priority areas. The aforementioned dialogues will serve as significant and useful input for the observatory. The OAS's CSHN began this work by collecting and systematizing the relevant data at the time the SIAR was established.

Strengthening the capacity to conduct quantitative and qualitative assessments and prioritizing areas for action will require integrated health and consumer protection methodologies and indicators, an estimate of the cost of the damage to health from the aforementioned sectoral and other potential risks, and incorporation of the gender and age perspective into consumer indicators. These tasks will require the support of universities and research centers.

## Diagnostic study: System for product replacement, redress, and indemnification for damages

It is extremely important to prevent and combat health risks posed by the consumption and use of goods and services. It is no less important to compensate consumers for any harm caused. A study of current systems for product replacement, redress, and indemnification for damages is therefore needed to learn from the different mechanisms currently in use and propose improvements. Indemnification is the right way to encourage good business practices. These studies will form part of the store of knowledge in the proposed observatory and were the subject of detailed debate at a seminar in November 2011 on indemnification for damages caused by defective products, organized by Colombia's Superintendency of Industry and Trade and the OAS, under the aegis of the CSHN.

## New transborder institutional and regulatory frameworks

Coordinating national and regional policies, programs, and actions in consumer health protection requires the creation of an institutional space. In addition to the work done on consumer product safety in partnership with PAHO, a joint initiative between the CSHN and the User and Consumer Defense Commission of the Latin American Parliament (PARLATINO) is under way at the OAS that involves the preparation of a model law for strengthening product safety regulatory frameworks. These initiatives by the OAS Member States indicate that consumer protection is becoming increasingly important in the development of public policy agendas in the Americas.

## Hemispheric action program

Consumer health is a citizen's basic right, and the State has an obligation to respect that right. It is therefore important for the American States to strengthen mandates within the framework of the OAS and PAHO to formulate and implement a Hemisphere-wide action program to give greater weight to, support, and prioritize this strategic public function so vital to consolidating democratic governance in the hemisphere.

Thanks to the CSHN, the region is now laying the foundations for a regional rapid alert system to guarantee consumer product safety. This system will ensure that rapid, coordinated, and proactive steps are taken whenever necessary. It will also enhance national market surveillance capacity from a global and multidisciplinary standpoint. The initiative has been enthusiastically received at the national, regional, and global levels, indicating that it responds to the real needs of stakeholders in the member countries. It is also an opportunity to replicate the experience with a view to strengthening the other areas of consumer protection described in this chapter that could affect the health of the population.

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## ■ Links

[www.oas.org/ddse](http://www.oas.org/ddse): Department of Social Development and Employment, Organization of American States (OAS)

[www.oas.org/rcss](http://www.oas.org/rcss): Safe Consumption and Health Network, Organization of American States (OAS)

[www.paho.org](http://www.paho.org): Pan American Health Organization

[www.fao.org](http://www.fao.org): United Nations Food and Agriculture Organization (FAO)

[www.oecd.org](http://www.oecd.org): Organisation for Economic Co-operation and Development (OECD)

[http://ec.europa.eu/consumers/index\\_en.htm](http://ec.europa.eu/consumers/index_en.htm): European Commission - Consumer Protection

[www.anvisa.gov.br](http://www.anvisa.gov.br): National Health Surveillance Agency (ANVISA)

[www.sica.int/](http://www.sica.int/): Central American Consumer Protection Council (CONCADECO), Central American Integration System

[www.consumersinternational.org](http://www.consumersinternational.org): Consumers International

[www.meic.go.cr](http://www.meic.go.cr) : Ministry of Economy and Trade of Costa Rica

[www.sernac.cl](http://www.sernac.cl): National Consumer Protection Agency of Chile (SERNAC)

[www.mj.gov.br/](http://www.mj.gov.br/) : Ministry of Justice of Brazil

[www.profeco.gob.mx](http://www.profeco.gob.mx): Office of the Federal Prosecutor for the Consumer, Mexico (PROFECO)

[www.mecon.gov.ar/secdef](http://www.mecon.gov.ar/secdef): National System of Consumer Arbitration, Under -Secretariat for Consumer Protection, Ministry of Economy and Public Finance, Argentina

[www.ftc.gov](http://www.ftc.gov): Federal Trade Commission of the United States (FTC)

[www.idec.org.br](http://www.idec.org.br): Brazilian Consumer Protection Institute (IDEC)

[www.elpoderdelconsumidor.org](http://www.elpoderdelconsumidor.org): Consumer Power Mexico

[www.cdc.org.sv](http://www.cdc.org.sv): Consumer Protection Agency, El Salvador

[www.invima.gov.co](http://www.invima.gov.co): National Food and Drug Monitoring Institute, Colombia (INVIMA)

[www.cofepris.gob.mx](http://www.cofepris.gob.mx): Federal Commission for Protection against Sanitary Risks, Mexico (COFEPRIS)

[www.sanidadambiental.com](http://www.sanidadambiental.com): Spanish Society of Environmental Health (SESA)

## ■ Annex 16-1. Rapid alert systems for unsafe products (2012)

<i>Country</i>	<i>Description</i>	<i>Information source</i>	<i>Procedure</i>	<i>Form of communication</i>
<b>Australia</b>				
<i>www.recalls.gov.au</i>	Information compiled by an organization, centralized in a database	The supplier (manufacturer, distributor, importer, etc.) is responsible for issuing a product safety recall within two days of commencing recall action (subject to criminal penalties if time limit is not respected). However, the Australian Competition and Consumer Commission can withdraw a product from the market if it has caused, or is likely to cause, a hazard or where it is confirmed that the supplier has failed to take remedial action	The information is entered on a form (available online). This form is then sent by fax, email or regular mail	Information can be found on the website by category of product. Each recall notice contains details about the product (description and picture), the risk, origin of product, importer and/or distributor, and advice to consumers on the steps to be taken in response to a recall. A recall press release is also circulated as a PDF
	Administered by: the Australian Competition and Consumer Commission (ACCC)	The ACCC assembles available information on public notices, articles in the press, or material from other public sources	The majority of recalls are issued voluntarily by manufacturers and suppliers when a safety hazard is detected	Ability to subscribe to an email alert system containing information on most recent alerts
		Regulating officers and other interested parties can also enter data	The ACCC monitors and audits the effectiveness of recalls of general consumer products. In certain cases, it notifies other national or foreign organizations, depending on the type of product involved	In addition to publicly available information, the website also has a confidential mechanism for access (user name and password required) to enable regulating officers to handle more sensitive data
<b>Brazil</b>				
<i>Recall Monitoring System</i>	Information on recalls available online from 2000 on	Suppliers must publish recall notices and advise the Department of Consumer Protection (DPDC) of recalls issued	The DPDC investigates recalls conducted over a certain period and retains the relevant data on its website, with products classified by type of product and brand name	Information can be found on the website by product category

<i>Country</i>	<i>Description</i>	<i>Information source</i>	<i>Procedure</i>	<i>Form of communication</i>
<b>Brazil</b>				
<i>portal.mj.gov.br/Recall/</i>	Administered by: the Department of Consumer Protection (DPDC) and the Brazilian Consumer Protection Authority, Ministry of Justice (SENACON/MJ)			Data published: name of product, name of manufacturer, date of manufacture, number of affected products, file number of notice to DPDC, text of notice issued by supplier
				The website also has a restricted access mechanism for use by State consumer protection authorities
<i>Consumer Portal</i>	General online information for consumers	This is an online reference tool jointly managed by civil and government entities to inform and educate consumers on how to make better use of their purchasing power, how to engage services, and how to use and discard products correctly	Surveys and consultations provide information on topics of public interest. The site content is organized accordingly	The site offers various services, such as reports on unsafe or defective products or services, contact information for local consumer protection agencies, etc.
<i>www.portaldoconsumidor.gov.br</i>	Administered by: the Ministry of Development, Industry and External Trade			
<b>United States</b>				
<i>www.recalls.gov</i>	Through an Internet portal, six federal agencies with jurisdiction over different types of products provide information for the public on the most recent product safety recalls, together with useful safety advice. Clicking on the required topic, the site sends inquirers to the website of the respective regulatory agency	Information is provided by the following agencies according to their areas of competence: U.S. Consumer Product Safety Commission (CPSC), U.S. Department of Transportation, National Highway Traffic Safety Administration (U.S. DOT, NHTSA), Department of Homeland Security, United States Coast Guard (DHS, USCG), U.S. Food and Drug Administration (FDA), Department of Agriculture (USDA), Environmental Protection Agency (EPA)	The CPSC and the other five agencies report on the latest product recalls. This information is centralized in recalls.gov and forwarded, as appropriate, to the websites of the respective agencies	Depends on each specialized agency's website (fed by recalls.gov). On the CPSC website, for example, information is highly detailed, with the name of the product, an image, number of units involved, name of importer or manufacturer, likely hazards, number of reported incidents, description, point of sale and price, country of origin, remedial action on the hazard, forms of indemnification, contact data for consumer

<i>Country</i>	<i>Description</i>	<i>Information source</i>	<i>Procedure</i>	<i>Form of communication</i>
<b>United States</b>				
	Administered by: the U.S. Consumer Product Safety Commission			
<i>FoodSafety.gov</i>	Similar to the previous system, but this focuses specifically on food safety. Also offers advice on eating well, safe food consumption, and other topics of interest	FoodSafety.gov is the link to food safety information provided by the following: U.S. Department of Health and Human Services; U.S. Department of Agriculture; USDA Food Safety and Inspection Service; U.S. Food and Drug Administration; Centers for Disease Control and Prevention; and the National Institutes of Health		Information on product recalls can also be found on the website of each specialized agency
	Administered by: the U.S. Department of Health and Human Services			
<i>National Electronic Injury Surveillance System - NEISS</i>	National-level probability sampling of accidents and injuries caused by electronic consumer products	NEISS-designated hospitals keep records of each visit by patients seeking emergency care for an injury related to a product or service	The data recorded by hospitals (special forms and a coding system assigned periodically to each type of product, injury, total number of product -or service- related injuries, etc.) make it possible to perform calculations and produce statistics that can help improve knowledge about product hazards. These data are used to conduct product safety recalls, carry out public awareness campaigns, and set product safety standards	Unlike the previous systems, no periodic information provided online for public access
<i>www.cpsc.gov/ LIBRARY/neiss.html</i>	Administered by: the U.S. Consumer Product Safety Commission			Information collected on the patient, the incident, the type of injury, and the product associated with the injury

<i>Country</i>	<i>Description</i>	<i>Information source</i>	<i>Procedure</i>	<i>Form of communication</i>
<b>Mexico</b>				
<i>www.profeco.gob.mx</i>	Internet portal for general consumer protection issues	Surveys, complaints, publications, voluntary notifications by suppliers, etc.	Specific information on unsafe products can be found by activating the link on this site to “Consumer Alerts.” This page contains relevant data produced by the Office of the Federal Attorney-General for Consumer Protection (PROFECO), (permanent surveillance of products and services on the market) and advises on consumer complaintsprocedures	Varied
	Administered by: Mexico’s Office of the Federal Attorney-General for Consumer Protection (PROFECO)		There is no single specific database for recalls. The site nevertheless contains regular reports on different measures adopted by PROFECO or private individuals concerning product safety recalls, etc.	
			The site also hosts an online publication called “ <i>The Consumer’s Journal</i> ”	

<i>Country</i>	<i>Description</i>	<i>Information source</i>	<i>Procedure</i>	<i>Form of communication</i>
<b>European Union</b>				
<i>Rapid Exchange of Information System - RAPEX</i>	System for rapid exchange of information among EU countries on product safety, designed to protect consumer health and safety	The authorities of each of the EU Member States with product safety competencies	Following confirmation of a product or products in a given market that pose a serious and tangible risk to consumer health and safety and that call for rapid intervention by the authorities to prevent, restrict, or subject the sale (of a product) to specific conditions, the EU Member State involved is required to inform the Commission immediately of the anti-risk measures that it has adopted in its territory	The information circulates among the competent authorities through a network of predetermined "contact points." Each country possesses a specific "liaison office" to link the national agencies with the EU Commission
<i>ec.europa.eu/consumers/safety/rapex</i>	Administered by: the European Commission	Suppliers are under an obligation to report the measures that they adopt or the risks that they detect to the national authorities, pursuant to each country's regulations, under the "safety obligation" governed by EU norms	In addition to administering RAPEX, the European Commission and EU Member States can adopt other "emergency measures" in certain cases	In addition to its information-sharing role with the competent authorities, RAPEX also provides publicly accessible information on recalled products (images, origin, description, supplier, risk level, measures adopted, etc.) and statistics and reports received, risks detected, products involved, etc.

**Source:** Websites of the systems described herein.

## Energy, sustainable development, and health

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### ■ Introduction

As the 21st century begins, the world faces a double threat in the sphere of energy and health: on one hand, an insufficient and unstable supply of energy at affordable prices; and on the other, global environmental damage wrought by the use of fossil fuels (1). Assessing the association between energy and health requires the adoption of a life-cycle approach to energy—one that extends from extraction to final waste disposal and examines fuel transport, energy generation and distribution, and end use. Each stage of this cycle can have positive or negative effects on health.

The major advances in health and, more generally, the economy have been due to multiple factors related to production and infrastructure development. One of the most important has been energy supply, which is essential to meeting society's basic needs. At the household level, energy is essential for cooking, heating water, and for lighting and heating or air conditioning; in urban areas, for transporting people and goods and providing the power for telecommunications and the production of goods and services.

Thus, access to energy and to clean, noncarbon-intensive fuels is required today to improve the living conditions and health of the population, fight poverty, boost international economic competitiveness, and achieve sustainable development.

However, the adverse health and environmental effects of energy production and use affect workers and the general public alike, constituting a public health and occupational health problem. Effects differ according to where and how pollutants are emitted, the type of exposure, and the nature of the accidents that occur. In rural areas, for example, exposure to energy-related pollutants stems from the use of wood for cooking indoors, since those who

prepare the meals —generally women— spend many hours near the source of the emissions. In urban areas, in contrast, there is less indoor pollution from combustion, since cleaner fuels (gas or electricity) and more efficient cooking and heating devices are usually available. In cities, outdoor air pollution occurs mainly as a result of fossil fuels burned in different processes that generate or consume energy —in homes, automobiles, industry, or service enterprises.

United Nations Millennium Development Goal 7 (2) calls for ensuring environmental sustainability by meeting various targets and monitoring specific energy-related indicators, especially the energy intensity of economic growth (kJ/unit of GDP), the per capita amount of carbon dioxide emitted by the burning of fossil fuels (CO<sub>2</sub>/inhab./year), and the use of firewood or charcoal inside dwellings (percentage of country population living in homes that use those fuels).

This chapter analyzes the use of energy and its health impacts throughout the Americas. The energy situation is extremely varied and unequal, ranging from the generation and consumption pattern in the United States —which has one of the highest per capita energy consumption figures in the world and is the world's second largest source of energy-related CO<sub>2</sub> emissions (18% in 2009) – to countries like Haiti, with electrical coverage of less than 28%, where firewood is the main fuel for meeting energy demand. Nor is that the whole picture, for in addition to those differences, the production and dissemination of information is scattered and unequal, with the United States being a prime generator of information at all levels. Consistency of the data is also an issue. For example, the majority of sources, including the International Energy Agency (IEA), analyze energy by blocks of countries that cover only Latin America (which includes Mexico) or North America (which also includes Mexico). The disparities among nations are due, among other factors, to their development levels, economic activities, and economic and natural resources, as well as to the roles played by the State and the private sector.

## ■ Energy use in Latin America

Energy use around the world depends to a great extent on the natural resources of the respective country and its degree of technological development and industrialization. Primary energy demand in 2011 was approximately 2,774 Mtoe<sup>1</sup> in the North American countries of the OECD (3) (Canada, Mexico, and the United States) and 649 Mtoe in Central and South American countries. Projections for 2030 for the two groups put average annual growth at 1% and 2.3%, respectively.

Oil and oil derivatives represent 40.6% of energy consumption in Latin America and the Caribbean (LAC), followed by natural gas (28.3%), biomass (13.8%), hydropower and electricity (8.7%), coal and coke (4.8%), nuclear energy (1%), and other sources, including biofuels and geothermal energy (2.8%) (see Figure 17-1) (4).

The following grouping shows some of the major differences among the countries of the region (5):

- Countries where over 70% of demand is met by oil and oil derivatives, in order of dependence on those resources: Jamaica, Grenada, Barbados, Ecuador, Cuba, Panama, Dominican Republic, and Suriname.
- Countries with major biomass demand: Haiti (72%), Nicaragua (44%), Guatemala (59%), Guyana (47%), and Honduras (44%). These figures almost exclusively represent the use of wood, except in the case of Guyana, which also uses bagasse.
- Countries where demand is met primarily by natural gas: Trinidad and Tobago (87%).
- Countries where major demand is associated with geothermal energy: El Salvador (21%) and Costa Rica (12%).
- Countries where hydroelectric energy plays a major role: Brazil (36%); Paraguay and Colombia (30%); Venezuela and Uruguay (25%) and Costa Rica and Peru (13%-18%).

Many international agencies specializing in energy issues agree that fossil fuels (oil, gas, and coal) will remain the predominant source of energy globally, and for the American continent in particular, in the coming decades. LAC as a whole produces a considerable surplus of crude oil and natural gas. However, the Region's vast reserves of fossil fuels are concentrated in only a few countries. Below is a brief summary by type of fuel.

**Oil.** Among the 20 countries with the world's largest proven oil reserves are Venezuela (ranking 2nd), Canada (3rd), the United States (13th), Brazil (15th), and Mexico (17th) (6). LAC has around 20.3% of the world's proven reserves. Venezuela, Brazil, and Mexico have over 96% of the region's reserves, while Ecuador, Argentina, and Co-

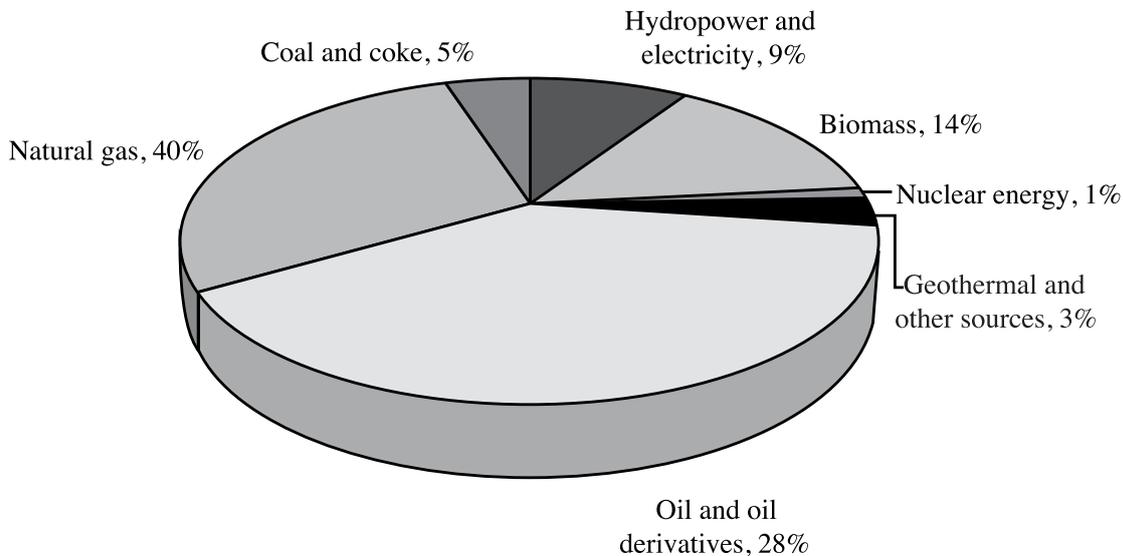
lombia have 4%. Only three Caribbean countries have oil reserves: Barbados, Cuba, and Trinidad and Tobago (7). The ratio of oil reserves to oil production, in years, is over a century in Venezuela and Canada, but less than two decades for the United States, Mexico, and Brazil (1).

**Natural gas.** In 2011, Venezuela had proven natural gas reserves 15 times greater than those of Mexico, Brazil, Bolivia, Argentina, and Trinidad and Tobago (8). Natural gas production in LAC remained almost constant from 2006 to 2011. During that period, proven reserves in the United States increased by over 30%, and there was an upturn in the country's consumption of natural gas, along with a price drop of more than 60% (6).

**Shale gas.** According to the U.S. Energy Information Administration (EIA), four nations in the Americas are among the world's top 10 countries with the greatest recoverable reserves: Argentina, with estimated recoverable reserves of 802 trillion cubic feet (tcf); the United States, with 665 tcf; Canada, with 573 tcf; and Mexico with 541 tcf. In percentage terms, these figures represent 28.4%, 23.5%, 20.24%, and 19.2%, respectively, of the Region's total recoverable reserves. Mexico has 7.46% of the world's reserves, making it the sixth richest country in shale gas reserves (9).

**Coal.** Coal is the planet's most abundant fossil fuel. The United States has close to 27% of the world's proven reserves (6) and is the Region's largest consumer, though other countries in the Region also have significant reserves: Colombia, with 40% of the reserves in LAC; Brazil, with 33%; Venezuela, with 13%; and Mexico, with 9% (10).

Figure 17-1. Energy demand by source in Latin America and the Caribbean, 2012



Source: OLADE, Latin American Energy Organization, *Energy Statistics Report 2012*.

**Nuclear energy.** Uranium is an abundant resource and is widely distributed across the globe. Canada, the United States, and Brazil are among the 10 countries with the world's largest uranium reserves; Canada is the second largest producer in the world, exceeded only by Kazakhstan (11). In 2010, nuclear energy supplied 2.3% of the region's energy and 14.3% worldwide (12). The accident at the Fukushima nuclear plant in 2011 led to the cancellation or slowdown in the construction of new nuclear plants in Latin America, Europe, and Asia, as well as the closing of other plants that were operating in Japan. In the wake of these developments, nuclear power's share of the power generation mix in LAC will grow only from 2% in 2010 to 4% in 2035.

**Renewable energy.** In 2006, renewable energy sources, including hydroelectric, represented 26% of the overall primary energy supply in Latin America, far above the global figure of 8%. Nevertheless, renewable sources have been declining as a share of the total, due to the oil and natural gas boom in several South American countries (principally Venezuela, Brazil, and Bolivia) and the difficulty of building new dams (7). Brazil has the largest renewable energy market, owing to its hydro potential and its bioethanol industry. These two sectors provide four fifths of the country's electrical energy and 39% of its total energy (13). It is hoped that renewable energy sources will be developed and play a larger role in electricity generation and biofuels production for the transportation sector, as they recently have in the United States, Central America, Mexico, and Brazil.

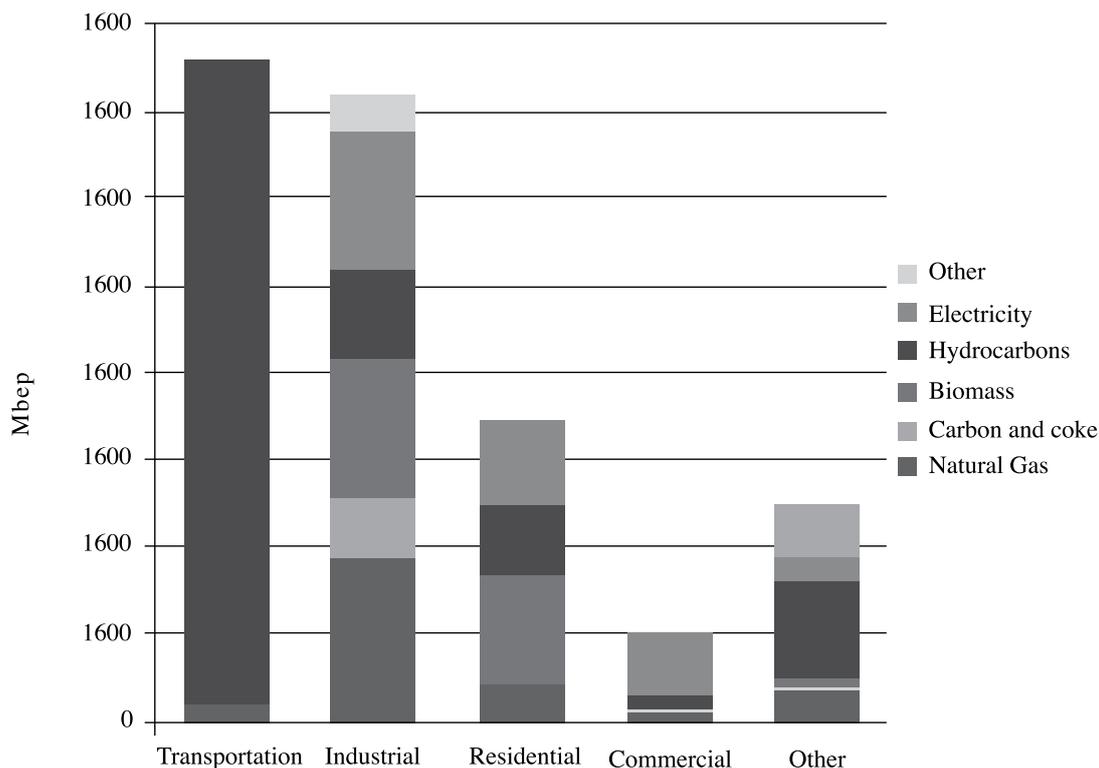
## Consumption

Between 2002 and 2011, average energy use, measured as oil consumption per unit of gross domestic product (GDP), declined slightly in the Region, although there were significant increases in Bolivia, Brazil, Haiti, Jamaica, Panama, Venezuela, and Trinidad and Tobago.

Energy consumption by sector in LAC is depicted in Figure 17-2, which shows that transportation is the most prominent sector, accounting for 35% of total energy consumption, followed closely by the industrial sector at 33%. Residential consumption, at 16%, is half that of the transportation sector, with transportation accounting for over 70% of the primary demand for oil (14). This sector's energy consumption rose 43%, between 2010 and 2030 with liquid hydrocarbons accounting for 97% of the fuel used and natural gas accounting for 2.7% (4). Gasoline represented nearly half of the consumption, and diesel, 40%. These figures include road and rail transportation, as well as air, inland waterway, and maritime transport, which generally emit pollutants in areas far from population centers. Diesel consumption in the region is a major concern, since diesel vehicles emit a large quantity of small, highly toxic particles. In the past 10 years, natural gas rose markedly as a proportion of energy demand in various LAC countries, including Bolivia, Argentina, and Colombia, where it represented 19%, 13%, and 6%, respectively, of the total (4).

Urban transportation remains the greatest hurdle in attempts to control air pollution in metropolitan areas and protect the population's health. The fact that the source of pollution is close to people, that vehicles are ubiquitous, and that the fleet is growing rapidly are features of the Region's urban problem, and although no city in the Region has managed to solve it, some success has been achieved through improved automotive technologies and innovations in public transportation.

**Figure 17-2.** Energy consumption by sector in Latin America and the Caribbean, 2012



**Source:** OLADE, *Energy Statistics Report 2012 Card*. [http://www.olade.org/sites/default/files/img\\_publicaciones/IEE2012/TARJETA-IE2012ingles.pdf](http://www.olade.org/sites/default/files/img_publicaciones/IEE2012/TARJETA-IE2012ingles.pdf)

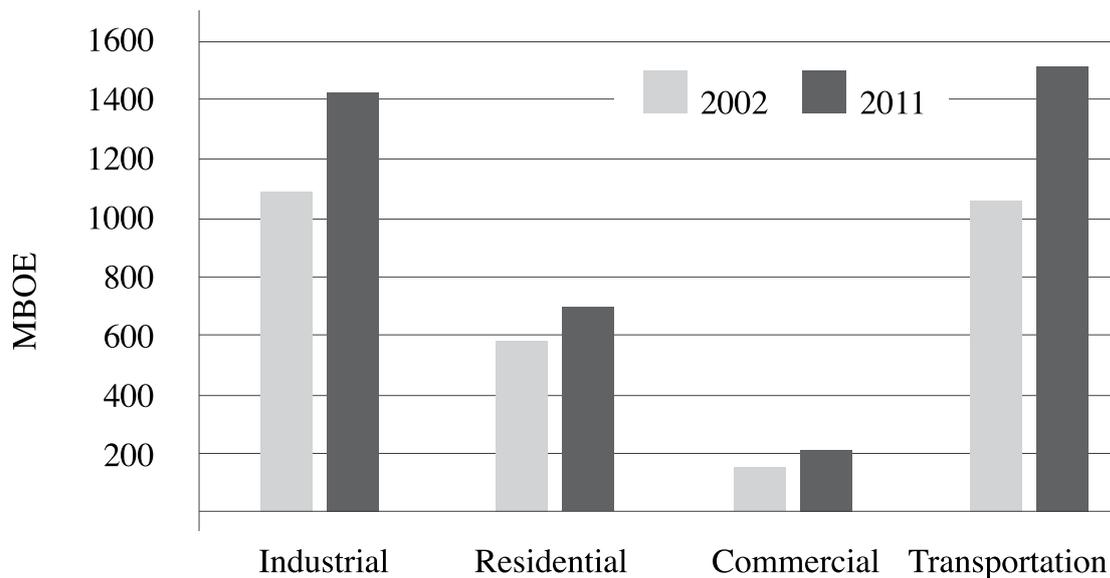
In the industrial sector, 42% of the energy consumed is in the form of electricity and natural gas. One positive reflection of this is the decrease in carbon intensity in several countries in the Region. Industry employs a wide variety of fuels, including the most polluting ones, such as coal coke and petroleum coke, fuel oil, petroleum, and coal. Industrial energy consumption in LAC in 2011 accounted for 32% of the total energy consumed, reflecting growth during the last decade. Natural gas was the energy resource with the highest consumption, constituting 26% of the total mix, followed by electricity at 22%. In Guyana, Barbados, Belize, Bolivia, Grenada, and Brazil, industrial consumption of bagasse ranges from 20% to 81% (4).

In the residential sector, slightly over one third of consumption consists of wood used for cooking and heating in rural and semi-rural areas—generally open-flame applications inside the dwelling—generating high levels of exposure for the women using them and posing health risks to children under the age of 2.

Per capita energy consumption in the industrialized countries is five times higher than in the Latin American nations. “However, the disparities in incorporating technical progress would, if there is no significant reduction in energy intensity and an increase in the renewal and cleanness of the energy consumed, lead to the developing countries’ being responsible for over three quarters of the increase in global CO<sub>2</sub> emissions by around 2030.” Their share of global emissions is expected to rise from 39% to 52% by around 2030 (7).

Figure 17-3 compares total energy consumption by sector in 2002 and 2011. The sector in which consumption grew most was transportation (43%), followed by commerce (42%), while industrial consumption rose 32% and residential consumption, 18%.

**Figure 17-3.** Energy consumption by sector in LAC in 2002 and 2011 (comparison)



Source: OLADE, Latin American Energy Organization, *Energy Statistics Report 2012*.

## ■ Health, environment, and energy

Human activities are major sources of pollutants, which are emitted above all by consumption of the energy needed to perform activities – transportation, electrical power generation, industrial processes, food production, and indoor temperature control.

### Burden of mortality and morbidity: comparative risk assessment

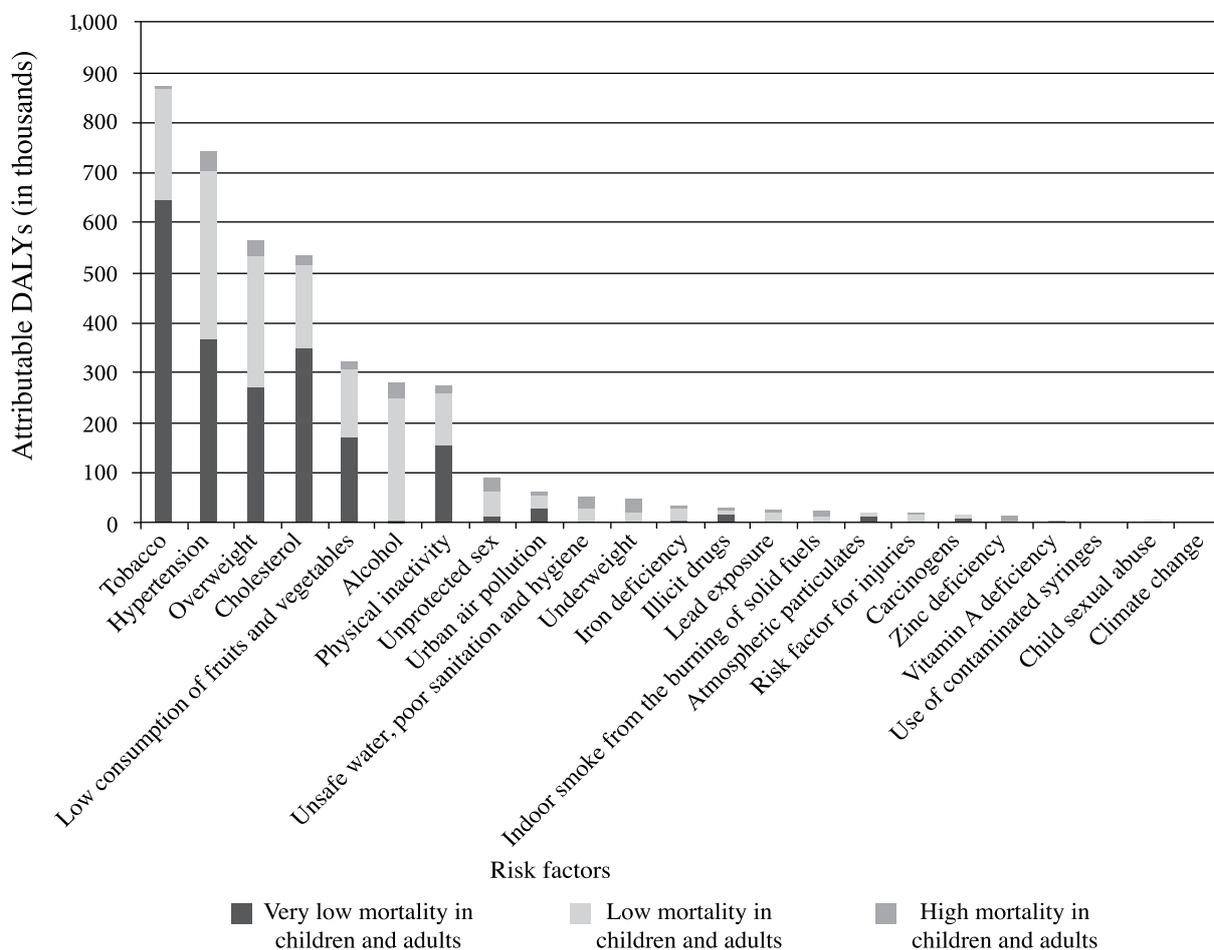
The World Health Organization (WHO) analyzed comparative risk, using 2000 as the baseline year (15), comparing 26 risk factors, including environmental risks, risks associated with diet and physical inactivity, sexual and reproductive risks, addictive substances, and occupational risks. The analysis describes the burden of morbidity,

disability, and mortality, both regionally and globally. The morbidity burden combines disease and health risks in a single measure: years of life lost due to mortality plus those lost due to disability.

Figure 17-4 shows the order of magnitude of the risk indicators. These data apply to the circumstances present at the beginning of the century, but some circumstances related to environmental risks and energy have changed—for example, the elimination of leaded gasoline throughout the Region, the size of the population, and the increase in extreme weather phenomena associated with climate change. Today, mortality linked with the environment is very low for 39% of the Region's population, low for 52%, and high for 9% (16).

Of the five environmental risks studied, four are directly related to energy use: urban air pollution, indoor air pollution from the burning of solid fuels, lead exposure, and climate change; the fifth is associated with unhealthy water and poor sanitation and hygiene.

**Figure 17-4.** Mortality in the Americas, by risk factor



**Source:** WHO, *Comparative Quantification of Health Risks. Global and Regional Burden of Diseases Attributable to Selected Major Risk Factors*. Vols. 1, 2, and 3 on CD-ROM. Nonserial Publication. Edited by Ezzati M, López AD, Rodgers A, Murray CJL. World Health Organization. Available at: [http://www.who.int/healthinfo/global\\_burden\\_disease/cra/en](http://www.who.int/healthinfo/global_burden_disease/cra/en)

By order of their effect on mortality, the environmental risks associated with energy are as follows:

- a) **Urban air pollution:** Air pollution in cities involves a complex mix of numerous toxic components. The risk analysis found that the most harmful health effects on the population are those associated with particulates, with mortality is clearly the most important of these effects. Mortality estimates are based on the incidence of cardiopulmonary diseases in adults, lung cancer, and acute respiratory infections in

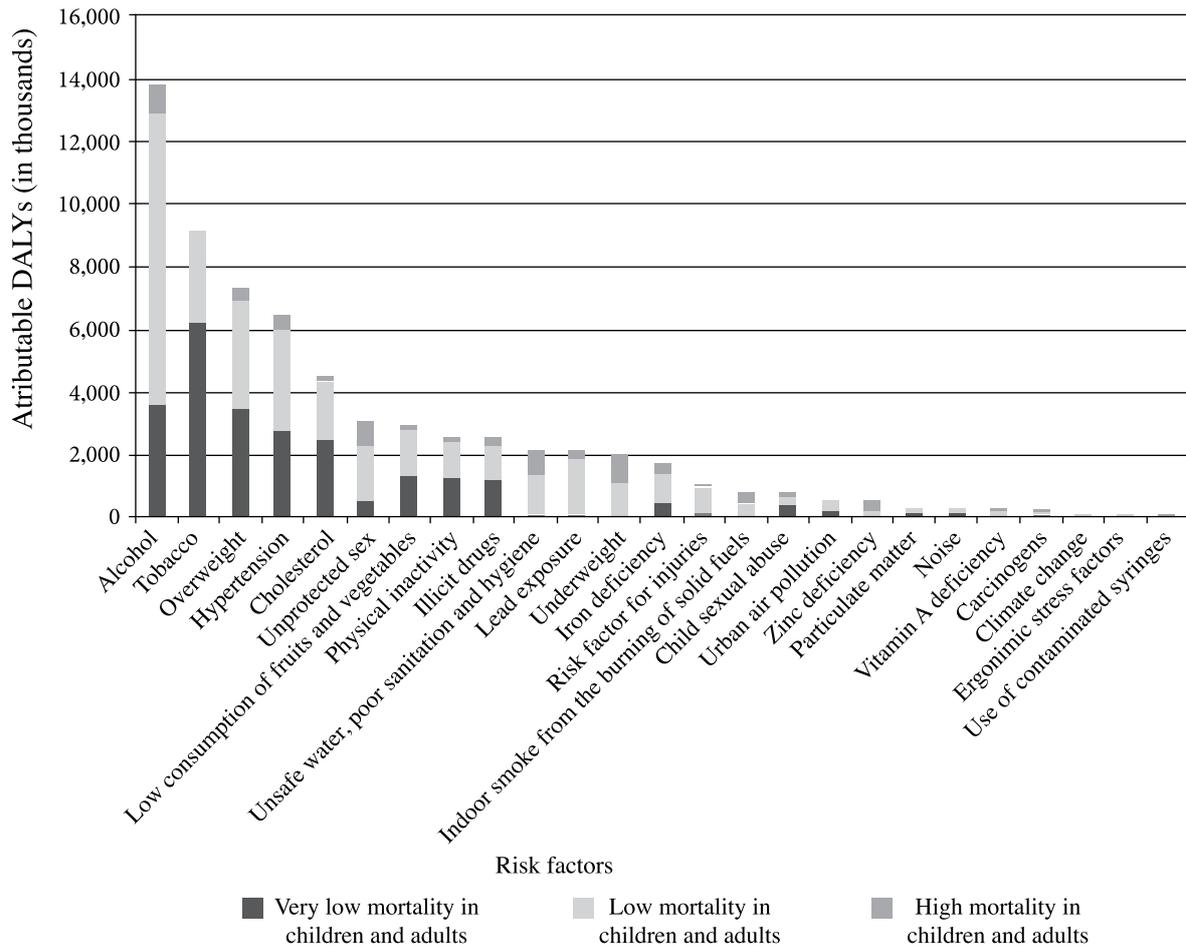
children under 4. To estimate the number of attributable deaths and years of life lost—for adults and for children under 4—the risk coefficients used were taken from a study of adult cohorts in the United States conducted by the American Cancer Society (data from nearly half a million people in 151 metropolitan areas in 50 states) (17), as well as from a meta-analysis of five time-series studies of mortality in children.

After other risks, such as addictive substances (tobacco and alcohol), those associated with diet (hypertension, overweight, cholesterol, and low consumption of fruits and vegetables), physical inactivity, and unprotected sex, air pollution poses LAC's principal environmental risk for mortality and is slightly higher in the countries of the AMR B block than in the AMR A block<sup>2</sup> (18). As indicated in the study "Global Burden of Disease: Generating Policy, Guiding Evidence," produced by the Institute for Health Metrics and Evaluation at the University of Washington, the countries in the Hemisphere with the highest rates of mortality associated with air pollution are the United States, Canada, and Mexico (19).

- b) **Lead exposure:** Lead in gasoline is the energy sector's greatest contribution to this risk. Estimates are based on lead concentrations in blood analyzed before 2005, when the sale of leaded gasoline ceased throughout the Americas. Various studies have found that declining use of leaded gasoline parallels reductions in blood lead levels. Projections for 2010 estimate a reduction of blood lead levels among urban dwellers in AMR B and AMR D countries amounting to 32% and 52%, respectively, in children, and 43% and 60%, respectively, in adults. However, lead exposure occurs in other ways as well—e.g., the recycling of batteries (an energy-related issue) and the use of ceramics with leaded enamel.
- c) **Indoor air pollution from the use of solid fuels:** Findings for the year 2000 point to the burning of solid fuels for cooking as one of the 10 greatest health risks at the global level. In the developing countries today, mortality from indoor air pollution is exceeded only by mortality from malnutrition, unprotected sex, and lack of safe drinking water and proper sanitation (20). Worldwide, it is responsible for 1.5 million deaths annually.

For the Americas, indirect estimates indicate that there have been approximately 800,000 disability-adjusted life years (DALYs) distributed between AMR B and AMR D countries attributable to indoor air pollution from the burning of wood or charcoal. This environmental risk factor ranks second after unsafe water and poor sanitation and hygiene. It is also estimated that around 560,000 DALYs are generated by urban air pollution in the Americas—posing a greater risk to men than to women.

- d) **Climate change:** The effects of climate change on health and the environment are chiefly the result of the increasing frequency and intensity of hydrometeorological phenomena (see the section 5 on energy and climate change).

**Figure 17-5. Attributable DALYs by type of risk, and stratification by mortality, in the Americas**

Source: WHO, 2002; WHO, 2004b.

Figure 17-5 shows risks in the Region by order of importance, in DALYs. According to the quantification of risks by DALYs, the energy sector's contribution to lead exposure has diminished with the elimination of leaded gas across the Region. As a result, mild mental retardation is expected to decline by around 21% in 2010 in the AMR B countries, and by around 32% in the AMR D block (16).

### Other proxies for the disease burden

Another indirect means of ascertaining energy-related morbidity is to study the illnesses that are influenced by environmental risks. This makes it possible to identify the regions or populations most vulnerable to these illnesses (21). A WHO study (16) based on the analysis of comparative risk and the opinions of 100 experts from several countries estimates that close to one quarter of deaths and DALYs worldwide are attributable to the environment. However, there are no scientific data to quantify the illnesses that may be associated with energy, despite the fact that energy is known to be one of the major factors affecting the environment.

According to the WHO study, certain groups have disproportionate disease burdens. Among children, for example, one third of deaths can be attributed to the environment, and the number of healthy years of life lost per capita among children under 5 globally is five times higher than in the general population and some 7 to 10 times higher in the case of respiratory infections. In addition, other health problems, such as diarrhea and malaria,

significantly affect mortality in children under 5. The developing countries also bear a disproportionate share of environmental morbidity.

With regard to noncommunicable diseases attributable to the environment, no significant difference was found between the developed countries and the developing countries. In the former, however, the number of per capita years of healthy life lost due to cardiovascular disease was seven times higher than in the less developed countries, and the cancer rate was four times higher (15).

Ranking second after diarrhea, lower respiratory tract infections are the factor with the greatest environmental component. In the developed countries, 42% of these infections are due to environmental factors, while in the developed countries the percentage is 20%. These illnesses are associated with indoor air pollution from the burning of solid fuels and are possibly due to passive exposure to tobacco smoke, as well as to urban air pollution. In the Americas –adjusting deaths from upper and lower respiratory tract infections for population size– the rate is six to eight times greater in countries with high infant and adult mortality than in countries with low infant and adult mortality (21).

An estimated 42% of chronic obstructive pulmonary disease (COPD) is associated with gradual loss of lung function due to environmental factors such as occupational exposure to dust and chemicals, indoor air pollution from the burning of solid fuels, vehicle emissions, and passive tobacco exposure (21). In North America, the proportion of COPD attributable to environmental factors is three times higher among men (22%) than among women (6%), probably due to patterns of tobacco use and occupational factors. In contrast to this AMR A region, however, women in the AMR D countries are more severely affected (47%) than men (38%), reflecting women's greater exposure to smoke while cooking with biomass fuels.

## Household practices and indoor air pollution

### Cooking with biomass fuels

A large percentage of rural households in LAC use solid fuels for cooking (see Table 17-1). Wood and charcoal are commonly used for cooking over an open indoor fire, thereby releasing a large quantity of pollutants. Food preparation involves a risk, especially for women, who spend hours each day cooking and who, as a result, inhale daily amounts of smoke equivalent to two packs of cigarettes (20).

Inefficient combustion of solid fuels in open fires releases a large volume of pollutants, chiefly particulates and carbon monoxide, but also nitrogen oxides, benzene, 1,3-butadiene, formaldehyde, polyaromatic hydrocarbons, and other toxins. The characteristic levels of  $PM_{10}$  (24-hour averages) in dwellings that use biomass in Africa, Asia, and Latin America range from  $300 \mu\text{g}/\text{m}^3$  to  $3,000 \mu\text{g}/\text{m}^3$  but can be as high as  $10,000 \mu\text{g}/\text{m}^3$  during periods of food preparation (20).

A study conducted in Michoacán (Mexico) found concentrations of  $PM_{2.5}$  (48-hour averages) near the cooking device that averaged  $693 \mu\text{g}/\text{m}^3$  (CI 95%: 246-1,338), while elsewhere in the kitchen measurements were  $658 \mu\text{g}/\text{m}^3$  (CI 95%: 67-1,448); measurements in the courtyard yielded  $94 \mu\text{g}/\text{m}^3$  (CI 95%: 36-236). Since most of the population cooks with wood, concentrations (24-hour averages) in the town's central plaza were on the order of  $59 \mu\text{g}/\text{m}^3$  (CI 95%: 29-92) (22), despite the fact that this is a small rural community. The study confirmed that indoor concentrations of breathable particulates and carbon monoxide in these microenvironments can be 10 to 50 times higher than the level in cities (23).

Wood as a proportion of final energy consumption in LAC declined from 35% to 34% between 2010 and 2011. At the subregional level, however, the figures are alarming: 82% in Central America, followed by the Caribbean, at 43% (4). This clearly indicates a public health problem that calls for priority attention.

### *Population using biomass, and annual number of associated deaths and respiratory illnesses*

Biomass and charcoal are fuels used in dwellings by over 80% of families in rural areas of Bolivia, Guatemala, Haiti, Nicaragua, Paraguay, and Peru, and by nearly half the rural population in Brazil, Colombia, and Mexico. Although cooking with biomass or charcoal is not as common in urban areas, Nicaragua (40%) and Haiti have high percentages of urban users. Haiti is the most critical case, since 100% of the rural population and 91% of the urban population uses these fuels (24).

Per capita consumption of wood in Latin America and the Caribbean is 20 BOE/inhab.<sup>3</sup> (see Table 17-1). The highest country figures, in descending order, are for Guyana, Nicaragua, Chile, Guatemala, Paraguay, Honduras, and El Salvador. It is estimated that in the countries of the Americas with high mortality rates, approximately 40% of the population cooks with solid fuels, while the corresponding figure in the low-mortality countries is barely 12% (20).

WHO recently examined the findings of epidemiological studies on the health implications of indoor exposure to polluted air (see Table 17-2). Smoke inhalation in dwellings doubles the risk of pneumonia and other acute respiratory infections in children under 5. Nearly 50% of the deaths from pneumonia in children under 5 are due to the inhalation of particulate air pollutants indoors. Such inhalation triples the risk of COPD and nearly doubles lung cancer rates in women over 30 (20). This burden falls on the poorest population groups, which use solid fuels for cooking.

Deaths from respiratory illnesses due to indoor air pollution in 2002 are estimated at nearly 85 per 100,000 population in the AMR D block, and 15 per 100,000 in the AMR B block. Worldwide, pneumonia remains the number one cause of death among children and is responsible for millions of deaths each year. In many countries, mothers carry their newborns and nursing babies on their backs, exposing them to the smoke from biomass for long periods of the day during their first year of life, when their respiratory passages are developing and their immune system is still immature, making these children especially vulnerable. Indoor smoke is one of the underlying causes of over 800,000 deaths per year in Latin America. The deaths are not distributed uniformly throughout the Region: two thirds of child deaths caused by indoor smoke occur in the countries of the AMR D block (20).

**Table 17-1.** Sustainability indicators

Country	Energy intensity (BOE/103 USD 2000)	Industrial energy intensity (BOE/103 USD 2000)	Final energy consumption per capita (BOE/pop.)	Total electrical coverage (%)	Per capita consumption of wood (BOE/pop.)	Wood as a share of final energy demand (%)	Total CO <sub>2</sub> emissions per capita (Gg CO <sub>2</sub> /103 inhab.)
Argentina	1.59	2.20	10.80	96.18	0.01	0.09	4.19
Barbados	0.55	1.80	8.11	99.29	0.00	0.00	4.76
Belize	1.49	3.43	6.04	92.94	0.15	2.48	1.78
Bolivia	3.64	8.38	4.51	79.78	0.83	18.40	1.58
Brazil	1.43	4.04	8.21	98.73	0.60	7.31	2.12
Chile	1.25	1.90	11.34	98.01	1.85	16.31	4.63
Colombia	0.91	1.57	3.74	95.43	0.25	6.68	1.41
Costa Rica	1.07	1.45	5.86	99.24	0.73	12.46	1.66
Cuba	0.90	4.55	4.52	97.46	0.07	1.55	1.98
Dominican Republic	0.64	0.64	3.13	92.08	0.21	6.71	1.92
Ecuador	1.65	2.76	5.32	93.76	0.17	3.20	2.35
El Salvador	1.09	1.49	3.24	92.10	0.52	16.05	1.03
Grenada	0.75	0.81	4.82	96.46	0.37	7.68	2.50
Guatemala	1.92	1.00	4.42	81.92	2.60	58.82	0.81
Guyana	2.65	11.15	6.01	79.99	0.35	5.82	2.28
Haiti	4.56	9.33	2.07	27.89	1.43	69.08	0.22
Honduras	2.28	2.02	3.53	83.26	1.58	44.76	0.99
Jamaica	1.69	2.49	6.97	92.83	0.54	7.75	3.27
Mexico	0.91	1.51	7.67	98.25	0.39	5.08	3.83
Nicaragua	2.71	2.18	2.68	65.78	1.18	44.03	0.82

Country	Energy intensity (BOE/103 USD 2000)	Industrial energy intensity (BOE/103 USD 2000)	Final energy consumption per capita (BOE/pop.)	Total electrical coverage (%)	Per capita consumption of wood (BOE/pop.)	Wood as a share of final energy demand (%)	Total CO <sub>2</sub> emissions per capita (Gg CO <sub>2</sub> /103 inhab.)
Panama	0.97	4.85	7.04	88.19	0.69	9.80	2.91
Paraguay	3.14	8.07	4.84	98.99	1.43	29.55	0.83
Peru	1.03	2.01	4.16	81.18	0.57	13.70	1.66
Suriname	2.29	1.33	8.60	89.58	0.37	4.30	4.57
Trinidad and Tobago	5.03	31.29	69.91	96.38	0.00	0.00	27.92
Uruguay	1.06	2.71	7.65	99.20	1.11	14.51	2.07
Venezuela	1.86	7.58	11.45	98.94	0.03	0.26	5.67
<b>LAC</b>	<b>1.29</b>	<b>2.82</b>	<b>7.38</b>		<b>0.57</b>	<b>7.72</b>	<b>2.70</b>

Source: OLADE, Latin American Energy Organization, *Energy Statistics Report 2012*.

Table 17-3 shows the values indicating the proportion of health problems attributable to the environment, and estimates the risks of different illnesses, such as diseases of the upper and lower respiratory tract, COPD, asthma, and cataracts, showing that indoor pollution is associated with higher rates than outdoor pollution.

Indoor pollution is associated with a variety of gender issues. These include the health of pregnant women living in rural areas, who, because they carry heavy loads when collecting wood, can suffer uterine prolapse, not to mention the risk of the embryo's exposure to pollutants produced during cooking, which can lead to low birthweight and even death (20).

Table 17-2. Health problems caused by indoor air pollution

Health effect	Evidence*	Population	Relative risk**	Relative risk (95% confidence interval)***	
Acute respiratory infections	Substantial	Children 0-5 years	2.3	1.9-2.7	SUFFICIENT
Chronic obstructive pulmonary disease	Substantial	Women ≥ 30 years	3.2	2.3-4.8	
	Moderate I	Men ≥ 30 years	1.8	1.0-3.2	
Lung cancer (charcoal)	Substantial	Women ≥ 30 years	1.9	1.1-3.5	
	Moderate I	Men ≥ 30 years	1.5	1.0-2.5	INSUFFICIENT
Lung cancer (biomass)	Moderate II	Women ≥ 30 years	1.5	1.0-2.1	
Asthma	Moderate II	Children 5-14 years	1.6	1.0-2.5	
	Moderate II	Adults ≥ 15 years	1.2	1.0-1.5	
Cataracts	Moderate II	Adults ≥ 15 years	1.3	1.0-1.7	
Tuberculosis	Moderate II	Adults ≥ 15 years	1.5	1.0-2.4	
<p>* Substantial evidence: Many studies on the use of solid fuels in developing countries, supported by probative data from studies of active and passive exposure to tobacco smoke, urban air pollution, and biochemical or laboratory studies. Moderate evidence: At least three studies on the use of solid fuels in developing countries, supported by probative data from studies on active tobacco use and animal studies. Moderate I: reliable evidence as to specific age or sex groups. Moderate II: limited probative data.</p> <p>** Relative risk indicates how many times more probable the illness is in people exposed to indoor air pollution than in people not exposed.</p> <p>*** The confidence interval represents the range of uncertainty. Large intervals indicate less precision, small intervals greater precision.</p>					

Source: PAHO-WHO, 2007.

**Table 17-3.** Values indicating the proportion of diseases or health risks attributable to the environment, by specific environmental risk factor

<i>Diseases or risks</i>	<i>Indoor air pollution</i>	<i>Outdoor air pollution</i>
Lower respiratory tract	***	*
Upper respiratory tract	**	*
Tuberculosis	*	*
Perinatal problems		*
Cancer	*	*
Cataracts	*	
Cardiovascular disease	*	*
COPD	**	*
Asthma	**	*
Proportion attributable to the environment: * <5% ** 5-25% *** >25%		

Source: WHO, 2004.

### ***Deforestation associated with the use of biomass as fuel and with CO<sub>2</sub> emissions***

In Brazil and Central America, 62% of the wood gathered is used for fuel (25). Worldwide, the use of biomass and charcoal for cooking and residential heating represents some 10% to 15% of total energy use. However, these household practices are not yet part of the debate on global warming or climate change. It is mistakenly assumed that biomass, being classified as a renewable energy source, is always sustainably collected and used (20). However, deforestation in LAC is responsible for 48% of the planet's carbon dioxide emissions, and when there is little wood and population density is high, considerable pressure is exerted on forests (25).

Wood as a share of final energy demand in LAC represents approximately 8% (see Table 17-1), with significant variation from country to country. Figures for Haiti, Nicaragua, Guatemala, Honduras, El Salvador, and Paraguay, for example, range from 19% to 69%. The burning of biomass does not convert all of the carbon into CO<sub>2</sub> and water. Open fires, including traditional open cooking devices, are extremely inefficient, produce large quantities of smoke, and lose a high percentage of energy in the form of incompletely combusted products such as methane (CH<sub>4</sub>), which is a powerful greenhouse gas that remains in the atmosphere for decades. When emissions of CO<sub>2</sub> and other greenhouse gases are combined in a single index, wood, crop residues, and manure account for a much higher share of the problem than do fossil fuels such as kerosene and liquid petroleum gas (LPG). This is the case even when the biomass used is renewable. Manure used in a biogas digester produces only 1% of the greenhouse gas emissions generated by using manure in a traditional kitchen to produce the same amount of energy (20).

### **Smoke from biomass, and respiratory effects in children: Guatemala**

One study, conducted over a two-year period in one of the poorest areas in Guatemala, analyzed the incidence of respiratory diseases in women who cook in the traditional way using an open fire and compared this with the incidence of such diseases among women who use improved stoves. The analysis examined the incidence and prevalence of respiratory symptoms, including chronic symptoms, as well as changes in lung function, allergies, sensitivity of the respiratory passages, effects on growth and development, and physiology (26).

The findings indicate that exposure to PM<sub>2.5</sub> (24-hour averages) in kitchens where cooking is done over an open fire was above 1,000 µg/m<sup>3</sup>, more than 60 times the acceptable upper threshold under U.S. air quality standards. Accordingly:

- Visits to doctors in the intervention group were 7% more frequent than in the control group (27).

- There was a positive correlation between respiratory symptoms and exposure. Prevalence was relatively high in women who cooked over open fires (cough: 22.6%; phlegm: 15.1%; sibilance: 25.1%; and chest pressure: 31.4%), but lung function appeared to be normal.
- It was estimated that nearly one third of these young nonsmoking women were at risk (stage 0) for COPD (28).

### ***Principal problems associated with the burning of biomass***

The rising prices of fossil fuels and the lack of access to them by marginal communities in the developing countries make it difficult for this population to use cleaner fuels. However, wood and other biomass fuels can be burned cleanly with the right technology. If harvested in a renewable manner, they can even play an important long-term role in sustainable development. Thus, in order to improve the health and quality of life in these communities, programs to modernize the use of wood in homes and small businesses in the poorest areas of developing countries should be included in development plans. This concern is shared by international organizations such as the Shell Foundation and WWF, which help finance programs to provide households with improved stoves (29).

### **Heating, ventilation, and carbon monoxide poisoning**

Many people die each year from carbon monoxide poisoning. Most cases in the developing countries are associated with the use of braziers or improperly installed or defective gas devices in poorly ventilated spaces. The risk of exposure increases in the winter, when, because of extreme temperatures, and the difficulty of accessing or paying for energy to heat their dwellings, people resort to biomass as a fuel, resulting in increased carbon monoxide poisonings and deaths.

Despite the socioeconomic level of the United States, the Centers for Disease Control and Prevention (CDC) (30) indicate that more than 500 people die annually from unintentional carbon monoxide poisoning from portable generators, cook stoves, and fuels and heaters. Over 20,000 emergency room visits and more than 4,000 hospitalizations also occur each year as a result of this problem. During the 2012-2013 winter (31) in Mexico, 24 deaths from carbon monoxide poisoning were reported, a figure believed to be an underestimate of the actual number of deaths.

### **Coverage of electricity**

Lack of electricity has a significant effect on the health of the population. Without access to electricity, health clinics can provide only limited medical care, and health programs and campaigns conducted via radio and television cannot reach the public. In addition, lack of electricity affects food preservation and thus leads to a higher incidence of food poisoning due to spoilage, in addition to causing increased health problems associated with the inability to pump and treat water.

The most critical example of this is Haiti, where electrical coverage is less than 28%. Honduras, Bolivia, and Nicaragua have 60% to 70% coverage rates; Peru and Guyana, 79%; Grenada, Panama, Guatemala, and Ecuador, between 80% and 90%; while the rest of the countries in the Americas have coverage levels of above 90% (see Table 17-1).

### **Transportation**

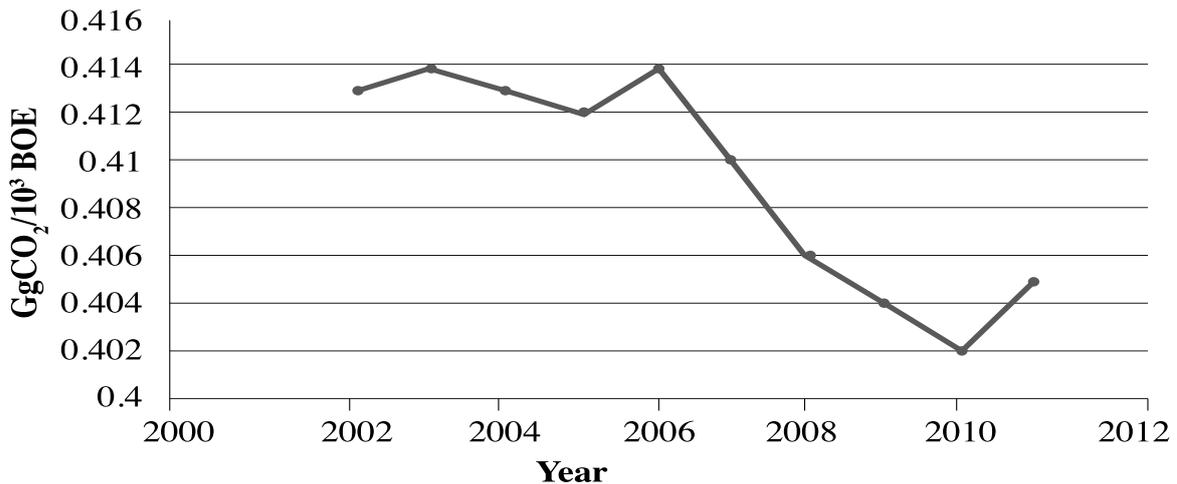
Transportation, a sector that plays a major role in economic activity and generates important benefits for the population, is one of the main sources of pollution in large cities around the world. Due to increasing roadway congestion, accidents, and lack of safety, transportation poses a major public health problem. Cities face the challenge of reducing the environmental and other negative effects of transportation, while at the same time maintaining the mobility benefits for passengers and freight (32).

Estimates of the contribution of motor vehicles to air pollution range from 25% to 75%, depending on such factors as vehicle design, the emission controls installed, and the type and quality of fuel (33). The main pollutants emitted are carbon monoxide (CO), unburned hydrocarbons or volatile organic compounds (VOCs), nitrogen (NO<sub>x</sub>), and particulates (PM). In the Valley of Mexico, emissions records for 2010 show that 78.7% of NO<sub>x</sub> and 31.3% of VOC was from mobile sources (32).

In 2011, transportation emissions in LAC, at 615 Mt, represented 38.6% of the world's CO<sub>2</sub> emissions. In the period 2002-2011, the ratio of CO<sub>2</sub> emissions to energy consumption by the transportation sector was trending

downward, with the highest ratio being in 2006 (0.414 Gg of CO<sub>2</sub>/10<sup>3</sup> BOE) and the lowest in 2010 (0.402 Gg of CO<sub>2</sub>/10<sup>3</sup> BOE), as shown in Figure 17-6 (4).

**Figure 17-6.** CO<sub>2</sub> emissions per unit of energy consumption in Latin America and the Caribbean



*Source:* OLADE, Latin American Energy Organization, *Energy Statistics Report 2012*.

The transportation sector consumes 60% of the world's oil production (34). Accordingly, it is expected to play the greatest role in increasing oil demand and, thus, in the health problems resulting from exposure to the pollutants emitted. Exposure varies with the time an individual spends near the source of the emissions (exhaust pipes) and the distance from them. At peak traffic hours, for example, pedestrians and drivers, surrounded by automobiles and buses, are exposed to much higher concentrations of emissions than those recorded by air quality monitoring stations.

Data like those cited above have shown that vehicles with better technologies, post-treatment devices, and cleaner fuels are effective in reducing air pollution (33). (See Table 17-4, which shows current standards in LAC.)

The United States exerts a major influence on the Region by exporting used vehicles that are more polluting than newer ones, thus slowing emissions reductions in the countries to which it exports. In the past seven years, for example, Mexico imported over 5 million used vehicles that were more than 10 years old, most of them SUVs and pickup trucks with very low fuel efficiency (<7 km/L), with used vehicles making up a larger share of sales than new ones. Potential United States exports of used vehicles to the Region amount to over 14 million units per year, which, added to those of Japan, create a less-than-encouraging scenario for public health.

In addition to the adverse effects of motor vehicles on air quality, more than 1.3 million people die and another 50 million are injured each year in traffic accidents. Over 90% of such deaths are in the low- and middle-income countries. In the Americas, 142,252 people die each year from causes related to traffic accidents, while over 5 million are injured and hundreds of thousands disabled. The Latin American economies are those most affected by poor vehicle maintenance; they also have the most varied mix of roadway users (pedestrians, bicyclists, and motorcyclists), as well as a marked lack of safety education among users and inadequate regulatory regimes (35).

### Gasoline-powered vehicles

In 2009, the number of gasoline-powered vehicles in North America (United States and Canada) is estimated to have been approximately 254 million, versus 86 million in LAC (36). As Table 17-4 shows, however, there are wide disparities in LAC in the number of automobiles per 1,000 population, with this ratio being:

- Very low ( $\leq 10$ ) in Haiti and Bolivia.
- Low (between 30 and 70) in Cuba, Nicaragua, Peru, Colombia, Ecuador, Guatemala, El Salvador, and Honduras.
- Moderate (between 70 and 120): in Paraguay, Venezuela, the Dominican Republic, Belize, and Panama.

- High (between 120 and 220) in Chile, Uruguay, Brazil, Jamaica, Costa Rica, Argentina, and Mexico.
- Highest in the Americas ( $\geq 220$ ): Trinidad and Tobago, Puerto Rico.

**Table 17-4.** Vehicle fleet, regulations in force, passenger vehicle inspection and maintenance, and sulfur content of diesel fuel, 2012 (37)

Country	Fleet (vehicles per 1,000 pop.)	Regulations	Inspection and maintenance	Maximum sulfur content in diesel fuel (ppm)	Current and future plans for diesel	Sulfur content in gasoline (ppm)	Current and future plans for gasoline
Argentina	181 (2003)	EURO IV (2012): new light vehicles, buses and pickups (gasoline and diesel)	Vehicle inspection (2008) I/M in the 7 major cities	1,500	300 national (2012) 50 cities (2012) 30 national (2016)	300	300 national (2012) 50 cities (2012)
Belize	91 (1998)	No standards	Vehicle inspection system				
Bolivia	10 (2003)		Vehicle inspection system	3,000	2,000 ppm (available on the market)	50	
Brazil	170 (2003)	Vehicle emissions standards for new trucks and buses EURO II (1993) EURO IV (2009) Also applicable to imported vehicles L-6 in 2014-2015 EURO IV (2013)	Annual state vehicle inspections (2012)	1,800	1,800 national and rural areas 50 public transportation and bus services 500 general public use (2014)	1,000	
Chile	136 (2003)	Gasoline-powered passenger vehicles: EURO III (2010) New public transport in metropolitan areas US Tier 1—FTP 5 applicable for PC and LDV Diesel: EURO IV or CARB Tier 1 HDV EURO III	Annual emissions and road tests (1994) Vehicle labeling (mandatory 2013)	50	50 ppm national (2010) 15 ppm metropolitan areas (2011)	30	15 ppm metropolitan areas

<i>Country</i>	<i>Fleet (vehicles per 1,000 pop.)</i>	<i>Regulations</i>	<i>Inspection and maintenance</i>	<i>Maximum sulfur content in diesel fuel (ppm)</i>	<i>Current and future plans for diesel</i>	<i>Sulfur content in gasoline (ppm)</i>	<i>Current and future plans for gasoline</i>
Colombia	51 (2003)	Catalytic converters in all vehicles Emissions standards: EPA (1987): Light gasoline-powered vehicles. All new vehicles must meet EURO I EPA (1994): heavy diesel vehicles. Other standards: EPA, 1991: other vehicles EURO I: heavy vehicles EURO II: new buses EURO IV: heavy vehicles (2014)	In progress	500	50 national (2014) 500 (2010) 50 for Bogotá and the national public transportation network	300	300 national (2010)
Costa Rica	185 (2003)	Catalytic converters in all vehicles Emissions standards: US 87 (Tier 0) or EURO I	In progress	50	50 national (2011) 15 national (2014)	1,000	
Cuba	37 (1990)		Vehicle inspection regime (2001)	8,000		1,200	
Dominican Republic	97 (2001)		Inspection and maintenance regime (2012)	7,500		1,500	
Ecuador	53 (2003)	EPA (1987) or EURO I: light gasoline-powered vehicles EPA (1994) or EURO II: heavy diesel vehicles	Emissions testing	7,000	500 (2009)	650	

Country	Fleet (vehicles per 1,000 pop.)	Regulations	Inspection and maintenance	Maximum sulfur content in diesel fuel (ppm)	Current and future plans for diesel	Sulfur content in gasoline (ppm)	Current and future plans for gasoline
El Salvador	61 (1997)	Catalytic converters in all gasoline-powered vehicles. US 87 (Tier 0) or EURO I: passenger vehicles and light vehicles. 3-way catalytic converters in gasoline-powered vehicles	Inspection system	5,000		1,000	
Guatemala	57 (2003)		I/M cancelled (US EPA)	5,000	500 ppm (2010)	1,000	500 ppm (2010)
Haiti	8 (1990)						
Honduras	61 (2003)		Inspection regime	5,000	500 ppm (2010)	1,000	
Jamaica	175 (2004)		Inspection regime (2004)	5,000		1,500	
Mexico	201 (2003)	Since 1993 EPA 1998, EPA 2004, EURO III or EURO IV: heavy diesel-powered vehicles EPA Tier 1: light gasoline/diesel-powered vehicles except for NO <sub>x</sub> and PM - Tier 2 (EURO IV) as of 2009	I/M in 16 states and in metropolitan areas of the largest cities (Mexico City and Guadalajara, among others)	500	50 ppm national (2015)	80	500 cities 30 average/80 national (2013)
Nicaragua	39 (2003)		In progress	5,000	500 (2010)	1,000	
Panama	107 (2003)		In progress (2010)	3,000	500 ppm (2010)	1,000	
Paraguay	88 (2003)		Vehicle inspection	5,000		1,000	
Peru	46 (2003)	EURO IV (2013): passenger buses (Lima)	Inspection and maintenance in some cities	5,000	50 metropolitan areas (2010) 1,500 national (2010)	2,000	

Country	Fleet (vehicles per 1,000 pop.)	Regulations	Inspection and maintenance	Maximum sulfur content in diesel fuel (ppm)	Current and future plans for diesel	Sulfur content in gasoline (ppm)	Current and future plans for gasoline
Puerto Rico	295 (1990)	Emissions standards US EPA	Annual inspections and emissions testing if vehicle is over 2 years old	15		15	
Trinidad and Tabago	220 (1998)		Vehicle inspection	1,500		500	
Uruguay	138 (1990)	EURO III: new vehicles	Vehicle inspection	7,000	50 (2013)	700	30 (2012)
Venezuela	90 (1990)		Emissions testing only in some areas	2,000	2,000 (2010)	1,500	400 (2010)

**Source:** UNEP (2011): *Latin America and the Caribbean passenger vehicle standards and fleets*. Available at: [http://www.unep.org/transport/pcf/v/PDF/Maps\\_Matrices/LAC/matrix/LAC\\_vehiclestandardsmatrix\\_august2011.pdf](http://www.unep.org/transport/pcf/v/PDF/Maps_Matrices/LAC/matrix/LAC_vehiclestandardsmatrix_august2011.pdf)

The trend in the Region, which first emerged in North America, has been to buy heavier, sport-utility-type vehicles, which, by their nature, consume more energy. On the other hand, due to the ban on the sale of leaded gasoline in every country in the Region since 2006, the introduction of more efficient gasoline-powered vehicles with emissions control systems has paved the way for post-treatment systems – catalytic converters in particular – thus reducing emissions even further. (See Table 17-4, showing current standards in Latin America.)

However, it remains to introduce ultra-low sulfur content gasolines, which will permit the use of better catalytic devices, filters, and other technologies to further reduce vehicle emissions. In the wake of several generations of reformulated gasolines designed to eliminate lead, sulfur, and a number of photoreactive and toxic compounds – a development that prompted the introduction of catalytic converters and other antipollution devices – hybrid options have the greatest appeal at present for a world in transition with regard to energy and automobiles.

In 1991, remote sensors in Mexico indicated that 4% of automobiles produced 30% of the hydrocarbon exhaust emissions, while 25% produced 50% of carbon monoxide (CO) emissions (38). In 1994, the same methods indicated a decrease of approximately 50% in average CO and hydrocarbon emissions, thus demonstrating the effectiveness of the catalytic converters required on cars as of 1993 (38). In 2000, measurements showed a 70% reduction in CO emissions and a 90% reduction in hydrocarbons as a result of on-board diagnostics (OBD) systems, which facilitate better monitoring of evaporative emissions than can be achieved through vehicle inspections. Currently, the U.S. Environmental Protection Agency (EPA) recommends the use of OBDII systems for vehicle inspections; the new OBDIII systems are already in the testing phase in intensive-use vehicle fleets, with taxis in Los Angeles and San Francisco being cases in point (32).

In addition, some cities have highly developed environmental regulations for direct emission controls, such as restricted use of automobiles. São Paulo (Brazil), Santiago (Chile), and Mexico City are examples of this. In the Mexico City metropolitan area, programs such as the “Hoy No Circula” (No Driving Day) are in place, as well as vehicle testing, which is widespread in most of the countries in the Region. These and other measures have helped by accelerating the turnover of old vehicles, introducing stricter emissions standards, and controlling traffic flows during air quality crises (see Table 17-2).

### **Brazil: Bioethanol**

Anhydrous ethanol (containing up to 5% water), whether pure or mixed with gasoline, can be used as fuel in motor vehicles without the need to modify the vehicles. Brazil and the United States are the world’s main producers

of ethanol. They have similar levels of production and together represent 92% of world output. In Brazil, ethanol production is exclusively from sugarcane, while in the United States it is produced primarily from corn.

With regard to energy consumption, the amount of biofuels consumed as a percentage of total fuel consumption is 13% in Brazil and 6.5% in Cuba –figures far higher than the world average. In Brazil, 80% of new cars run either on ethanol or “petrol” (a mix containing 25% ethanol) and consume 40% of the country’s fuels (13). In the United States and Canada, the respective figure is less than 2%; in light of this, in 2005 the United States mandated that, between 2006 and 2012, the percentages of biofuels in gasoline be increased (7).

The use of biofuels offers environmental advantages by reducing greenhouse gas emissions. However, it can have an adverse effect on sustainable development and food production without providing the anticipated degree of pollutant reductions, since more energy is used in producing them than is obtained from the product itself. Reducing emissions depends on the energy associated with the fertilizers and pesticides used, the water required, the energy needed to harvest and transport the biomass, the type of biomass involved, the alternative uses of the soil, and the type of primary energy utilized. Thus, an energy balance sheet, indicating the life cycle of the biofuels involved, provides a more complete picture of the specific benefits of producing and using these fuels (7). For example, the production of ethanol from sugarcane in Brazil has a positive bottom line in terms of CO<sub>2</sub> emissions, while corn-based production in the United States appreciably increases the problem of climate change.

Moreover, alcohol combustion emits aldehydes, many of which are irritants and potential carcinogens, while contributing to the formation of photochemical smog.

### ***Agricultural workers and biofuels (39)***

The rapid growth of bioethanol in the past few years has intensified the changes taking place in the rural environment, sometimes with negative repercussions on living and working conditions and on the health of rural workers.

Sugarcane cutters perform physical labor and are exposed to chemical and biological agents that can cause disease, trauma, and accidents, including dermatitis, conjunctivitis, dehydration, poisoning, cramps, dyspnea, respiratory infections, hypertension, and a variety of injuries. In addition, the intensification of the biophysical burden of agricultural work increases the frequency of chest, head, and lower back pain, mental health crises, and other psychosomatic disorders that can lead to ulcers, hypertension, or alcoholism.

The repetitive, monotonous, and mechanical nature of sugarcane harvesting makes it easy for workers to become distracted and have accidents. Since their pay is commonly based on the number of tons cut, work days become longer and the pace of the work intense, increasing fatigue, distraction, and, thus, accidents. Although protective equipment is mandatory, not all employers or workers observe the rule. In addition, some equipment is made of poor materials or is not the right size, making it uncomfortable and, ultimately, an obstacle to performing the work.

In the fields, it is also common to transport workers in inappropriate vehicles that are poorly maintained. This increases the incidence of accidents, often with serious consequences. According to Silva *et al.* (40), there were 73 accidents with trucks transporting workers in the state of São Paulo (Brazil) in the 15 years preceding the study, causing 269 deaths and injuring or disabling 1,103 laborers for work.

### **Diesel-powered vehicles**

Diesel-powered vehicles emit a complex mix of pollutants that include fine particulates, nitrogen oxides –an important precursor of ozone– and over 40 potentially carcinogenic substances, most of which are adsorbed to the particles emitted in the exhaust (41). In Mexico City, where diesel trucks more than 20 years old and cars without catalytic converters are still in operation, street-level studies found average concentrations of polycyclic aromatic hydrocarbons (PAHs) of 300 µg/m<sup>3</sup> –concentrations several times higher than those found in the United States (42).

In many Latin American cities, old, poorly maintained diesel buses are used for public transportation, with little or no regulation of their polluting emissions. In some Central American countries, as well as Peru, Chile, and Mexico, black smoke emissions from vehicles with diesel engines are subject to static opacity tests (“snap” tests), which have only a limited ability to detect improperly maintained vehicles. Many private vehicles imported from Japan to Central and South America have diesel engines, and cars emitting plumes of black smoke are a common sight in the countries of the Region.

Diesel emissions can be reduced by improving the quality of the fuel, which can lower sulfur content by 5,000 ppm or more. Fuel of this type is available in most LAC countries (see Table 17-4) and can have sulfur levels lower than 50 ppm, as is the case in Chile. The average sulfur content of diesel sold in Mexico is between 350 ppm and 500 ppm. Recently, however, ultra-low-sulfur diesel (ULSD), similar to that used in Puerto Rico, has become available for public transportation in urban areas.

Most of the countries are making efforts to reduce the sulfur content in diesel. Some scheduled the introduction of ULSD (<15 ppm) for 2009, others for 2013, with large cities being the primary target for introducing this type of fuel in the market.

The use of ULSD not only reduces the emissions of particles smaller than 2.5 micrometers ( $PM_{2.5}$ ) but also makes it possible to design new technologies for controlling exhaust emissions –technologies that include post-treatment devices such as particle filters, NO<sub>x</sub> absorber catalysts, and selective catalytic reduction systems (33).

It is projected that, in the United States, particulate reductions of more than 90% will be achieved by 2030 through the introduction of ULSD (<15 ppm). Since 2007, new trucks are as much as 95% cleaner than earlier models (43). The environmental and public health gains are 17 times greater than the costs of the investment involved. These benefits involve an estimated annual reduction of 8,300 premature deaths, 5,500 cases of chronic bronchitis, 17,600 cases of acute bronchitis in children, 360,000 cases of respiratory symptoms in asthmatic children, 1.5 million lost work days, 7,100 hospital admissions, and 2,400 emergency room visits (44).

One alternative to diesel is plant-based biodiesel, obtained from vegetable oils such as sunflower oil, rapeseed oil, palm oil, soy oil, and peanut oil, or from animal fat. Biodiesel can be used in its pure form or in combination with conventional diesel to lower the concentration of sulfur and other impurities. The United States and Brazil have recently begun producing biodiesel from soy, and they remain the largest producers in the Americas. As of January 2008, Brazil mandated that diesel contain 2% biodiesel. This figure was increased to 3% in July 2008 (45), with 5% the target figure to be reached by around 2013 (13).

Biodiesel emissions as a whole are less harmful than conventional diesel, but probably include more NO<sub>x</sub> and certain carcinogens (46). Analysis of the life cycle of biodiesel produced from vegetable oils has been a source of controversy. Criticism has focused on: the negligible reduction of greenhouse gas emissions achieved; the unsustainability of production, given the deforestation caused and the water use required; the resulting problems in connection with land management issues; competition with other crops, exerting upward pressure on food prices; and the need for extensive government support to maintain competitiveness, even when the technologies have matured. The greatest source of hope in regard to biodiesel has been second-generation biofuels, made from inedible biomass such as straw, bagasse, forestry residues, grasses, and the organic content of municipal waste (46).

## Industry

The energy used in the industrial sector, particularly energy associated with the burning of fossil fuels or the processing of oil derivatives, is one of the main causes of environmental pollution –in air, water, and soil– resulting from the direct and indirect production of toxic substances. Cities and regions with intense industrial activity in the Americas have at various times been faced with serious public health problems.

In 2006, the industrial sector emitted 16% of global CO<sub>2</sub> emissions, 56% of which were from coal. Some 65% of industrial CO<sub>2</sub> emissions come from the steel, chemicals and petrochemicals, paper and nonmetallic minerals, cardboard, and printing industries (47). These emissions are also accompanied by emissions of mercury and other heavy metals, along with the precursors of acid rain and deposits of chemicals such as sulfur oxides and dioxide.

In 2011, the industrial sector accounted for 18.6% of total CO<sub>2</sub> emissions in LAC, having stabilized at 0.21 Gg CO<sub>2</sub>/10<sup>3</sup> BOE as a result of the decline in emissions in a certain countries. In Mexico, for instance, industrial energy intensity was lower than in 2010, owing to more efficient energy use (4).

In Mexico City, polluting industrial emissions represent 18.1% of PM<sub>10</sub> emissions, 91% of SO<sub>2</sub>, 6.5% of NO<sub>x</sub>, and 13% of PM<sub>2.5</sub>.

Industrial facilities in the Region that use obsolete technologies lack emission controls and are normally not subject to effective enforcement measures, thus contributing significantly to the air pollutant load (36).

## Life cycle of electricity generation

Not all forms of electricity generation show a positive environmental bottom line, since they have different life cycles. Figures 17-7 and 17-8 compare the greenhouse gas emissions from electrical power plants that use fossil fuels with those that use renewable energy sources. Emissions are divided into direct (smokestack) and indirect (other phases of the life cycle) emissions. The study, conducted by the World Energy Council (WEC), which also

compiled the data, demonstrates that the CO<sub>2</sub> emissions of power plants that use lignite, coal, oil, and natural gas are higher than those of plants using photovoltaic solar cells, hydro power, wind, or nuclear energy. The emissions of plants using fossil fuels can be significantly reduced by processes that capture and store carbon. In general, the polluting emissions associated with renewable energy are generated in the extraction and processing of the minerals, the manufacture of components, transportation, construction, and the dismantling of power plants (48).

## Extractive activities

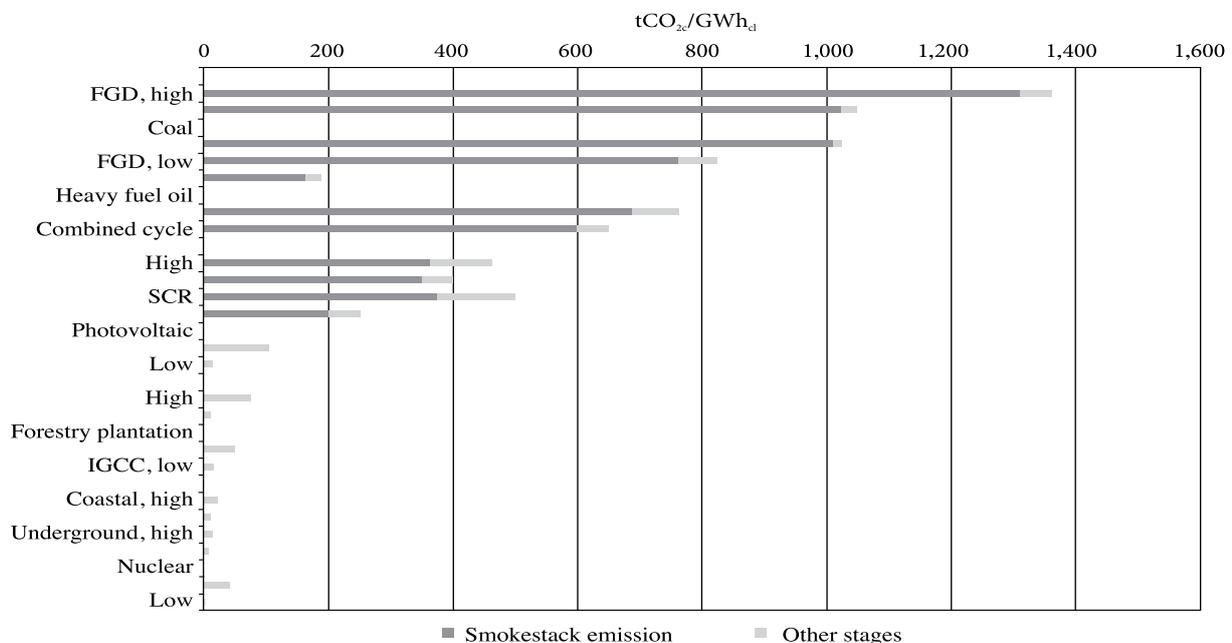
Prospecting and the extraction of fossil fuels such as coal, oil, natural gas, and uranium are generally accompanied by changes in the environment (e.g., the opening of roads), industrial and workplace accidents (e.g., oil spills and mine collapses), air emissions (e.g., the burning and venting of wastes and associated gases), and the generation of solid and hazardous wastes (e.g., drilling mud, etc.), which have repercussions for the health of workers in this sector and residents of nearby communities.

### Coal mining

Historically, underground coal mining has been one of the activities posing the highest risk to the physical safety and health of workers. However, some improvements have been made to reduce accidents. Internationally, and most notably in the Americas, coal is the most abundant and most commonly used fuel for producing electricity. Within the Americas, the United States, Canada, and Colombia are the countries with the largest reserves. Open-pit and underground coal mines range from mines with the most advanced equipment and highly skilled labor to hand-dug mines in which the coal is extracted and transported manually under intrinsically unsafe conditions that are harmful to health (49).

If improperly managed, the extraction, transport, and processing of coal can cause injuries, disease, and even death. The risks associated with these activities vary widely and include: explosions; fires; mine collapses; exposure to toxic substances; pulmonary diseases leading to disability or premature death; partial or total hearing loss due to noise; the release of gases, water, or other materials from old mines or geological faults; falls, slips, and stumbles; and exposure to excessive temperatures and vibration. The respiratory tract can be harmed by exposure to toxic substances in poorly ventilated environments, leading to acute pulmonary lesions, pneumoconiosis, pulmonary dysfunction, and lung cancer. Pneumoconiosis is calculated to have caused 30,000 deaths and 3.7 million DALYs globally in the year 2000 (50).

**Figure 17-7.** Comparative CO<sub>2</sub>-equivalent emissions in electricity generation using different types of technologies, based on life cycle analysis



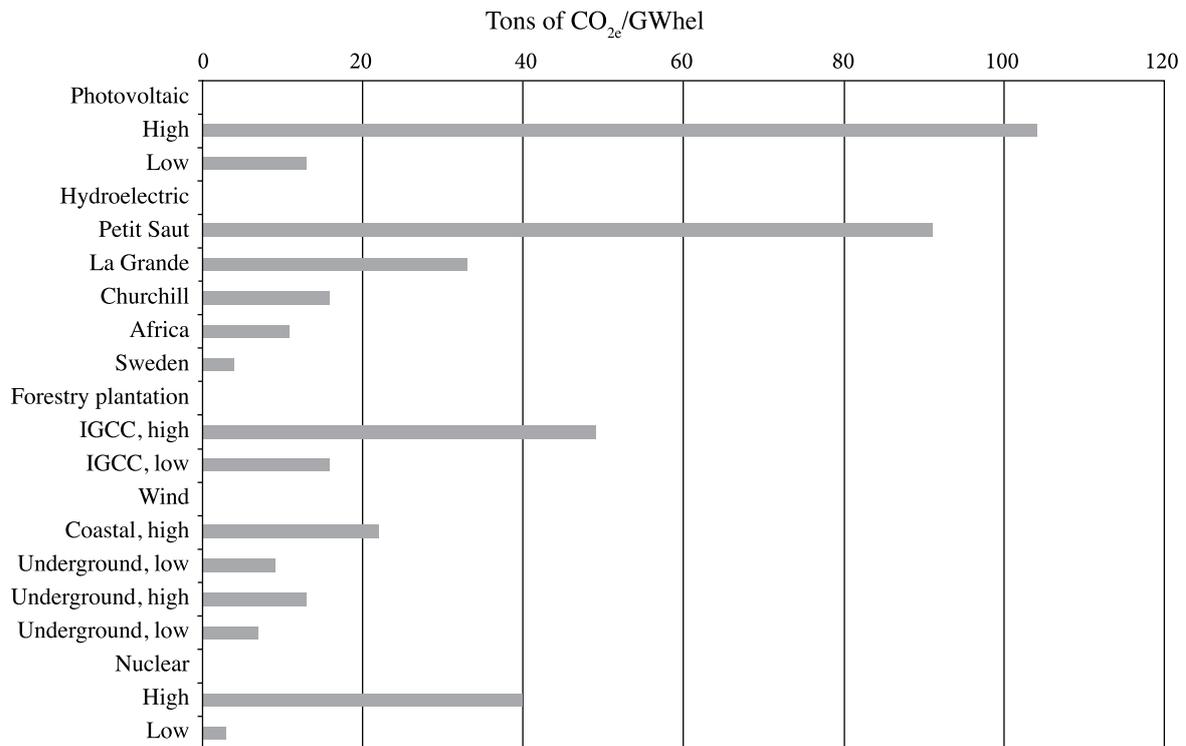
**Source:** WEC (World Energy Council), *Comparison of Energy Systems Using Life Cycle Assessment, A Special Report of the World Energy Council*, 2004.

The most feared type of accident in these mining activities is the irruption of methane gas or firedamp, which can exceed the forced ventilation capacity of a mine, cause explosions leading to internal collapses, or simply exhaust the oxygen in the air, asphyxiating the miners. Extractive work inside coal mines also produces clouds of dust in the underground galleries or tunnels, with a high saturation of small coal particles, which can explode if they accumulate and are not kept at controlled levels (49), as illustrated by the case of the Pasta de Conchos mine in Mexico in 2006, in which 65 miners died. In the United States, there were 1,400 coal mines in 2008, 800 of which were surface mines and 600, underground mines (51). Between 1900 and 2006, the United States had 11,606 coal miner deaths in 513 disasters, over 80% of which were caused by explosions (52). Those accidents led to a review of safety standards and the issuing of new regulations for underground coal mines (53), resulting in a decline in the annual number of deaths from 300-400 per 100,000 miners per year at the beginning of the 20th century to 20-40 per 100,000 miners per year in the most recent decade (54). The worst accident in the past 10 years in LAC occurred in June 2010 at the San Fernando de Antioquia coal mine (Colombia), where an explosion caused by the accumulation of gases killed 73 people.

Despite these reductions, mining in the United States is classified by the Bureau of Labor Statistics as the second most hazardous occupation (55). An epidemiological surveillance study in the United States determined that between 1996 and 2002 there was a 3.4% incidence of pneumoconiosis among coal miners who worked in underground mines, with a 1.9% incidence among those working in surface mines. The incidence of progressive massive fibrosis among underground and surface miners was 0.2% and 0.1%, respectively. After passage of the Federal Coal Mine Health and Safety Act in 1969, the incidence of this disease among coal miners dropped markedly up to 1995, at which point it flattened out, except among miners who had worked for more than 25 years (56).

Surface mining destroys vegetation and compromises the genetic profile of the soil. It displaces or destroys wildlife and wildlife habitat, degrades air quality, alters soil use, and in most cases, changes the topography and hydrology of the area being mined (55). The amount of earth extracted by mining activities is greater than the amount of earth eroded naturally by rivers. Thus, in some countries, such as the United States and Mexico, laws have been passed requiring the remediation of land used for mining.

**Figure 17-8.** Comparison of CO<sub>2</sub>-equivalent emissions from electricity generation using renewable technologies, based on life cycle analysis



Source: WEC, 2004.

### *Oil and gas*

Oil extraction can involve deforestation, soil pollution, and the degradation of aquatic and terrestrial ecosystems. Spills are common during extraction and can pollute bodies of water, while enormous waste, which must be properly removed to avoid polluting, is often generated. In remote areas, the oil industry requires that roads and infrastructure be built, and workers from outside the community must be brought in, thus changing the life of the local population and potentially affecting local public health. Valuable biologically diverse areas can be threatened by new oil operations, as has been the case with the National Wildlife Refuge in Alaska (36), the Mesoamerican Biological Corridor, and the Amazon rainforest in Bolivia and Brazil.

The largest oil spill from a marine oil well was the incident at Ixtoc I in Campeche Sound, in the Gulf of Mexico, which occurred in 1979-1980, lasting nine months and discharging approximately 475,000 tons of crude oil, much of which reached the Texas coastline. Ixtoc I was the second largest oil spill in history, exceeded only by the deliberate spill that occurred during the Gulf War in 1991 (57). Also memorable was the April 2010 spill in the Gulf of Mexico, which released 4.9 million barrels of oil –19 times more than the amount released in the *Exxon Valdez* disaster of 1989. The health repercussions of these accidents have not been well documented, but it can reasonably be surmised that the contamination of food chains, the pollutants released into the air, and the hydrocarbon pollution of seas and beaches have medium- and long-term effects on local and regional populations.

Natural gas also has its problems. Large quantities of methane, which is considered the second-ranking greenhouse gas in terms of its contribution to global warming, are released during the extraction and distribution process (58).

In February 2013, the EPA announced that, according to the updated inventory of greenhouse gas emissions, the extraction of oil and natural gas, as a whole, in the United States –including hydraulic fracturing (“fracking”) – represented the second largest sector in terms of emissions, accounting for 225 mmt CO<sub>2</sub>e (2011 was the first year in which data from this sector were reported) (59).

In view of the declining oil and natural gas reserves, the world’s technically recoverable reserves of shale gas are becoming increasingly important. These are estimated at 7,299 trillion cubic meters, according to the EIA. However, fracking’s effects on health and the environment have received little study. This extractive technology, involving the injection of large quantities of water and chemicals, fracturing the rock that holds the gas, is associated with the pollution of surface and groundwater, due to the migration of the products used. Local seismic activity has also been detected, landscape and environmental services are degraded because of the large number of wells required, and health is affected by the release of volatile chemical substances, such as benzene, into the atmosphere. The EPA is currently conducting a study on the potential impact of this extractive technique on water resources (60).

### *Uranium mining*

In 2008, Canada was the world’s largest uranium producer (20%), with extraction taking place in three mines, two subterranean and one open-pit. Canada’s proven reserves are exceeded only by those of Australia (61).

The United States is the world’s eighth largest uranium producer. In 1970, it had 250 mines, but production declined sharply in 1980, leaving only 50 mines in operation. This decline has continued, with only two mines operating as of 2003. Some 45% of potential production involves *in situ* leaching, while the other 55% involves conventional mines. There are currently 14 *in situ* leaching operations. In the 1940s and 1950s, uranium mines and treatment plants in the United States were abandoned, and large investments were required in the 1980s to decontaminate them. For example, the Urvan mine on the San Miguel River (in Colorado) was designated a hazardous waste site in the Superfund program and was cleaned up between 1987 and 2007 at a cost of over US\$120 million (61).

Brazil is the world’s 12th largest uranium producer. It has had uranium mines since 1982, although only one is in operation today. Argentina began uranium exploration in the 1950s. In 1997, its production came from one open mine in Mendoza (now closed) and from seven leaching operations (61).

Uranium mining involves risks from two sources: dust and the release of radon gas. Radon is naturally present in uranium mines and, though not explosive, is a source of ionizing radiation. In the air, the radiation can cause lung cancer, thus accounting for the higher-than-normal incidence of this disease among mine workers.

In 1950, the U.S. Public Health Service began a series of studies to evaluate the health of uranium mine workers. These studies, which were later taken up by the National Institute for Occupational Safety and Health (NIOSH), pointed to a significant level of mortality from lung cancer among white (Caucasian) miners: six times higher than

the average for the general population. The research also found mortality from pneumoconiosis to be 24 times higher than the average for the general population, while the incidence of tuberculosis was 4 times higher, and that of emphysema, 2.5 times higher (52).

## Fuel storage and transport

Storing and transporting fuel entails risks; spills and accidents sometimes exceed the capacity of ecosystems to assimilate the material released and pose a hazard to the population's health. Over one third of oil spills of more than 100,000 tons have occurred in the Americas. The largest spills have been from oil tankers and have occurred in the Gulf of Mexico and the northwestern United States (62).

The largest of these spills in the Americas occurred in 1979 and 1989. One was the *Atlantic Empress* spill in Trinidad and Tobago, which released 287,000 tons of crude; the other was the *Exxon Valdez* in Alaska, which released nearly 36,000 tons of hydrocarbons, covering 1,200 square kilometers and affecting over 2,000 kilometers of coastline. Because of the scope of its effects, the *Exxon Valdez* spill is considered to have been the most harmful to the environment, causing the death of thousands of animals—nearly 250,000 marine birds, 2,800 marine otters, 250 bald eagles, 22 killer whales, and billions of salmon and herring eggs. The cost of the cleanup was roughly US\$2.1 billion, and even today some areas of the coast closest to the spill are contaminated with oil. It is estimated that remnants from the spill are spreading by up to 4% per year. The incident severely impacted the population living in nearby areas, causing enormous stress and economic and cultural disruption (63).

Most tanker spills occur in the course of routine operations such as loading, unloading, and fueling; thus, they typically occur in ports or at oil terminals. Some 91% of these operational spills involve less than seven tons of oil. In collisions and groundings, the spills are much larger: 84% of such accidents discharge more than 700 tons of crude (64). This has aroused concern about the risks to human health from inhalation of, or contact with, the materials from oil spills, as well as concern about the consumption of contaminated marine products (65).

Oil industry accidents are likely to be tragic when they occur in densely populated urban areas. The explosions of gas tanks in San Juanico (Mexico) in 1984 caused the death of some 500 to 600 people, who were instantly incinerated. The sewer explosions in Guadalajara (Mexico) in 1992, which were caused by a massive gasoline leak, destroyed 12 kilometers of streets, leaving 500 people injured and 15,000 homeless.

## Electricity generation

The generation of electricity varies widely across the Region. In North America, for example, 61% of the electricity in Canada is generated by hydroelectric plants; in the United States, 49%, by coal plants; and in Mexico, 74% by thermoelectric plants (66).

In 2011, a number of electrical power plants went into operation in LAC. The Region's energy is generated from the following mix of sources (in descending order of generating capacity): 16 hydroelectric and 11 thermoelectric plants in Brazil; the Central Termoeléctrica Andina in Chile; the Garabito thermal plant and Los Santos wind farm in Costa Rica; the cogenerating plant of the Tres Valles sugar refinery in Mexico; the Las Cañas and Hidropantasma hydroelectric plants and the San Jacinto Tizate geothermal plant in Nicaragua; the Arauco wind farm in Argentina; and the Honduras 2000 wind farm in Honduras (4).

### *Fossil fuels*

Emissions from electric power plants vary with the fuel and technology used, and tend to be higher in older plants and countries with little regulation.

In LAC, 38% of the electricity is generated in thermal plants. However, there are countries such as Barbados, Cuba, the Dominican Republic, Grenada, Guyana, Jamaica, Mexico, Nicaragua, and Trinidad and Tabago in which thermal energy provides 70% of total electricity generation.

Throughout the world, power plants that use fossil fuels are a major contributor to global warming, emitting 41% of global CO<sub>2</sub>, a percentage that is projected to rise to 45% by around 2030 (3). With regard to the other atmospheric pollutants, calculations based on North American data indicate that the electricity sector in the United States accounts for 69% of the emissions of SO<sub>2</sub>, 22% of NO<sub>x</sub>, and 40% of mercury, while the same sector in Canada produces 20% of the SO<sub>2</sub>, 11% of the NO<sub>x</sub>, and 25% of the mercury; in Mexico, the respective figures are 55% for SO<sub>2</sub>, 27% for NO<sub>x</sub>, and 3% for mercury (67).

Given their role in the formation of fine particulates and ozone, SO<sub>2</sub> and NO<sub>x</sub> compounds are major contributors to mortality and the increase in severe respiratory diseases, such as asthma and bronchitis. These pollutants acidify bodies of water, reduce their biodiversity, and kill fish. They harm forests through their direct effect on leaves, acidification of the soil, and the resulting loss of nutrients. Moreover, they reduce visibility and damage historic buildings and monuments. Nitrogen oxides also harm vegetation, since they are ozone precursors, and they contribute to the eutrophication of bodies of water. Mercury poisoning in human beings occurs, above all, through the ingestion of contaminated fish, causing damage to the nervous system and compromising cognitive and motor functions. There is also strong suspicion that mercury affects the immune and cardiorespiratory systems (68).

These issues have spurred initiatives such as the Clear Skies Act of 2003 in the United States, aimed at achieving close to a 70% reduction in SO<sub>2</sub> and NO<sub>x</sub> emissions from all electric power plants of over 25 MW, as well as a similar reduction in mercury emissions from coal-fired plants. This initiative protects the environment and public health by improving air quality, reducing exposure to fine particulates and ozone, and curbing depositions of sulfur, nitrogen, and mercury. Public health benefits by 2020 are projected to include 8,400 to 14,100 fewer premature deaths, 8,800 fewer cases of chronic bronchitis, and 30,000 fewer emergency room visits due to respiratory and cardiovascular symptoms. In addition, it is expected to lead to 12.5 million fewer days of pollution-related respiratory symptoms and illness, lost work days, restricted activity, and lost school days. The initiative also helps protect ecosystems by attempting to reduce nitrogen depositions nationwide by nearly 35% and sulfur depositions by some 30% to 60%, in addition to reducing the concentration of fine particulates in the eastern and midwestern United States by 25%, decreasing mercury by 15% to 60%, and nearly eliminating chronic acidity in the lakes of the Adirondacks and other parts of the northeast (68).

SO<sub>2</sub>, NO<sub>x</sub>, and mercury emissions cause chemical reactions that produce compounds capable of traveling great distances, affecting populations and ecosystems far from the source and crossing state and national borders. Depending on the chemical form in which mercury is emitted, its polluting effects can have local, regional, and even global repercussions (68).

Among fossil fuels, natural gas produces the least emissions when burned. It is currently one of the best fossil fuel options for generating electricity, although it is a major source of CO<sub>2</sub>. Globally, the electricity sector will account for over 50% of the increased demand for natural gas (7).

Coal, in contrast, produces higher emissions of regulated pollutants –principally SO<sub>2</sub>, NO<sub>x</sub>, and particulates, which are the chief causes of acid rain– than any other fossil fuel. For this reason, substantial regulations to control emissions from coal have been issued in North America, which has led to the use of a variety of technologies designed to reduce smokestack emissions.

In 2003, the government of Ontario (Canada) announced a plan to retire coal-fired electric power plants by 2007, due to their negative health and environmental impact. That target was to be met by the end of 2013 with the closing of one of the province's largest coal-fired plants, leaving in place only a small auxiliary plant for periods of high demand, which was slated to close in 2014. Though technical difficulties delayed the closures by seven years, the provincial government remains confident that eliminating coal will contribute to a 44% reduction in greenhouse gas emissions (58).

In an economy governed by increasingly stringent standards on atmospheric emissions of greenhouse gases, mercury, particulates, toxic pollutants, and photochemical oxidants, the only way that coal can be viable is by controlling all gases produced in its combustion, ensuring maximum use of byproducts in the form of heat and material, and guaranteeing safe final disposal of the waste generated. This can be achieved more economically per unit of energy generated through integrated gasification combined cycle (IGCC) plants. If these plants operate with modules to capture the CO<sub>2</sub> gas flows generated and inject them into geological formations (such as disused oil fields) capable of storing them for hundreds or thousands of years, the technique will close the carbon life cycle and make the use of coal sustainable.

IGCC technologies for coal and petroleum coke should be encouraged. These technologies could be used in countries with large reserves of heavy crude, such as Mexico and Venezuela. Since IGCC plants generate concentrated carbon dioxide flows (by separating this gas before the power generation process takes place, through combination with hydrogen and vapor in conventional turbines and fuel cells), petroleum coke plants could replace fuel oil plants, with the added benefit of controlling other polluting gases such as sulfur and nitrogen oxides, along with particulates, which in most developing countries are generally not controlled. It is reasonable to believe that the global electricity sector will invest in the construction of IGCC plants that capture and store CO<sub>2</sub> –a development that would have desirable effects. This will occur initially in the highly industrialized countries where the techno-

logy was developed; in the developing countries, transfer of the technology could be supported through new carbon markets or as part of the second phase of the Kyoto Protocol commitments.

### ***Nuclear energy***

Six nuclear reactors are producing energy in Latin America: two in Argentina, two in Brazil, and two in Mexico. North America has 122 reactors: 18 of these are in Canada, while the United States, with 104, has more nuclear reactors than any country in the world (nearly double the number in France, which has 59). In addition, one 1,165 MWe plant is currently under construction in the United States.<sup>4</sup>

Among Latin American countries, Brazil produces 13.77 TWh of electricity from nuclear power, while Mexico and Argentina each produce 8.18 TWh – amounts that cover 2%, under 1%, and 3% of the countries' respective energy demands (5). North America produces 895 TWh from nuclear power – representing 14.7% of the demand in Canada and 19.4% of the demand in the United States. The nuclear capacity of the United States is expected to increase significantly by 2020<sup>5</sup> (61).

In the case of certain energy sources, the associated risks have declined as a result of technological innovations. One illustrative example is nuclear energy, where the chief health concern consists of leaks of radioactive material and consequent exposure of the population to radionuclides, which cause cancer and have serious genetic effects. Thus, the main problems with this type of power generation relate to safety, including the safe transportation and disposal of radioactive waste. (See the section on wastes, which details measures adopted by the different countries.)

The most serious nuclear power-related accidents that have occurred in the Americas and Asia are the following:

- The world's first nuclear accident occurred at Chalk River (Canada) in 1952. Fission products were released from the atomic pile, and 30 kg of uranium were released, as well as irradiated light water from the reactor building's refrigeration circuit, which had been damaged. Close to 4,000 cubic meters of the irradiated water were pumped into a waste area to avoid contaminating the Ottawa River, and subsequent monitoring of water sources in the area showed no signs of contamination. There were no deaths or injuries as a direct result of the incident, and a 1982 study of plant workers who had been exposed revealed no adverse health effects.
- In 1979, a combination of equipment failures and operator errors at the Three Mile Island nuclear plant in the state of Pennsylvania (United States) led to a refrigerant leak and a meltdown of more than a third of the plant's core. This remains the worst civilian nuclear accident in the United States to date. Exposure to radiation outside the plant remained under 1 mSv (less than the annual exposure from natural sources), and some 2 million people were exposed to 10 µSv. There were no immediate casualties, and the incidence of cancer in the region has not increased. However, the accident was accompanied by poor communication between State and Federal agencies over evacuation plans, based not on what was actually happening at Three Mile Island but on what government officials and the media imagined might happen: this contributed to fear among the population. The cleanup of the plant took more than 14 years; 10 years were devoted to extracting nearly 100 tons of nuclear fuel from the plant. The contaminated water used as refrigerant, which had entered the containment building, leaked through the building's concrete, leaving a radioactive residue that was impossible to eliminate, and the interior of the containment building, which is still considered dangerous, remains permanently closed.
- In 1983, an operator at a nuclear power plant in Argentina committed an error while reconfiguring a fuel plate and caused a so-called "criticality accident" in an experimental reactor. An explosion of  $3 \times 10^{17}$  fissions occurred, and the operator absorbed 2,000 rads (20 Gy) of gamma radiation and 1,700 rads (17 Gy) of neutron radiation, resulting in his death two days later. Another 17 people outside of the reactor room received doses of radiation of between 1 and 35 rads (between 0.01 Gy and 0.35 Gy).
- In March 2011, a tsunami caused by an earthquake measuring 9.0 on the Richter scale hit the northeast coast of Japan, causing failure of the cooling systems in three reactors at the Fukushima Daiichi nuclear plant, leading to nuclear fusion and the release of radioactive particles into the environment. Direct injuries were sustained by 23 people, and over 20 more were affected by radioactive contamination. The event also led to the displacement of over 170,000 people within a 40-km radius of the plant. The sea water registered radioactive iodine concentrations of up to 7.5 million times more than the legal limit, and cesium concentrations of 1.1 million times the legal limit.

## Renewable energy

### *Hydroelectric plants*

With regard to renewable energy sources such as water power, the World Commission on Dams (WCD) states that large dams have caused:

- the disappearance of forests and natural habitat of populations and species and the degradation of upriver basins due to flooding in the dam areas;
- loss of aquatic biodiversity in upriver and downriver fisheries and loss of the services provided by downriver flood plains, wetlands, and the riparian ecosystems and adjacent estuaries; and
- cumulative effects on the quality of water during natural floods and on the composition of species, when multiple dams are built on a river.

The associated problems involve the way in which dams alter the course of rivers and affect people's right to water and the resources of the rivers themselves. Dams can also cause the displacement of existing settlements, affect the culture and livelihoods of local communities, and reduce or degrade environmental resources. In short, it remains open to question whether dams represent a wise economic investment of public funds and resources. The population's health can also be impacted by the diseases spread by the vectors that proliferate in dam reservoirs in tropical zones or by the accumulation of heavy metals, such as mercury, in fish. Most dam and irrigation projects undertaken in areas where malaria is endemic have accelerated transmission of the disease.

The cost-benefit debate surrounding large dams for electric power generation led to the creation of the Dams and Development Project (DDP) under the United Nations Environment Programme (UNEP) in an attempt to depolarize the debate and determine the most appropriate way of building dams. The WCD report (69) *emphasizes* that although dams have made a major contribution to development and have provided considerable benefits, in many cases they unnecessarily exact an unacceptable price to obtain the benefits, particularly in terms of their social and environmental impact, which includes the displacement of populations and communities living downriver. The resulting unequal distribution of benefits has raised serious questions about the value of many dams vis-à-vis other alternatives in attempting to meet water and energy needs.

The WCD found that, to date, all the dams that have been subjected to scientific scrutiny are emitters of greenhouse gases, as are natural lakes; this occurs as a result of the decomposition of vegetation and the fact that carbon from the basin is released into the atmosphere. The magnitude of these emissions varies widely. Preliminary data from the study of a hydroelectric dam in Brazil indicate that the gross level of greenhouse gas emissions is significant when compared with emissions from an equivalent thermoelectric plant. In other dams studied, however (particularly in boreal areas), the gross emission of greenhouse gases is considerably lower than in the case of their thermoelectric alternatives.



### HEALTH EFFECTS OF THE TUCURUÍ (BRAZIL) HYDROELECTRIC COMPLEX (72)

The health effects from the construction of this hydroelectric complex are significant and decidedly negative. The population growth fueled by the arrival of migrants attracted to the area by the dam's construction led to a pronounced rise in the incidence of vector-borne diseases such as malaria and schistosomiasis, along with an increase in industrial accidents, alcoholism, and sexually transmitted diseases such as AIDS.

During the project implementation phase in 1980, the infant mortality rate in the Tucuruí municipal district was six times that of the rest of the state of Pará

and nearly five times the national rate in Brazil. The use of defoliants to clean the power cables affected the health of the communities living in the area, since the defoliants contained dioxin. In the areas where this herbicide was used, there were widespread deaths of animals and plants, pollution of wells and streams, and adverse health effects among people of all ages, including miscarriages and symptoms consistent with acute exogenous poisoning: headaches, vomiting, dizziness, conjunctival hyperemia, and weakness, followed by erythrocytes in urine, deficient diuresis and

inability to urinate, fever, convulsions and tremors, and in some cases death.

The construction of the dam and related facilities led to a massive increase in mosquitoes and other insect vectors and pests. The higher incidence of malaria outbreaks coincided with the construction and operation of the hydroelectric complex. Moreover, the proliferation of certain aquatic microphytes is closely related to surges in populations of *Mansonia* mosquitoes, which are the principal vector of filariasis. The threat posed by these insects grew to such proportions that it interfered with daily agricultural

activities, causing some groups to migrate to other areas.

A study by a group of Finnish scientists to determine the origins and effects of mercury at the site of the dam indicates that average mercury levels in area residents who consumed fish from the lake were close to the lowest threshold at which there is risk of brain lesions. The levels were significantly higher than in communities where people ate less fish from the lake. Although it was determined that gold mining in the basin was the principal source of pollution, the dams had the effect of concentrating the mercury present in the water, while the uptick in human activity

contributed to greater discharges into the water. To date, there are no conclusive data showing the effects of the Tucuruí dam on mercury levels.

More than half the major rivers in North America have either been rechanneled, had their flows altered, or had dams built on them (36). The United States has 14% of the world's dams, while Canada has 2% and Brazil 1%. In the United States, however, more dams are being dismantled than are being built. There are plans to demolish the Elwha and Glines dams in the state of Washington, in the wake of findings that the harm they cause outweighs their benefits. It is predicted that removing the obstacle these dams pose to fish migration will lead to a tripling of the salmon population.

### ***Wind, solar, and geothermal energy***

Renewable energy sources are witnessing a considerable boom in the Region as a result of global concerns aroused by national and international climate change agreements and programs. These energy sources have many co-benefits for public health, since they largely eliminate direct emissions of atmospheric pollutants from the burning of fossil fuels. However, they still have technological and logistical limitations, making the cost of using them high and therefore requiring economic subsidies.

In the Americas, the United States leads in the use of wind turbines to generate power; as a result, the cost of wind generation has dropped by a factor of 20 in the past 20 years. Installed capacity in the United States in 2012 was 60,007 MW, surpassing that of Germany, which had had the world's largest wind generation capacity. Argentina is developing its own wind-based technologies (7), and over the past five years, developing countries such as Costa Rica and Mexico have increased their production of wind energy, installing hundreds of generators on mountaintops and hills and in coastal plains. In 2013, Honduras put a 102 MW wind park into operation, and Guatemala will have 71 MW of wind power by 2014 (70).

The energy harvested through wind power is directly proportional to the size of the blades. Thus, wind generators, which were once merely 50 kW installations atop small towers, can now have turbines spanning up to 104 meters and generating as much as 3.6 MW (70). Though they produce very few pollutant emissions, wind generators today pose aesthetic problems, are noisy, and can cause accidents. Lines of wind turbines alter the landscape, and depending on the urban or cultural context in the area where they are located, this can represent a significant deterioration in the population's quality of life in terms of aesthetics (as, for example, in Massachusetts, in the United States, and Oaxaca in Mexico). In mixed land-use areas (for example, wind plus agriculture, or wind plus cattle ranching), noise from the turbines disturbs the people living or working at the foot of the towers. Moreover, there is a risk of accidents from the destruction or collapse of towers, blades, and turbines during hurricanes or high winds. In terms of environmental effects, wind turbines cause the death of various animal species, principally birds and bats, though this hazard can be minimized with techniques to keep these animals away from the turbines.

Given widespread social objections to the installation of turbines in fields and the need to lower the cost of generation, wind technology is successfully migrating to floating sea-based generators with capacities of up to 6 MW. These are distant from populations, yet close to where winds are strongest. This option is still not highly competitive in terms of cost, but it promises to offer a solution in areas where extreme weather phenomena are infrequent.

Solar energy, though abundant in the Region, is still a costly way of generating electricity and remains in the early stages of development. The environmental effects of photovoltaically produced electrical energy are concentrated in the production of the cells' substrate, which contains metals and requires mining activities that are highly energy-demanding. In addition, improper disposal of solar cells can pollute the soil with heavy metals.

Thermal solar energy for electricity generation on an industrial scale, however, is less problematic in its effects, since it involves few pollutants and requires less-complex materials (such as mirrors, glass, water, and salts that concentrate heat).

The potential of geothermal energy for industrial, commercial, and household use is still largely untapped. After a period of technological stagnation, geothermal energy use has moved from the industrial realm to the household and commercial areas with the use of ground-source heat pumps (71). Over 1 million such units have been installed, the majority of them in the United States, Canada, Sweden, and other parts of Europe. Not far beneath the surface there is sufficient thermal energy to provide comfort in homes and buildings through heat exchange systems constructed with buried pipes. These pipes are capable of collecting heat in the winter and cold in the summer, reducing to a minimum the consumption of conventional forms of energy used to run air conditioning and heating systems, which, in industrialized countries, account for up to 50% of final energy consumption in commercial buildings (72). The main advantages of these systems are that they can be disconnected from the energy grid, are ideal in rural and suburban settings, and produce no direct greenhouse gases or pollutants.

## Transmission and distribution of electrical energy

### *Polychlorinated biphenyls*

Polychlorinated biphenyls (PCBs) are man-made compounds with a high boiling point, making them very resistant to heat. They do not oxidize easily and are chemically very stable. They do not conduct electrical energy and have low volatility at normal temperatures. Because of their great thermal, biological, and chemical stability, as well as their high dielectric constant, the electrical industry used PCBs massively as insulation in electrical equipment until the mid-1970s, primarily for transformers, switches, capacitors, and thermostats, as well as in ballasts for fluorescent light bulbs. PCBs are highly resistant to biodegradation and therefore persist in the environment, while also having great capacity to disperse across wide areas.

PCBs were introduced in Central America between 1950 and 1960 in cooling systems, heat exchange fluids, and condensers and transformers. Their use in electrical transformers is the largest source of PCBs in the Region.

These contaminants cause endocrine disorders in organisms and have been determined to be carcinogenic in laboratory animals and, possibly, humans (group 2A of the IARC). They are considered toxic to the immune system, liver, reproductive organs, digestive tract, and thyroid gland (73). They also affect learning and memory. UNEP considers PCBs to be one of the 12 most harmful pollutants produced by human beings.

The transformers now manufactured in Panama and Guyana do not contain PCBs, but a great number of those imported years ago are still in use. Panama has approximately 200 tons of transformer oil containing PCBs. Costa Rica banned PCBs in 2001.

UNEP's 2002 regional evaluation of persistent toxic substances states that no Central American or South American country has complete national inventories of PCB reserves and uses. However, countries such as Colombia, Costa Rica, Cuba, El Salvador, Nicaragua, Panama, and Venezuela have conducted preliminary inventories. The Costa Rican inventory covers reserves but not uses. Costa Rica reported exports of 56,472 kg in transformers between 1998 and 2001. Nicaragua's preliminary estimates of PCBs in transformers used for national electricity distribution from 1980-2000 indicated 820,684 gallons, as well as 4,430 gallons in transformers in private hands. In El Salvador, a preliminary inventory of PCBs indicates approximately 165,000 kg of PCBs warehoused pending export for destruction. PCBs are found in 17 transformers and 153 condensers in the country. The national electricity company (Empresa Nacional de Energía Eléctrica) is the principal source of this pollutant. Panama has conducted a preliminary study on PCBs and indicates that one company is storing approximately 95 tons of PCBs in liquid and solid states, and that an electrical power plant has 30,000 kg in a transformer, while another 200 tons of PCB in liquid form are being exported for controlled incineration.

Monsanto, which is the only PCB manufacturer in North America, produced 634,900 tons before halting production in the 1970s because of its harmful effects on the environment and human health (74). The United States banned production of PCBs in 1976, and in 1977 the manufacture, importation, and most nonelectrical uses were also banned, as was the use of PCBs in electrical and mechanical equipment. Despite these measures, however,

PCBs continue to be used in applications that predate the ban. According to the United States database on transformers (for the 10 regions), as of 30 November 2007 there were approximately 14,000 transformers with 500 ppm or more of PCBs, weighing a total of approximately 46,000 tons (75).

Canada's national PCB inventory estimated the net weight of askarels used in transformers and capacitors in 2005 at approximately 6,600 tons, along with 2,300 tons in stored waste from transformers and capacitors. With regard to minerals currently in use, there are calculated to be 1,300 tons of waste, including 1,700 tons of waste from fluorescent light bulbs (76). In Mexico, PCBs have been used most of all in transformers, electrical capacitors, and fluorescent light bulbs. Mexico's PCB inventory, updated as of May 2011, calculates that the country has close to 2,700 tons of PCBs (77). A Mexican regulation (NOM-133-ECOL-2000 and its amendment) required that PCB equipment, PCB electrical equipment, and equipment contaminated with PCBs be eliminated by December 2008.

In terms of major accidents, between 1974 and 1977 nearly 600 tons of PCBs were discharged into the Hudson River, in the United States, by a private company, leading to a ban on swimming and fishing for consumption purposes along hundreds of miles of river, from the Hudson Falls to the ocean (78).

### *Electromagnetic fields*

Electrical and magnetic fields are present during the production of electrical energy, along transmission lines and cables, at substations, in household installations, and around the devices that use the electricity. Electrical fields are generated by electrical charges, while magnetic fields originate from the movement of electrical charges. The intensity of these fields is greatest next to the source, diminishing as distance from the source increases.

People working near transformers, electrical closets, circuit boxes, or other electrical equipment with high currents can be exposed to 60-Hz magnetic fields measuring tens of microteslas or more, while levels of between 0.05  $\mu\text{T}$  and 0.4  $\mu\text{T}$  are common in homes and offices.<sup>6</sup> However, these levels can be much higher near certain types of equipment (79). The recommended limit for the population as a whole is 83  $\mu\text{T}$  at 60 Hz (80).

Based on a review of scientific publications, WHO has determined that existing findings do not confirm any adverse health effects from exposure to low-intensity electromagnetic fields, though doubts about this persist. The state of knowledge concerning the biological effects of these fields remains incomplete and warrants further research (80).

In terms of increased cancer risk, the International Agency for Research on Cancer (IARC) classifies magnetic fields of extremely low frequencies as possible carcinogens in human beings (group 2B) (16). However, although findings to date are highly contradictory, no substantial increases have been found in either children or adults. Some epidemiological studies point to small increments in the risk of childhood leukemia associated with exposure to low-frequency magnetic fields in the home. However, scientists have not found a cause-and-effect relationship between exposure to electromagnetic fields and this disease; rather, based on tests with laboratory animals, they have suggested that the apparent effects are artifacts unrelated to exposure to the fields. Large-scale studies currently under way in various countries could help clear up these questions (80).

In the Americas, Canada, the United States, Brazil, and Peru have standards or guidelines on high frequency electromagnetic fields related to the telecommunications sector.

## **Energy use**

### *Benefits*

Historically, achieving major health benefits has been dependent on the population's access to energy. Most of the countries in the Region have electrical coverage of over 90%. There is, however, the critical case of Haiti, which has less than 28% coverage. Honduras, Bolivia, Nicaragua, Peru, Grenada, and Guyana have coverages ranging from 65% to 85%. As a result, breaking the vicious circle of energy poverty and lack of development in the world's poorest countries requires rigorous and rapid action to expand the delivery of this service (20).

Throughout the world, roughly 80% of expenditures for energy services by poor people are for cooking fuel, while the remaining 20% goes toward other fuels or is spent on batteries for lights (81).

### *Batteries*

Batteries store electrochemical energy, which they then release as electrical energy. Batteries can have either a single cell or a number of interconnected cells. Designs vary widely, but all contain a vast number of toxic components. Their use normally poses no health risk, although as waste they constitute a latent risk (see the section on waste).

The use of batteries in everyday life has grown at a dizzying pace, due to the introduction of portable electronic and communication devices. For example, between 1993 and 2003, the number of cell phones per 1,000 population (36) rose from 70 to nearly 530 in North America (United States and Canada), while it increased from less than 5 per 1,000 to nearly 230 per 1,000 in Latin America. In 2012, the number of cell phones in Brazil, Colombia, Argentina, Peru, Chile, and Guatemala exceeded the number of inhabitants in each of these countries, and this ratio seems about to be replicated in the United States, Mexico, Venezuela, Canada, and Paraguay.

In Mexico, the formal battery market grew by a factor of 13 between 1996 and 2007, tracking the rise in consumption, which rose from 5.2 batteries per year per capita in 1996 to 12.6 per year per capita in 2007. Current consumption is estimated to have increased to 20 batteries per year (82). In nearly every country in the Region, the accuracy of these statistics is compromised by the prevalence of battery smuggling and the large number of batteries included in imported electronics.

In view of this increase and the toxic content of batteries, some countries, such as the United States, Canada, Brazil, and Argentina, have regulated potentially toxic metals. Regulation of the heavy metal content of batteries began in the 1990s in the United States and Canada, when the mercury content of carbon-zinc and alkaline batteries was restricted. Later, mercuric oxide button-cell batteries were banned (83). Canada and the United States also employ ecolabeling for products that are free of toxic content or that are environmentally friendly. Mexico has a proposed standard that would restrict mercury and cadmium content in commercial batteries to limits similar to those stipulated in European Directive 2006/66/CE, prohibit the marketing of mercuric oxide batteries, and institute ecolabeling (84). In February 2007, Mexico City, in collaboration with the *Imágenes y Muebles Urbanos* (IMU) company, designed a program for responsible disposal of batteries in the Federal District; by 2012, some 313 tons of batteries and approximately 27,000 used cell phones had been collected and recycled.

Bolivia has drafted a Hazardous Waste Law governing the entry, use, and final disposal of batteries (85). Argentina has prohibited the manufacture, assembly, marketing, and importation of common primary batteries of zinc-carbon and alkaline manganese dioxide design if they have mercury, cadmium, or lead content above specified limits (86). In October 2009, Argentina's Chamber of Deputies passed a bill to "institute proper mechanisms for the disposal of batteries under the environmental plan to eliminate urban and pathogenic waste."

### *Fluorescent light bulbs*

Vaporized mercury mixed with argon is used in the tubes for fluorescent lighting, which, when they break, release mercury and argon vapors that are highly toxic and harmful to the environment. According to WHO, inhalation of mercury vapor can harm the nervous and immune systems, digestive tract, lungs, and kidneys, and can sometimes prove fatal (87).

## **Waste disposal**

### *Mine tailings*

Mining typically produces large quantities of waste. Spills of large volumes of mining residues or tailings, which can occur if the dams or depositories containing them break, can cause death, destruction, and serious environmental pollution, including the contamination of water with heavy metals or radioactive materials (88).

### *Oil drilling waste*

Oil drilling generates large amounts of waste requiring effective and responsible handling, adequate infrastructure for disposal, and industrial waste storage facilities or plants for neutralizing and recycling the material. Although oil drilling technologies and practices have been developed to control all of the waste products generated,

using plastic covers and containment barriers, many countries in Latin America still have drilling operations in which there is improper disposal of waste products, with the consequent pollution of soil and water resources. This water pollution can affect surrounding populations if the water is used for irrigation or household purposes.

### ***Nuclear waste***

One of the principal problems with nuclear energy is the disposal of radioactive waste. Argentina, Brazil, and Mexico generally keep spent nuclear fuel in the nuclear plants themselves. In those countries, waste with low and medium radioactivity levels is handled in special facilities, and there are regulatory agencies and firms specializing in its collection, treatment, and safe storage (61).

In Canada, both the nuclear plants and the public enterprise, Atomic Energy of Canada Ltd., are responsible for disposing of low- and medium-level radioactive waste. A long-term storage plant in Ontario is expected to commence operations around 2017. Having examined various options for highly radioactive waste, Canada is slated to decide in the near future where such materials are to be stored (61).

In the United States, the reprocessing of spent nuclear fuel has been prohibited since 1977 and all radioactive waste is considered highly radioactive. The government is responsible for its final disposal in deep underground geological deposits, which are not yet available. Given the lack of storage sites, since 1998 the Department of Defense has allowed spent fuel to be stored in the nuclear plants that generate it, some of which are no longer in operation. The original plan of depositing highly radioactive waste in the Yucca mountains in Nevada (a site with a capacity of 70,000 tons) by 2010 has been postponed until 2020.

For low-level radioactive waste, the United States has four processing plants (61). However, there have been accidental leaks of radioactive material, as occurred, for example, in 1984 on the border with Mexico, where the undetected melting of a cobalt-60 pump for radiotherapy caused a health alert in the two countries.

### ***Polychlorinated biphenyls***

The Stockholm Convention requires its signatories to eliminate the use of equipment and oils containing polychlorinated biphenyls (PCBs) by 2025. UNEP considers PCBs to be one of the most harmful pollutants produced by human beings. The Convention also calls for their treatment and elimination in an environmentally safe way by 2028. In view of this, partnerships have been forged to promote and encourage appropriate environmental treatment of these compounds. Every country in the Americas, with the exception of the United States, Belize, Haiti, and Suriname, have ratified, accepted, and approved the Convention (73).

Between 1929 and 1989, approximately 1.7 million tons of PCBs were produced, and much of the equipment containing them is still in use or is being stored for final disposal. There are calculated to be 5 million tons of PCB oil and contaminated equipment, which will pose a significant risk to the environment and human health if not properly dealt with. Many countries have limited financial and technical capacity to treat and store PCBs, since it is a costly process (73).

The worldwide inventory of installations with the capacity to destroy PCBs (89) lists 12 facilities in the Americas, located in the United States, Canada, Mexico, and Chile.

### ***Photovoltaic cells***

Improper disposal of solar cells can pollute the soil with heavy metals, with the potential for harm depending on the type, size, and quantity of the cells. For the moment, these materials are not considered to have important health effects, since the use of photovoltaic cells is not expanding in the Region. When their use increases, it will be necessary to effectively manage the recycling and final disposal of these materials.

### ***Batteries***

If not disposed of properly, dead batteries deteriorate and corrode from climatic and mechanical processes and from the fermentation of garbage, releasing their components into the environment. Depending on the type of battery involved, they can release mercury, cadmium, lead, lithium, manganese, and zinc, as well as corrosive acids and bases, which are harmful to people if ingested or inhaled. Some of these metals (such as cadmium and nickel) are carcinogenic; others (like mercury, lead, and manganese) have adverse effects on the nervous system; some (like

lithium) are reactive or explosive. Exposure is usually indirect, since many of these compounds accumulate in the environment and the food chain. For example, they can pollute water, accumulate in fish, and, through that pathway, enter the human body. Although not highly soluble, many of the compounds used in batteries, including the heavy metals and their derivatives, reach water sources by being adsorbed to particles suspended in the air, which later settle (90). During accidental burning or intentional incineration of batteries, the toxic substances they contain can be released into the environment and enter the food chain through various routes.

An environmental assessment of batteries in Mexico (81) indicates that the batteries sold in the formal market contain levels of mercury and cadmium that exceed the maximum limits set by the European Directive (2006/66/CE) (91). All of the battery technologies analyzed, except for carbon-zinc, have alkaline pH levels above the level permitted under the Mexican standards. Given their corrosive potential, they should be handled as hazardous waste. Mexico currently has no restrictions on the importation and marketing of batteries or regulations limiting the mercury and cadmium content of primary batteries. To date, the country has not prohibited the sale of button-cell mercuric-oxide batteries, which can contain a significant percentage of this highly toxic metal.

Given concerns about the disposal of batteries in the industrialized countries, strict limits have been placed on the content of heavy metals in batteries, and sanitary landfills have been designed with geomembranes and systems to capture lixiviates to deal with the disposal of urban waste containing batteries. Programs to collect and recycle batteries have also been created, and initiatives to encourage shared responsibility among producers, users, and governments have been promoted in an attempt to improve the environmental management of batteries throughout their life cycle (81).

Only 2% of used batteries were recycled in Canada in 2004 (83). According to the book *Ecoholic* (92), some 50% to 70% of the heavy metals found in sanitary landfills come from batteries used in everyday life.

### ***Fluorescent light bulbs***

Because of their mercury content, fluorescent light bulbs no longer in use are considered hazardous waste, but very few countries have adequate facilities for treating them, and they usually end up in open-air dumps or sanitary landfills. The growing use of these light bulbs, however, makes it necessary to regulate their treatment as waste and their final disposal in order to avoid the associated health risks.

## **Air quality and fossil fuels**

Scientific data indicate that urban air pollution, caused primarily by combustion (energy) processes, has a wide range of health effects, from eye irritation to death; even in very low concentrations, particulates affect mortality rates.

Air pollution contributes significantly to climate change. In 2006, cities consumed 67% of the world's energy and emitted close to 71% of the CO<sub>2</sub> related to energy use (58). Fossil fuels are the chief source of outdoor air pollution in many of the cities in the Region and elsewhere in the world.

According to a comparative risk analysis by WHO (15,16), urban air pollution in the Americas is the environmental factor with the greatest effect on mortality (see Figure 17-4). Total mortality attributable to this type of pollution is estimated to be over 60,000 cases per year, with a slightly higher incidence among men than among women. In terms of attributable DALYs (Figure 17-5), the only problems with greater health impacts are poor water, sanitation, and hygiene, and indoor air pollution, which in combination account for over 500,000 deaths per year, with more deaths among women than among men.

These estimates of mortality and DALYs (15,16) are based on exposure to PM<sub>10</sub> and PM<sub>2.5</sub> particulates, which are taken as indicators of combustion sources, since the characteristics of the mix in a specific locality depend on the relative contribution of different sources of pollution, as well as on atmospheric and geographical conditions that affect the transport, distribution, and dilution of the pollutants. These mixes contain particulates emitted directly, such as diesel, as well as ones generated secondarily, such as sulfates and nitrates, gases such as carbon monoxide (CO), nitrogen oxide (NO<sub>x</sub>) and sulfur dioxide (SO<sub>2</sub>), and certain carcinogens, such as benzene, 1,3-butadiene, and the benzo[a] pyrenes.

Particulate levels are considered indicators of exposure, since numerous epidemiological studies around the world on both morbidity and mortality have corroborated their role in the most serious health effects of pollution, including daily and chronic mortality (93).

The Latin American and Caribbean region is the world's most urbanized developing Region. Between 1972 and 2000, its urban population grew from 176.4 million to 390.8 million, owing primarily to the increase in births, as well as to migration from rural to urban areas. This has led to the persistence of profound inequities in the region, where poverty is concentrated in urban areas (*GEO3-Fact Sheet*).

According to the PAHO/WHO 2007 report *Health in the Americas*, air pollution severely affects the health of over 80 million people in LAC and is the chief cause of over 2.3 million cases of respiratory insufficiency in children annually, as well as over 100,000 cases of chronic bronchitis in adults.

The economic benefits of controlling air pollution, though potentially great, are highly uncertain. The benefits of reducing ozone ( $O_3$ ) are estimated to be around one tenth the benefits to be gained by a comparable reduction in  $PM_{10}$ , while the benefits from reducing toxic substances in the air are smaller yet. An assessment of the health benefits associated with a 10% reduction in  $PM_{10}$  levels in Mexico City estimates that there would be 2,000 fewer cases of cohort mortality annually, 1,000 fewer cases of mortality in time series, and 10,000 fewer cases of chronic bronchitis. A 10% reduction in ozone levels led to a projected 300 fewer deaths in times series, and 2 million fewer days of reduced activity.

Air pollution is recognized today as a significant modifiable determinant of cardiovascular disease in urban communities. The principal causative agents appear to be nanoparticulates from combustion. The problems of environmental pollution are intensified by rapid economic development and industrialization in cities and are associated with the slow pace of adopting effective pollution control measures. In many cases, fuel quality is poor, while automobiles, industrial facilities, and power plants use technologies that are obsolete or in disrepair.

Some megacities, such as Mexico City and São Paulo, monitor and control air pollution and the intensive use of fossil fuels in transportation and industry. Others, such as Bogotá, have succeeded in reducing motor vehicle pollution but are still struggling to control industrial emissions. The health effects of pollution are increasing in medium-sized and small cities, where controls and technology are less prevalent.

## ■ Energy efficiency

Increasing energy efficiency will require reducing energy consumption from the demand side through practices, equipment, and machinery that save energy or use it more efficiently. In this regard, there have been many tangible advances in household appliances, lighting, and electronics, but the fact that the world's governments tend to finance economic growth with inexpensive or subsidized energy encourages waste and does little to promote greater public awareness about conservation.

Various studies indicate that worldwide, only 37% of primary energy is converted to useful energy (94). In the chain of transformations and processes that energy-producing materials undergo before providing the service for which they are intended, 63% of their capacity is lost (82). Energy efficiency policies and actions are designed to reduce energy demand (and, in some cases, address energy supply) while curbing transmission and distribution losses, thereby diminishing potential adverse health effects. Increasing global energy efficiency has been proven possible with the introduction of vehicles that use less fuel, devices that use less electricity, and light bulbs that consume one quarter of the energy used by traditional bulbs.

Energy intensity (the amount of energy needed to generate one U.S. dollar of GDP) in Latin America averages 1.29 BOE/ $10^3$  USD (2005), while the corresponding figure for industrial energy intensity is 2.8 BOE/ $10^3$  USD. There are major disparities between countries. The lowest figure is for Barbados (0.55), while the highest figures are for Trinidad and Tobago (5.03), Haiti (4.56), Guyana (2.65), and Suriname (2.29). In the industrial sector, the countries with the lowest figures are Grenada (0.81) and the Dominican Republic (0.64), while the highest are for Trinidad and Tobago, Guyana, Haiti, Bolivia, Paraguay, and Venezuela. In slightly less than half the countries, overall energy intensity and intensity in the industrial sector are at similar levels; however, in Cuba, Ecuador, Barbados, and Suriname, industrial energy intensity is more than three times the overall figure. This low efficiency is due to a combination of factors, including the presence of old, inefficient, and poorly maintained automobiles and industrial plants, as well as pricing policies that have proven inadequate for promoting rational energy use.

Although it is true that energy intensity is not a measure of efficiency, changes in intensity do reflect improvements in energy use over time (95). In LAC, energy intensity has been reduced by only 0.2% since 1990. This is because few countries maintain energy efficiency programs over the long term and at the same time fail to adopt efficient technologies to modernize industry, household appliances, and automobiles. In contrast, the European Union has shown sustained annual reductions of 0.9% in energy intensity (95).

An increase in energy productivity has been observed throughout the Region, with Mexico and the Andean subregion particularly notable in this regard. Other subregions, however, have not been part of this trend; thus, the annual reduction for the Region between 1995 and 2005 averaged barely 0.2%.

In the more developed countries, industry is the most significant component of the energy efficiency/energy productivity equation, while in the less developed countries, the commercial and residential sectors are a more important factor. Given that energy intensity varies considerably from country to country, the regional index offers only a wide-angle view of energy consumption.

According to conservative estimates by OLADE for the period 2003-2018, the Region could achieve cumulative savings of US\$156 million in fuel costs were it to adopt sound, long-term energy efficiency programs. Investment in such programs is highly profitable.

Long-term energy efficiency programs must be overseen by independent, technically respected institutions and must have the resources needed to carry out their mandates. Energy savings programs are distinctly profitable for the State, according to Mexico's National Commission for Efficient Energy Use (CONUEE), which, with an annual budget of US\$5.5 million and investment in efficient technology by its clients, achieved total savings of US\$398 million in 2005, with a 2% annual reduction in energy intensity.

The Region's efforts at achieving energy efficiency have been limited and are concentrated in a few countries. The nations with the strongest energy-saving initiatives are Brazil, Mexico, Costa Rica, Cuba, and Peru, but only Brazil and Mexico have concrete experience, specialized institutions, standards, and equipment-labeling regimes. The other countries of the Region have not moved forward with their energy efficiency programs, or such programs are still in the early stages of development (95).

Within the Region, Mexico is particularly notable for its Special Program on Climate Change (PECC) and its National Program for Sustainable Energy Use (PRONASE), which include strategies for implementing structural changes that encourage the use of more efficient and low-carbon-intensity technologies in the industrial, residential, commercial, and service sectors.

## Cities

Cities, which are currently responsible for 70% of energy-related CO<sub>2</sub> emissions, have significant potential for reducing energy use and CO<sub>2</sub> emissions. There are three areas in which local government policy can exert significant influence on reducing energy use and CO<sub>2</sub>, namely, by:

- Promoting integrated energy-generating technology.
- Improving modes of passenger transportation.
- Increasing energy efficiency in large buildings and houses.

## Transportation

Urban growth has lengthened travel times, partly because of the growth of private modes of transportation. Consequently, steps must be taken to encourage public, over private, transportation, while at the same time adopting energy-efficiency regulations for the transportation sector as a whole.

In the United States, sales of light trucks fell sharply in early 2008, with a corresponding increase in the sale of compacts and hybrids (which, for the first time, exceeded 3% of the total), while sales of pickup trucks and sport-utility vehicles declined significantly (58). Cities such as Curitiba, Belo Horizonte, Río de Janeiro, and São Paulo (Brazil), along with Bogotá (Colombia), Santiago (Chile), Mexico City, Buenos Aires (Argentina), Guayaquil and Quito (Ecuador), Guatemala City, Lima (Peru), Montevideo (Uruguay), and Caracas and Mérida (Venezuela) have moved forward with bus rapid transit (BRT) systems. These systems designate lanes exclusively for buses, encourage public over private transportation, discourage private automobile use, and promote bicycling.

Over the past 30 years, air pollution control programs in the developing countries have demonstrated that more efficient fuels and vehicles are an effective means of achieving cleaner air. Benefits include lower emissions from the current fleet of vehicles as a result of improved fuel quality, along with greater ability to incorporate more ecologically friendly vehicles and technologies, thus reducing the pollution associated with transportation (33).

## Biomass as an energy source in the rural environment

The use of improved stoves in rural settings helps reduce indoor air pollution and its adverse health effects, while at the same time reducing the pressure on forest ecosystems. These stoves make more efficient use of solid fuels (wood, charcoal), emit less smoke, and have chimneys to expel the smoke from inside the kitchen. In addition to reducing the amount of fuel required, they minimize the risk of burns and lighten the burden of collecting firewood for women and children (20).

Many rural communities have only limited access to other fuels, such as LPG; thus, biomass continues to be the most practical fuel. Improved, well-designed stoves must be manufactured, installed and properly maintained to reduce indoor smoke levels. One example of such stoves is the flat-top stoves used in Latin America, which prevent exposure to harmful emissions by reducing indoor smoke by as much as 90% by optimizing combustion and venting smoke through pipes and chimneys and by reducing cooking times as a result of greater efficiency (20).

In the Purépecha region of Michoacán (Mexico), the introduction of 4,000 efficient flat-top wood stoves reduced indoor concentration of fine particulates ( $PM_{2.5}$ ) and carbon monoxide by nearly 65% from the levels created by traditional stoves. The reduction was greatest in dwellings with the highest initial concentrations (where open-fire methods were used) (90). Findings in a subsample indicated a 30% reduction in respiratory illnesses and a 50% reduction in eye infections as a result of lower indoor pollution. Moreover, half as much firewood as before was required (96).

Growing prosperity is making it possible to gradually replace traditional biomass and charcoal cooking methods with others based on cleaner, more efficient, more convenient fuels (20). However, switching from one method to the other is a slow, lengthy process. In rural areas, LPG does not entirely replace wood but is used as a supplementary fuel, since some foods are traditionally cooked with wood fires (tortillas, nixtamal, pozole, tamales, etc.). The LPG ends up being used above all to heat water and reheat food (a function similar to that of microwave ovens in cities) (96).

Interventions that target household energy use have a variety of benefits: they improve children's and women's health, save time and money, promote gender equity, and reduce deforestation and greenhouse gas emissions. At the global level, a WHO analysis shows a yield of US\$91 million per year from the US\$13 million invested annually in efforts to halve by the end of 2015 the number of people cooking with solid fuels (20).

## ■ Energy and climate change

### *CO<sub>2</sub> emissions*

In 2010, across the globe, 62% of greenhouse gas emissions, measured in terms of CO<sub>2</sub> equivalent, came from CO<sub>2</sub> associated with energy, with 65% of this from industrial processes. Four countries in the Americas –United States, Canada, Brazil, and Mexico– are among the world's largest sources of CO<sub>2</sub> emissions, with the United States ranking second in the world after China in energy-related CO<sub>2</sub> emissions (34).

In 2006, electricity generation from fossil fuels was responsible for 20% of energy-related CO<sub>2</sub> emissions, while the transportation sector accounted for 38% of the total.

Per capita CO<sub>2</sub> emissions in Latin America average 3.2 tons per year, but this figure varies from country to country. The extremes are Haiti, with an annual figure of 0.22 tCO<sub>2</sub> per capita, and Trinidad and Tobago, with 28 tCO<sub>2</sub>. Peru, Bolivia, El Salvador, Paraguay, Honduras, Colombia, Nicaragua, and Guatemala emit between 1 tCO<sub>2</sub> and 2 tCO<sub>2</sub> per capita per year; Costa Rica, Ecuador, the Dominican Republic, Uruguay, Grenada, Panama, Cuba, Brazil, and Guyana emit between 2 tCO<sub>2</sub> and 4 tCO<sub>2</sub> per capita per year; and Argentina, Mexico, Barbados, Chile, Jamaica, Venezuela, and Suriname have annual emissions of between 4 tCO<sub>2</sub> and 6 tCO<sub>2</sub> per capita.

Average energy-related CO<sub>2</sub> emissions in 2011 in the Region were 15 tCO<sub>2</sub> per inhabitant –16.6 tCO<sub>2</sub> in the United States and 2.7 tCO<sub>2</sub> in Latin America (58). For the period 2006-2030, projections indicate an annual increase of 0.3% in energy-related CO<sub>2</sub> emissions in North America and a 2.1% increase in Latin America. In non-OECD countries, urbanization is one of the chief causes of increased emissions (58).

Energy-related CO<sub>2</sub> emissions associated with the exportation of goods and services also play a significant role. In 2006, North America imported goods and services representing 1.171 billion tons of CO<sub>2</sub>, while its exports represented only approximately 339 million tons of CO<sub>2</sub>.

### The Kyoto Protocol and projects promoted by the Clean Development Mechanism

International efforts to slow and reverse greenhouse gas emissions coalesced in the United Nations Framework Convention on Climate Change and the associated Kyoto Protocol, which established commitments to reduce emissions by 2012. As of 2011, however, no countries in the Americas had reduced greenhouse gas emissions, either because they were not parties to Annex I (as in the case of all of LAC), they had not ratified the Kyoto Protocol (as was true of the United States), or they had withdrawn from the agreement (as did Canada).

With the flexibility mechanism known as the Clean Development Mechanism (CDM), the Annex I parties to the Kyoto Protocol – most notably Europe and Japan – met their emission-reduction commitments by transferring to low-carbon technology in the energy sector, as well as by allocating economic resources to projects specifically targeting Latin America. As a result of this mechanism, the Region has been responsible for 21% of the global reduction in emissions (less than one third the contribution of the Asia-Pacific region). Measuring CDM participation by country, Brazil leads the emissions-reduction efforts, with a 50% reduction, followed by Mexico (22%), Argentina (14%), and Chile (9%). With the onset of the financial crisis in late 2008, however, and the subsequent economic slowdown in Europe, the price of Certified Emission Reductions (CERs) in the market fell considerably, reaching 0.08 euros per ton of carbon reduction in April 2013. This led to changes in CDM procedures, limiting participation to economically less developed countries as of January 2013. In Latin America, Haiti is the only candidate eligible to access this regime; thus, new funding sources must be found, such as the Green Climate Fund. Efforts in this regard are directed to having the developed economies provide US\$100 million per year in aid to the developing or emerging economies by 2020 at the latest. There is hope that a commitment on this will be secured during the 19th Conference of the Parties in Warsaw.

These new agreements arose as a result of the conclusion of the first phase of Kyoto Protocol commitments in December 2012, and as a consequence of the fact that the Protocol's second phase –running from 1 January 2013 to 31 December 2020– was ratified at the 18th Conference of the Parties (COP 18) on climate change, in Doha. Through this ratification, the signatory nations committed to reviewing their emissions objectives, with a view to implementing more ambitious goals before 2014 while also meeting the commitment made at the COP 17 (held in Durban, South Africa) to adopt a binding international protocol in 2015 slated to enter into force in 2020.

## Sustainable energy development and health

Two types of concerns are involved here. The first is social in nature and relates to access to the energy supply and prices (many people lack access to energy or cannot afford it), energy efficiency, and the frequency of accidents related to home energy use; the second is environmental and concerns energy-related emissions.

## Millennium Development Goals

None of the Millennium Development Goals (MDGs) deal directly with energy. However, energy shortages, particularly lack of electricity and cleaner fuels for cooking, are one of the manifestations of poverty; in much of LAC they are a common feature of rural households and the poorest urban neighborhoods. Thus, inasmuch as the MDGs address poverty and environmental sustainability, they indirectly address the issue of energy.

**Goal 1: To eradicate extreme poverty and hunger.** Access to energy is essential for job creation and the production of food and other goods, as well as for commerce and transportation. Use of inefficient and polluting household energy is an obstacle to breaking the vicious circle of poverty. Poor families tend to spend a larger proportion of their income on energy than do wealthy households.

**Goal 2: To achieve universal primary education.** Schools need light. Also, many children miss school in order to collect firewood and water, or to care for their siblings if their mother is sick, which, in some cases, is related to the indoor use of solid fuels.

**Goal 3: To promote gender equality and empower women.** Lack of access to modern fuels contributes to inequality, since women devote considerable time to firewood collection and food preparation, activities in which their daughters also participate when they could otherwise be educating themselves or engaging in productive activities.

**Goals 4, 5, and 6: To reduce child mortality, improve maternal health, and combat disease.** Rates of environment-related mortality among children under 5 are estimated to vary by a factor of 180 from one world region to another. Environmental interventions can prevent deaths from diarrhea and lower respiratory tract infections for over 2 million children under 5 each year (17). Better energy supply services can reduce child mortality, im-

prove maternal health, reduce work time and the work burden for women and girls, and reduce pressure on fragile ecosystems (15).

Cleaner fuels, as well as electricity, can help reduce morbidity and mortality indirectly:

- By reducing illnesses related to unsafe drinking water and by providing energy to pump, treat, and boil water.
- By reducing illnesses related to the indoor use of solid fuels. These fuels pose a disproportionate risk to women and young children as a result of food preparation activities. Good health is crucial when a family's livelihood depends on the health of its members. In addition, collecting fuel leads to accidents, broken bones, back pain, and snake bites. The hope is to halve by 2015 the number of people with inadequate access to modern cooking fuels and to make improved stoves widely available.
- Energy drives agricultural production and fosters productive opportunities, raising incomes and thus reducing malnutrition and increasing family health budgets.
- Health clinics need electricity to provide effective services. Lighting, refrigeration, sterilization, medical equipment, etc., require energy. Energy also makes it possible to conduct health campaigns via radio and television.

**Goal 7: To ensure environmental sustainability.** Many adverse local, regional, and global effects are due to energy production, distribution, and consumption. Burning fossil fuels damages the environment through indoor and outdoor air pollution, soil degradation, acidification of land and water, the generation of hazardous wastes, and climate change. It is essential that environmental interventions provide and promote clean forms of energy that reduce pressure on ecosystems, curb atmospheric pollutants, and improve health. Environmental damage and its adverse effects can be reduced by boosting energy efficiency through the design of modern technologies for energy production and use, substituting traditional fuels with cleaner fuels, including renewable energy.

**Goal 8: To forge a global partnership for development.** This goal is aimed at creating partnerships involving public entities, development agencies, civil society, and the private sector to foster sustainable development, which includes an affordable, reliable, and environmentally sustainable energy supply.

## ■ Sustainable energy for all

At the World Future Energy Summit, held in Abu Dhabi in January 2012, United Nations Secretary-General Ban Ki-moon outlined the two great energy challenges of our time: lack of access to electricity, which affects one out of five people worldwide, and climate change. It was in this context that he launched the "Sustainable Energy for All" initiative, aimed at providing sustainable energy for all human beings by 2030, eradicating poverty, maintaining economic growth, and protecting the planet (97).

Inefficient combustion of fossil fuels and biomass for energy production is the principal cause of climate change. Close to 1.3 million deaths per year are due to air pollution in urban areas, and approximately 2 million deaths are associated with indoor air pollution. Progress on this initiative can therefore be gauged by health indicators related to energy access, since some illnesses are directly associated with environmental pollution.

Achieving this objective requires technology development, the corresponding will on the part of those in government, and commitment by all nations. It will require the developed countries to support a transition to low-emission technologies, while the developing nations will need to adopt production systems based on cleaner energy. It is therefore essential to design policies that promote the shift to cleaner energy and to continually evaluate the action taken (98).

### Trends and predictions: Energy, climate change, and opportunities for innovation and change

Climate change has become one of humanity's major challenges. The global model of sustainable development has led us, collectively, to imagine a future in which our societies function with energy sources that do not alter the environmental balance and are sufficiently abundant or renewable to meet the basic needs of the world population and satisfy people's aspirations for well-being, within the context of their cultures and income levels. To sustainably

produce and use energy, some of the available options require new systems of social and industrial organization, locally as well as globally, if they are to be affordable, competitive, and safe.

According to the Johannesburg Declaration on Sustainable Development, health is not only a resource, but also the product of sustainable development (20). It is therefore urgent that dependence on fossil fuels be eliminated, while diversifying energy sources and utilizing the advantages offered by the various alternatives. The change will be gradual, however, and the consumption of fossil fuels will continue growing significantly over the next two decades, owing to their price advantage over renewable energy sources, the still-large reserves around the world that are profitable to exploit at current prices, and the availability of the technologies and infrastructure needed to exploit them immediately. In most of the developing countries, the quickest and cheapest way of gaining the benefits of energy is through coal and other hydrocarbons.

The fossil fuel industry has produced scientific and technological advances that, in just over a decade (99), will provide combustion based on combined processes that boost efficiency by an average of 32% to 45%, while eliminating more than 90% of CO<sub>2</sub> emissions, reducing negative environmental effects, and thereby removing the urgency of replacing fossil fuels (100).

Environmentally sustainable energy supply and use can be expected to lead to reduced environmental and health risks. Achieving this requires enhanced energy efficiency, the introduction of modern technologies for energy production and use, utilization of cleaner fuels, and the incorporation of renewable energy sources. Key actions are needed at the global, regional, and national levels to take advantage of energy as a tool for achieving sustainable development and poverty reduction, and for meeting the Millennium Development Goals (81).

Unless major international agreements are reached on goals to reduce greenhouse gases and on imposing a real price on their externalities, fossil fuels (oil, natural gas, and coal) will remain the predominant source of global energy in the coming decades. If oil consumption trends remain unchanged, oil will represent over 30% of the world's energy matrix, followed by coal and natural gas (7), while current infrastructure investments for supplying energy will define the technology for decades to come, particularly in the area of power generation (3).

Much of the current policy to alleviate energy insecurity can also help mitigate pollution and climate change; conversely, mitigation measures can help alleviate energy insecurity. It is therefore essential to adopt an integrated approach in policy-making (3). Since many of the actions that affect health determinants are generated outside the health sector, it is important for different sectors to cooperate in efforts to reduce the environmental health burden. Costs in the health sector are rising, and demand often cannot be met. It is therefore unlikely that development will be sustainable without intersectoral cooperation (21).

Certain cities have been actively engaged in combating climate change and have launched programs to reduce greenhouse gas emissions by specific percentages within specific time frames. Examples of this are Mexico City (with its goal of a 3% reduction by 2010) and cities with stricter limits: Toronto (Canada) specifies gradual reductions aimed at achieving an 80% decline by 2050, while Berkeley (United States) is exploring the idea of setting the target of reducing emissions by 33% by 2020 (58).

Both Canada and the United States have programs –current, proposed, or announced– for a system of trading in greenhouse gas emissions (58).

The pace of innovation in the energy field has doubled over the past two decades (101), with an even greater acceleration since the start of the 21st century. This has been reflected in a growing number of patents related to new electrical power plants. Unfortunately, the development of new energy production technologies is concentrated in a very few industrialized nations. However, globalization shortens the time required for the transfer of new technologies, while largely leveling the costs of using the technologies.

The Asia-Pacific Economic Cooperation (APEC) countries have recently recommended reducing energy dependence through diversification of energy sources, interconnection of energy systems, and investment in efficient technologies (102), whether fossil-based or renewable. The possibility of “citizenizing” energy can provide an important push for new, sustainable ways of producing energy.

## ■ Recommendations

### *Recommendations for research*

Reducing the effects of energy consumption on people's health requires a transition to low-carbon-intensity fuels, accompanied by regulatory schemes that limit and discourage the use of fossil fuels. This means exerting

greater pressure to pursue research in this area, with periodic assessments of the comparative risks associated with different energy sources. By generating country- and source-specific data, such research can provide more accurate information for local decision makers.

Life cycle analysis must also be conducted to determine the cost of public health externalities from energy use in the Region. Almost no such studies have been conducted outside the United States and Canada, where electrical energy has been the principal focus. Mexico is now making substantial efforts to incorporate analyses of this type in formulating public policy on electricity, transportation, construction, and certain industrial activities. These studies are especially important in the context of climate change, since that phenomenon is directly related to the burning of fossil fuels and has countless repercussions for public health, given the increasing intensity of extreme weather events (hurricanes, heat waves, drought, frosts, etc.), the proliferation of new disease vectors in cold and temperate regions, the advance of desertification, and the disappearance of species and ecosystems, among the many other effects already evident in the Region.

Topics that have yet to be studied extensively with respect to the interactions between energy and public and occupational health in the Region include the production, use, and final disposal of biofuels (first generation and cellulosic), batteries, fluorescent light bulbs, photovoltaic cells, and wind generators.

The population's ever increasing exposure to pollutants generated by modes of transportation merits special attention from the health sector. Studies conducted in the conurbations of the Valley of Mexico, Santiago (Chile), São Paulo, and Los Angeles and other cities in the United States highlight the close relationship between the transportation sector and morbidity and mortality rates among the Region's growing urban population.

Since the use of biomass in isolated rural communities exacerbates deforestation and entails substantial health risks from exposure to particulates among vulnerable groups such as children, the elderly, and women, there is a need for ongoing research and technological innovation aimed at providing safe and clean energy in the rural environment.

### ***Recommendations for decision makers***

The most important recommendation for decision makers in the energy sector is that they take public health externalities from different energy sources into account when evaluating new projects and determining different ways of producing and using energy. It is essential to include health costs in fuel prices, since the morbidity associated with different types of energy makes itself felt, if not immediately, then in ever shorter time frames, and imposes high costs in terms of medical care, absenteeism, and labor productivity.

The Region requires a real push toward exploring and implementing renewable energy sources, along with the application of technologies capable of preventing and controlling pollution in cases involving conventional energy generation. In particular, plants that generate electricity or steam through the use of fossil fuels must have equipment to control particulates, sulfur dioxide, and nitrogen oxides. New electrical power plants that use coal or petroleum coke should not be approved unless they are equipped with the means of capturing CO<sub>2</sub> and storing it in secure geological formations. There is also a need for fuels with low sulfur content, a prerequisite to introducing catalytic converters –or particulate filters, depending on the engine technology– for all motor vehicles.

Under new policies that address energy security, sovereignty, and sustainability, biofuels will play an increasingly important role in the Region. Thus, there needs to be concerted intensification of research and development efforts regarding cellulosic ethanol and biodiesel to ensure that their production does not compete with agricultural areas devoted to food production and that biofuel production does not push the agricultural frontier into forested and protected ecosystems.

In the health sector, emphasis should be placed on symptoms and illnesses associated with the generation and use of energy –particularly energy produced with fossil fuels– that causes air pollution (in the form of particulates and ozone) and water pollution (e.g., from mercury).

With regard to urban development and land use regulation, energy-related effects on health are increasing day by day. Direct exposure of the population to pollutants produced by the industrial sector must be reduced, as must the risks of fuel leakages, explosions, and spills. In urban areas, it is common to find energy infrastructure abutting residential areas – a less than ideal situation. New land use policies must be adopted, given the various phenomena associated with climate change, in order to pare back urban development, provide more infrastructure development to protect vulnerable areas (coastal, riparian, and semi-desert areas, etc.), and implement long-range programs aimed at adapting to the new climatic conditions, particularly in island nations, tropical areas, and regions that depend on annual cycles of snow or ice melt from mountains and glaciers.

With regard to household energy, renewed attention should be given to the concerns expressed by Eva Rehfues (19), who has emphasized that the problems in this realm affect many sectors and tend to get lost in the cracks between different areas of responsibility: the problem is an energy problem and yet is not a traditional concern of the energy sector; a health problem, but one that the health sector can only partially solve; an environmental problem, though the environmental sector tends to be too isolated to implement the necessary solutions. Thus, to deal effectively with the challenges in this area, closer ties must be forged between the energy, environmental, and health sectors.

Cities, which are currently responsible for 70% of energy-related CO<sub>2</sub> emissions, have great potential for reducing energy use and CO<sub>2</sub> emissions. There are three major areas in which local government policies can play a significant role in reducing energy consumption and CO<sub>2</sub>:

- promoting integrated energy generation technology;
- improving modes of passenger transportation; and
- increasing energy efficiency in large buildings and houses.

Finally, the vicious circle of energy poverty and lack of development in the Region's poorest countries must be broken, particularly in Haiti and the other Caribbean nations and in the Central American countries. In this regard, there is a need for regional partnerships to ensure a secure energy supply, given the very limited energy resources in those nations.

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## ■ Notes

- 1 Mtoe: millions of tons of oil equivalent. One toe is equivalent to the quantity of energy released by burning one ton of crude oil, approximately 42 GJ.
- 2 Mortality strata (WHO, 2000): AMR A (very low in children and adults): Canada, Cuba, Saint Vincent and the Grenadines, and United States; AMR B (low in children and adults): Dominican Republic, El Salvador, Grenada, Guyana, Honduras, Jamaica, Mexico, Panama, Paraguay, Saint Kitts and Nevis, Saint Lucia, Suriname, Trinidad and Tobago, Uruguay, and Venezuela. AMR D (high in children and adults): Bolivia, Ecuador, Guatemala, Haiti, Nicaragua and Peru.
- 3 BOE/inhab.: total energy consumption of each country in tons of oil equivalent per capita.
- 4 MWe: electricity generated by a nuclear plant, equivalent to thermal capacity times efficiency.
- 5 TWh: a unit of electrical energy equivalent to 1,000 gigawatts/hour; it is a measure of the energy delivered to consumers.
- 6 The tesla (T) is the unit of measure that expresses the strength of an electromagnetic field;  $1 \text{ T} = 1 \text{ weber/m}^2$ ;  $1 \mu\text{T} = 10^{-6} \text{ T}$ .

# Challenges for universal basic sanitation

Adalberto Noyola  
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## ■ Introduction

One of the most serious problems facing most of the inhabitants of Latin America and the Caribbean is undoubtedly their deteriorating quality of life due to poverty and the lack of opportunities offered by the decades-long political and economic system. The inadequate health care, nutrition, education, and security faced by broad segments of society are exacerbated by population growth, particularly in urban areas, and limited opportunities to raise income levels among the poorest groups. In the current context, any government action to bring basic services to marginalized areas is a titanic undertaking. As a result, drinking water and sanitation services have not been provided at the pace required to protect public health and preserve the environment and natural resources. Furthermore, basic sanitation—understood as the least expensive technology to ensure hygienic disposal of excreta and wastewater and a clean and healthy environment in homes and their surroundings—is rarely a priority in government plans, and when it is, the resources are often used inefficiently.

Despite the great efforts in Latin America and the Caribbean to supply drinking water to new urban housing developments and rural communities, there has been a failure to address sewage problems—in particular, treatment prior to final discharge—due *inter alia* to the high cost of conventional infrastructure. As a result, in responding to a priority demand of the population, new health and environmental problems have been created. Conflicts over water use can also occur, particularly in areas where the resource is not abundant. In light of this, in several countries in the region it is common practice to reuse raw sewage to irrigate crops, with all the health risks that this implies.

In 2001, 589 million people (8.4% of the world's population) were living in Latin America and the Caribbean, a region historically marked by vast social and economic inequalities: in 2011, annual gross domestic product (GDP) in the countries ranged from US\$726 per inhabitant in Haiti to US\$10,047 in Mexico and US\$14,394 in Chile (1). In this context of scarce economic resources, public services in the region, particularly basic sanitation and health, are deficient.

According to World Bank data (1), 94% of the inhabitants of Latin America and the Caribbean have access to safe drinking water. This figure is based on a minimum availability of 20 liters per person within a 1-km radius, an unchallenging baseline that the WHO/UNICEF Joint Monitoring Program set for the Millennium Development Goals (MDGs). Meanwhile, 82% of the population has access to improved sanitation, either through an adequate drainage network or on-site treatment and disposal systems, compared to global figures of 89% for drinking water and 64% for sanitation. This means that 35 million people in Latin America and the Caribbean are without access

to safe drinking water and 106 million lack adequate sanitation systems for excreta disposal. In this context, an improved sanitation system is one that ensures that people do not come into contact with human waste. Facilities that do not guarantee this include dry pit latrines, hanging latrines, and bucket latrines (2).

Clearly, the lack of sanitation services creates an environmental problem that exposes a large portion of the region's inhabitants to the risk of disease and death. Human excreta are implicated in the transmission of many infectious diseases, including diarrhea, infectious hepatitis, cholera, typhoid fever, poliomyelitis, cryptosporidiosis, and ascariasis. According to the abundant information in technical publications, there are several mechanisms for the transmission of waterborne infectious and parasitic diseases (3,4). Furthermore, traditional water related health hazards are accompanied by new threats stemming from the proximity of industrial development to poverty-stricken areas, including water and soil pollution with toxic wastes such as heavy metals, pesticides, chemical solvents, and endocrine disruptors. Poor and marginalized populations as a rule are more exposed to these environmental risks, exacerbating their existing health problems. Considering the progress made in recent years, and comparing the development of sanitation services in Latin America and the Caribbean with those in Africa and South East Asia, the current coverage could be considered acceptable. However, given the goal of universal coverage, the absolute numbers are troubling, since only 50% of the population is connected to conventional sewerage systems and only 15% of wastewater is treated—and part of it with inefficient systems. These figures for 2007 from the World Bank Water and Sanitation Program (5) are among the few published references to the state of wastewater treatment in the Region.

The situation is more critical in rural areas, since services are provided under conditions that fail to meet needs and water supply and sanitation facilities are often poorly managed. Low income levels and distances between rural communities are the main problems in service delivery. According to World Health Organization (WHO) data (2), 87% of the population in the region's urban areas has access to improved sanitation, compared to 63% in rural areas.

An important factor to consider is that 79% of the region's population lives in urban areas (1), implying centralized services, including wastewater collection and treatment. On the plus side, the urban scale lowers the cost per inhabitant; on the minus side, centralization leads to the automatic use of traditional sanitation models while concentrating the impact on the bodies of water that receive the wastewater.

In the face of this daunting challenge, it is imperative to develop and implement new solutions to the persistent shortage of infrastructure for both wastewater management and the expansion and improvement of water supply systems. In designing new administrative, social, and technology systems, consideration should be given to the region's limitations and potential, employing a large dose of innovation and adaptation and abandoning conventional solutions in many cases.

Different management models for water supply and sanitation services have been developed and implemented in the region, with varying degrees of success. There is growing understanding that to ensure the long-term sustainability of systems and their benefits, the focus must be on public policy and civic engagement by the citizens who receive these services. In order to maximize the benefits to users, it is absolutely essential that management models be appropriate to each situation and compatible with local competencies, and that they guarantee participation, an intersectoral approach, and financial and administrative efficiency, so that water and sanitation interventions are not limited to the creation of infrastructure.

## ■ Water: A resource at risk

Water demand is surging with demographic growth, industrial activity, and tourism, while agricultural irrigation (where the most water is used) also continues to expand (6-9). The pressure on water resources is heightened by many unsustainable patterns of water use. Extracting water from aquifers faster than they can be replenished is a particularly important aggravating factor, and there is general ignorance of natural limits in this regard. Rising rates of deforestation may also be contributing to severe annual flood cycles. Fresh water resources are being degraded as water demand increases. In arid and semiarid areas in particular, competition for limited water resources has increased.

The Latin America and Caribbean region is very rich in water resources. However, they are not located near major human settlements: 60% of the population is concentrated in 20% of its territory, with only 5% of the region's water resources. At the same time, the Amazon, Orinoco, San Francisco, Paraná, Paraguay, and Magdalena rivers carry more than 30% of the world's continental surface water. In contrast, two-thirds of the region is arid or semiarid, including large swaths of central and northern Mexico, northeastern Brazil, northern Argentina and Chile, and

the Altiplano region of Bolivia and Peru (10). The island of Barbados, in the Caribbean, is among the most arid countries in the world, and the island states of this subregion have considerably fewer water resources per inhabitant than the world's other island groups (only 13.3% of the available supply in the Indian Ocean and 1.7% of the supply in the South Pacific) (11).

Water availability is a growing problem in the region, particularly in countries with a significant proportion of arid zones. In 1995, Mexico was the only country in the hemisphere that consumed more than 10% of the available fresh water in its territory, but now, both Mexico and the Dominican Republic use over 15% of their total reserves every year, putting them in the category of countries with “moderate” pressure on the availability of this resource. The same figure for Cuba is 22%, making it the only country in the region in the “medium-high” category (12).

Given the lack of adequate comprehensive sanitation, the leading cause of water pollution is the direct discharge of domestic and industrial waste into bodies of surface water or onto land, with the risk of polluting the underlying aquifer. The health hazards associated with industrial sources are greater, due to the potential presence of toxic, carcinogenic, or mutagenic compounds that are normally absent in municipal discharge. Furthermore, improper final disposal of urban solid waste generally ends up affecting the quality of surface or groundwater.

The geographic distribution of water pollution in the region is directly related to the presence of medium-sized and large cities. In addition to the concentrated population and industrial production found in these locations, the following important factors also play a role: the growth of conventional sewer systems without accompanying treatment infrastructure; more intensive agricultural land use near metropolitan areas; changes in the economic structure, with growing emphasis on manufacturing; concentrated runoff from paved areas in developing urban areas; and poor management of solid waste, which ends up in open dumps or riverbeds.

Of particular importance in groundwater pollution is leaching due to the improper use and disposal of heavy metals, synthetic chemical products, and hazardous waste. The amount of such compounds that reaches groundwater from garbage dumps and other nonpoint sources (runoff, infiltration in agricultural areas) is apparently doubling every 15 years in Latin America (13).

Aquifer exhaustion and salt water intrusion are also major sources of groundwater pollution. Salinization is a particularly critical problem in the small island states of the Caribbean, where groundwater availability is limited and there is a risk of salt water intrusion. A threat yet to be properly assessed in this area is climate change, resulting in the intensification of droughts and rising sea levels.

The sediments produced by erosion and the pollutants found in the discharge of domestic, industrial, and agrochemical waste are among the leading causes of deteriorating water quality. As industry, agricultural areas, and populations grow, the environmental and financial costs of providing additional water also increase. In fact, the cost of providing water to cities is steadily rising, with dramatic examples in growing major urban areas: water from 130 km away is pumped to altitudes of more than 1,000 meters to deliver it to Mexico City; pollution in the upper watersheds of Lima has increased treatment costs by nearly 30%; and high desalination costs have been observed in the Caribbean (11).

The availability of water has been fundamental to the development of agricultural irrigation throughout the region, which has an irrigated surface area of 18.3 million hectares (14), equivalent to 0.9% of its territory. On average, agricultural demand accounts for some 70% of the volume of fresh water used in the region, although demand is lower in some countries, such as Brazil (55%) and Cuba (56%) (15). Salinization and flooding, however, are undermining the productivity gains achieved through 40 years of irrigation investments in countries such as Mexico, Chile, and Argentina (16). Agricultural diversification often requires more irrigation, increasing the pressure on available sources.

In recent decades, persistent environmental problems have affected the availability and quality of water in urban areas, since housing continues to be built in sensitive areas, such as high slopes above water catchment areas very close to aquifers.

In summary, the Region's water resources are threatened or have been heavily affected, particularly in densely populated industrial areas. Furthermore, the water shortages already affecting large areas of the region are further exacerbated by the lack of sanitation infrastructure, negatively impacting water quality and aggravating the situation.

## ■ Water and sanitation: Key factors for improving health in the Region

The use of polluted water for drinking and washing can spread a variety of infectious diseases. Furthermore, lack of water in the home leads to poor hygiene, furthering the development of another group of diseases com-

monly associated with poverty and marginalization. Some of these diseases are present in several countries of the region, and outbreaks occur particularly in the poor urban population.

Diseases closely associated with water can be divided into four categories:

- a. *Diseases caused by drinking water polluted by human, animal, or chemical waste.* These include cholera, typhoid fever, shigellosis, giardiasis, dysentery, poliomyelitis, meningitis, hepatitis A and E, and diarrhea and for the most part can be prevented with proper excreta and wastewater management. Diarrhea merits special mention, since WHO calculates that nearly 1.8 million people die annually from diarrheal diseases, 90% of them children under 5, mainly in developing countries (17). Nearly 80,000 children under 5 in the region die from this cause every year. The main toxic chemical pollutant in drinking water is arsenic. An estimated 4.8 million Latin Americans are exposed to arsenic in drinking water, making this a major public health problem. Toxicological and epidemiological studies confirm that the chronic intake of arsenic through drinking water causes skin lesions such as hyperpigmentation and palmoplantar hyperkeratosis, nervous system disorders, diabetes mellitus, anemia, alterations of the liver, vascular diseases, and skin, lung, and bladder cancer (the latter, especially in children) (18).
- b. *Diseases caused by aquatic organisms that spend part of their life cycle in (polluted or clean) water, and another part as animal parasites.* These diseases, which include dracunculiasis, paragonimiasis, clonorchiasis, and schistosomiasis, are caused by a variety of trematodes, tapeworms, pinworms, and nematodes, collectively known as helminths, which infect humans. Although normally not fatal, these diseases keep people from living normal lives and impair their ability to work.
- c. *Vector-borne diseases associated with water,* transmitted by vectors such as mosquitoes, which breed and live near polluted and unpolluted waters, infecting millions of people with diseases that include malaria, yellow fever, dengue, sleeping sickness, and filariasis. The incidence of these diseases appears to be on the rise, among other reasons because the vectors develop resistance to the drugs used to fight them and because climate change is creating new breeding sites.
- d. *Diseases associated with water shortages and closely linked to the resulting poor hygiene.* These include trachoma, tetanus, conjunctivitis, and some skin diseases. These diseases are spreading around the world but can be controlled with better hygiene, for which an adequate supply of clean water is essential.

To ensure minimum conditions for public health, excreta and wastewater must be removed from residential areas and disposed of properly. Readers of the *British Medical Journal* chose the “sanitary revolution” as the “greatest medical advance since 1840” (2). However, only 64% of the world’s population has access to improved sanitation. Although coverage of this service is relatively high in the region (82%) (2), just under two-thirds of the population has access to conventional sewerage systems (61%); the rest of the population (21%) has only latrines or septic tanks (19). In any case, as mentioned earlier, municipal wastewater treatment remains very limited (15% of the total amount generated) (5).

Deficiencies are observed in the quality of water provided to the population in many countries in the region, mainly due to the poor operation and maintenance of water systems as a result of various technical, economic, social, and/or political factors. There is considerable inequality in the implementation of water quality monitoring programs, as national health authorities concentrate their greatest efforts in urban communities, while such efforts are limited or nonexistent in rural communities. PAHO/WHO has expressed concern about conditions in the many households in the region that lack a water connection, especially poor households. A WHO/UNICEF study to evaluate drinking water quality in Nicaraguan households (20), based on stratified sampling and multiple indicator cluster surveys (MICS), showed that 89% of the samples collected from homes did not contain free chlorine in systems that are normally chlorinated, and that 45% of the samples contained heat-resistant coliform bacteria.

Water safety plans (WSPs) are being promoted and implemented in several countries of the region to support water monitoring and quality control programs. These plans employ a comprehensive approach involving the assessment and management of health risks to maximize the safety of drinking water from the watershed to the consumer to protect the health of the population. This issue is addressed further on, in another section.

Concerning the technologies employed to treat municipal wastewater in the region, recent data from a sample of 2,734 facilities in six representative countries (21) show that the most common treatment method is the use of stabilization ponds, with 38% of municipal wastewater treatment plants using this method. The activated sludge

process ranks second, at 26%. Upflow anaerobic sludge blanket (UASB) reactors now rank third, accounting for 17% of the facilities in the sample. In terms of the volume of treated effluent, activated sludge accounts for the greatest proportion (58%), followed by stabilization ponds (15%), advanced primary treatment (9%), and UASB reactors (7%).

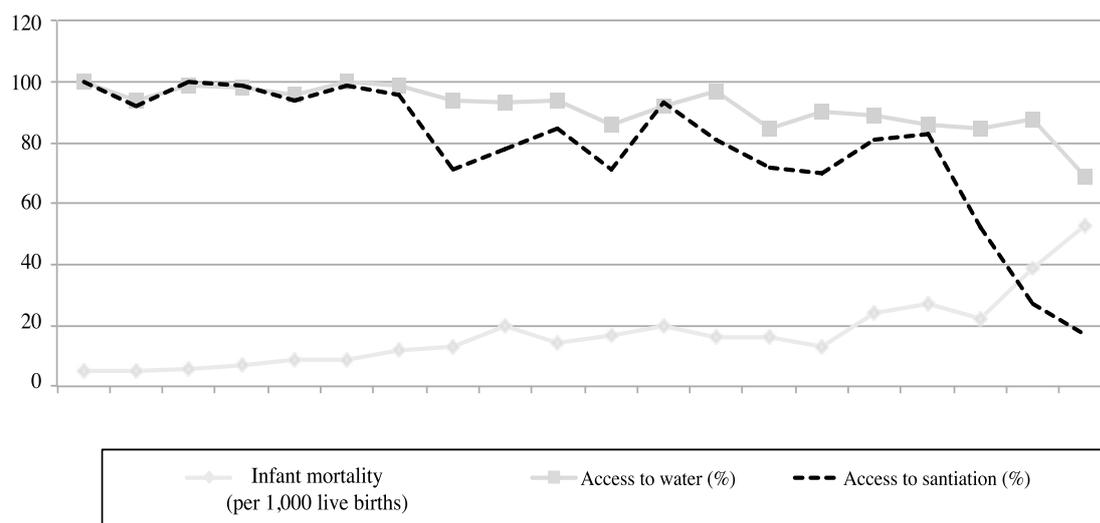
As the next section shows, meeting the demand for drinking water and sanitation comes with enormous financial needs. New challenges and the failure of global and regional programs to significantly reduce the segment of the population without access to these basic services point to the need for a radical change in the ways the problem is being addressed.

The health impact of investing in water and sanitation has been demonstrated. Several developing countries have adopted measures in these areas that are cost-effective or very cost-effective, as defined by the WHO Commission on Macroeconomics and Health (22). “Cost-effective” means an annualized cost of less than three times the per capita GDP for each disability-adjusted life year (DALY) prevented, while “very cost-effective” means an annualized cost of less than the per capita GDP (23). The same holds true for household interventions that help improve water quality (24). Furthermore, such measures are considered to have a very favorable cost-benefit ratio, since the performance of an invested unit of currency can range from 5% to 46% in developing countries.

The cost saving is attributable to: *a*) benefits directly related to health (i.e., health care and other costs avoided due to fewer cases of gastrointestinal disease); *b*) economic benefits indirectly related to health, associated with increases in productivity; and *c*) benefits unrelated to health, such as time saved that would otherwise be spent when nearby water and sanitation facilities are lacking. Economically, the latter is the factor with the greatest impact (25).

Figure 18-1 vividly illustrates the relationship between infant mortality and access to water and sanitation services in some countries in the Americas (2,26).

**Figure 18-1** Infant mortality (per 1,000 live births) and access to safe drinking water and sanitation (in percentage of the population) in Latin America



	CAN	CUB	USA	CHI	COR	URU	ARG	PAN	COL	MEX	PAR	ECU	BRA	PER	ELS	HON	DOM	NIC	BOL	HAI
Infant mortality*	5	5	6	7	9	9	12	13	20	14	17	20	16	16	13	24	27	22	39	53
Access to water** (%)	100	94	99	98	96	100	99	94	93	94	86	92	97	85	90	89	86	85	88	69
Access to sanitation* %	100	92	100	99	94	99	96	71	78	85	71	93	81	72	70	81	83	52	27	17

**Source:** \*2010 data. Health Situation in the Americas. Basic Indicators, 2012. Pan American Health Organization

\*\* 2011 data. Progress in sanitation and drinking water, 2013. World Health Organization

## ■ The Millennium Development Goals: A firm step toward universal access to water and sanitation

In years past, international organizations and national governments launched initiatives to close the gap in the provision of water and basic sanitation. All were very ambitious and did not meet their targets to any significant extent. In September 2000, the United Nations General Assembly adopted the Millennium Development Goals. MDG 7 is aimed at ensuring environmental sustainability; target 7.C refers specifically to water and sanitation and calls for halving, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation, compared to a 1990 baseline.

In keeping with target 7.C, the region should increase the proportion of its population with access to safe drinking water from 84% in 1990 to 92% in 2015. “Basic sanitation” poses an even greater challenge, since the figure is supposed to rise from 68% to 84%. This increase in service will involve higher demand for both conventional and on-site sanitation infrastructure. If wastewater treatment is included, the necessary step is enormous, raising coverage from 15% to 57%.

It should be acknowledged that target 7.C was relatively modest for Latin America, since the 92% target for safe drinking water was exceeded by two percentage points in 2010. In that same year, basic sanitation coverage stood at 79%, and by 2011 it had already reached 82%. In 1980, when the United Nations launched the International Drinking Water Supply and Sanitation Decade, the aim was to achieve universal access to safe water by 1990; however, this goal was far from met, largely due to the global financial crisis during that decade (which came to be known as the “lost decade”). In fact, most Latin American countries met and exceeded the water supply target early, indicating that the region could have committed itself to more ambitious figures. However, some exceptions should be noted: Haiti shows a significant lag in this regard, with 69% coverage, while other countries such as Bolivia, the Dominican Republic, Nicaragua, and Paraguay had achieved less than 86% coverage by 2010 (26). Periodic United Nations monitoring of progress in meeting the MDGs shows that reaching the sanitation target will require an intensification of the efforts made to date (27). It should also be noted that the indicators used by the WHO/UNICEF Joint Monitoring Program to monitor target 7.C do not consider the costs, continuity of service, quantity, or quality of water at its source or in the home. In particular, as mentioned earlier, an unchallenging baseline was used to evaluate access to water, requiring availability of 20 liters per person within a 1-km radius.

The estimated investments needed for progress toward meeting the MDGs are enormous, demanding a huge economic effort from the countries of the region. In its 2012 report (28), WHO estimated that US\$599 million would be needed annually in Latin America and the Caribbean to achieve the component of MDG 7 (target 7.C) corresponding to water supply, and US\$1.782 billion annually for the sanitation component (a cumulative US\$2.996 billion and US\$8.910 billion, respectively, in the period 2010-2015, for a total of US\$11.906 billion). To achieve universal services, the annual figures come to US\$5.822 billion for water supply and US\$7.866 billion for sanitation (totaling US\$68.441 billion for the period 2010-2015).

That same WHO report also stated that the relative cost of building new water supply infrastructure and maintaining the existing infrastructure in the region would be US\$110 billion in the period 2010-2015. The corresponding cost of sanitation infrastructure would be US\$78 billion in the same period.

Despite the progress in recent years toward achieving the MDGs in the region, deficiencies in the maintenance of existing systems persist, due in part to the political situation; although users may receive enough water, its quality may be deficient and the supply irregular. Furthermore, existing sewerage systems are not connected to the water treatment infrastructure; thus, untreated wastewater is discharged into the environment.

## ■ Integrated water management

One characteristic of water is that in some cases it can be reused again and again, even as its quality deteriorates: between one stage and another it can be treated to ensure its proper reuse. These potential multiple uses require rational management of this resource, which is considered scarce, with costs depending on the quality desired. With adequate financial, technological, and organizational support, this is a viable approach—even a necessary one if water is scarce—for achieving close to 100% drinking water supply coverage without constraining other production, services, or recreational activities requiring water.

In societies with a decidedly commercial outlook, when water becomes scarce, its value increases dramatically. The view that water should be a free service shifts to one in which it is considered a vital input whose price is sub-

ject to the law of supply and demand. In times of scarcity, it is essential to ensure comprehensive management of this resource through an approach that takes into account social inequalities and the inability of the poorest social groups to pay for the service.

The technology developed to treat all types of wastewater varies widely and can include a “treatment train” that makes it at least technically feasible to obtain specific water qualities. However, due to the relative availability of water, its cost in most cases is low or even subsidized for social and political reasons. In this situation, the treatment of wastewater for reuse will be limited by its economic feasibility if treated water cannot be offered at a competitive price that will motivate users to opt for a lower-quality product than first-use water. Accordingly, new reuse programs should address both technical and economic issues to create a rate structure that recovers the actual cost of water supply services. It is clear that for water services to be economically viable, water prices must reflect the real cost of the resource, and current subsidies must be reduced and granted only to those who really need them.

One aspect not to be ignored is the risk to human health from the reuse of treated wastewater for the irrigation of crops or green areas or for other urban uses. Conventional water quality indicators are inadequate in this context, making it necessary to pay special attention to the presence of compounds such as endocrine disruptors and active pharmaceuticals such as antibiotics (29). To move forward with a program for treatment and safe reuse, wastewater treatment systems must be improved and accompanied by more efficient procedures for monitoring the quality of the treated water as it leaves the plant, in the delivery system, and in bodies of water that receive it and are the source of supply for different uses.

In many countries in the region, wastewater (mostly untreated) is used in large scale agricultural irrigation. It is estimated that at least 510,000 hectares in Latin America are irrigated with raw waste-water (30), mainly in Mexico (260,000 hectares), Colombia (26,000 hectares), and Peru (8,400 hectares). Moscoso *et al.* (31) calculate that over 2 million hectares in the region are irrigated with improperly treated wastewater. The use of municipal wastewater in agricultural irrigation is a characteristic of developing countries that must be addressed with evidence-based approaches and local experience, not necessarily following conventional patterns. Increasingly, countries with water shortages are reusing treated wastewater in ways that are becoming a basic element of sustainable water management.

In this context, there has been a growing debate about how to apply the concept of *integrated urban water management* to improve water management in cities, from both an economic and a social and environmental standpoint. This strategy would help remedy the often splintered management of water by offering a comprehensive vision for the joint management of water supply, sanitation, rainwater, urban irrigation, and even solid waste, among other forms in which water is present in cities. Such a model has major technological implications, since it includes strategies for reusing rainwater for household and public use, retaining rainwater to prevent floods, and reusing treated wastewater, in addition to promoting more productive discussion of the false “separate” sewerage systems (systems designed to receive only wastewater, but which, in practice, take in rainwater) found in most cities in the region. How water is managed also has political and institutional implications at the municipal level.

Integrated management is supported by experiences in Brazil, where national legislation passed in 2007 establishes guidelines for basic sanitation, understood as water supply, sanitation, and rainwater and solid waste management. This definition could have major implications for integrated water management, since providers and regulators receive increasing incentives to act on all four components as a group, rather than dealing separately with water supply, or at most with water and drainage, as is traditional in Brazil and throughout the region. In this regard, Brazilian legislation calls for certain instruments, such as the preparation of municipal basic sanitation plans that integrate water and solid waste services. This will facilitate better linkage between the services and make it possible to take advantage of their important role in promoting public health while relegating the commercial vision of providers to a secondary plane. The incentives for adopting an intersectoral approach, also included in the new Brazilian legislation, will strengthen the integration of basic sanitation, public health, urban planning, environmental and water resource management, and other sectors.

## ■ Management models for water and sanitation services in Latin America and the Caribbean

It is increasingly recognized that for basic sanitation services to achieve their ultimate goal —providing quality service to the entire population while protecting public health— it is not enough simply to meet technical requirements; rather, aspects of public policy, management, and citizen participation are equally important. It is point-

less for a system to be well-conceived, designed, and constructed using modern techniques, and even to function properly, if it is not structured so as to ensure its economic, operational, sanitary, and environmental sustainability. Supporting this assertion, Table 18-1 presents the evaluation made by the United Nations Human Settlements Programme (UN Habitat) (32) on the factors that contribute to poor water supply and sanitation in urban areas. Safe service is limited by factors related not only to technical issues but in large part to lack of suitable national and local policies, lack of planning for universal services, pricing policies that fail to guarantee the poor access to services, and little coordination with urban policies.

**Table 18-1.** Causes of inadequate urban water supply and sewerage systems (32)

<i>Underlying causes (action at regional, national, and international level)</i>	<i>Contributing causes (action at the city or municipal level)</i>	<i>Proximate causes (action at the household or neighborhood level)</i>
<ul style="list-style-type: none"> <li>· Lack of support from national governments (by political choice, the effect of indebtedness, etc.)</li> <li>· Lack of support from international agencies</li> </ul>	<ul style="list-style-type: none"> <li>· Water shortages</li> <li>· Rapid population growth that exceeds efforts to provide services</li> <li>· Ineffective local (municipal) institutions</li> <li>· Institutions' refusal to act in informal settlements</li> </ul>	<ul style="list-style-type: none"> <li>· Limited ability of residents to pay for the services</li> <li>· Illegal status of settlements</li> <li>· Limited ability of households and communities to build installations on their own (often due to the unavailability of water at the local level)</li> </ul>

In Latin America, many failures in basic sanitation systems are the result of poor management models that lead to poor coverage, exclusion of the poorest population, and, above all, services that are unsustainable over time. This is illustrated by the case of Guayaquil, Ecuador, where, despite observed examples of proper management, a detailed study confirmed that much of the population (significantly, the most disadvantaged segments) lacked access to piped water (33). The author of the study includes the “productivist” logic of Guayaquil administrators among the factors that hinder access by the poor.

Different management models and types of service providers have coexisted in the region. In the 1970s, local management prevailed, with major development fostered by municipal governments and little interest by national governments in undertaking countrywide projects. In the 1970s and 1980s, services began to be centralized under national or state/provincial agencies (19,34). In the 1990s, international financial institutions began promoting the privatization of services in various forms (35). Today, different models are found in the region, a product of the social and political dynamics in each country, province/state, or municipality.

To date, there have been no detailed studies comparing these management models in terms of their effects on health. A study in Germany found that privatization led to a higher risk of carcinogenic compounds in water (36). In principle, this problem can occur whenever productivist logic prevails over the social and public health role that should be the priority of water services. In any case, since the privatization of water services has been going on for nearly two decades in Latin America, comparative studies of the health impacts of the various management models should be encouraged.

Many basic sanitation services are provided by local public operators, with varying support from national governments. Although some of these services are clearly deficient (e.g., the aforementioned example of Guayaquil in the 1990s), there are also noteworthy examples of successful experiences—for example, in Porto Alegre and Bogotá (37), as well as other activities in Brazil (38).

There are also examples of satisfactory community experiences—for example, in Nicaragua and Argentina (Moreno and Buenos Aires) (39), in Bolivian and Argentine cooperatives (37), and in rural sanitation cooperatives in Chile and Argentina. Venezuela's water boards (*mesas técnicas del agua*)<sup>1</sup> deserve special attention, given their potential for changing the structure of water coverage in the country. The water boards are a permanent channel for community participation to secure, improve, and monitor high-quality local water supply and sanitation services and to promote a water and sanitation culture that values and exercises stewardship over this resource and the environment. The boards serve as a liaison between institutions and communities and are responsible for holding meetings with technical personnel and disseminating the information generated in the process. Such experiences in community organization offer interesting potential for the sustainable organization of services but are generally

dependent on external resources and specialized technical assistance, making support from the national government indispensable.

Another management model worth mentioning, given its importance in some countries, is the *centralized model*, in which provinces/states or even nations are responsible for providing the services. State-owned companies are the prevailing model in small countries with a unitary government, such as Paraguay, Uruguay, Guyana, Costa Rica, and several Caribbean nations. In contrast, the provincial model implemented in Brazil through the National Sanitation Plan (Planasa) (34) is also found in other countries, such as Argentina and Chile (private-sector model), Colombia, Peru, and Venezuela. In Brazil, this has been a controversial issue, since, despite the successes of state-owned water and sewerage companies in expanding coverage (especially in water supply), there have been frequent conflicts with the municipal authorities constitutionally responsible for these services. There is also a recent trend toward sharing the ownership of these companies with private capital through the creation of joint ventures whose social effectiveness has yet to be properly evaluated. Furthermore, business arrangements of this kind tend to distribute the sector's revenues among private shareholders, for the most part foreigners.

It is important to emphasize that national governments have played an important role in sanitation policy in some countries. In several Central American and Caribbean countries, for example, national water supply and sewerage institutes have been created and given the authority to oversee operators (19). National governments have also been drafting national water and sanitation plans to guide sectoral decision-making and, at the same time, make long-term commitments that last beyond the current administration's term of office. It is also important to highlight the role of national governments in setting standards (e.g., environmental standards), especially for the coordination of initiatives to monitor the quality of water for human consumption. In this regard, research by the Ministry of Health of Brazil—in collaboration with PAHO and several Brazilian universities and research centers, USEPA, and INHEM/Cuba—found very significant differences in development levels and types of practices among the countries of the region, while also noting regional disparities (40).

Private-sector participation in services takes different forms, beginning with traditional contracts with companies for materials and equipment supply, the design and implementation of engineering projects, and the execution of works. However, especially in the 1990s, international financial institutions began promoting the privatization of services, initially through two main forms: private acquisition of the assets of public corporations (e.g., in Chile); and the concession of operating rights for a set time—a model that spread throughout the Americas, notably in Argentina, Bolivia, Colombia, Brazil, Mexico, Central America, and even the United States. Indeed, private investment in the sector dramatically increased in Latin America over previous levels, soaring to US\$25 billion in the period 1990-1997—a figure nearly 100 times higher than the US\$297 million in the period 1984-1990 (41).

Whether private participation in service delivery is the right option, especially in socioeconomic environments where regulation is not part of the national culture, has been the subject of considerable debate: some studies point to success and others to resounding failure. After nearly two decades, limitations in regulations illustrate the State's troubling inability to regulate the monopolies that characterize water supply and sanitation services. In the context of privatization, ECLAC itself acknowledges miscalculations with respect to the existence of effective competition, the consideration of externalities, and the nature and commercial viability of services subject to transactions (42). As a result, incentives to foster competition or monopoly in the water sector may lead to unwanted transfers of revenue that are neither transparent and explicit nor open to public scrutiny. Water laws and the regulation of related public services offer examples of what happens when legislation and regulations governing market forces and incentives for competition are based on assumptions that are not borne out in practice (43).

Even the Chilean experience, heralded as a model to be followed in several parts of the world, has received mixed evaluations, with some experts interpreting it as successful (44) and others considering it exclusive and segregating (45), as well as misguided in its principle of transferring the ownership of water resources to private hands (46). The only similar model is found in the United Kingdom—implemented under Margaret Thatcher's ultraliberal economic policies—although some problems derived from that option (47,48) have now been clearly identified in that country.

The collapse of major private concessions in the region, including those in Buenos Aires, the Greater Buenos Aires area, and Tucumán in Argentina, La Paz and Cochabamba in Bolivia, Atlanta in the United States, and Puerto Rico, although for different reasons, confirms the theory that private concessions are unable to increase access for the poor, invest private resources, and set rates commensurate with the social conditions of the population. These negative experiences influenced the decision of multinational water companies to withdraw from the region, despite the persistence of some defenders of the model. Clearly, such a conclusion cannot be generalized, but it can at

least be said that, contrary to what the multilateral agencies were promoting in the 1990s, this is not how the region will achieve universal access to services or even meet the MDG targets.

At the 6th World Water Forum (49), it was emphasized that improving the management of water and sanitation services will require strategic and sustainable financial planning based on an appropriate and specific case-by-case combination of contributions from users, public budgets, private financing, and bilateral and multilateral sources. The need for effective and sustainable cost recovery was also noted, as was the need for specific innovative mechanisms to subsidize the lowest income strata. In this context, private investment should be imbued with a spirit of solidarity, justice, and equality. Experts at the World Water Forum identified public-private joint ventures as an opportunity for countries with limited budgetary resources, provided that they create a regulatory framework that clearly defines investor participation to ensure equitable service delivery, especially to the social strata with the least purchasing power.

Finally, it is important to consider the multiple dimensions of sanitation services in terms of management and public policies, as well as the role of the human factor in this context. Jury and Vaux (50) point out that there is still much to learn about the role of human behavior in water use, which suggests the need to gather information on the determinants of water use levels, the role of culture, and the organization of social actors. These authors conclude that research on institutions has been neglected in the past two decades, even though the most innovative among them will be part of the solution to the world's emerging water problems.

## ■ What the sector needs to achieve universal service coverage

Given the challenge of securing better health and living conditions for all the inhabitants of the region, solutions for expanding and improving water and sanitation services may be more successful if they include innovative components and are based on an in-depth understanding of the problems specific to the region. The conventional approach imported from developed countries has proven to have its limitations, mainly because it requires major investments and very high operating costs while increasing technological dependency. Furthermore, in many cases, it does not translate into systems tailored to conditions in the region. To meet the sector's goals, therefore, administrative, financial, and technological procedures must be developed and implemented that truly respond to the needs and limitations of Latin American users. Experiences in several countries in the region already offer a valuable set of options that need the wholehearted support of society, which will play a key role, as well as political commitment from governments.

An analysis of water quality legislation across the region reveals major differences. Only in four countries (Brazil, Colombia, the Dominican Republic, and Mexico) does it formally include programs for monitoring and quality control of drinking water (51). Although there are still no specific guidelines for developing this type of program, many countries in the region report initiatives coordinated by the health sector in this area that have a structure and personnel for planning and implementation. However, only a minority of countries report policies for the financial management of these programs (40).

In any case, positive developments in political, management, and social aspects of the water sector have been observed in several countries in the region. Society in general and politicians in particular exhibit a heightened awareness that the water and sanitation sector is not only indispensable for improving quality of life and preserving human and environmental health but is an effective way to reduce social inequalities linked with poverty. There has been progress, albeit unequal, in separating the functions and roles assigned to the entities involved in running these services, among them regulatory and oversight agencies. Using different models, several countries can now boast examples of efficient management, which can be tailored to local conditions and replicated.

This framework favors new programs and adjustments to traditional policies, with a view to meeting domestic and international challenges, such as those identified in the United Nations General Assembly resolution of 28 July 2010, which recognizes access to safe and clean drinking water and sanitation as a human right, essential for the full enjoyment of life and other human rights (52). Similarly, the ministerial declaration of March 2012, promoted by the World Water Council and signed in Marseille, reaffirms that water is "key to peace and stability...in the context of sustainable development and poverty eradication," and recognizes its role in guaranteeing well-being and progress in the sphere of human health (49).

With regard to target 7.C of MDG 7, Latin America and the Caribbean have contributed decisively to the world's meeting the part of the target related to drinking water: by 2010, the proportion of people without sustainable access had been reduced by more than half. However, the region must make substantial progress in the part

related to sanitation, an issue fraught with difficulties. Moreover, since target 7.C is not very ambitious and the criteria for defining access to water and sanitation services are insufficient in the context of the Americas, there is no reason to be satisfied with the achievements announced by WHO and UNICEF (53). The target for the region could be more ambitious, particularly in sanitation, the service with the most shortcomings, with a view to achieving universal coverage in the areas of water, sanitation, proper treatment and disposal of wastewater, and urban solid waste management, all on a horizon not long after 2015.

Water safety plans (WSPs), an initiative promoted by WHO, are a tool that can help improve water supply services in terms of quantity and quality (54). This quality management tool for water supply services is the result of a WHO recommendation found in the fourth edition of the *Guidelines for Drinking-water Quality*, originally published in 2004 and updated in 2006 and 2011 (55). The general purpose of WSPs is to characterize health risks in water supply systems to improve service quality. These plans include the systematization, detailed evaluation, and prioritization of control measures to mitigate the microbiological, chemical, and/or physical risks inherent to the service. They are based on operational monitoring through multiple barriers or control measures that are continuously verified, validated, and reported.

By attempting to ensure not only the continuity and quantity, but most importantly the quality of the water supply, WSPs are a useful tool for improving operator performance. Oversight agencies and regulatory authorities should therefore promote their use. WSPs also add value by following the risk assessment process from the watershed to the consumer, establishing the need to involve other, nontraditional actors in water monitoring and quality control, among them watershed, environmental, agricultural, and municipal authorities, as well as the organized community—all of whom must exercise their role and responsibility in monitoring and safeguarding water sources. The WSP strategy should have a place in integrated watershed management as a major tool for guaranteeing the quality of water for human consumption.

The region also needs a clearer definition of “basic” access to water and sanitation services, instead of simply using the overly tolerant definitions of the WHO/UNICEF Joint Monitoring Program (JMP) for Water Supply and Sanitation (53), which accepts questionable solutions such as a 20-liter per person supply of water at long distances from dwellings (1,000 meters), or on-site excreta disposal systems that are not necessarily free of health risks. The region should develop its own definitions and indicators, in coordination with pertinent international organizations, such as PAHO, UNICEF, and the Organization of American States (OAS), and the participation of financial institutions such as the World Bank and the Inter-American Development Bank. The objective would be to adjust regional targets by assessing the progress made and setting the goal of universal access to services on a horizon consistent with regional trends and conditions.

A successful example of the development of technologies for our environment is the Research Program on Basic Sanitation (PROSAB) conducted in Brazil over a 10-year period.<sup>2</sup> This is an example of continuity and cooperation that shows that ambitious targets can be met with a long-term research and development policy. Technologies appropriate to Brazil and, therefore, potentially applicable in the region, were developed for drinking water and wastewater treatment, urban sludge and solid waste management, and agricultural water reuse. One of the most significant tangible achievements was the application of anaerobic UASB technology to low-cost domestic wastewater treatment.

## ■ Conclusions and recommendations for decision makers

The countries of the region face a historical lag in services, particularly in basic sanitation and health. Great efforts have been made to meet water supply needs, but the problems of wastewater disposal and, especially, treatment prior to final discharge, have been addressed very slowly for financial, regulatory, and institutional reasons, given the very high cost of conventional infrastructure.

An essentially quantitative vision has prevailed in the region’s public policies, sometimes as a result of international goals such as the MDGs, with efforts focusing more on improving coverage statistics than on the quality of service.

The region already has experience with efficient management through the use of various models in different countries, making it possible to extrapolate and adapt successful cases, learn from mistakes, and apply this knowledge to specific local conditions. To date, no detailed studies have compared the health impact of the different management models. This is a line of work that should be pursued.

The key factors for meeting and exceeding the MDGs and facing the enormous challenges in the region in this area can be grouped under three headings: *a)* institutional reform; *b)* capacity-building; and *c)* the promotion of social participation in decision-making and water management. Specifically, the following necessary interventions are recommended:

*Political agenda:*

- Make addressing the lag in sanitation a priority on government agendas.
- View water and sanitation services not simply as a component of infrastructure, but as a civil right whose interdisciplinary and intersectoral relationships must be understood, especially the links with public health, the environment, urban and rural development, and other social policies.
- Formulate or adapt public policies to strengthen the sector.
- Equip the local authorities that operate the systems with greater and more effective legal, financial, and technical capabilities.
- Establish regulatory and monitoring frameworks that are efficient and tailored to local conditions.
- Promote organized and informed citizen participation, particularly in rural and marginalized areas.
- Develop and implement comprehensive programs that contribute financing and support to achieve not only greater coverage but greater operating capacity among the agencies responsible for the services.

*Institutional agenda:*

- Prioritize efficient professional management of operating agencies, while shielding them from political vagaries.
- Adopt a real user-pay system that includes subsidies for the most disadvantaged users.
- Address the sustainability of the service through long-term planning, not just new infrastructure.
- Develop alternative technologies tailored to conditions in the region: solutions of its own based on research and development.

Water supply involves not only reaching more users but improving the quality of drinking water and guaranteeing continuity of service. The concept of safe water, which includes aspects such as the protection of water sources and system-wide risk evaluation, should be given the same priority as increasing coverage rates. WSPs are a useful way of meeting both these goals and having sustainable systems with a guarantee of quality and quantity.

With regard to sanitation, the need for wastewater collection and disposal should be associated with a clearer vision of appropriate technologies and the potential impact of each of them on health and the environment. Furthermore, international financial institutions should recognize the technologies developed in the region and not just conventional ones.

The region should set its own criteria and indicators for basic access to water and sanitation services and tailor them to its own conditions and the expectations of its peoples. This is because the region has its own level of development, which cannot be compared to that of other regions.

Given the magnitude of the challenge, new solutions with new administrative, social, and technology systems must be developed and implemented that take the region's limitations and potential into account and include a large dose of innovation, adaptation, and citizen participation. Ensuring that investments in the sector yield a long-term return requires decisive action in the public policy sphere and effective, efficient, professional management of services.

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## ■ Notes

- 1 Lacabana and Cariola (personal communication).
- 2 See: [www.finep.gov.br/prosab/index.html](http://www.finep.gov.br/prosab/index.html).



# Genetically modified food and public health

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## ■ Introduction

Since the dawn of history, man has eaten what nature has provided, and plants have always been—and continue to be—an important source of food. Humanity has learned by trial and error that only some plants are safe to eat, while many are toxic. In an ongoing process of domestication, it has focused exclusively on those that are safe. It has also learned that some foods can be eaten only after cooking or some other kind of processing. This knowledge of food safety has been passed down from generation to generation (1).

In the past century, and especially the past 50 years, chemical analysis and toxicity testing have provided more knowledge about plants. In efforts to discover why some plants can only be eaten after processing or treatment of some kind, researchers have found that many of our present foods contain certain levels of toxic substances that are destroyed by cooking or other processing (1).

Most national agencies charged with food *safety* allow new varieties of conventional food crops that are already on the market to be introduced without formal toxicological evaluation, provided that specific levels of certain toxic compounds are not exceeded in the plants grown. Food is generally considered safe if proper care is taken during its development, primary production, processing, storage, handling, and preparation (9). Such acceptance of foods without formal evaluation is based on their “history of safe consumption.” The history consists not of empirical evidence, but of basically anecdotal evidence demonstrating that the foods in question are not harmful. In a world of rapidly changing eating habits, this approach may be questionable from the standpoint of safety. Moreover, many new published studies are going beyond the few known toxic compounds to explore other positive and negative effects that constituents of food plants can have on health, and scientists even admit that very little is known on their potential long-term effects (1,3).

Today, the issue of food safety has become extremely important, and a number of questions about the safety of genetically modified (GM) foods—foods that consist of, contain, or are produced from genetically modified organisms—have flooded the pages of scientific journals as well as the front pages of newspapers. Many aspects of the question remain to be explored scientifically. Safety assessments of GM foods and GM derivatives designed for consumption must follow the stipulations of the Joint FAO/WHO Codex Alimentarius Commission (2,5,5,7). The risk assessment process includes a safety evaluation to determine whether nutritional or safety problems are present, and if so, what and how serious they are.

Like conventional reproduction, genetic engineering has the potential to alter the toxicity of foods. A recently introduced protein may be toxic, but random changes due to an insertion or pleiotropy can also lead to significant

changes from a toxicological standpoint. Unlike conventional crops, genetically modified foods require formal food safety evaluation, because they have no history of safe consumption (1).

Given the history of safe consumption associated with conventional foods, they are generally regarded as an appropriate benchmark for assessing the safety of GM foods. Safety assessment of a GM food must determine whether it is as safe as its conventional counterpart. As a starting point, the concept of “substantial equivalence” has been adopted as the basis for determining whether food products are suitable for consumption. Four components are involved in evaluating genetically modified foods: (1) a molecular description of the inserted genetic material; (2) the identification of any undesirable direct toxicological effect that could result from the nature of the inserted sequences; (3) the identification of any undesirable indirect toxicological effect that could result from the modification; and (4) analysis of the plant’s morphology and behavior under relevant field conditions. A broader concept called “comparative safety assessment” has recently been proposed to replace this approach (8). Safety assessment can be defined as a process designed to identify the uncertainties associated with a GM product, as well as the probability and seriousness of one or more adverse effects in each case of human or animal consumption. Comparative safety evaluation is basically a two-phase process. The first phase consists of meticulous comparison of the new product with its closest conventional counterpart to identify any difference that may have implications for consumer safety. The comparison covers both phenotype characteristics and an analysis of the product’s composition (9). The latter component of the process focuses on the key substances being studied and is subject to change as scientific knowledge advances. The second phase consists of a toxicological and nutritional assessment of the observed differences between the GM food and its conventional equivalent. The findings from this second phase may indicate the need for more testing and lead to an iterative process designed to obtain all the information needed for the final safety assessment. The importance of monitoring the effects on consumers’ health for a period of time after the product is placed on the market is clearly recognized.

It should be noted that debate on the advantages and disadvantages of genetically modified organisms (GMOs) is invariably a function of how people view new technology and of their widely differing economic, environmental, moral, socioeconomic, and ethnic perspectives. Sensitivity to political issues and socioeconomic and ethnic perspectives is of paramount importance in assessing the benefits that biotechnology might offer in improving food safety but does not appear to be sufficient to put an end to the controversy surrounding the technology. Only continuing basic research on the risks and benefits of GMOs will convince the public of the advantages that genetic engineering can provide for public health and environmental sustainability.

It is widely recognized that the criteria used in assessing the safety of GMOs or foods containing or consisting of GMOs must be designed to ensure that proper steps are taken to prevent adverse effects on human and animal health and the environment. The purpose of this chapter is to provide scientific information on the safety of GMOs in a public health context.

## ■ The evolution and production of genetically modified organisms

Genetically modified crops can play an important role in food security and can make food more accessible by adding to the supply and lowering production costs. They can also reduce adverse effects in terms of climate change. A number of modified products began to be produced and consumed with biotechnology advances in the 20th century.

The production of genetically modified foods is driven by many forces, ranging from economic incentives to public health factors. On the economic side, GM products can be created to boost production, reduce losses, and improve final yield. Today’s first-generation GM plants are designed to incorporate agronomic characteristics that reduce productivity losses in the field due to insects, viruses, fungi, and bacteria and to reduce competition with weeds for nutrients and water (10). Genetically modified corn is the most widely known such product, but others, such as soy and cotton, are also on the market. Such crops help countries produce more competitively and ensure a place in the world market for their output.

A second generation of GMOs is designed to improve the nutritional value of food and even to incorporate features that prevent or reduce the risk of disease. It may eventually be possible, for example, to produce protein- and vitamin-rich potatoes; vitamin-rich strawberries; canola, rapeseed, or soy with more monounsaturated fats; corn and soy with more essential amino acids; vitamin-enriched wheat; products enriched with omega 3; etc. So-called “golden rice” has already been developed and is an excellent supplementary source of vitamin A for poor populations. Other possibilities include foods that function as vaccines by helping the immune system respond to

certain pathogenic viruses such as the human papilloma or cholera viruses, and foods modified to eliminate toxic or allergenic substances (10).

In addition to food quality, we must remember that the planet's cultivable land area has declined. The per capita cultivable area (the amount of land per person available to produce food) was 0.44 hectares in 1960, but had fallen to 0.26 hectares by 1997, and the projection for 2050 is 0.15 hectares. Today, the world population stands at nearly 7 billion and is projected to reach 9 billion by the end of this century, with the developing countries playing a major role in the increase (11). Food demand will rise by nearly 40% with the burgeoning population, and the challenge that this poses will be exacerbated by two other problems —a shortage of water and reduced soil fertility (12). Biotechnology is indubitably an important tool for attacking this problem, since it can improve the quality and quantity of food produced.

GMOs have been a daily part of the lives of millions for over two decades. The first GM plants began to be tested in the field in the early 1980s and were first marketed in the early 1990s in China. Specifically, scientists succeeded in adding genes from a bacterium to two plants in 1983, producing the first GM vegetables. The first production crops from that biotechnology were virus-resistant tobacco and tomatoes. In 1994, the Flavr-Savr tomato was put on the market in the United States. Its slow-ripening characteristic reduces loss between production and consumption.

In 2012, 17 years after genetically modified crops were first marketed, they represented over 10% of crop production worldwide. They had steadily increased at a rate of 6% annually to 170 million hectares under the management of 17.3 million farmers in 30 countries. Biotech crops have set a precedent in that the biotech area has grown impressively every single year for the past 17 years, with a remarkable increase of almost 100 fold since they were first marketed in 1996. This is the fastest embrace of an agricultural technology in history, and it shows that GM crops are increasingly accepted by wealthy, large-scale farmers and poor, small-scale farmers in industrialized and developing nations alike. Notably, EMBRAPA, a Brazilian public-sector institution, gained approval to market a virus-resistant bean, demonstrating its impressive technical capacity to develop, deliver, and deploy a new state-of-the-art biotech crop (12).

As Table 19-1 shows, the United States leads the world in output, with 40% of the world area planted in genetically modified crops, followed by Brazil (21%), Argentina (14%), Canada (7%), India (6%), China (2.3%), Paraguay (2%), and South Africa (1.7%). Soybeans remain the principal GM crop, with 47% of the world area, followed by maize (32%), cotton (14%), and canola or rapeseed (5%). The main characteristics of genetically modified crops are tolerance to herbicides and resistance to insects (12).

**Table 19-1.** Global area of biotech crops in 2012 (in millions of hectares)

	Country	Area		Country	Area
1	United States	69.5	15	Myanmar	0.3
2	Brazil	36.6	16	Mexico	0.2
3	Argentina	23.9	17	Spain	0.1
4	Canada	11.6	18	Chile	< 0.1
5	India	10.8	19	Colombia	< 0.1
6	China	4.0	20	Honduras	< 0.1
7	Paraguay	3.4	21	Sudan	< 0.1
8	South Africa	2.9	22	Portugal	< 0.1
9	Pakistan	2.8	23	Czech Republic	< 0.1
10	Uruguay	1.4	24	Cuba	< 0.1
11	Bolivia	1.0	25	Egypt	< 0.1
12	Philippines	0.8	26	Costa Rica	< 0.1
13	Australia	0.7	27	Romania	< 0.1
14	Burkina Faso	0.3	28	Slovakia	< 0.1

Source: James, 2012.

## ■ General safety assessment principles applicable to genetically modified foods

### The concept of substantial equivalence

Strategies to assess the safety of genetically modified foods are based on methods and criteria for comparing genetically modified organisms and their derivatives with similar non-GM products. The basic assumption behind this comparative approach is that conventional foods have a longstanding history of use that demonstrates their safety for the environment and for normal human or animal consumption. They can therefore serve as a benchmark against which to compare the safety of GMOs. Thus, in 1993, a Working Group on Food Safety and Biotechnology established by the Organisation for Economic Co-operation and Development (OECD) considered the concept of substantial equivalence the most practical approach for addressing the issue of food safety and the nutritional quality of new foods or food components deriving from modern biotechnology (13). The concept and principles for the application of substantial equivalence set out by the Working Group have been criticized (14) which has led to a review of its application (22). In addition, the concept has been discussed by the Codex Alimentarius Commission, which has stated that even though it considers substantial equivalence determination a key step in the safety assessment process, it is not a safety assessment in itself; rather, it represents the point of departure for structuring the safety assessment of a new food relative to its conventional counterpart (6). The differences the genetic modification has produced and what further differences may arise in the course of subsequent handling of the food should be clarified (15,16,17,18).

The safety assessment of genetically modified foods thus begins by comparing the GM food with its conventional counterpart. It then examines the safety of the foods for human beings or animals and the nutritional consequences of any intentional or unintentional differences observed between the conventional and GM versions of the food. When genes or other DNA segments from a donor organism are inserted in a host organism, the resulting organism is inevitably different from the parent to some extent. Assessing the potential risks associated with the new organism means not only meticulously studying the intended modifications, but also examining the results of the genetic modification in comparison with similar conventional plants. Thus, the safety assessment of GMOs has two steps—first, a comparative analysis to identify the points in which it differs from the conventional organism, and then an assessment of its safety as a human or animal food. The second step must consider the nutritional consequences of whatever differences have been detected, both intentional and unintentional.

Although risk assessment has long been applied to hazardous chemicals (pesticide and veterinary drug residues, contaminants, food additives, etc.) and is increasingly used to assess microbiological hazards and nutritional elements, the principles of risk assessment were not developed specifically for whole foods. The approach is generally applicable to foods, including those produced with modern biotechnology, but it must be modified when used for a whole food rather than isolated analysis of a specific hazard present in a food (2).

### Comparative safety assessment

Any safety assessment of a genetically modified food begins with a comparison to identify the similarities and differences between the GM product and a product, or products, that provide an appropriate basis for comparison and have a history of safe consumption (19).

The first step in the process is a comparison of the molecular, agronomic, and morphological characteristics of the products being examined, as well as a chemical analysis. The second step, which depends on the results of this first step, must include an analysis of the GM product's safety and nutritional characteristics, using the similar conventional product's history of safe consumption as a benchmark. This process should yield evidence for concluding whether the genetically modified food is as safe as its conventional counterpart (15,16,17,18).

Once comparison between the genetically modified product and the benchmark product reveals the differences due to the modification, the differences should be subjected to toxicological and allergenic evaluation, as well as to an assessment of their nutritional consequences. Toxicological, allergenic, and nutritional studies must be conducted even if there is no conventional product to use as a standard for comparison (15,16,17).

Comparative safety assessment of genetically modified foods is a generally recognized application of the concept of "substantial equivalence." It is based on the idea that new foods derived from genetically modified organisms must be at least as safe as the conventional products that they are likely to replace in the diet. Although substantial

equivalence is a key step in evaluating the safety of GM foods, however, it does not by itself constitute a food safety assessment (4,6).

Comparative evaluation can determine whether a genetic modification entails undesired indirect effects, and it is a guiding principle of safety assessment. It calls for comparing the modified plant with its unmodified counterpart. This is a more direct method than merely searching for symptoms. It examines substances that are relevant toxicologically, nutritionally, or for health. Foods currently on the market have been analyzed in this way without significant differences being detected. If important changes were detected, this would be an indication of an undesired effect by (1) pleiotropy (2), insertion, or (3) somaclonal variation. When significant changes are found, new analyses must be conducted to determine the cause. This is not easy, and explanations cannot be expected to be found in all cases. It is expected that new methods (proteomic, metabolomic, microarray) that are being developed will facilitate better comparison between GMOs and their conventional counterparts.

If an appropriate benchmark for comparison cannot be found, a comparative safety assessment cannot be performed, and comprehensive evaluation of the safety and nutritional characteristics of the human or animal food produced from the GM crop is called for. This occurs, for example, if a feature or features are introduced that modify the composition of the food in relatively major ways.

Comparative safety assessment must include steps to consider the following factors: the transformation process involved in the genetic modification, including the sequence of the inserted material before and after the insertion; the number of copies and the site or sites of insertion; analysis of the sequence at the insertion sites (i.e., adjacent areas); stability of the incorporation (over multiple generations); the safety of any recently expressed protein, including analysis of its allergenicity; the appearance and implications of unintentional effects; the role of the new GM food in the diet; and the potential effect of processing or deterioration on the new genetically modified product. The Codex guidelines include more precise criteria applying to the molecular description (5,6,7,20).

### Intentional and unintentional effects

Intentional effects are those that the insertion of the new genes is designed to produce. Thus, they respond to the initial purpose of the modification. Phenotype alterations can be detected by comparative analysis of growth, yield, disease resistance, and other such factors. The presence of intentional alterations in the composition of a food can be detected by comparison with the modified food's conventional counterpart (the parent plant, for example). This can be done by measuring simple compounds, such as recently expressed proteins, macronutrients, and micronutrients (targeted analysis). The analytic methods used to detect components must meet specific quality and validation criteria (15,16,18).

Unintentional effects consist of uniform differences between the GM foods and the conventional foods that are being used as controls, not including the expected primary effects of introducing a new gene or genes. Unintentional effects may be the result of a reordering of genetic material or of metabolic changes. These effects can sometimes be observed in the phenotype or the composition of the GMO when the GMO is grown under the same conditions as the control plants. Our current biological knowledge, including knowledge about the integration of and connections between metabolic pathways, can in some cases predict or explain unintentional effects. One starting point for identifying potential unintentional effects is analyzing neighboring regions of the transgene to determine whether the insertion could affect the function of some endogenous gene whose function is known or predictable. It is also important to conduct a targeted analysis of the simple compounds in the GMO that play an important role in the organism's metabolic pathways, in comparison with the corresponding compounds in the conventional organism. The relevant components here are macronutrients, micronutrients, and secondary metabolites, as well as known antinutrients and toxins. Statistically significant differences between the parent lines and the GM plants that are not due to intentional modification may be an indication of unintentional effects and, hence, should be evaluated specifically to determine their implications in terms of safety and nutritional impact (21).

### Factors that must be considered in relation to genetically modified foods

Evaluating human health risks from ingesting foods or ingredients derived from genetically modified plants or animals should take the following elements into account (15,16,17,18):

- characteristics of donor and recipient organisms;
- genetic modification and its functional consequences;

- potential environmental impact;
- agronomic characteristics;
- potential toxicity and allergenicity of genetically modified products (including proteins, metabolites, and the whole food);
- composition and nutritional characteristics;
- influence of processing on the food's properties;
- potential alterations when the food is ingested;
- possible long-term nutritional impact;
- predictable and unpredictable effects of and the genetic modification.

While recognizing that the secondary effects of these new technologies may increase over time, we can say that the comparative safety assessment process is sufficiently well founded to evaluate the safety of human and animal foods produced with technologies that effect plants' endogenous regulatory pathways and genetic expression.

## Risk assessment

The risk assessment process begins with a safety assessment to determine the presence of hazards, nutritional issues, or other reasons for concern and then gathers information on the nature and seriousness of the hazards. Assessment should be comparative, identifying the similarities and differences between the modern biotechnologically produced food and its conventional counterpart. If the assessment detects a new problem, or a new form of an old problem, whether nutritional or of another sort, with implications for the product's safety, a risk assessment should be conducted to determine the relevance of the problem to human health. It is highly recommended that the product be monitored after it is put on the market, as well as beforehand (2,6,22,23).

## Identifying and describing hazards

Determining that a hazard exists means identifying biological, chemical, or physical agents that could have adverse effects on human health or the environment.

Evaluating the existence of a hazard can be considered a form of qualitative risk assessment. It requires ascertaining exposure as well as identifying the nature of the predicted adverse effect (24).

Describing a hazard involves a qualitative or quantitative assessment of the nature of the adverse health effect due to biological, chemical, or physical agents. Where chemical agents are involved, a dose-response evaluation should be conducted (25) to determine the relationship between the dose that a population receives and the incidence or seriousness of the adverse health effects affecting it (24).

Determining and describing the hazard is normally the first step in any safety assessment. The comparative safety assessment's revelation of differences is equivalent to the steps of determining and describing hazards in a conventional risk assessment paradigm. For complex GMO-based foods, however, determining and describing hazards is not as easy as it is in the case of well-described simple chemical compounds because of the variety and magnitude of the unintentional effects that may occur and need to be tested for in complex food products.

## Describing risk

In the risk assessment process, describing the risk involves a quantitative or semiquantitative calculation of the probability of an adverse effect and its seriousness in a given population under defined conditions. The calculation, which takes any uncertainties into account, entails estimating exposure, as well as identifying and describing the hazard itself. Risk assessment for a GMO involves generating, collecting, and evaluating information on the GMO and the foods derived from it, so as to establish what effect it may have on human or animal health and the environment (15,16).

The final description of the risk associated with a genetically modified plant and the foods derived from it includes an evaluation of all the existing data identifying and describing the hazard and defines the nutritional or safety impact of exposure or ingestion for human beings or animals, as well as the environment.

The risk description reflects all the scientific data available through a variety of methods (such as molecular analysis, agronomic and chemical composition analysis, toxicity testing, allergenicity testing, and environmental impact) that can provide information on the potential adverse effects and/or nutritional effects of the genetically modified plants and the foods derived from them for human beings, animals, and the environment.

Risk assessment for GM plants should be conducted on a case-by-case basis. It will depend on the type of genetic modification involved, growing practices, and human or animal consumption practices as they relate to foods derived from GMOs. In this context, the description of the risk should address the following questions (15,16):

- whether the cultivation of the genetically modified plants is as safe for the environment as the growing of conventional plants;
- whether the consumption of foods derived from genetically modified plants, as compared to foods derived from conventional plants, is safe for animals and human beings;
- if necessary, the specific conditions for the cultivation of genetically modified plants; and
- the scientific basis for managing the risk.

The description of the risk is the final step in the safety assessment process. It requires fully integrating the results of the toxicological and nutritional evaluations to arrive at a general conclusion about the safety of the food being considered. The history of similar conventional food products is the mandatory benchmark for establishing the safety of new GMO-derived foods produced with biotechnology.

If some question about the safety of the GMO-based food remains after the initial comparative safety assessment, additional tests may be necessary, including studies with the whole organism or with the parts used as foods. If thorough evaluation fails to demonstrate that the product meets the safety criterion (namely, that the GM product be as safe as its conventional counterpart), the GMO-derived product should not be marketed. Risk description as described here should be done on a case-by-case basis for GMO-derived food products.

### The precautionary principle

The precautionary principle is one of the best-known environmental policies in both domestic and international trade. Precaution can be defined as the use of “anticipatory warning,” “caution in the face of uncertainty,” or as “being careful for sound reasons.” The precautionary principle has been formulated as a way of avoiding human and environmental hazards when there is a high degree of uncertainty, and where the effects of policy decisions may be irreversible.

There are many definitions of the precautionary principle. The most widely cited appears in the 1992 Rio Declaration, which states that “Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation” (Rio Declaration, quoted in Cameron, (26). Under this principle, “measures must sometimes be taken to protect against a possible hazard, even when evidence is not sufficient to conclude that the hazard is a scientific fact.” Thus, if the scientific evidence is not complete, the precautionary principle should be applied; if the scientific evidence is decisive, prevention rather than precaution is in order (27).

In February 2000, the European Commission issued a statement asserting that the precautionary principle applies “where scientific information is insufficient, inconclusive, or uncertain and where there are indications that the possible effects on the environment, or human, animal, or plant health may be potentially dangerous and inconsistent with the chosen level of protection (28). This principle, which the European Commission formally established later (29), gives officials responsible for managing food risks the authority to adopt protective measures if they fear that an unacceptable health risk may be present. The measures are defined as ranging from total prohibition of a substance to requiring additional safety tests by food manufacturers.

Under World Trade Organization (WTO) agreements, there is a right to take precautionary measures but not as “a means of arbitrary or unjustifiable discrimination between countries or a disguised restriction on international trade.” One of the WTO agreements most relevant to the risks that GMOs may pose for trade is the Agreement on the Application of Sanitary and Phytosanitary Measures. A basic requirement pervading this agreement is that imported agricultural products be safe and not pose risks to human or animal health, or to the preservation of plants. The agreement also stipulates that for the purposes of food safety oversight and to prevent the introduction of diseases as a result of trade, countries may impose rules to protect human and animal health (sanitary measures) and to protect plants (phytosanitary measures). However, the Agreement on the Application of Sanitary and Phytosanitary Measures requires such rules to be grounded in scientific principles. Therefore, countries have the right to determine their own levels of protection, provided that they meet the conditions set forth in the Agreement on the Application of Sanitary and Phytosanitary Measures. Precaution is involved here, but that does not mean that the precautionary principle is necessarily applicable. Nor is it clear whether the WTO considers that measures

to protect human health and the environment, or to preserve nonrenewable natural resources, can be based on the precautionary principle (30).

In addition, the standards of the Codex Alimentarius are internationally accepted as food safety standards, and the WTO's constitutive agreement uses them to resolve trade disputes concerning foods—specifically those in connection with observance of the Agreement on the Application of Sanitary and Phytosanitary Measures and the Agreement on Technical Barriers to Trade. The Codex works actively to ensure that trade barriers are scientifically based, protect human health, and promote fair trade. The Agreement on the Application of Sanitary and Phytosanitary Measures specifically stipulates that regulations must be based on science, while the Agreement on Technical Barriers to Trade stipulates that unnecessary trade barriers must be avoided.

In the past few years, the Codex Alimentarius Commission has devoted a great deal of its time to examining aspects of the precautionary principle. Nevertheless, when the Working Principles for Risk Analysis for Food Safety for Application by Governments were adopted in July 2007, the document published did not include the precautionary principle. The principle was controversial because it permitted governments to adopt certain preventive measures related to foods in cases where scientific evidence on their safety was uncertain, and many governments and organizations considered it a tool to create unjustified trade barriers. It should be noted that the object of the Codex's Practical Principles is to guide national governments in the evaluation, management, and communication of food-related human health risks (6).

It should also be noted that, in the area of potential public health risks, the precautionary principle has been promoted, but not accepted, in relation to the marketing of genetically modified foods.

### Labeling regime for foods derived from genetically modified organisms

In formulating policies governing the labeling of GM foods to ensure that consumers receive meaningful information, standards authorities have had to deal with a variety of complex problems related to GMOs—scientific, sanitary, environmental, political, cultural, and economic—with the respective execution and enforcement problems.

At the international level, two intrinsically broad approaches to standards are followed where the labeling of genetically modified foods is concerned:

- (a) Voluntary labeling functions largely in response to market forces, without legislation requiring that use of GMOs in the production of food be indicated when foods are marketed.
- (b) Mandatory labeling requires indications of characteristics that are incorporated in a food through genetic technology; it also requires that any use of such technology in the production of the food be stated.

Most of the world's major countries have adopted or plan to adopt mandatory labeling standards for foods produced with genetic technology (Table 19-2). The standards generally require statements regarding the health and safety characteristics of GM foods being sold, as well as an indication that genetic technology has been used in the production of the foods. The most common legislative requirement is that the term “genetically modified” be associated with the name of the food or relevant ingredient.

Some countries use labeling on genetically modified foods to provide consumers with information on the safety of relevant ingredients. Almost all countries refer to the consumer's right to know and regard the labeling of GM foods as a tool that allows consumers to choose among products. The different forms of labeling and labeling proposals reflect national cultures and societies. Thus, it will probably be difficult to achieve international harmonization.

The lack of international uniformity in regulating genetically modified foods, with respect to both safety assessment and labeling, has heightened uncertainty about the development, continuous use, and international marketing of these foods. The lack of uniformity appears in the types and varieties of foods that different countries require labeling for, as well as in levels of tolerance and thresholds. Countries have adopted different labeling practices for GM foods, based on the following percentages: under 0.9%, 1%, 3%, or 5% of total ingredients or unintentional ingredients, or for the three or five principal ingredients.

**Table 19-2.** Examples of national GM food labeling regimes

<i>Labeling regimes</i>	<i>Countries</i>
<b>Fully regulated mandatory labeling regime</b> <i>Food production method or composition:</i> Mandatory labeling of all foods produced with genetic technology, or where the new DNA or protein is present in the final food.	European Union, Australia, New Zealand, China, Russian Federation, Republic of Korea, Japan, Malaysia, Switzerland, Brazil, Thailand, and others.
<b>Mixed mandatory/voluntary labeling regime</b> <i>Equivalence and voluntary labeling:</i> Mandatory labeling of GM foods only if they are significantly different from their conventional counterparts; voluntary labeling if the genetically modified foods are similar to the conventional counterparts.	Canada, United States, Hong Kong, South Africa.
<b>No regulation</b> <i>Other:</i> No regulations in place. Voluntary labeling may be permitted, but there is no evidence of the use of guidelines or codes.	Many developing countries.

In Switzerland, the upper limit of genetically modified content at which a product may be not labeled as genetically modified is 0.1%. In the European Union since 2004, the limit is 0.9%. In Australia, New Zealand, Israel, Saudi Arabia, and Brazil, the limit is 1%; in Malaysia and Korea, 3%; and in Russia, Hong Kong, Taiwan, Thailand, and Japan, 5%. In Canada, labeling is not mandatory, but foods that have up to 5% of GMOs can be labeled as GMO-free. In the United States, although recent legislation does not make labeling mandatory, the government has recommended voluntary labeling, and it also requires companies to notify the FDA at least 120 days before marketing products (12,31).

## ■ Safety evaluation of genetically modified foods

### Recombinant DNA in food

The total quantity of DNA in a food varies with the type of food. For example, edible meats and muscle tissues of animals contain high DNA levels, while plant-based foods (vegetables) such as grains and potatoes contain less, because they generally have fewer nucleated cells than muscle tissue. The amount of DNA that populations consume on a daily basis varies widely with diet. The presence of recombinant DNA in food does not increase the total ingestion of DNA in the diet, because it represents only a small part of the proportion of all the DNA in food.

Food processing can lead to partial or complete degradation, or even elimination, of DNA. The nature of the processing determines how much DNA is degraded or eliminated.

There has been much study of where ingested DNA ends up. Most DNA —both recombinant and nonrecombinant— is broken down during digestion.

Some studies have revealed that not all ingested DNA degrades completely in the gastrointestinal tract. Some fragments of DNA can resist digestion and may be detected there. They can even pass into the bloodstream and other tissues. This is a normal biological phenomenon that is to be expected with recombinant DNA as with nonrecombinant DNA, and there is no evidence that it represents a human health or safety hazard. The cells of the human body have effective defense mechanisms against integrating or allowing the continued expression of foreign DNA that is present in food or the environment (32).

The recombinant DNA in approved new GM foods and food ingredients can be considered as safe as the DNA consumed with existing foods. All DNA, including the recombinant DNA in GMOs, is composed of the same four nucleotides. Genetic modification involves a reordering of the sequence of nucleotides but does not alter their chemical structures. Hence, the DNA of a GMO is chemically equivalent to any other DNA, and the only unique thing about it is the difference in the sequence. Considering the natural variations in DNA sequences, the current use of recombinant techniques in the food chain does not produce changes in the chemical characteristics of DNA. Our traditional diet includes grams of DNA and RNA every day.

The nucleic acids that we ingest are generally inside cells and are released with cell lysis. Nucleic acids outside the cells mostly disintegrate in the digestive apparatus (9), which makes it possible for their basic elements (nucleo-

sides and nucleic acid bases) to be absorbed. Some DNA fragments escape this disintegration, although it is unlikely that complete genes will survive the process. There is evidence that such fragments can be absorbed by enterocytes and macrophages. The rest is excreted with the feces, along with the residual nucleic acids connected with the cell. There is no indication that genetic modification itself, as used in food applications, has any effect on the digestibility or stability of nucleic acids. Because they are chemically identical, toxicological concerns about the basic components can be excluded. Chemically and metabolically, the toxicological profiles of DNA or RNA from GMOs are the same as those of conventional food organisms.

There is no indication that DNA has allergenic or immunological properties of any other kind that would be relevant in a context of GMO-based food consumption. Hence, safety concerns could only relate to the small proportion of extracellular DNA that does not disintegrate. This can interact with digestive tract cells in mammals, or with intestinal microflora, and give rise to genetic changes. In the case of intestinal bacteria, the cells would have to be capable of absorbing the DNA. Then, the DNA would have to be incorporated in the genome, either as a linear fragment (which would require an extensive similarity in the sequences) or by forming an independent replicon. In addition, for a gene to be expressed in the DNA thus integrated, it would have to associate itself with the appropriate regulatory sequences. A new feature could be maintained without selection, but for the transformed bacterium to become a large part of the population, it would have to be selected. Each of these phenomena is very uncommon, and the various phenomena would have to occur in sequence. In mammals, the cells of the intestinal wall, including immune system cells, can take up fragments of DNA. After passing through the intestinal wall, the fragments can be actively extracted by the intestinal immune system cells, or they can enter the bloodstream. Here too, they would be subject to the activity of immune system cells, in which endosomal digestion takes place. Orally administered plasmidic DNA fragments have been observed to be absorbed by immune system cells in mice. There is also some evidence that the nuclei of various types of cells can absorb DNA. Mammals have effective mechanisms to prevent the incorporation of DNA foreign to their genome. There are no indications that foreign DNA ingested is incorporated in the genome, although human beings and other mammals have always been exposed to foreign DNA in their food. The DNA of GM foods is equivalent to the DNA of existing food organisms that people have always consumed (33).

There will always be risks associated with the ingestion of DNA, but this is independent of its origin, because the body processes all DNA identically. The fact that DNA in food degrades as the food travels through the digestive tract and is processed reduces the probability that intact genes capable of coding for proteins foreign to the intestinal microflora will be transferred to a host. Hence, the likelihood that DNA from genetically modified foods will be transferred and functionally integrated in intestinal microflora or human cells is minimal. Consequently, this type of DNA is considered as safe as any other DNA present in food.

## Phenotype analysis

Phenotype analysis draws on chemical analysis but also examines general performance parameters such as growth rate, plant morphology, flowering time, daily temperature threshold for maturation, length of time during which pollen is viable, response to pathogenic agents and insect pests, sensitivity to abiotic stress, and in the case of animals, the efficiency with which food is converted, as well as reproductive and clinical factors.

Chemical composition analysis is a key component of the comparative method that the risk assessment process uses to identify unintentional effects. However, unintentional effects can also manifest themselves in such forms as changed susceptibility to important diseases, morphological and developmental alterations, or different responses to agronomic and crop management regimes. Therefore, comparisons between GMOs and appropriate conventional counterparts should also examine the organisms' biology and phenotypic performance.

## The safety of genic products

The safety of genetically modified foods is assessed by comparing them with their conventional counterparts (3,6).

The concept of substantial equivalence is applied for this purpose. A conventional —i.e., genetically unmodified— food with a history of safe consumption can be used as a point of reference with which to compare a GM food so as to assess its safety. Whatever differences are detected should be evaluated for their toxicological effects

and their nutritional impact on human and animal health (16). The following is a list of the aspects of GM foods that should be thoroughly evaluated during the GM food safety assessment process:

- identity;
- origin;
- composition;
- effects of food preparation or processing;
- form of processing;
- recombinant DNA (stability of insertion, potential for gene transfer);
- protein expression in the product with the new DNA;
- functional effects;
- potential toxicity;
- allergenic potential;
- possible side effects of the genetic expression or disturbance of the host DNA or effects on the host's metabolic processes; the nutritional composition of the macro-, micro- and antinutrients, endogenous toxins, allergens, and physiologically active substances is a critical factor here;
- potential ingestion of genetically modified foods, and potential repercussions of introducing them in the diet (22).

The safety of the genic product must be evaluated on a case-by-case basis. Depending on what knowledge is available about the genetic features expressed, testing can range from a limited evaluation of available data on the protein, such as its amino acid sequence and rate of expression in different tissues, to (in the case of less-documented proteins) extensive toxicity testing, including animal studies. In theory, the production of GMOs can lead to the introduction of many new proteins without a history of safe human consumption. The evaluation of new proteins should be based on current knowledge of toxic substances and should include a search for similarities between the protein's sequence and the sequences of known toxins, as well as a study of the new protein's function. In the case of unknown proteins, the evaluation should include a complete conventional toxicological assessment. The number of different genes used to produce GM foods is fairly limited, but this could change as genome sequencing programs advance and most likely become capable of furnishing abundant data on important physiological pathways.

### Gene transfer

The structure of the recombinant DNA used for making genetic modifications should be considered in any assessment, especially if the gene or its promoter comes from a viral source, since horizontal recombination or transfer may occur. In addition, bacterial material from the host may include additional fragments of the sequence that are not related to the gene being sought.

Horizontal transfer of the construction of genes cannot be ruled out, for foreign DNA ingested in food does not degrade completely in the digestive tracts of mice and pigs. Thus, for the purposes of food safety assessment, it should be assumed that some fragments of recombinant DNA may survive the human digestive process, and—although the probability is very small—be absorbed by intestinal microflora. In assessing the safety of the genetic structure, marker genes should be included. The commonly used marker genes are those that encode resistance to antibiotics. Risk assessment of these selectable genes should center on gene transfer to microorganisms that live in human and animal gastrointestinal tracts. However, since it is impossible to entirely dismiss the possibility of gene transfer, the safety assessment should also consider information on the role of the relevant antibiotic in human and veterinary medical uses.

Generally speaking, the marketing of GMOs requires eliminating all unnecessary DNA sequences in the genetic structure, including marker genes.

### Allergenicity

Food allergies result from an abnormal immune response to antigens (proteins) ingested in food. The blood of individuals who are sensitive to these antigens has antibodies (IgEs) specific to food antigens, and the reactions that they produce can affect any of various organs, including the skin (in the case of urticaria), the respiratory apparatus

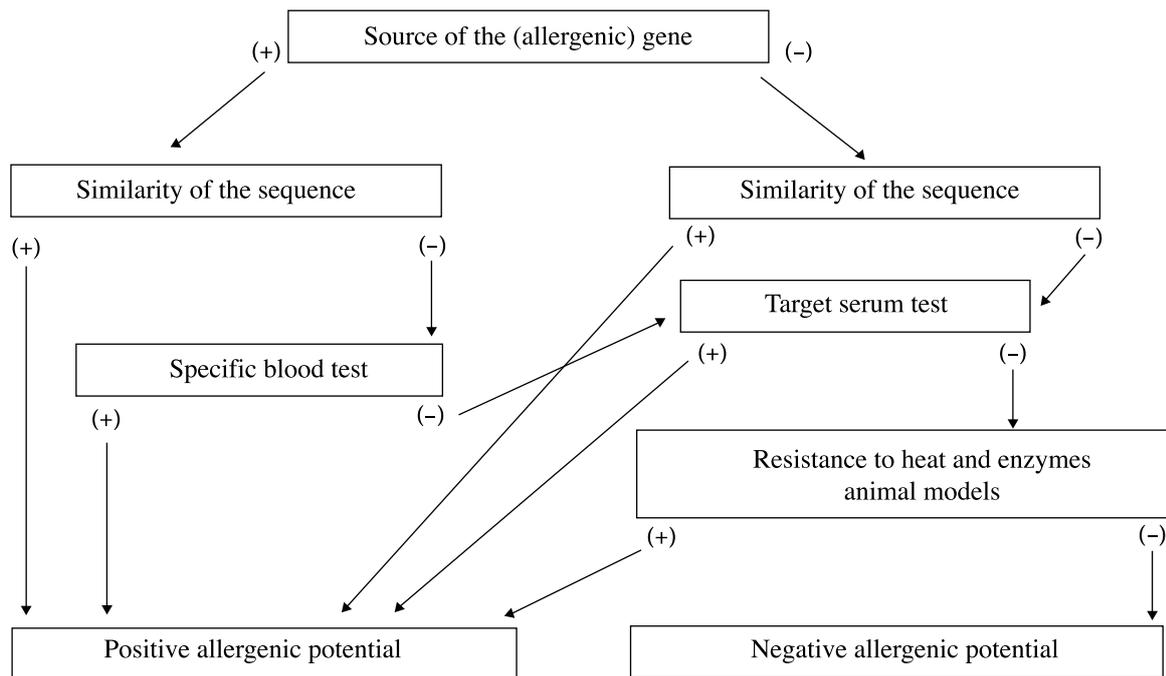
(rhinitis and asthma), the digestive apparatus (pain and diarrhea), and the cardiovascular system (anaphylactic shock). Allergic reactions can be fatal (34,35).

The allergenic potential of genetically modified foods is an important factor to keep in mind in assessing the safety of these foods. Biotechnological modifications lead to the presence of proteins in a food that did not previously contain them. While not all proteins are allergenic, most allergenic agents are proteins. To prevent incidents of food allergy, GM foods should be subjected to accurate and trustworthy assessment (36).

Some epidemiological studies point to a significant increase in the prevalence of allergic diseases in the past two or three decades. This has made food allergies a matter of concern. Figures suggest that around 3% to 4% of the adult population, and over 6% of children, suffer from some type of food allergy caused by IgE antibodies (34,37). Recent studies show that fatal cases of anaphylaxis have also increased. As a result, food allergy is a recognized public health problem today. The increased prevalence of allergic disease has been related to improved control of parasites and microbiological infection. The theory that attempts to explain this—the “hygiene theory”—is based on a paradox: since the immunoregulatory mechanisms that control inflammatory response to combat parasites are no longer necessary, immunologically unregulated responses occur, and people become more vulnerable to their bodies’ exaggerated responses to innocuous proteins. There is a clear relationship between increased allergies in children in developed countries who are members of small families and the lack of such a phenomenon in children in developing countries who are members of large families—and who are generally more subject to parasites and microbiological infections. A related observation is that we have a much greater variety of natural and industrially processed foods available to us today, which encourages the appearance of allergies.

Cases of fatal allergic reaction are obviously a concern, but the effects of nonfatal cases should also be considered a public health problem. These can include depressed appetite and increased metabolic rate. For children, this can mean less available energy, which can compromise growth and learning. Where recently expressed proteins in a GMO are involved, one must assess their allergenic potential. Where the particular proteins produced by a GMO have been well described, one must ascertain whether the modifications that occur after the transfer result in the same substances that are produced by conventional organisms, so as to assess the possible altered toxicological or allergenic properties of the recently synthesized proteins. As has been recognized, no single parameter is adequate to predict a substance’s allergenic potential. The Codex Alimentarius Commission recently designed a strategy to evaluate the allergenicity of biotechnology products (38). The strategy includes the following parameters: the source of the gene, the similarity of the sequence, serum testing of patients who are allergic to the allergenic substance or to distant related substances, resistance to pepsin, the prevalence of the feature, and evaluation based on animal models (Figure 19-1). It is a confirmed fact, however, that there is no single definitive test to determine the allergenic potential of these new foods.

The strategies and methodologies for assessing the allergenicity of GMOs are not fundamentally different from those that continue to be used to evaluate GM plants. Regulations follow the international guidelines of the Codex Alimentarius Commission for assessment of the food safety of GM organisms. Animal models for testing allergenicity, even those that have not yet been validated, are considered to have potential for identifying potential allergens. Recommendations have been made to further develop and validate these models.

**Figure 19-1.** Proposed decision tree for evaluating the allergenic potential of a genetically modified food (39,40).

### Source of gene

To date, nearly 160 foods have been associated with allergic reactions. However, approximately 90% of food allergies are associated with milk, eggs, peanuts, chestnuts, shrimp, fish, wheat, and soy. Nonfood sources of allergens include grass pollen, mites, animal epithelia, fungi, insects, parasites, bee venom, and latex.

The fact that the gene comes from an allergenic source does not in itself mean that the new food will have allergenic potential, since not all of a food's proteins are responsible for its allergenicity. For example, the peanut has over 32 different proteins, 18 of which can bond to the IgEs of individuals who are allergic to peanuts (40). Thus, it is possible that individuals allergic to peanuts will be allergic to GM corn if the corn includes a gene that codes for a peanut allergen (such as Ara h1). A real example of this situation, and of the importance of assessing the allergenicity of genetically modified foods, comes to light in a study of a variety of GM soy in which a gene of the Brazil nut (*Bertholleria excelsa*) was inserted. The intention in this case was to improve the nutritional quality of the soy by inserting a gene that codes for albumin 2S, a protein rich in methionine. However, extracts of the GM soy and the Brazil nut were shown to react positively to the serum of individuals allergic to the nut, as well as being positive in skin puncture tests (41).

In the sequence suggested in the decision tree, the next test should be analysis of the structural similarity of the new protein with known allergens, regardless of whether the gene is from an allergenic source.

### The structure of the protein: Similarity of amino acid sequences

To date, we know of no structural characteristic that identifies a protein as allergenic, although some studies have pointed out certain relevant similarities. For example, food allergens are generally glycoproteins with a mass of between 10 and 70 kDa. Though their amino acid sequences are not similar, a similarity between a new protein in a food and the allergens could be an indication that the protein is allergenic. Only the most polar and exposed regions of the antigen molecule are capable of stimulating the B lymphocytes into forming antibodies. These more surface portions, which are called antigen determinants, or epitopes, are the part that comes in contact with the bonding portion of the antibody (or paratope). Epitopes are created by the primary sequence of the residues in the polymer, or by the molecule's secondary, tertiary, and quaternary structure.

Some allergenic proteins have been observed in foods to which allergies have been reported. They include beta-lactoglobulin, alpha-lactalbumin and casein in cow's milk, globulins 2S, 7S, 11S, and hemagglutinin in soy, proteins Sa-I, Sa-II, antigen I, and antigen II in shrimp, allergen M in fish, ovalbumin, ovotransferrin, and ovomucoid in egg whites, apovitelin I and apovitelin VI in egg yolk, and Ara h1 and Ara h2 in peanuts. The amino acid sequences in these proteins and other allergens can be used as a database for comparison. According to the FAO/WHO report, databases with this information can be obtained in the SwissProt and TrEMBL programs ([www.allergenonline.org](http://www.allergenonline.org)). As regards a minimum extension of peptides for the epitope, initial documents proposed eight contiguous amino acids as the criterion for similarity (42). More recent documents propose analyzing six (39).

Thus, if the protein is found to share a sequence of six amino acids with a known allergen in the database, the protein's allergenic potential is considered positive, whether or not it comes from an allergenic source. And if the new protein's amino acid sequence (newly expressed in corn, for example) has a similarity with the allergenic peanut protein (regardless of whether the gene comes from the peanut), an individual allergic to peanuts may react allergically to GM corn. If there is no similarity between the new protein's amino acid sequences and the allergens in the database, the assessment should proceed to blood tests with allergic individuals.

Two things must be borne in mind in comparing the amino acid sequences, since this should not be the only test. The first is that, even if the test detects an amino acid sequence similar to one found in a known allergen, the sequence does not necessarily correspond to the epitope that bonds to the IgE. In such cases, the test could give a false positive for allergenicity, and even then, the number of amino acids analyzed is questionable, for some authors show that analyzing six amino acids can produce false positives (43). Furthermore, the possibility of a false negative should also be borne in mind. Note that this type of analysis is accurate when an epitope is continuous (or linear) —i.e., when it is composed of a single fragment of the polypeptide chain. In most cases, epitopes are discontinuous (or conformational) — i.e., the recognized structure is composed of protein segments that are not adjacent in the antigen's amino acid sequence but are contiguous in the three-dimensional structure, since the protein folds on itself. Consequently, a linear comparison of the proteins may not provide total certainty about the protein's allergenic potential.

Also, to evaluate unintended effects in GM food, proteomic, transcriptomic, and metabolomics profiling techniques can be used (44).

### **Serum IgE immunoreactivity: Testing with clear or specific serum samples**

A bond between the IgEs of allergic patients and the protein being tested indicates that the protein has allergenic potential, since the bond suggests that when the food is ingested, the protein, if it remains whole, could bond with the IgEs of mastocytes and basophils and trigger allergic symptoms. If the protein is from an allergenic source, the test should be done with the serum of patients allergic to that source (i.e., that serum is considered specific for this test). In this case, if the test is positive, it means that the protein is associated with the allergy to that food and that individuals with that type of allergy could have allergic reactions to the GM food. A negative result shows that, despite being from the same source, the protein is not associated with the food allergy in question.

When evaluating the allergenic potential of proteins from sources not known to be allergenic, serum IgE immunoreactivity is used to judge the possibility of a cross-reaction. Cross-reactions appear when an antibody recognizes similar epitopes that belong to different proteins. This occurs in pollen-food allergy syndrome, where sensitization is produced by inhaling pollen, and the IgEs then react with the food allergens (apple, carrot, banana, and kiwi, among others). The phenomenon in this case is due to the similarity between the food proteins and the pollen proteins (34). Other examples are the cross-reaction between shrimp tropomyosin and the house dust antigen, and the cross-reaction between peanut on one hand and soy and pea on the other (40). These cross-reaction tests can be done with the serum of allergic patients for any group of foods or can be targeted to groups of vertebrate or plant proteins. In this case, the test is designated a "clear serum" test.

For genetic, socioeconomic, and environmental reasons, allergies differ very substantially from region to region. For example, pollen allergies are more common in Holland than in the Philippines. Given the possibility of a cross-reaction between pollen and fruit proteins, introducing a GM fruit may lead to allergic reactions in Holland and not in the Philippines (45). In such cases, it is best to test the GM foods with serum of patients grouped by regions.

Using the serum of allergic individuals to analyze the immunological reactivity of genetically modified proteins has been questioned. The first criticism cites the absence of serum banks of standardized allergic patients, a situation that can lead to a great deal of variability in the findings. A criticism related to the test itself is that the ability to

bond with an IgE *in vitro* does not necessarily imply similar *in vivo* effects, such as degranulation of the mastocytes and basophils. This suggests that false positives could be produced. Another important factor has to do with the carbohydrate domain in allergens. The glucosylation of proteins is considered very important in diagnosing allergy. The glucoproteins' carbohydrate domains interfere with the diagnosis, since they induce reactivity with IgEs, and the bond between the IgE and a protein's carbohydrate domain does not always lead to clinical symptoms. The second of these objections could be addressed by animal models employing skin puncture tests, and indeed, there has been a great deal of research on how to minimize false negatives and false positives.

### Physicochemical stability

In normal situations, digestive proteases transform proteins in the diet into peptides with little immunogenic activity. Proteins that escape the digestive process are absorbed and interact with the immune system in a way that promotes tolerance —i.e., there is a response by regulatory cells, regulatory cytokines, and class A immunoglobulin (IgA). Even under normal conditions of digestibility in human beings, a protein that is hard to digest will have more chance of escaping degradation and being absorbed in a more intact form. Where individuals are predisposed to allergies, the response in such cases may take the form of activator cells (Th2 lymphocytes), activator cytokines (IL-4), and the production of IgEs.

In general, resistance to digestion with higher levels of intact absorption has been found to correlate with allergenic potential. The degree of glucosylation is one of the properties that can affect a protein's susceptibility to processing and proteolysis. Food allergens are generally water soluble and resistant to heat, gastric acid, and proteolysis. Thus, a GM protein's resistance to digestion by pepsin under low-pH conditions is generally considered a relevant factor in determining the allergenic potential of a GM food (38,43). Testing is based on the earliest studies, conducted in 1996, in which the stability of a protein was tested in systems that simulate normal human conditions and gastric juice (simulated gastric fluid, or SGF, systems). Although there is much evidence that SGF testing and analysis can be standardized and that the results are replicable and sound, the relevance of such testing to digestion and allergenic potential continues to be uncertain. In general, the test is conducted with 0.32% pepsin, pH 1.2, at 37°C. However, different testing and analysis protocols vary these parameters, and as a result, contradictions between the results of different laboratories are common. Protocols call for different concentrations of pepsin, different pHs, different concentrations of the substrate protein, and different analytical methods (including SDS-PAGE, Western blots, and others). Another critical argument is that *in vitro* tests do not necessarily represent real-life conditions, since the digestibility of proteins varies from person to person.

In addition to digestibility, processing alters a protein's properties and can interfere with allergenicity. Heat treatment destroys proteins' tertiary structure, causing folding, division, and reordering of the disulfide bands. Some epitopes may not be exposed, and others may be formed on the surface of the proteins. Consequently, allergenic potential can increase, diminish, or remain the same. Processing can also change a protein's resistance to digestion and the nature of its interaction with the immune system. In general, resistance to processing is considered an indicator of allergenicity. However, the opposite can occur. One example of this is what happens with banana treated with ethylene. South American children who are allergic to latex have been shown not to be allergic to banana, unlike North American children. One suggested explanation is that bananas in North America, but not in South America, are treated with ethylene, which may modify proteins that are cross-reactive with the latex protein (46).

This test, like the others, is considered of major importance, but its results should not be judged in isolation or regarded as absolute. They must be considered in conjunction with the other types of analysis.

### Animal models

Although there is no doubt about the importance of all the parameters presented so far, each has demonstrable limits. Thus, final conclusions should be based on an analysis of the results of all of them as a whole. Since this is not the complete story, but a complement to the analysis, FAO/WHO, the Codex Alimentarius Commission, and the European Food Safety Authority (15,16) are interested in developing *in vivo* models as an element in assessing the safety of GM foods and are calling for tests with animal models.

Animal models make it possible to evaluate the whole food, not just the protein in question. Proteins are not ingested in isolation but as part of a complex of nutrients, and this overall context may interfere with a protein's

allergenicity. For example, whole peanut extracts are more allergenic than purified extracts. Another example of the complexity involved is that a new protein may act as an intensifying agent, rendering other proteins in the food more allergenic (47,48).

Rats and mice are among the animals most used in scientific research on food allergies, and among these, BALB/c mice and Brown Norway rats are most indicated. Murine models are especially recommended, because these animals are smaller, have a shorter reproductive cycle, and have various types of genetic modifications that facilitate immunological evaluation (47). Due to some technical limitations, it has been suggested that use of more than one model may be necessary for predicting allergenic potential of proteins. The current data is shown in recent reviews (49,50).

Food allergies, like others, have two phases: sensitization and antigen response attendant with the digestive process. In the sensitization phase, the protein enters into contact with the organism in some way and triggers the production of IgE. Contact in the response phase is oral and produces the allergic inflammation. In the case of human food allergies, both phases occur through oral contact. To reproduce this in laboratory animals, strategies must be developed to mimic the possible errors that render a person allergic rather than tolerant. Simply introducing the protein in a mouse's diet under normal conditions—as with human beings—will not lead to allergy, but to tolerance.

Because of this, various strategies are used to induce sensitization with the production of IgE. Some models administer the substance orally, but use intensifying agents or antacids to prevent immunological oral tolerance to the protein. Other models produce sensitization through other channels—e.g., intraperitoneally or subcutaneously. Most often, intensifying agents such as aluminum hydroxide must be used. This is effective in stimulating the production of cytokines related to the allergy and the IgE. To induce the allergic inflammation (with a second exposure to the antigen), the protein must be introduced orally. Response is generally quite similar to what is seen in human beings: IgEs are produced, histamine and mastocyte protease levels increase, a proliferative splenocyte response appears, inflammatory infiltration takes place in the intestine, and weight loss occurs (45,47,51).

A variety of foods (soy, milk, eggs, and peanuts, among others) have been used to study food allergies in mice, with clinical and immunitary signs comparable to those occurring in human beings (45). Many of these models can be used effectively to distinguish allergenic from nonallergenic proteins and to supplement the analysis of all the above parameters to arrive at final determinations regarding the allergenic potential of GM foods.

## Nutritional assessment of genetically modified foods

Genetically modified foods have the potential to improve people's nutritional status and benefit health through functional improvements. However, they also have the potential to produce nutritional imbalances as the result of both expected and unpredicted alterations of nutrients and other food components.

For this reason, GM foods should be evaluated nutritionally, considering the following elements:

- the composition of the genetically modified food (levels of nutrients and antinutrients, which are substances that can block the body's use of other substances, or that have toxic properties);
- the bioavailability and efficacy of the food's nutrients, including the potential influence of the transportation, storage, and other treatment to which the food is expected to be subject;
- prior analysis of the ingestion of the food and its nutritional consequences (16); and
- nutritional studies with laboratory animals, measuring body weight and food ingested, among other variables (52).

Chemical analysis is the starting point and cornerstone of the nutritional assessment of human and animal foods. The determination of what analyses should be conducted must be made on a case-by-case basis. This can vary with the feature introduced by the genetic modification. Since the composition of conventional plants varies significantly, the results of chemical analysis of GM crops should be judged in the context of the information on the conventional crop's natural variability. The ILSI database on the chemical composition of cultivated plants has been suggested as a key source of this type of data.

The development of genetically modified foods has the potential to improve the nutritional status of individuals and populations, and to provide products with more functionality. However, GM foods can also produce nutritional imbalances as a result of both expected and unpredictable alterations in nutrients and other food components. The nutritional assessment of genetically modified foods should include an examination of (a) their nutritional compo-

sition, (b) the biological effectiveness of the food's nutritional components, and (c) the ingestion of the food and its nutritional consequences.

When substantial equivalence with an existing food is demonstrated, the only additional nutritional evaluation needed is to study how introducing the genetically modified food is likely to affect general eating habits. This requires information on intake and on the amount of the GM food that is likely to be consumed. Nutritional consequences should be evaluated both in relation to average intake and at the extreme levels of daily consumption. The influence of nonnutrient components of the genetically modified food must be considered as well.

Genetic modifications designed to change a food's nutritional quality must meet specific additional requirements. Such cases require other detailed studies on specific biomolecules adapting to the expected genetic modification. A significant nutritional modification in a food may require evaluation subsequent to marketing to determine whether the population's general diet has changed as a result of the modification, and to what extent.

## Toxicology

In genetically modified foods, it is important to study the toxicological impact of any alteration resulting from the expression of the genes introduced, or from any other genetic alteration, such as the silencing of genes or the overexpression of endogenous genes.

Toxicological analysis should be done:

- to demonstrate that the anticipated effects of the genetic modification do not adversely affect human and animal health. Potential differences between a genetically modified food and the comparable conventional food may call for different toxicological approaches and varying testing methods; and
- to demonstrate that unexpected effects from the genetic modifications, as well as effects that can be identified through molecular or chemical analysis or comparison with previous phenotypes, do not adversely affect human or animal health. Here, proposed tests for isolated chemical compounds (e.g., new proteins or other new constituents) or for the whole GM food may be useful.

Toxicological studies that assess risk to human or animal health are complementary. Most of the studies recommended for the human safety of GM foods are relevant for animal safety purposes as well. The testing methods are basically the same, and the data need to be of the same quality. When specific studies are needed to examine the effectiveness, nutritional value, or edibility of GM animal foods, the information obtained can be drawn on to enhance the certainty of food safety findings for humans as well. The need for toxicological tests in assessing the human and animal safety of GMO-derived foods should be considered on a case-by-case basis, and the tests conducted will depend on what differences are found (or provided by information on intentional modifications) between the GM product and its conventional counterpart.

Toxicological testing should include not only studies of recently expressed proteins but of the consequences of any genetic modification (e.g., the silencing of a gene or the overexpression of an endogenous gene). In principle, a safety assessment should examine the presence of new proteins expressed as a result of genetic modification, the potential presence of other new constituents, and possible changes in the level of natural constituents that exceed the range of natural variation. These potential deviations from natural counterparts may require different toxicological approaches and different degrees of testing (15,16).

An integrated toxicological evaluation combines all the available information on the safety of the complex GM food. The evaluation should indicate what safety aspects merit further investigation, including conventional toxicity testing.

Standardized *in vitro* and *in vivo* tests of toxicity are used to ascertain the direct toxicity of products created by genetic engineering. In addition, searches for similarities with known toxic substances listed in databases can be a useful tool for safety assessment. Methods used for evaluating whatever direct toxicity can be predicted from the nature of the transgene may vary with the type of modification performed. The simplest modifications involve the addition of a single gene, where no interactions with other components of the plant are expected. The situation becomes more complicated when multiple genes are involved and the modification leads to changes in one or more pathways. In these cases, for proper design of the analysis and tests, it is important to have complete knowledge of the genic products used and the pathways affected (1).

Determining direct toxicological effects can be fairly simple. For example, if the GM plant is transformed to produce a protein, it should obviously be analyzed for presence of the protein, and the protein's direct toxicity should be evaluated. This is done through classic toxicological tests that can also be used for substances such as additives or pesticide residues, as occurs with *in vitro* toxicity tests or studies on animal feeds. However, the situation can become even more complex when, for example, multiple genes are introduced that interfere with the plant's metabolic pathways (1).

Assessing potential indirect toxicological consequences is less simple, since it deals with effects that cannot be known, predicted, or expected. This also makes it difficult to design direct methods to measure such effects. Current approaches, based on the concept of comparative safety assessment, compare the GMO with its non-GMO counterpart, and any difference detected is studied in greater depth. If the comparison reveals no significant differences other than those to be expected from the inserted sequences, the genetically modified plant can be considered as safe as the conventional plant. If the comparison reveals qualitative or quantitative differences, these are evaluated further, and additional analyses may be required. The need for toxicological tests, and the type of tests that may be required, can depend on the nature of the differences observed (1).

### Long-term effects

Knowledge about potential adverse effects on human health from chronic ingestion of genetically modified foods is still quite limited. Although the great genetic variability of the population adds to the difficulty of predicting or evaluating long-term effects, safety assessment prior to the marketing of genetically modified foods is recognized as already providing some assurance that GM foods will be as safe as their conventional, or unmodified, counterparts.

Accordingly, genetically modified foods have been considered unlikely to produce adverse long-term effects (3,53).

### Evaluation of food intake

The goal of evaluating food intake is to ascertain the quantity of foods or food ingredients that a person or population might be expected to ingest. Precise criteria have not yet been formulated for what factors should be considered in such premarketing evaluation of new complex foods. Some food consumption paradigms base their assumptions on per capita intake, while others use per capita distribution. Evaluations of intake may also consider cooking or whatever other process is used in preparing the type of food being studied.

Food intake evaluations also include calculations of the extent to which current food products will be replaced by new GM foods. Thus, determining the precise amounts of genetically modified foods projected to be ingested depends on the available data regarding the eating habits of relevant groups of consumers and on the validity of the underlying parameters. The specific groups of consumers considered may be different age groups but may also include particularly vulnerable groups, such as pregnant or nursing women or specific groups of patients.

Evaluation of food intake should be based not only on available data regarding consumption but on our knowledge of the bioavailability of food components that have been studied in the digestive tract. In some specific cases, probabilistic mathematical models can be used to bring food consumption and distribution together in a comparative method to more precisely calculate future intake (54).

## ■ Postmarketing monitoring

In general, potential safety problems should be adequately addressed through rigorous evaluation prior to marketing, since the feasibility of conducting studies at a later stage is currently very limited. Nevertheless, once a product is on the market, monitoring can be an appropriate risk management approach in some circumstances. The need and utility of such an approach should be considered during the risk assessment process, and its applicability to the risk management process should be evaluated. When appropriate, monitoring should be conducted once a GM product is on the market. Though not a substitute for careful toxicological testing before marketing, such a program may increase the possibility of detecting unintentional extraneous effects. The various direct stakeholders should therefore consider this approach as providing a reliable and validated source of information on GM foods—one that may reveal relationships between the consumption of genetically modified foods and any (adverse) effects on health.

Since premarketing risk assessments do not reproduce the full diversity of the populations that will consume the product, there is a latent possibility of unforeseen side effects in some members of the population, such as people with certain diseases (e.g., allergic persons), individuals with special genetic or physiological characteristics, or those who consume these products in large quantities. Indeed, calculations of exposure to the food are part of the risk assessment process. Exposure is variable and cannot be ascertained with certainty before a product is marketed. A program of monitoring once the product is on the market should therefore seek to answer the following questions: (a) Is the product used as foreseen or recommended? (b) Are the known effects and side effects as predicted? (c) Does the product have unexpected side effects (55)?

Monitoring once the product is on the market can be conducted in order to (a) verify conclusions about the absence or possible occurrence, consequences, and importance of potential effects on the consumer's health, and (b) monitor changes in quantities of nutrients ingested as a result of introducing new foods—a situational change that may significantly alter consumers' nutritional status—and determine the health consequences.

## ■ International guidelines and regulations

The comparative approach described in the initial food safety assessment report (32) has laid the foundations for subsequent safety evaluation regulations and strategies. Other organizations, such as the Organisation for Economic Co-operation and Development (OECD), the Food and Agriculture Organization (FAO), the World Health Organization (WHO), and the International Life Sciences Institute (ILSI), have developed broad consensus documents that provide further guidelines for safety assessment. These documents have been used largely as the basis for developing individual country guidelines on food safety risk assessment procedures for GM food and feed.

Countless government authorities are intensely involved in the regulation of genetically modified plants, and basic risk assessment methods for GM food and feed are in place. The toxicity potential of GM plants is not comparable to that of chemical substances in general. Yet, most toxicity evaluations of genetically modified plants are based on, or even identical to, tests for chemical substances. Various international—and even local—institutions are currently working on this issue.

### Codex Alimentarius

In 2009, the FAO/WHO Codex Alimentarius Commission published a second edition of the document *Foods Derived from Modern Biotechnology*. This publication represents the outcome of the work of the Codex Alimentarius Commission on principles and guidelines for the safety assessment of foods derived from modern biotechnology and offers guidance on how to assess the safety of such foods and thus protect the health of consumers. This second edition includes text adopted by the Codex Alimentarius Commission up to 2008, as follows (7):

Principles for the risk analysis of foods derived from modern biotechnology:

The purpose of these Principles is to provide a framework for undertaking risk analysis on the safety and nutritional aspects of foods derived from modern biotechnology. This document does not address environmental, ethical, moral and socio-economic aspects of the research, development, production and marketing of these foods.

Some key elements of the Principles are as follows:

- The risk assessment should include a comparison between the food derived from modern biotechnology and its conventional counterpart, focusing on determination of similarities and differences. If a new or altered hazard, nutritional or other safety concern is identified by the safety assessment, the risk associated with it should be characterized to determine its relevance to human health.
- A risk assessment is characterized by an assessment of a whole food or a component thereof relative to the appropriate conventional counterpart: (1) taking into account both intended and unintended effects; (2) identifying new or altered hazards; (3) identifying changes relevant to human health in key nutrients.
- A premarket safety assessment should be undertaken following a structured and integrated approach and be performed on a case-by-case basis. The data and information, based on sound science, obtained using appropriate methods and analyzed using appropriate statistical techniques, should be of a quality

- and, as appropriate, of a quantity that would withstand scientific peer review.
- Risk assessment should apply to all relevant aspects of foods derived from modern biotechnology.
  - Risk management measures for foods derived from modern biotechnology should be proportional to the risk, based on the outcome of the risk assessment and, where relevant, taking into account other legitimate factors in accordance with the general decisions of the Codex Alimentarius Commission as well as the Codex Working Principles for risk analysis.
  - Risk management measures may include, as appropriate, food labeling conditions for marketing approvals and postmarket monitoring.
  - Postmarket monitoring may be an appropriate risk management measure in specific circumstances. Its need and utility should be considered, on a case-by-case basis, during risk assessment, and its practicability should be considered during risk management. Postmarket monitoring may be undertaken for the purpose of: (1) verifying conclusions about the absence or the possible occurrence, impact, and significance of potential consumer health effects; and (2) monitoring changes in nutrient intake levels, associated with the introduction of foods likely to alter nutritional status significantly, to determine their human health impact.
  - Specific tools may be needed to facilitate the implementation and enforcement of risk management measures, which may include appropriate analytical methods; reference materials; and the tracing of products for the purpose of facilitating withdrawal from the market when a risk to human health has been identified or to support postmarket monitoring.
  - Risk communication should include transparent safety assessment and risk management decision-making processes. These processes should be fully documented at all stages and open to public scrutiny, while respecting legitimate concerns to safeguard the confidentiality of commercial and industrial information. In particular, reports prepared on the safety assessments and other aspects of the decision-making process should be made available to all interested parties.
  - Regulatory authorities, international organizations, and expert bodies and industry should facilitate, through appropriate contact points (including but not limited to Codex Contact Points) and other appropriate means, the exchange of information, including the information on analytical methods.
  - When new scientific information relevant to a risk assessment becomes available, the assessment should be reviewed to incorporate that information and, if necessary, risk management measures adapted accordingly.

## Organisation for Economic Co-operation and Development

Food safety is also a trade issue; in this context, different food safety regulations reflecting different national evaluations of acceptable risk can be accommodated in international trade agreements so long as such regulations are based only on scientific risk assessment. However, several groups have argued that science is unable to assess unquantifiable risks, and they consequently urge precaution (57).

The difficulty applying traditional toxicological testing (such as that applied on single chemicals) and risk assessment procedures to whole foods meant that an alternative approach to the safety assessment of genetically modified foods was required. This led to the development of the concept of substantial equivalence (29), which acknowledges that the goal of safety assessment is not to establish absolute safety but to consider whether the GM food is as safe as its traditional counterpart where such a counterpart exists or as safe as an earlier approved GM variety (29). Subsequently, any significant intended and unintended differences become the focus of the food assessment, which might include further toxicological, analytical, and nutritional investigations before marketing.

The most significant aspect of the Edinburgh Conference on the Scientific and Health Aspects of Genetically Modified Foods (57) was that it included all sides of the debate surrounding GM foods and identified certain areas of agreement. The Conference also succeeded in identifying issues in which there is disagreement or uncertainty due to lack of knowledge, and in separating issues subject to scientific analysis from those related to political factors, beliefs, and values.

The main concerns of consumer organizations and trade unions appeared to converge on the question of the health and safety involved in GM food production. Both groups of organizations seemed to agree that these issues should be treated as part of public health monitoring or research programs. Specific research is needed to assess hazards related to the development, production, and processing of new foods and GMOs. Consumer rights to information about products or processes must be guaranteed and enshrined in legislation (47).

## Cartagena Protocol on Biosafety

The Cartagena Protocol is a legally binding international instrument that regulates cross-border movement of live biotechnologically modified organisms in order to protect the environment. The protocol's backbone is the principle of prior agreement, which requires an importing country's consent before a modified live organism can be introduced into its environment.

The protocol sets out a harmonized set of international rules and procedures designed to ensure that countries receive the necessary information through the Biosafety ClearingHouse. This Internet-based information system permits countries to make well-founded decisions before permitting importation of living modified organisms (LMO). The protocol, which has been in force since September 11, 2003, also calls for organisms to be accompanied by proper identifying documentation when transported. It is important to note that there is currently no internationally recognized framework for considering the ethical issues involved in the use of modern biotechnology.

### ■ Public health considerations

It is the responsibility of the health authorities and government agencies to protect and restore the health of the population. Undeniably one of the most important physiological determinants of health, food must be nutritious and acceptable to the senses, as well as safe to consume. Inadequate food intake causes health problems and can also lead to the presence of substances that cause metabolic disorders and generate pathological conditions.

The potential direct health effects of GM foods are generally comparable to the known risks associated with conventional foods and include, for example, the potential for allergenicity and toxicity of components present, and the nutritional quality and microbiological safety of the food.

The World Health Organization outlined the main health concerns related to GM food, associated with allergenicity, toxicity, and unintended effects, such as elevated levels of antinutritional or toxic constituents. Although horizontal gene transfer is a rare event that cannot be completely discounted, GM foods can potentially transfer genes that could have adverse health effects, such as antibiotic resistance. The increase in pesticide use with the proliferation of GMOs is also a relevant health concern (58).

It is important that the health authorities improve their governance capacity in this area, especially in developing countries, so that they can effectively assess, manage, and communicate risks as well as achieve regulatory and surveillance advances. This includes developing and enforcing the use of standards for foods produced by modern biotechnology. In addition, an international cooperation effort, coordinated by health organizations, should be organized to strengthen the developing countries' capacities in a way that facilitates the effective application of food safety principles (2,58).

## ■ Legislation and regulations governing genetically modified organisms in the Latin American region

Table 19-3 presents the official institutions of Latin American countries responsible for regulating matters related to foods and genetically modified organisms.

**Table 19-3.** Official institutions of Latin American countries responsible for regulating matters related to foods and genetically modified organisms.

<i>Countries</i>	<i>Responsible entities</i>	<i>Relevant links</i>
Argentina	Ministry of Agriculture, Livestock, and Fisheries. National Advisory Commission on Agricultural Biotechnology (CONABIA)	<a href="http://64.76.123.202/site/agregado_de_valor/biotechnology/20-ONABIA/index.php">http://64.76.123.202/site/agregado_de_valor/biotechnology/20-ONABIA/index.php</a>
Bolivia	Ministry of Rural Development and Lands. National Agricultural Health and Food Safety Service (SENASAG)	<a href="http://www.senasag.gob.bo/">http://www.senasag.gob.bo/</a>
Brazil	National Technical Biosafety Commission (CTNBio)	<a href="http://www.ctnbio.gov.br/index.php/content/view/12840.html">http://www.ctnbio.gov.br/index.php/content/view/12840.html</a> <a href="http://www.ctnbio.gov.br/index.php/content/view/12847.html">http://www.ctnbio.gov.br/index.php/content/view/12847.html</a> <a href="http://www.ctnbio.gov.br/index.php/content/view/12848.html">http://www.ctnbio.gov.br/index.php/content/view/12848.html</a> <a href="http://www.ctnbio.gov.br/index.php/content/view/15164.html">http://www.ctnbio.gov.br/index.php/content/view/15164.html</a>
Chile	Ministry of Agriculture. Technical Committee on Genetically Modified Organisms (GMOs)	<a href="http://www.sag.gov.cl/OpenDocs/asp/pagVerRegistro.asp?argInstanciaId=51&amp;argTablaNombre=Doc_Documento&amp;argRegistroId=3788&amp;argCarpetaId=0">http://www.sag.gov.cl/OpenDocs/asp/pagVerRegistro.asp?argInstanciaId=51&amp;argTablaNombre=Doc_Documento&amp;argRegistroId=3788&amp;argCarpetaId=0</a>
Colombia	Ministry of Agriculture. Colombian Agricultural Institute (ICA)	<a href="http://www.ica.gov.co">http://www.ica.gov.co</a> <a href="http://www.ica.gov.co/Areas/Agricola/Servicios/Bioseguridad-y-Recursos-Geneticos-Agricolas.aspx">http://www.ica.gov.co/Areas/Agricola/Servicios/Bioseguridad-y-Recursos-Geneticos-Agricolas.aspx</a>
Costa Rica	Ministry of Agriculture and Animal Husbandry. Costa Rica Technical Commission on Biosafety	<a href="http://www.mag.go.cr/">http://www.mag.go.cr/</a>
Ecuador	Ministry of Agriculture, Livestock, Aquaculture, and Fisheries (MAGAP)	<a href="http://www.agricultura.gob.ec/">http://www.agricultura.gob.ec/</a>
Mexico	Secretariat of Agriculture, Livestock, Rural Development, Fisheries, and Food (SAGARPA). National Health, Food Safety, and Quality Service (SENASICA)	<a href="http://www.senasica.gob.mx">www.senasica.gob.mx</a> <a href="http://www.diputados.gob.mx/LeyesBiblio/pdf/LBOGM.pdf">http://www.diputados.gob.mx/LeyesBiblio/pdf/LBOGM.pdf</a>
Panama	National Directorate of Plant Health	<a href="http://aplica.mida.gob.pa/dinasave/">http://aplica.mida.gob.pa/dinasave/</a>
Paraguay	Ministry of Agriculture and Animal Husbandry	<a href="http://www.mag.gov.py/">http://www.mag.gov.py/</a> <a href="http://www.senave.gov.py/">http://www.senave.gov.py/</a>
Peru	Ministry of Agriculture. National Agrarian Health Service (SENASA). Ministry of Environment (MINAM)	<a href="http://www.senasa.gob.pe">http://www.senasa.gob.pe</a> <a href="http://www.minam.gob.pe/">http://www.minam.gob.pe/</a>
Uruguay	Ministry of Livestock, Agriculture, and Fisheries Law 16811 of February 21, 1997, regulates the biosafety of plants and their genetically modified components. Decree 353/008 of July 21, 2008, provides for regulations under the policy that addresses the coexistence of modified and unmodified organisms.	<a href="http://www.presidencia.gub.uy/_web/decretos/2009/06/149.pdf">http://www.presidencia.gub.uy/_web/decretos/2009/06/149.pdf</a> <a href="http://www.vertic.org/media/National%20Legislation/Uruguay/UY_Bioseguridad_OGMs.pdf">http://www.vertic.org/media/National%20Legislation/Uruguay/UY_Bioseguridad_OGMs.pdf</a>

## ■ Conclusions

There is still widespread public concern about the safety of GM foods. Health and regulatory authorities, international agencies, organizations with specialized expertise, and industry should tighten the safeguards against specific risks to facilitate broader risk assessment and management, as well as better risk communication and information dissemination, including information on analytical methods. For the developing world, the most serious dangers arise from limited risk assessment capacity and safety testing for GM food, and limited management of their commercial use and postmarket monitoring.

GM food derived from microorganisms should have a history of safe consumption and well-defined use, and the safety of microorganisms without such a history of safety must be established. Since mutations and the exchange of genetic material in nature are unpredictable, it will be essential to periodically determine the safety of GM microorganisms used in food production. The approaches described here include comparative evaluation of GM microorganisms in comparison with their conventional counterparts, verifying their safety as well as the safety of their metabolites. The ability of living organisms that are ingested to survive in the intestine should be assessed, since they may compete with the native intestine flora and cause undesirable consequences.

Of the main health concerns about GM food outlined by the World Health Organization, allergenicity seems to be the most important pathology related to these foods. It is also true that allergenic foods represent a small proportion of all foods and the population with food allergies also represents a low portion of the global population. Notwithstanding, all GM foods should be assessed for allergenic potential. It is also agreed that food labeling is an important information measure to prevent general consumption of food with allergenic potential or recognized ingredients or that is part of an industrially produced food. Relevant public health entities should also promote the implementation of programs to recognize the relationship between potentially allergenic foods and allergy symptoms.

The authors also underscore the World Health Organization's concerns about GM food and recognize the need for further investigation related to the allergenicity, toxicity, unintended effects, and antinutritional or toxic effects of GM foods.

Postmarketing monitoring and surveillance must be conducted and is a valuable tool for monitoring adverse and long-term effects of GM foods, as well as ensuring that these effects are documented. The use of antibiotic resistance as a selection method for GM microorganisms is a topic of great interest.

Finally, in our view, GM food represents an important new technology for improving food quality and food security. However, all those involved in developing the new technology, be they researchers, health and regulatory authorities, industry, farmers, or food manufacturers and retailers, must recognize and accept a very heavy responsibility to the consumer. The production chain must ensure impartial information and that GM food is safe for human consumption and that transgenic technology poses no additional risk.

## ■ Recommendations

Public measures with respect to GM foods should be especially comprehensive, since they are relatively new and even the scientific and medical community and health authorities still have limited knowledge about adverse effects. GM foods can have allergenic potential, given that new proteins are introduced (which may be allergenic). Technical evaluation is required to determine the allergenic potential. In this context, public health authorities and agencies should:

1. Ensure that the assessment process for the approval of GM food provides technical information on:
  - a. analyses of the new protein to determine similarities between its amino acid sequence and those of known allergens in databases;
  - b. analyses of the new protein to determine its resistance to processing and its digestibility;
  - c. analyses of the new protein to determine its allergenicity; and
  - d. analyses of the new protein and the GM food in animal models, especially with mice, to standardize methods.

2. Stipulate that the assessment process for the approval of GM food contains the detailed methodology of each of the studies conducted and that it presents the results clearly and in a way that enables those wishing to analyze the process to interpret the findings. If evaluations have already been conducted and published, the process should provide copies of the scientific articles, not simply citations.
3. Ensure that all GM foods are identified as such, for the population deserves information on the industrially processed foods that it consumes.
4. Document allergic reactions to GM foods and take appropriate steps commensurate with the scale of the problem (i.e., how many people are affected) and its seriousness. In such cases, the competent public agencies, through their oversight branches, should prohibit the production and marketing of the product or regulate labeling and invest in informing consumers, as they do with currently produced foods that cause allergic reactions in some people.
5. Conduct information programs to notify the population about the safety of consuming GM foods that have been approved through a transparent process to prevent unnecessary rejection of these foods.
6. Promote and create incentives for research to improve techniques for evaluating the allergenicity of GM foods.

In general, it is advisable that requests for commercial GMO or GM food approval be accompanied by:

- a. the name and address of the requester;
- b. the food designation and specification, including the processing operation(s) used to produce it;
- c. relevant information to comply with annex II of the Cartagena Protocol on Biosafety to the Convention on Biodiversity;
- d. a relevant and detailed description of production and manufacturing methods;
- e. copies of research, including, if available, any independent peer-reviewed studies;
- f. the analysis, with the relevant information and data, that shows that the characteristics of the GM food are no different from those of its conventional counterpart, taking the recognized range of natural variation of such characteristics into account, and in the absence thereof, a proposed labeling standard for the food;
- g. the conditions for the marketing of the GM foods or those derived from them, including specific use and handling conditions;
- h. methods used to detect, sample (including references to existing official or standardized methods), and identify processing operations, and, where relevant, methods used to detect and identify processing operations used in GMO foods or foods derived from GMOs;
- i. a proposal for monitoring once the product is on the market as a human food, if relevant;
- j. a labeling proposal for the GM foods or foods derived from them; and
- k. a summary of the file on a standardized form.

Finally, the authors recommend that a network for coordination be established to promote and strengthen interaction between health authorities and experts to improve standards, operating procedures, good laboratory practices, and good clinical practices to facilitate the evaluation of FAO and WHO concerns associated with GM foods.

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# The quest for sustainable agricultural systems

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## ■ Introduction

It is widely acknowledged that health is shaped by the inextricable link between human activity and the various facets of natural systems. Food, water, and physical security (subject to the adverse effects of extreme atmospheric and weather events), along with deforestation, stratospheric ozone depletion, surface ozone (with or without photochemical smog), loss of biodiversity, atmospheric deposits (dew and frost), acid rain, and other events and processes—individually and in combination—directly or indirectly impact the physical and mental health of human beings.

This purpose of this chapter is to provide authorities in the Americas, particularly public health administrators in the developing countries, with information on the relationship between human health and the agricultural sector—and on how climate change could affect that relationship. At the same time, it proposes measures for the surveillance of local and regional health conditions, drawing on studies, research, and the operations of the systems and sectors involved. Only an integrated analysis of the environmental processes that together constitute major determinants of health and disease will ensure the necessary efficiency of surveillance, health alert, and risk management systems whatever the origin of the health problem.

## ■ Relationship between health and agricultural production

When considering the negative effects of agricultural activities on human health, a distinction should be made between:

- a) traditional subsistence agriculture and modern commercial agriculture; and
- b) the direct and indirect health effects of agricultural activities.

The types of potential risks that agricultural production poses to human health depend on the methods and practices involved: risks from subsistence farming differ from those caused by the inputs and capital associated with intensive agriculture.

Agriculture involving the intensive use of inputs and capital, known as “agribusiness,” services local and global food and energy needs. This sector contributes to the advance of agricultural frontiers, the intensification of production (and the trend toward the expansion of monocultures and increased use of agricultural chemicals),

as well as greater income concentration within the sector. Subsistence farming, in turn, has its own problems: the proliferation of small landholdings, brought on by the successive subdivision of property—and the ensuing environmental degradation—causes subsistence farmers to migrate to areas where more profitable activities can be found. The problems that this creates are complex and require simple, concrete, and coherent government actions that offer viable solutions. Such actions must be reviewed and modified both regularly and in critical situations (e.g., in outbreaks of endemic diseases and other high-risk situations) to ensure their effectiveness across time and space. Information and advice to communities should be accompanied by sustainable basic health services that offer equitable care to all citizens.

The agricultural sector impacts the health of entire communities in a variety of ways, while also affecting people at the regional and national levels. The effects depend on the type of agriculture involved (intensive or subsistence) and can have a direct or indirect impact on the environment or social dynamics. Unquestionably, all groups have been and will continue to be directly affected by global warming through weather events and climate phenomena and by certain aspects of agricultural activities such as greenhouse gas (GHG) emissions, extreme deforestation, and overuse of water and agrochemicals in farming. In several countries in the Region, excessive indiscriminate use of agricultural chemicals has been proven to cause disease and death through air and water pollution.<sup>1</sup>

Several recent publications have studied and presented conceptual frameworks for understanding the relationship between the agricultural sector and human health (1–4).

This section presents an overview of some of the health issues related to producers and agricultural systems but does not consider what the conceptual framework of Hawkes and Ruel (3) calls the “product” stage of the agricultural production chain.

Table 20-1 lists some of the most widely recognized health problems in the Americas deriving directly or indirectly from the region’s agricultural activities. Included are categories of health problems often associated with the social, environmental, and economic processes involved in agricultural activity.

Because of the numerous socioenvironmental effects of agriculture, the sector—particularly modern, large-scale agribusiness—engenders and shapes a multitude of harmful influences on human health. Owing to a variety of indirect mechanisms, agricultural activities affect human health through socioenvironmental changes. Table 20-1 highlights two examples of this:

- a) Often, during periods of nonmechanized harvesting, large numbers of people move from place to place seeking temporary work. In some countries, such as Brazil, workers move from region to region, especially for the sugarcane harvest. This leads to a geographic redistribution of the endemic infectious disease foci present in the workers’ places of origin; schistosomiasis caused by *Schistosoma mansoni* is one example of this (5).
- b) Although it may seem paradoxical, intensive mechanized agriculture can adversely affect food security over the long term, with clear implications for health, due in part to the irreversible soil degradation and desertification it causes and the resulting loss of cultivable land.

The removal of significant expanses of plant cover is a phenomenon that occurs both in large-scale mechanized crop production and across extensive areas used in raising livestock for meat, such as the Brazilian Amazon. Habitat destruction causes wildlife (especially mammals) to move closer to populated areas, increasing their contact with people and raising the specter of pathogens transferring from animals to human hosts—a process that has historically occurred in the Americas with a number of hemorrhagic viruses, producing such diseases as Argentine hemorrhagic fever, in Junín (Argentina), and pulmonary hantavirus syndrome in Machupo (Bolivia), Guanarito (Venezuela), and, more recently, throughout the Americas (6,7). There is also the possibility that disease vectors with foci in natural ecosystems may adapt to residential or surrounding areas, as in the case of Chagas disease.

The disappearance of natural ecosystems, causing the scarcity or extinction of uncatalogued plant species, also reduces the potential use of plants for their therapeutic properties.

Alterations in the hydrologic cycle (often the result of changes in plant cover) lead, most problematically, to the formation of reservoirs of water that become the habitat of vectors and intermediate hosts of endemic infectious diseases—generally tropical diseases. Such is the case with the mosquitoes that transmit malaria, dengue, and yellow fever, as well as the mollusks that serve as hosts for the parasite that causes schistosomiasis. Irrigation canals used for agriculture are favorable environments for these vectors. In some parts of Latin America, such canals have led to the geographical expansion of *Biomphalaria*, a species of mollusk that is an intermediate host of schistosomiasis (7).

**Table 20-1.** Effects of the agricultural production chain on human health in the Americas (based on Horrigan and

Walker (2), updated with recent information)

<i>Socioenvironmental problem</i>	<i>Process</i>	<i>Status and consequences</i>	<i>Health effects</i>	<i>Type of effect</i>
Removal of natural plant cover	Destruction of habitat	Migration of animals that are reservoirs for infections; migration of predators	Infectious disease outbreaks	Indirect
	Loss of biodiversity	Destruction of medically and pharmaceutically useful active principles	Development of therapeutic agents eliminated	Indirect
	Local changes in the hydrologic cycle	Development of habitat for vectors; heightened impact from extreme events (e.g., floods and droughts)	Foci of tropical diseases (malaria, dengue, and schistosomiasis); injuries and deaths	Indirect
Use of chemicals	Occupational exposure of communities, particularly women and children	Absorption of chemical residues	Acute poisoning due to occupational or personal exposure; deaths	Direct
	Contamination of air, soil, and water	Inhalation and ingestion of chemical residues	Chronic poisoning: morbidity and mortality	Direct
	Food contamination	Pesticide, heavy metal, and chemical residues in food	Acute and chronic poisoning	Indirect
Proximity of domestic animals	Pathogen transfer	Emergence and reemergence of zoonosis	Outbreaks of infectious diseases	Direct
	Production of large volumes of manure	Soil and water pollution	Exposure to pollutants	Direct
Migrant labor	Spatial redistribution of endemic diseases	Appearance of new foci of endemic diseases (e.g., schistosomiasis and leishmaniasis)	Outbreaks of infectious diseases	Indirect
Soil degradation	Shortage of fertile soils	Food insecurity	Malnutrition	Indirect

The most visible and widely known environmental impacts on human health in the Americas are probably the effects of the mass use of agrotoxics (see Box 20-1). Both the North American and Latin America and Caribbean region are large consumers of these chemicals (8,9). The health effects take the form of acute poisoning from the direct occupational exposure of workers and the population's ongoing intake of the chemical residues present in food (10,11).

Another risk associated with agricultural activity is zoonosis—the ability of pathogens present in domestic animals to infect and cause disease in humans. There are numerous examples of such transmission, the most recent being bird and swine flu (H5HN1 and H1N1). Other examples of such infectious processes include SARS, several causative agents of gastroenteritis (*Campylobacter spp.*, *Cryptosporidium spp.*, etc.), rabies, tuberculosis, and hepatic hydatitis.

A further health risk arises from the pollution, particularly of water, from crop and livestock production (see Box 20-2). One example of this is the manure from livestock herds, which in times past was not a serious problem

in the context of primary production systems but has now become a major concern. The massive volume of manure produced in intensive poultry, beef, and other livestock production<sup>2</sup> is a major source of both chemical (nitrogen, etc.) and microbiological environmental pollution (12,13). Nutrient pollution can cause eutrophication of water bodies, with the resulting proliferation of harmful microorganisms such as *Pfiesteria* (14) and cyanotoxins (15) (a dinoflagellate that reproduces in eutrophized estuaries and kills fish). People exposed to water containing this latter species can develop allergic skin reactions, neurological deficits, mental confusion, gastrointestinal disorders, and visual problems, while cyanobacteria commonly produce the cyanotoxin microcystin, which can cause severe gastroenteritis, hepatotoxicity, and liver tumors if absorbed by the human organism through direct ingestion of water or fish-muscle tissue.

## BOX 20-1. REDUCTION OF PESTICIDE POISONING IN CENTRAL AMERICA, AND THE DEVELOPMENT OF ALTERNATIVES TO THE USE OF



### AGROCHEMICALS

Central America has been one of the world's largest per capita importers of pesticides at 1.5 kg/person/year, well above the 0.6 kg/person/year world average estimated by the World Health

Organization (WHO). This excessive use of pesticides has created significant human health problems in the form of both acute poisoning and chronic effects. The environmental damage inflicted by pesticides in Central America includes the pollution of watersheds, loss of species, and contamination of the food chain.

In light of the problems caused by intensive pesticide use, PAHO has participated in efforts to reduce pesticide related illnesses while supporting the use of sustainable agricultural alternatives in this subregion. Through its Sustainable Development and Environmental Health Area, PAHO, in conjunction with the governments of the region, executed the PLAGSALUD project between 1994 and 2003.

The most important outcomes of this project were a heightened awareness of the problem within civil society and among workers and the most exposed community in particular, about prevention, control, and the use of alternative practices; and the governments' determination to make the reduction of pesticide pollution a priority on their agendas.

All the countries have made surveillance of acute pesticide poisoning an integral part of their national epidemiological surveillance systems, enabling them to

more accurately design targeted prevention and control measures. During the initial years of project execution in the subregion, reports of acute poisoning trended upward, owing primarily to improved notification and recording of poisoning incidents: the rate rose from 10.34 per 100,000 inhabitants in 1994 to 20.37 per 100,000 inhabitants in 1999. The regional impact of the project's measures can be seen in the lower incidence of poisoning over the past three years, with the rate per 100,000 inhabitants falling from 19.5 to 15.82.

In its efforts to promote the adoption of alternatives, the project collaborated with other organizations involved in similar work, supporting national initiatives to develop integrated pest management and organic farming through the preparation and publication of educational materials (pamphlets and videos), workshops and seminars, and the creation of organic gardens at schools.

*Source:* PAHO-PLAGSALUD Project. Final report 2003.

There are reports of epidemic outbreaks of human diarrhea caused by *Cryptosporidium* of bovine origin, attributable to fecal contamination of water tables (16).

Forest fires, which are common in the Americas because of widespread agricultural practices in Latin America

(17) and natural and anthropogenic processes in North America (18), are a major contributor to air pollution. In Latin America, the burning of jungles, forests, and pastureland is primarily the result of efforts to expand the agricultural frontier and the traditional practice of clearing the fields. An estimated 40,000 km<sup>2</sup> of plant cover are burned annually in South America during the winter months, with atmospheric processes spreading the smoke over a far more extensive area of approximately 4.5 million km<sup>2</sup> (17).

## BOX 20-2. HEALTH AND NITROGEN POLLUTION FROM CROP AND LIVESTOCK PRODUCTION



Soil and water pollution resulting from the excess nitrogen used in modern cropping and livestock activities is a major environmental and human health concern. The main sources of

nitrogen are fertilizers (crops absorb approximately 50% of the nitrogen applied) and animal waste, particularly the waste from pigs and poultry that exceeds the amount that can be absorbed by crops and retained by the soil. This problem is especially serious in intensive livestock production, where the large volumes of waste produced are difficult to store and expensive to transport.

The pollutants from these deposits usually end up in water courses and groundwater, where an excess of nutrients causes the eutrophication of bodies of water. Excess nutrients stimulate the proliferation of algae, leading to oxygen depletion, with a consequent effect on biodiversity and health—the toxins from cyanobacteria being one example of this.

The nitrates produced by animals fed in confinement (on feedlots) can pollute water in concentrations potentially fatal to children: contact between nitrates and bacteria in the mouth produces nitrate poisoning, which in turn leads to the well-

known “blue baby” syndrome, or methemoglobinemia. In addition to such poisoning, nitrates have been linked to the development of bladder, prostate, and stomach cancers, as well as non-Hodgkins lymphoma.

Massive quantities of nitrogen are used on pastures in certain countries in the Americas: the United States, 4,697,000 tons/year; Canada, 897,000 tons/year; Brazil, 678,000 tons/year; and Argentina, 126,000 tons/year. A dairy cow in a high-productivity environment excretes close to 129.6 kg of nitrogen per year (69% in mineral form); the corresponding figure for lower-productivity environments is 35.8 kg/year. For pigs, the figures for nitrogen in high- and low-productivity operations are 37.0 kg/year and 15.1 kg/year, respectively, with mineral rates of 73% and 64%.

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The smoke from forest fires is not homogeneous, with the gas and particle content of the emissions varying with the type of biomass burned (19). A recent review (20) examined the general effects of forest fires on human health. Other authors (18,22) have analyzed the economic influence of health effects associated with forest fires in both South and North America. According to Mielnicke *et al.* (23), smoke affects respiration due to the presence of carbon monoxide and other combustion gases and the volatilization of agrochemicals, as well as the size of particulates, especially when they are on the order of 10 microns, the scale at which they affect the respiratory passages.

Recent studies of specific localities in the Amazon (an agricultural frontier area subject to frequent seasonal fires) have documented the health effects associated with emissions from forest fires. Mascarenhas *et al.* (24) observed that in Rio Branco (in Brazil's western Amazon) there was a correlation between the concentration of PM<sub>2.5</sub> and the incidence of asthma in children under the age of 10. Hacon *et al.* (25) and Castro *et al.* (26) observed that exposure to 10 µg/m<sup>3</sup> of PM<sub>2.5</sub> in aerosols among older persons (over the age of 65) led to a 4% increase in hospital admissions for respiratory problems, while the higher mortality levels in this group were associated with the number of forest fire foci.

The residual antibiotics excreted in livestock feces and urine are another significant agricultural byproduct, polluting the environment and promoting the emergence of antibiotic-resistant pathogens (27,28).

## ■ Agriculture, the environment, and social conditions

Deforestation, the degradation of soil and plants, the impoverishment of cultivated land, the salinization of irrigated land, and the depletion and pollution of water resources are among the problems affecting much of Latin America and the Caribbean, and all have serious implications for the health and well-being of the population.

In certain countries in the region, natural resources play a key role in the economy. In the countries of the Andean Community, for example, they represent roughly 20% of the gross domestic product (GDP), exerting excessive pressure on ecosystems and fostering their overexploitation (29). The threats from ongoing environmental degradation put the sustainability of medium- and long-term development in doubt, while jeopardizing the food security of a large percentage of the population.

In recent years, agricultural production systems in Latin America have undergone major changes, with a marked proliferation of increasingly technified systems, or “technology packages.” Such packages include transgenic products, new sowing strategies (direct sowing, precision sowing, etc.), intensive use of knowledge and dependence on information technologies, and a heightened need for chemicals. These systems have aspects that are both positive (e.g., increased use of direct or zero-labor sowing) and negative (including the overuse of agrochemicals). Many of these technology packages are designed to expand monocultures and intensive livestock production (feedlots in particular). They create problems associated with the encroachment of agricultural frontiers on natural ecosystems (leading to deforestation and loss of biodiversity), increased pollution from excessive agrochemical use, and continuing soil degradation and erosion. Moreover, this new type of agriculture has not solved the problems of rural poverty and access to land; indeed, it has unleashed a process of concentration that pushes out smallholders and peasant farmers, creating a climate of conflict in some regions (as, for example, among Peruvian peasant communities, Mapuche groups in southern Chile, and the landless population in Brazil) (30).

One example of the growing reliance on chemicals is the change in fertilizer and herbicide use in the Americas. In the 2007-2008 season, global consumption of fertilizers approached 168 million tons. Of the 10 countries that consume the highest quantities of nitrogen fertilizers, three are in the Americas: the United States (ranked third), Brazil (sixth), and Canada (eighth). In 2008, Latin America and the Caribbean consumed 9% of the fertilizers used worldwide, while North America accounted for 13%. Use of these fertilizers in Latin America is trending upward (Figure 20-1). In Brazil, for example, the annual increase in fertilizer use in the period 1960-2006 was almost 220,000 tons per year, while the increase in Argentina in the period 1993-2008 was nearly 191,000 tons per year (30,31). Brazil, which uses close to 10 million tons annually, is currently Latin America’s largest consumer. South America has seen an upward trend in pesticide use, with Brazil, which used over a million tons of agrotoxics in 2009, being the world’s largest consumer.<sup>3</sup>

With regard to herbicides, there has been a marked increase in the use of glyphosate, mainly due to the expanding cultivation of transgenic soy. Figure 20-2 shows the rise in the use of this product in Argentina between 1991 and 2007 (32). A report on Brazil (<http://inforganic.com/node/451>) indicates that glyphosate was the primary cause of poisoning between 1996 and 2000, accounting for 11.2% of poisoning incidents. In Uruguay, glyphosate accounted for 82% (9,000 tons) of the herbicides imported in 2007. According to CIAT (32), glyphosate was the agrototoxic responsible for the highest number of acute poisoning incidents in the country in 2006 (approximately 20% of all cases).

In Argentina, the use of phytosanitary products doubled between 2002 and 2010, exceeding 300,000 tons, with herbicides representing 75% of the total. Of these products, glyphosate had the largest share, accounting for 85% of the volume of herbicide demand and 65% of the volume of all phytosanitary products marketed in Argentina in 2010 (Rajzman N, Silva Failde D, 2012).

The data from five other countries in Table 20-2 make it possible to compare average pesticide consumption (herbicides + fungicides + insecticides) between the 2005-2007 and 2008-2010 triennia. In all countries except Colombia, which shows a substantial reduction, consumption increased, with a particularly sharp rise in Bolivia (59%) and Peru (48%).

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**Table 20-2.** Average consumption of herbicides, fungicides, and insecticides (in tons) in the 2005-2007 and 2008-2010 triennia

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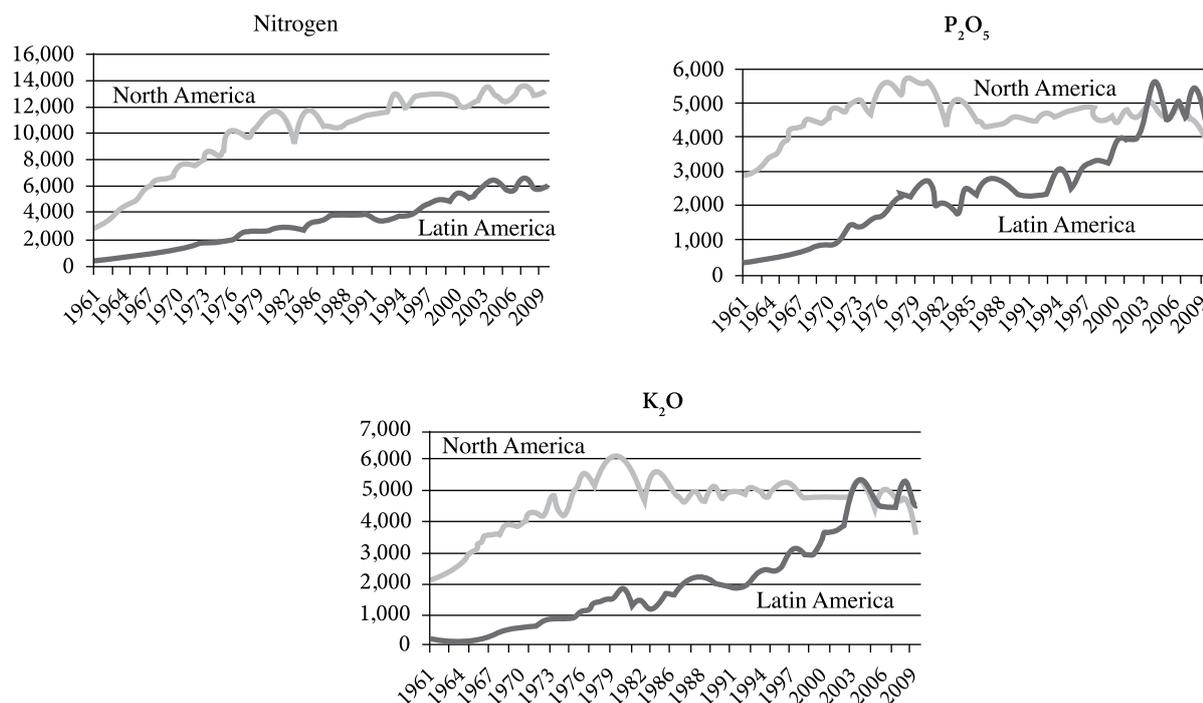
	2005-2007	2008-2010
Bolivia	17,423	27,770
Colombia	99,551	49,528
Ecuador	13,448	18,700
Peru	8,334	12,358
Uruguay	9,977	12,934

Source: FAOSTAT

## ■ Deforestation and changes in land use

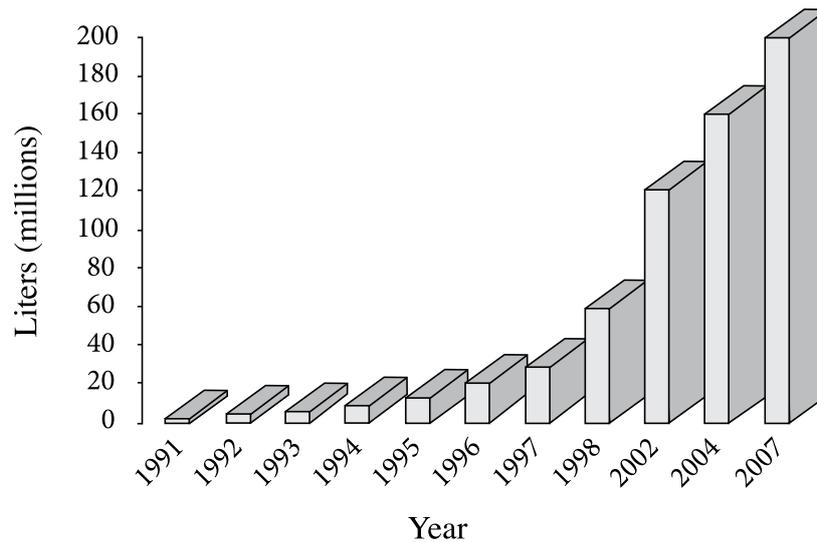
Natural ecosystems —forests and mountains in particular— moderate the effects of intense precipitation by weakening the impact of raindrops and hail on the soil, thus reducing erosion, slowing runoff, and preventing washouts and mud- and landslides. Moreover, they reduce the adverse effects of flooding on slopes. In flat regions, they activate evapotranspiration and reduce the time the land remains flooded. Wooded, jungle, and mountain ecosystems encourage infiltration, keep moisture in the soil, and mitigate the effects of drought and cold waves on soils and plant cover.

**Figure 20-1.** Changing consumption of nitrogenated, phosphorous ( $P_2O_5$ ), and potassium ( $K_2O$ ) fertilizers in North America and Latin America (in thousands of tons)



Source: Roberts (31)

**Figure 20-2.** Changing consumption of glyphosate in Argentina between 1991 and 2007



Source: [http://www.ecoport.net/layout/set/print/content/view/full/81762/\(printversion\)/1](http://www.ecoport.net/layout/set/print/content/view/full/81762/(printversion)/1)

## ■ Deforestation in Latin America

In the tropical and subtropical areas of Latin America, it is primarily small-scale livestock producers and soy and oil palm growers that are responsible for deforestation. Between 2000 and 2005, Latin America had the highest rate of deforestation in the world (accounting for 60% of deforestation in the world's tropical rainforests) (33). During that period, over 27 million hectares of tropical rainforest were destroyed to convert land to agricultural use (34).

Although in the past, deforestation was attributable largely to small producers engaged in rotational (“slash and burn”) farming, the trend has changed dramatically in recent years; in South America, large-scale agriculture is now the principal cause of deforestation (35).

The rotational agriculture practiced by native populations is now responsible for only a small proportion of total deforestation (36,37,38); in this sector, the greatest conversion of forest land is linked to the migration of families searching for new land. In the Peruvian Amazon, for example, less than 9% of the deforestation that occurred between 1999 and 2000 was in indigenous territories (39).

Livestock production is the principal activity in the deforested areas of the tropical and subtropical regions (38-41). Over two thirds of the deforested area in the Brazilian Amazon (42,43) and Colombia (43) is now used for livestock operations. Similarly, in Bolivia's lowlands, the conversion of forest to pasture for cattle is the main driver of change in land use (44).

In the wooded border areas of South America's tropical and subtropical regions, soy production is one of the most recent and significant examples of agricultural expansion (43-45). Brazil and Argentina rank second and third in the world in soy production, respectively; between them, they supply over 50% of the world's soy ([www.soystats.com](http://www.soystats.com)). Although soy cultivation began in the savannahs and pasturelands of Argentina and Brazil, the past few decades have seen a gradual expansion toward wooded areas such as the Chaqueña region in Argentina, the lowlands of Bolivia, and the southern Amazon (39,46).

In the tropics of South America, palm oil is the main industrial crop associated with deforestation. While the size of the crop is small in comparison with that of soy, it is important and is expected to increase as a result of the rising demand for the production of biofuel in the region and palm oil in the international market (e.g., in Asia). Colombia is the leading producer of palm oil in Latin America, ranking fourth in the world, with close to 300,000 hectares devoted to oil palm cultivation (<http://www.fedepalma.org/>). Oil palm is grown primarily in medium- and large-scale operations: 35% of plantations are smaller than 500 hectares, while around 32% are larger than 2,000 hectares. The main forested regions that have witnessed an expansion in oil palm cultivation are the department of

Chocó, in Colombia (47,48), and Sucumbios, in Ecuador. Oil palm production is also important in Brazil (where 75% of the land area in the state of Bahia is devoted to it), and it is beginning to appear in the Peruvian Amazon, particularly in the San Martín and Ucayali regions.

### Expansion of agriculture in the Southern Cone

The Southern Cone of South America (Argentina, Bolivia, Brazil, Chile, Paraguay, and Uruguay) is one of the world's main producers and exporters of food and is thus a region key to global food security. In the past 20 years, the region's relative contribution to global food availability has increased significantly, a trend that can be expected to continue in the coming decades.

The Southern Cone is also one of the world's principal hotspots in terms of converting land to agricultural use. According to U.S. Department of Agriculture statistics (49), the land area planted in soy increased by more than 160% between 1990 and 2007, with a tripling of production during that period (Figure 20-3), making the area one of the most important for monitoring and evaluating changes in land use. The region currently produces 44% of the world's soy, with approximately 50% of its total agricultural area devoted to this crop.

Traditionally, much of the region has been devoted to sustainable livestock production, making use of natural pastures, particularly in Argentina, Paraguay, southern Brazil, and Uruguay. During the 20th century, vast regions with fertile soils were gradually converted to agricultural use, although a large portion of the region continued to support livestock production on natural grasslands. In the 1990s and 2000s, however, the pace of agricultural expansion dramatically increased, due mainly to the growing demand for soy and grains in emerging Asian markets, especially China and India. Moreover, in certain regions (semi-arid or sub-humid areas) such as the western Argentine Pampas, agricultural expansion and the advance of agricultural frontiers were furthered by a significant increase in annual precipitation, a phenomenon particularly noticeable during the last three decades of the 20th century (50-52).

As a result of these changes in markets and climatic conditions, some 18 million hectares of forest and grasslands have been converted to the cultivation of annual crops (particularly soy, and to a lesser extent corn, wheat, sunflower, and rice) (53). In four of the six Southern Cone countries (Argentina, Brazil, Paraguay, and Bolivia) soy has become the leading export.

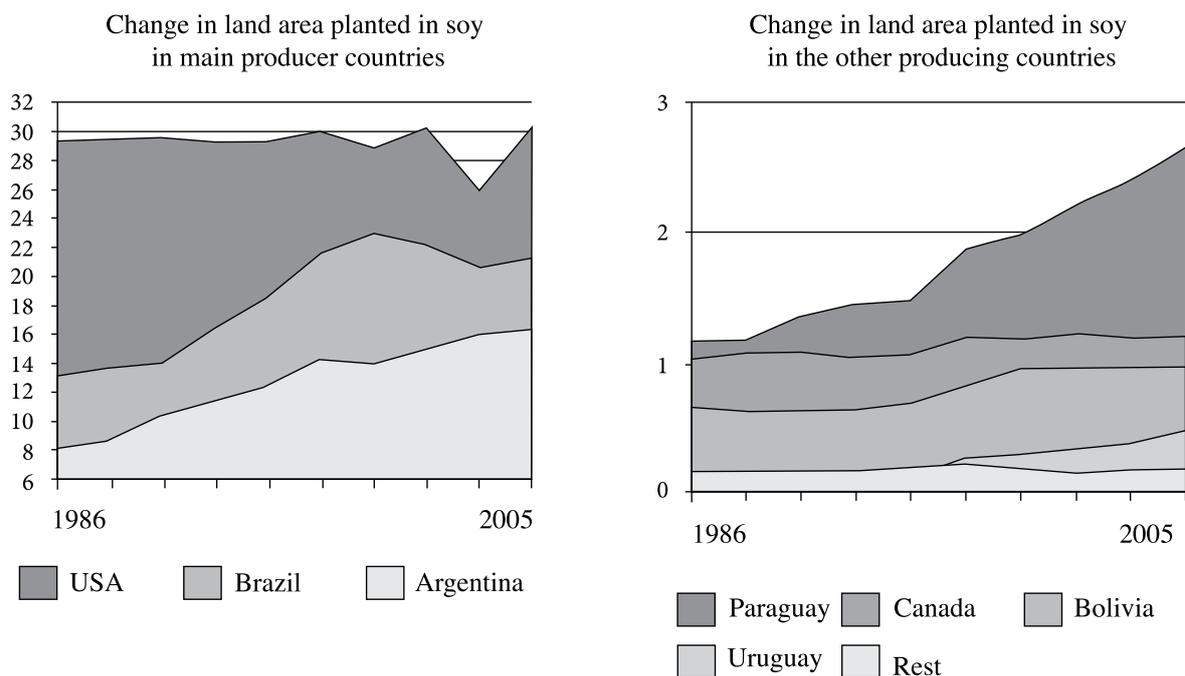
These changes in land use bring with them drastic social changes: large-scale commercial agriculture has gradually replaced extensive cattle ranching and displaced the region's traditional producers, with managers of large investment flows becoming key figures in the reorganized territory. In Uruguay, for example, over 50% of the agricultural land is cultivated by 1% of the producers (54).

The sustainability of these changes in the Southern Cone is open to question on various counts. They pose a grave threat to the continuing delivery of ecosystem services, such as carbon sequestration and soil conservation (55).

Moreover, the concentration of production in a small number of large agribusinesses creates enormous challenges for the social sustainability of small and medium-sized producers and small cattle ranchers, who have traditionally focused on beef-cattle production. There are serious questions as to whether that community of producers is "socially sustainable" and can continue to maintain the livelihood of its population (56).

In addition, many of the landholdings that have been converted to agriculture are only marginally viable for producing annual crops, owing to climate constraints, the physical-chemical characteristics of the soils, and the availability of water. Added to this is the fact that vast areas that for the past 40 years have employed sustainable crop rotation and grazing practices have been transformed to accommodate the continuous cultivation of annual crops (particularly monocultures) using direct seeding. The sustainability of both of these changes in land use—conversion of marginal land and intensification of production—is in doubt throughout the region.

**Figure 20-3.** Changes in land area planted in soy in the Americas (in millions of hectares), 1986-2005



Source: The authors, based on FAOSTAT statistics.

## Biofuels

The problems associated with the lower availability and higher prices of fossil fuels — particularly natural gas and oil— spurred the development of agroenergy industries for the production of hydrocarbon substitutes such as ethanol and biodiesel to mitigate the effects of climate change while promoting local development and job creation. Three times in the past three decades, oil-dependent economies have been hit by sharp increases in the price of crude: in the mid-1970s, the early the 1980s, and, more recently, between 2004 and 2008.

In Latin America and the Caribbean, the principal biofuels crops are sugarcane, soy, corn, and palm oil. While the United States and Brazil currently dominate the liquid fuel industry, most of the countries in the region have legal frameworks (laws and decrees) to encourage the development of these crops (57). These attempts to grow the industry are often accompanied by the expansion of monocultures (e.g., soy in the Southern Cone; sugarcane in Brazil, Colombia, Central America, and the Caribbean; and palm oil in several tropical countries) to provide material for energy production, a process that involves the replacement of natural ecosystems or, in some cases, the use of marginal land for crop production (58).

The main argument for producing energy from biomass is its potential for mitigating the effects of climate change. However, for a variety of reasons (for example, the way in which the land is used), the use of biomass as a renewable resource does not ensure sequestration of the amount of CO<sub>2</sub> produced by burning biofuels. CO<sub>2</sub> emissions from deforestation and the burning that accompanies it —along with the release of greenhouse gases from the burning of fossil fuels to generate the energy used in producing the crops, the loss of carbon through soil degradation, the release of nitrous oxide, and the pollution of water by fertilizers— cast doubt on the benefits of these practices (59). In the case of sugarcane, burning of the leaves during harvest emits polluting gases (carbon monoxide, methane, nitrogen oxides, including nitrous oxide), with negative effects in terms of climate change, as well as ozone production. Moreover, it has been shown that the pollutants generated by the burning of sugarcane increase respiratory illnesses in children and the elderly (60).

It is hard to determine the degree to which bioenergy helps mitigate climate change (61). Large-scale expansion of energy-producing crops entails potential risks. The most serious of these risks is perhaps that energy production will compete with food production for land use, given the limited availability of arable land and the effect that alternative uses could have on the profitability of land and, hence, on food prices (62). According to a recent report (63), biofuels bear some of the responsibility for the 2006-2008 food crisis and subsequent rise in food prices. Moreover, massive expansion of these crops can be expected to increase the evapotranspiration potentially available

for human use. This is a major risk factor in countries already suffering from water shortages (64,65). These crops can, in some cases, jeopardize the quality of water, air, and soil; some, such as sugarcane, oil palm, and corn, require relatively large amounts of water and are grown as rain-fed crops. Although the availability of water is not a problem in certain countries, soil erosion and the pollution of water resources with fertilizers and agrochemicals are major concerns (66,67). At the moment, large-scale production of biofuels using sustainable production practices such as organic agriculture does not appear to be feasible (68). In this connection, Lysen and van Egmond (69) recently conducted a review of the available research on bioenergy production and the availability of land and water, as well as the associated economic constraints.

Various opinions from reputable scientific sources question the benefits of biofuels. According to the United Nations (May 2007), “Biofuels could do more harm than good,” while the University of Minnesota (February 2008) reported that “Deforesting to produce biofuels aggravates global warming.” Comprehensive research on the impacts of biofuel production has yet to determine not only the cost-benefit ratio of such practices, but also the effect of biofuels on air quality—a concern relevant to the issues considered in this chapter.

### Soil degradation

Of the 1.9 billion hectares of degraded soil on the planet, 16% are in Latin America—8% in Andean countries. Nearly 250 million hectares in South America and 63 million hectares in Mesoamerica are affected by soil degradation. Soil erosion poses the greatest threat (68% of the affected land is in South America, 82% is in Mesoamerica), while chemical degradation affects some 70 million hectares in South America and approximately 7 million hectares in Mesoamerica. In South America, nearly 100 million hectares have been degraded by deforestation and some 70 million hectares by overgrazing, while in Mesoamerica the chief cause of degradation is poor management of agricultural land (70).

In some regions, soil degradation and desertification threaten the population’s food security. One clear example of this can be seen in certain areas of Bolivia (see Box 20-3).

#### BOX 20-3. DESERTIFICATION AND FOOD SECURITY IN BOLIVIA

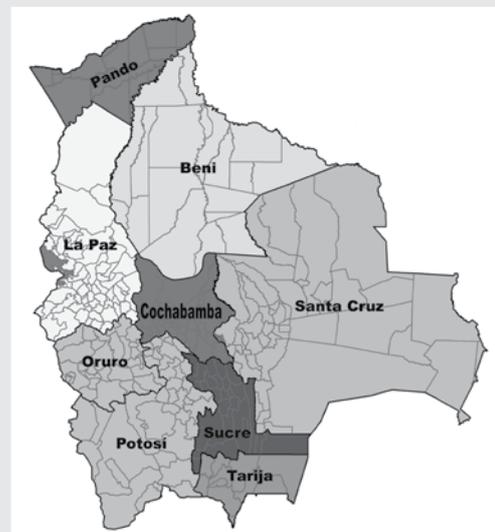


Desertification and soil degradation—major problems in any circumstance—are especially

serious problems for poor communities, not only jeopardizing the sustainability of the environment and production but compromising the community’s food security and livelihood. In Bolivia, agriculture employs over 50% of the population and represents 14.3% of GDP. A major portion of the agricultural contribution comes from small farmers, who, while owning a relatively small proportion of the country’s cultivated land, are largely responsible for the nation’s food availability. Of Bolivia’s 8 million inhabitants, 38% live in rural areas, where 82% of the population is poor—with more than half of these (59%) being indigent and owning only 13% of the cultivable land.

The country is divided into three main regions: the Andean (the Altiplano and mountains), the sub-Andean, and the plains. In the Altiplano—the most populous zone—subsistence agriculture predominates. In the Altiplano and valleys, the trend toward smallholdings is accelerating, with the emergence of 16,000 new farms annually. The sector is highly vulnerable, due in part to the fact that there has been little technological development among smallholders, who rely on rainfall, make little use of agricultural inputs or machinery, and receive no subsidies.

**The accompanying maps of Bolivia show the location of the country’s departments and the projected advance of desertification.**



Erosion is a major problem that ranges from serious to very serious in approximately 61% of the arid, semiarid, and sub-humid dryland. The majority of ecosystems that are fragile due to topographical or hydrologic constraints or poor soil quality are extremely susceptible to degradation, especially in the face of intensive farming.

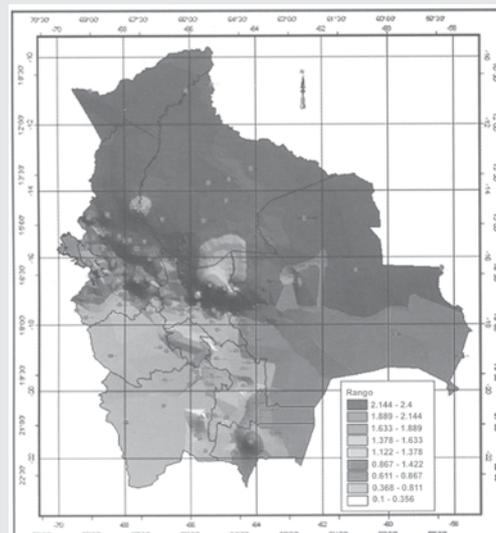
While desertification is a nationwide problem, its consequences are most severe at the higher elevations, where most of the population is concentrated. In the southwestern departments, which are the country's poorest, moderate increases in temperature (+1.5°C) and slight reductions in precipitation (-15%) – a situation predicted by various global climate models (GCMs)– could seriously jeopardize food security. Projections indicate that nearly 53% of Bolivia's communities are among the groups most vulnerable to food insecurity. Moreover, 16% of Bolivia's population is concentrated in 7,718 particularly vulnerable communities, where 78% of the residents are extremely poor. In the departments of Chuquisaca and Potosí, 8 out of 10 communities are highly vulnerable, while 50% of the communities in Oruro, Cochabamba, and La Paz are among the most vulnerable.

Increased aridity, added to poor management practices, can be expected to hasten desertification and intensify soil degradation, making the region extremely vulnerable unless urgent adaptation and response measures are adopted.

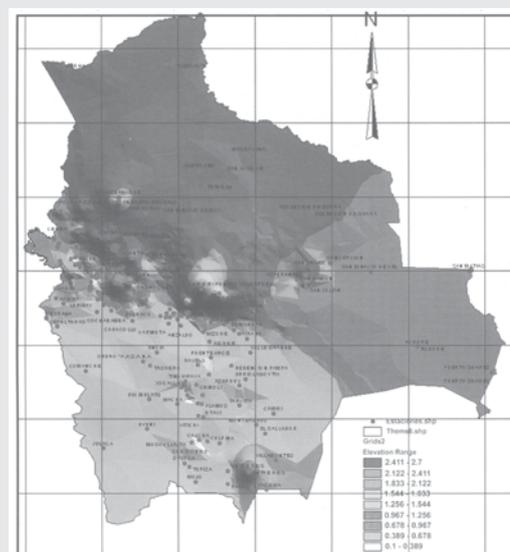
PNCC, Programa Nacional de Cambios Climáticos, Bolivia. *El cambio climático en Bolivia: análisis, síntesis de impactos y adaptación*, 2007.

Böhrh JP, *Hacia una estrategia de seguridad alimentaria en Bolivia. Políticas de seguridad alimentaria en los países de la Comunidad Andina*.

### Desertification, present conditions.



### Desertification with +1.5°C and changes in rainfall.



## Water resources

Latin America as a region is fortunate in having access to fresh water. It is home to four of the world's 25 largest rivers (the Amazon, which represents 20% of the planet's runoff, the Paraná, the Orinoco, and the Magdalena), as well as some of the world's largest lakes. However, the uneven spatial and temporal distribution of water resources, compounded by the accelerating disappearance of glaciers in the intertropical Andes, threatens the continued availability of water and the normal course of human and productive activities. In recent decades, runoff in several watersheds in the tropical Andes increased as a direct result of shrinking glaciers – a flow that will eventually stop, creating critical tensions in the area over water during the period when glaciers are shrinking and when they ultimately disappear.

Furthermore, water pollution, combined with social inequality, makes access to potable water a major problem for a large proportion of the region's inhabitants, who are unable to access the amounts they theoretically need. One

aspect of the problem is attributable, at least in part, to the agricultural sector: the expansion of inappropriate agricultural practices and policies favors large operations and forces many rural dwellers to migrate to overpopulated cities, further exacerbating the water problem (70-73).

The issue of water availability has been a concern for certain populations since ancient times. One example of this is the Andean countries, where agriculture in areas with hostile climates (such as hillsides and valleys) has relied largely on rich biodiversity and the native population's ability to acquire the appropriate knowledge and devise the necessary technologies to survive in a water-scarce region. Since pre-Incan times, the inhabitants of these areas understood that the irregular distribution of water was a major constraint on the community's normal life; they therefore developed the ability to adapt to local environmental conditions (see Box 20-4). Harvests made possible by rainwater ensured the permanence of plant species in paradigmatic places such as Machu Picchu (70).

Droughts and lack of water, in addition to jeopardizing harvests, increase dust in the environment and lead to more frequent forest fires, which in turn produce smoke and particulates with adverse effects –e.g., respiratory diseases caused by inhaling dust or smoke, and even mental illnesses caused by the stress of economic losses from the fires, especially among farmers (73).



#### BOX 20-4. STRATEGIES TO ENSURE THE SUPPLY OF WATER

Water is fundamental to human health. The water situation in the Andean region is especially critical, due to the rapid melting and projected disappearance of the glaciers in the intertropical Andes in the coming decades. As noted by the Intergovernmental Panel on Climate Change (IPCC), the melting of the region's glaciers is already creating water supply problems in several Andean countries. With the anticipated disappearance of the glaciers in the decades to come –leaving tens of millions of people without this vital resource – renewed attention should be given to the potential for obtaining water for drinking and irrigation from the enormous reservoir of sea and ocean water.

To accomplish this, solutions involving the distillation of sea water, such as those adopted by Singapore and Algeria –and, as early as the 1960s, by a number of Caribbean countries – will have to be used. The available information indicates that some islands in the region have already begun to distill sea water using solar energy. Newly available technologies, and technologies currently being developed, hold promise for reducing costs and making it feasible to utilize this resource. On South America's Pacific coast, water obtained from coastal fog (the *camanchaca*) – extracted from coastal vegetation and through human intervention, as in northern Chile and the area around Lima– is being used as a source of natural irrigation.

Simple measures, such as collecting water from the condensers of air conditioning systems, offer additional solutions. Current information indicates that millions of liters of water have been “harvested” in industrial complexes –e.g., during summers in the United States – by channeling the condensation from air conditioning systems. Reuse of wastewater, for irrigation or to create wetlands to regulate the hydrologic cycle, offers another viable alternative.

In addition to the necessary political decisions, there will need to be an environment favorable to “harvesting” and appropriately treating wastewater. One model for water-scarce communities can be found in the experience of the Puerto Madryn community, in the Argentine Patagonia, where 13 million liters of wastewater are recycled to obtain 8 million liters of irrigation-ready water. This water is used to sustain a wetland area, with the potential to inject the excess water into water tables for further purification.

As food consumption is a vital component of public health, decision makers should also consider using water with some salt content for irrigation purposes. Experience in Italy and Israel provides information regarding successful yields from certain plants (olives and tomatoes) irrigated with brackish water.

#### Sources:

Magrin GC, Gay García D, Cruz Choque JC, Giménez AR, Moreno GJ, Nagy C, Nobre, Villamizar A. Latin America. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel. In: Parry ML, Canziani OF, Palutikof JP, Van der Linden PJ, Hanson CE (eds.). *Climate Change*. Cambridge, UK: Cambridge University Press; 2007. Kundzewicz ZW, Mata LJ, Arnell NW, Döll P, Kabat P, Jiménez B, Miller KA, Oki T, Sen Z, Shiklomanov IA. Freshwater Resources and Their Management. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In: Parry ML, Canziani OF, Palutikof JP, Van der Linden PJ, Hanson CE (eds.). *Climate Change*. Cambridge, UK: Cambridge University Press; 2007. Information provided by the embassies of Italy and Israel in Buenos Aires.

These problems can be seen in reverse on islands and in low-lying coastal areas subject to flooding, although, strictly speaking, saltwater invasion is the primary issue in these cases. According to the Synthesis Report of the Fourth Assessment Report of the IPCC, 2008 (AR4 SYR), global warming and rising sea level projections indicate that:

- Low-altitude coasts and islands, especially in estuaries, are exposed to increasing risks, including coastal erosion. This is exacerbated by intensified human pressures in coastal areas.
- During the 21st century, many millions of people more than those currently affected will lose their land. The global projection indicates that, under the socioeconomic scenarios that shape the progress of human society, an additional 5 million to 35 million people will be uprooted due to the flooding of their lands (AR4, SYR).

These conditions have serious health implications, both because of their local effects and the fact that human displacement will import causative agents of exotic diseases, especially when quarantine measures are not in place.

Although migration, and particularly, individual decisions to migrate, depend on many factors, including health, age, sex, ability to survive, power, property ownership, job quality, etc., there is a very significant relationship between migration and rising sea levels with the associated loss of land (74,75).

By way of summary, Tables 20-3 and 20-4 show the effects of excess and insufficient precipitation and their extremes –floods and drought– on human health and well-being.

**Table 20-3.** Scenarios in which excess precipitation can affect health

<i>Event</i>	<i>Type</i>	<i>Description</i>	<i>Potential impact</i>
Intense precipitation	Meteorological	Extreme event	Change in the abundance of mosquitoes (reduction if storms destroy breeding sites)
Flood	Hydrologic	Overflowing rivers/streams	Change in quantity of vectors and transmitters Water and soil pollution
Flood	Social	Property and crop damage	Contamination of water and soil with rat feces and urine (leptospirosis) Changes in the abundance of vectors
Flood	Disaster	People killed, injured, and/or otherwise affected Migrations Destruction of structures Spread of pollutants and chemicals Need for external aid	Water and soil contamination from rat feces and urine Risk of respiratory illnesses and diarrhea Drowning, wounds, injuries Chemical pollution and other health problems stemming from migration Loss of food supplies Psychological effects

**Table 20-4.** Scenarios in which lack of precipitation can affect health

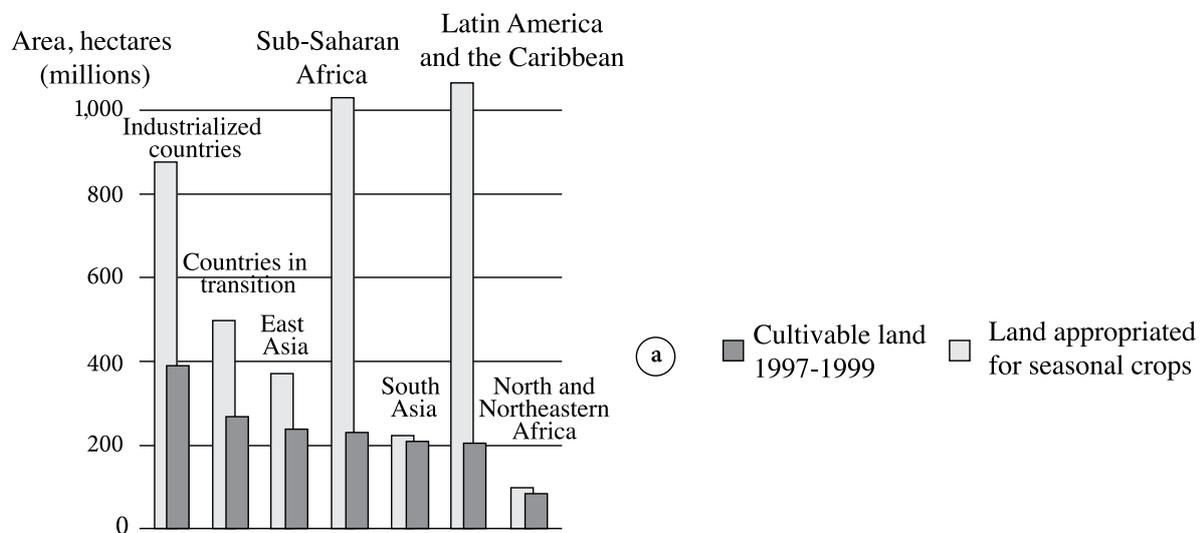
<i>Event</i>	<i>Type</i>	<i>Description</i>	<i>Potential impact</i>
Drought	Meteorological	Hydrologic balance	Changes in the abundance of vectors
Drought	Agricultural	Drier-than-normal conditions, leading to smaller harvests	Effect dependent on socioeconomic factors (e.g., availability or unavailability of structures and means of obtaining food from other sources) Dependence on availability
Drought	Social	Significant reduction in food supplies Deterioration of water quality and reduction in supplies	Lack of food; malnutrition Disease (increased risk of infection) Increased risk of disease due to lack of water for hygiene
Drought	Lack of food Famine Natural fires Disasters	Food shortages leading to starvation and death Air pollution Need for external aid	Malnutrition Famine Respiratory complaints and damage (particulates and gases) Effects associated with migration

## ■ Climate change and global warming

Toward the end of the 20th century, the region had 160 million hectares of land under cultivation (18% of the estimated potential) and another 600 million hectares of grazing land, with a population of approximately 505 million (76), along with the greatest reserve of cultivable area in the world, with an estimated agricultural potential of 576 million hectares (69).

Projections indicate that Latin America will be one of the regions that contributes most to supporting the growing demand for food (Figure 20-4) and that part of the region's increased productivity will be the result of the encroachment of agricultural frontiers on natural ecosystems, a factor that could accelerate climate change and loss of biodiversity (63).

**Figure 20-4.** (a) Cultivated and potentially cultivable land in different world regions. (Source: FAO, *The State of Food and Agriculture. Biofuels: Prospects, Risks and Opportunities*. Rome, 2008) Increases in the productivity of crops due to increasing yields and the expansion or intensification of activity. (Source: FAO, *World Agriculture: Towards 2030/2050*. Rome, 2006. Available at: <http://www.fao.org/es/ESD/AT2050web.pdf>)



The region's population is expected to reach 725 million by 2030 (an increase of more than 40%), with the rural population declining from 128 million to 121 million (that is, from 25% to 17% of the total population), although with wide spatial variations. The poorest countries will continue to experience high levels of population growth, leading to increases in the rural populations of Central America, Bolivia, Paraguay, and Haiti in absolute terms, while countries such as Argentina and Brazil will see a reduction of at least 20% in their rural populations (74).

During the 2000-2030 period, per capita daily nutrient intake is projected to increase by 10% (from 2,791 calories to 3,080 calories), primarily due to an increase in the consumption of meats and vegetable oils (33% in each of the two categories) and dairy products (18%). The number of people suffering from malnutrition (currently 53 million) will drop to 32 million by 2030 –from 11% to 5% of the population. However, this decline is a mere 50% of the target set in the Millennium Development Goals (75).

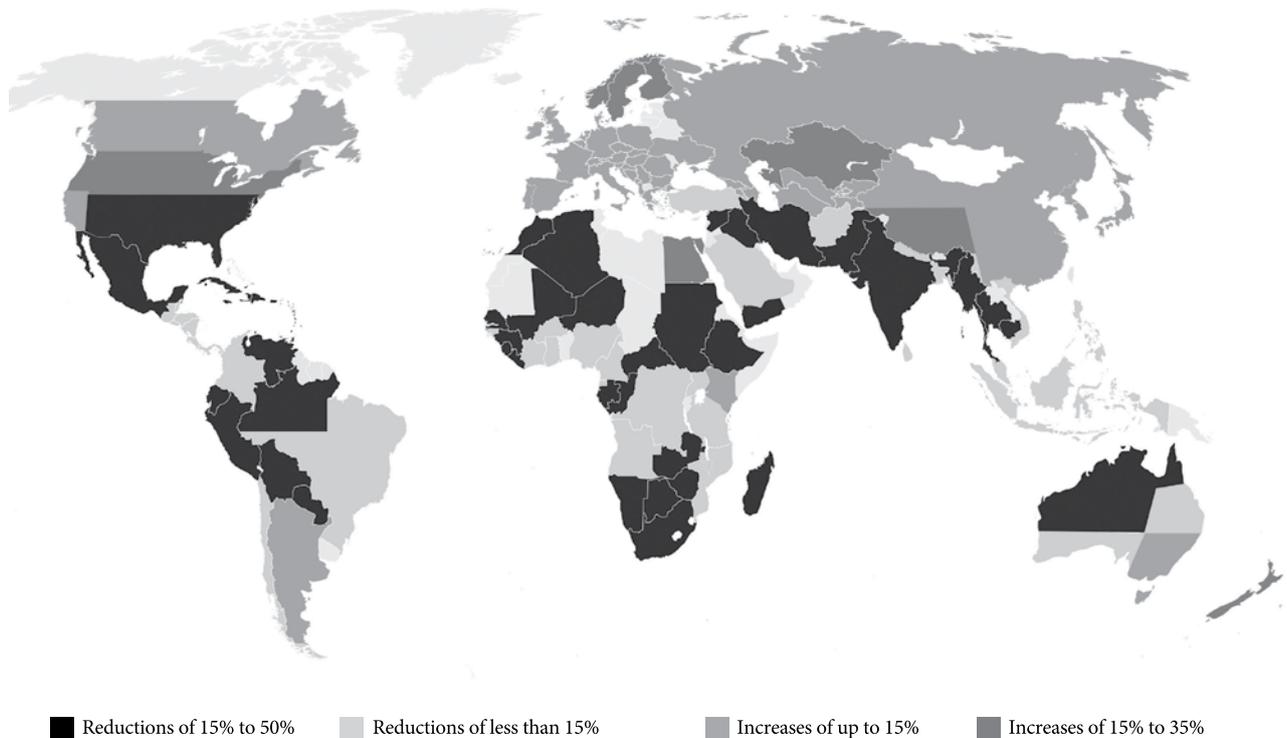
The effects of climate change on the agricultural sector will vary from crop to crop and region to region. In temperate zones (such as parts of Argentina, the United States, and Canada), moderate temperature increases could have positive effects on the sector within certain time horizons. In tropical regions and Central America, however, rising temperatures will have adverse impacts (Figure 20-5). In all regions, increases of more than 2°C will produce more negative than positive effects (77-78).

Another important negative impact of climate change will be soil degradation. This will be a fundamental long-term problem in the Region and will increasingly affect the conditions under which agricultural production takes place. Table 20-5 summarizes the available data and projections on the degradation of land in a number of countries and shows the potential for significant degradation in Bolivia, Chile, Ecuador, Paraguay, and Peru by 2100, affecting some 22% to 62% of the territory of those countries (78).

Although growing global food demand will drive the expansion and intensification of agriculture, water availability toward mid-century will constrain production. Projections point to greater than 20% reductions in available water in much of South America, Central America, and parts of North America (78).

In addition, the frequency and intensity of extreme phenomena (heat waves, droughts, and floods) are likely to increase, causing major damage to the agricultural sector. Increased water shortages in northeastern Brazil and parts of the Amazon and Central America are predicted, while increased flood risks are expected in southern Central America and southeastern South America (75,79).

**Figure 20-5.** Projected changes in food production by the late 21st century (2080), taking into account the potential beneficial effect of CO<sub>2</sub> on plant productivity



**Source:** Cline, Country-Level Agricultural Impact Estimates. Peterson Institute for International Economics, 2007, [www.petersoninstitute.org](http://www.petersoninstitute.org).

The projected climate changes can be expected to create greater pressure from pests and diseases, especially for potatoes, coffee, soy, and wheat. These changes will contribute to the propagation of existing pests and the invasion of new ones, accelerating their development so that there are more cycles per growing season and a lack of spatial and temporal synchronization between pests and beneficial insects, resulting in an increased risk of infection (75,79). Rising use of pesticides to curb losses in production can therefore be expected, despite the attendant risk to the environment. Integrated pest management, aimed at minimizing the use of chemicals, would offer a means of reducing environmental pollution and the incidence of diseases caused by pesticide use.

**Table 20-5.** Estimated losses caused by the degradation of land in selected countries

	<i>Degraded area (km<sup>2</sup>)</i>	<i>Territory (%)</i>	<i>Degraded area by 2050 (km<sup>2</sup>)</i>	<i>Degraded area by 2100 (km<sup>2</sup>)</i>	<i>Percentage of territory in 2050</i>	<i>Percentage of territory in 2100</i>
Bolivia	60,339	5,49	123,301.4	243,979.4	11,2	22,2
Chile	77,230	10,2	157,817.8	312,277.8	20,8	41,2
Ecuador	40,136	14,15	82,017.0	162,289.0	28,9	57,2
Paraguay	66,704	16,4	136,308.2	269,716.2	33,5	66,3
Peru	197,211	15,34	402,996.4	797,418.4	31,3	62,0

Source: *Estudios por países. Proyecto de valorización económica y social de la degradación de las tierras*. Global Mechanism, (GM), in coordination with the ECLAC regional Study on the Economics of Climate Change (ERECC).

Another major concern in relation to disease is the effect of future climate on the production of mycotoxins, particularly in wheat and corn crops. The presence of mycotoxins in grains is associated with risks to human and animal health, owing to their toxicity and potential carcinogenic qualities. The most common mycotoxins in corn crops are the aflatoxins, which flourish at a temperature of 33°C. Temperate zones are likely to be at higher risk in the future, while rising temperatures in tropical zones will lead to above-optimal temperatures for fungus survival. The production of aflatoxins can also be stimulated by drought (80). In the case of wheat, fusarium head blight is one of the most common diseases and the associated toxin is desoxinivalenol (DON). Warm, humid environmental conditions encourage the development of DON in grains (81-82). An increase in this toxin is therefore likely in currently temperate areas where higher temperatures and precipitation are expected to occur.

## Challenges

The agricultural sector's attempts to meet growing demand for food, address the challenges of climate change, conserve the quality of natural resources, and mitigate the direct and indirect adverse effects of agricultural production on human health and well-being face a range of complex challenges.

## Food security

One of the principal challenges that society is facing, and will continue to face, is ensuring the global food security. According to the World Food Summit (1996), "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life."

Food security depends on a variety of factors –not least on food production. In various areas of the region, desertification, soil degradation, pollution, over-exploitation of water resources, and the trend toward the cultivation of high-yield energy-producing crops for export are jeopardizing the food security of a large portion of the population.

According to a report by the Food and Agriculture Organization of the United Nations (FAO) (75), close to 20% of the population in Central America and the Caribbean suffers from malnutrition (Figure 20-6); in South America, the problem is most prevalent in the Andean countries, especially Bolivia (Figure 20-7).

According to a study by the Economic Commission for Latin America and the Caribbean (ECLAC) (83), the majority of those most vulnerable to food insecurity are members of poor communities and indigenous groups, along with communities in rural mountain areas, the Altiplano, and periurban areas that rely on a subsistence economy. This segment of the population lacks sufficient access to safe drinking water and sanitation and suffers from the effects of little or no schooling. In the Andean countries, most indigenous people live in rural areas, where nearly 90% of the population engages in subsistence farming on smallholdings or performs seasonal work (mining and crafts). This population group is highly vulnerable, due largely to the pressures arising from large-scale mining and the expansion of agricultural frontiers.

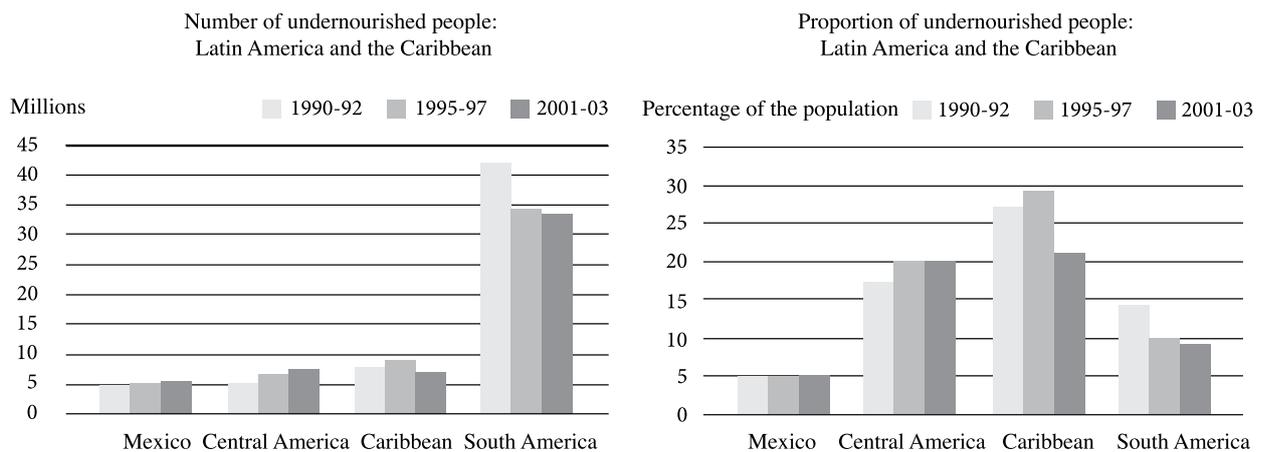
## Sustainable production

Establishing sustainable production systems capable of ensuring food availability and the quality of the environment poses an additional challenge. According to FAO, sustainable development is the “management and conservation of the resource base, and the orientation of technological and industrial change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development conserves land, water, plants and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable.”

FAO (84) defines sustainable agriculture and rural development as a process that meets the following criteria:

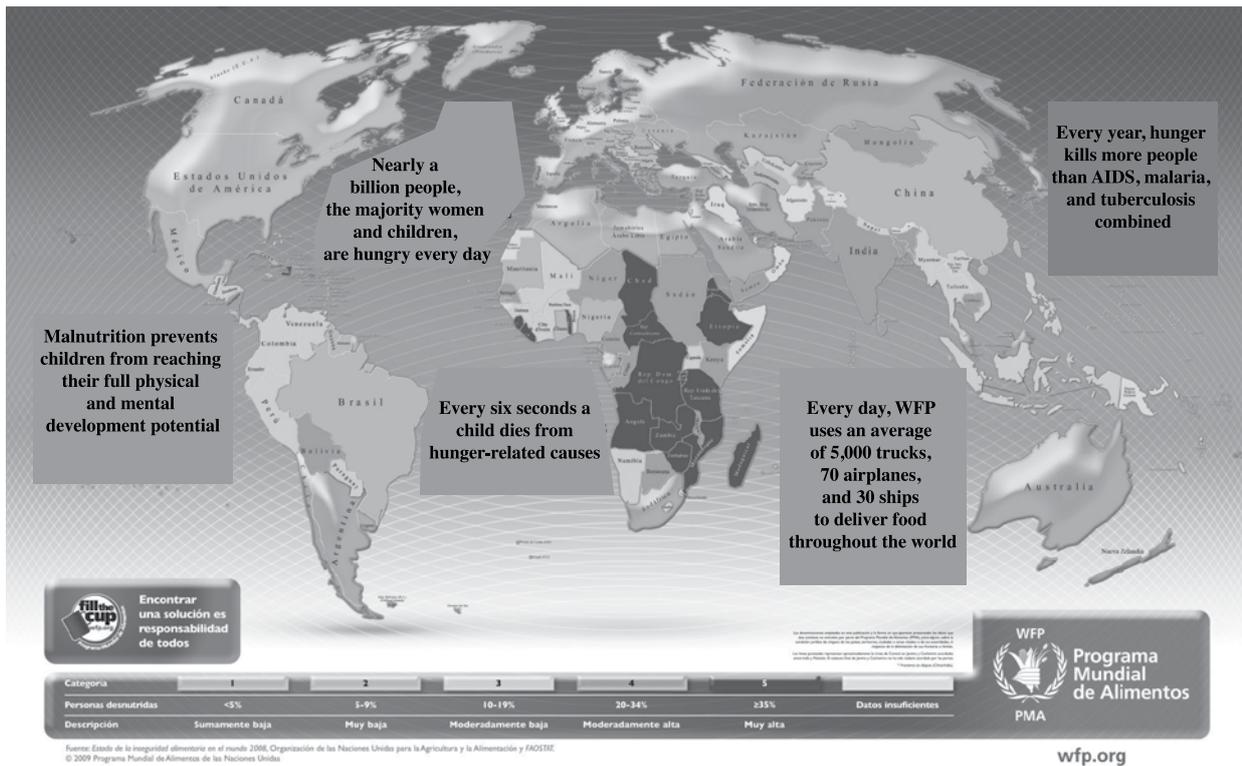
- It ensures that the basic nutritional requirements of present and future generations, qualitatively and quantitatively, are met while providing a number of other agricultural products.
- It provides durable employment, sufficient income, and decent living and working conditions for all those engaged in agricultural production.
- It maintains and, where possible, enhances the productive capacity of the natural resource base as a whole, and the regenerative capacity of renewable resources, without disrupting the functioning of basic ecological cycles and natural balances, destroying the sociocultural attributes of rural communities, or contaminating the environment.
- It reduces the vulnerability of the agriculture sector to adverse natural and socioeconomic factors and other risks, and strengthens self-reliance.

**Figure 20-6.** Changes in absolute and relative numbers of undernourished people in Latin America and the Caribbean



**Source:** FAO, *World Agriculture, Towards 2030/2050*. Rome, 2006. Available at: <http://www.fao.org/es/ESD/AT2050web.pdf>.

Figure 20-7. Hunger map, 2009



Source: World Food Program (WFP), World Food Program Hunger Map 2009. Available at: <http://www.wfp.org/hunger/map>

The sustainable management of natural resources and the reversal of resource degradation are fundamental elements for areas with stable development systems, as well as frontier areas experiencing rapid growth. Many factors account for the lack of sustainability, and remedying this situation requires a range of different measures, depending on whether small/subsistence farming or large-scale agriculture is at issue.

Smaller-scale agriculture employs a variety of practices and techniques to achieve sustainable production, such as plant cover, zero or reduced tillage, windbreaks, agroforestry, terraces, controlled grazing, and the selection and distribution of appropriate varieties. Organic agriculture, which is gaining an increasing foothold in a certain Central American countries and in Latin America more broadly, is a further option that minimizes the use of synthetic fertilizers, replacing them with organic fertilizers. However, if this form of production is to be adopted on a massive scale by peasants and farmers, it will need to demonstrate the ability to yield income levels similar to, or greater than, those obtained through traditional agriculture.

Organic farming and integrated pest control are two examples of ways in which small and medium-sized producers can farm sustainably. According to FAO's definition, organic farming is a system of production that attempts to maximize the use of a farm's resources (with emphasis on soil fertility and biological activity), minimize the use of nonrenewable resources, and avoid synthetic fertilizers and pesticides to protect the environment and human health. Furthermore, in view of global warming, this system of production can be expected to have major mitigation potential (85). The organic approach integrates crop growing with livestock-raising: animal waste is used as fertilizer for growing crops while helping to reduce environmental pollution and greenhouse gas emissions. This method also promotes soil fertility through the use of legumes, crop residues, and cover crops to provide nitrogen, thus helping to stabilize organic matter in the soil and improve the soil's water retention, while simultaneously reducing losses from erosion.

Although organic farming frequently produces lower yields than conventional farming, it offers excellent benefits. In the industrialized countries, the surplus price paid by consumers, along with government subsidies, has increased income from organic farming operations. In the developing countries, well-designed organic systems are

producing yields, profits, and wages that are higher than in traditional systems. Consumers in the developed countries have shown a willingness to pay a 10% to 40% premium for organic products. The demand for these products is expected to continue to grow, perhaps beyond the 20% increase of the past few years, while the scarcity of supply offers developing countries opportunities to fill the gap, especially by providing off-season products (86).

According to FAO, integrated pest management “means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment.” This approach emphasizes:

1. Prevention and/or suppression of harmful organisms. This is often best achieved by a combination of the following options: crop rotation, intercropping, use of adequate cultivation techniques (e.g., sowing dates and densities, conservation tillage), and, where appropriate, use of pest resistant/tolerant cultivars.
2. Promotion of monitoring and early warning services.
3. Priority to nonchemical methods of control.
4. Pesticide use only as a last resort, and in minimal quantities, applying the most targeted products possible, so as to prevent damage to other organisms, human health, and the environment.

A number of initiatives that employ this approach have been successful in containing or eradicating pests on a large spatial scale (87). A case in point, among medium and small producers, is the control of whitefly in Central American vegetable farming (88) (see also Box 20-1) (85).

In marginal or highly degraded areas, where the use of such measures is unable to ensure the sustainable continuation of activities, there will be a need for more energetic measures such as financing the migration of producers to allow reforestation to occur, while providing new activities to stimulate job creation and income opportunities (74, 89).

The region has considerable potential for reducing poverty in the agricultural sector –a chief cause of hunger– by intensifying and diversifying production (and adding value), expanding the farmed area, creating non-farm jobs, or, in extreme cases, abandoning farming activity in certain areas (75).

## Intersectoral coordination

A further challenge is the need to increase coordination among interdisciplinary teams in every country in the region, and, through PAHO, provide strategies for effective regionwide coordination, bearing in mind that the Organization’s fundamental purposes are “to promote and coordinate efforts of the member states to combat disease, lengthen life, and promote the physical and mental health of their people.”<sup>4</sup> Indeed, given the incontrovertible fact that human health and well-being are intimately linked to the environment and environmental changes, it is clearly advisable that PAHO staff be kept constantly informed about the multisectoral developments that shape the environment and influence physical safety (such as systems used for risk management and to provide early warning of extreme events), as well as the problems that, as this document points out, affect food and water security. The San Pedro Sula agreement (May 2008) is an important regional pillar for the implementation of monitoring, hydrometeorological surveillance, and multi-use forecasting systems. In relation to public health services, the agreement should serve as the basis for planning, executing, developing, and operating systems to help prevent diseases associated with, or exacerbated by, global warming. However, consideration must be given to the constraints imposed by the lack of integrated analyses of the factors involved in public health administration, which is influenced in many ways by the effects of climate change.

A prerequisite to meeting these challenges is the approval of sustainable commitments. Important in this regard is PAHO’s follow-up to commitments, both directly and through the Representative Offices of the United Nations Development Programme (UNDP) in each country. As noted in the *Report on Climate Change and Human Health*, and underscored in *Integration of Public Health with Adaptation to Climate Change*, measures needed to deal with endemic diseases or pandemics in a particular area or region require actions whose scope extends beyond any one watershed or climate zone. Once a decision has been made to conduct surveillance, implement prevention measures, or carry out massive vaccination campaigns, there must be thorough follow-up, a process that, in turn, requires ongoing sustainable coordination.

Formulating and meeting such commitments is essential; all too often, societies are overly complacent, settling for the illusion that problems have been solved, despite the absence of complete and reliable proof of results, merely because the desire to solve them has been expressed.

A further problem often encountered is the weakening of commitments or failure to fulfill them. At times this takes the form of insufficient efforts to provide sustained observation and monitoring of outbreaks and their recurrences. Moreover, the need to evaluate the effectiveness of the measures implemented is sometimes neglected.

One unfortunate but common example of such shortcomings is the suspension of sanitation work in the wake of extreme events—an important lesson for those who have embarked on the process of adapting to climate change. Lessons learned suggest that, given the need for sustained commitment to adapting to climate change, it is necessary to:

- Monitor the results of evaluations on a continuous basis, and conduct periodic analyses, since health risks and infections change over time.
- Act prudently, by initially undertaking small-scale interventions to test the efficacy of proposed strategies and solutions, before adopting large-scale implementation efforts.
- Bear in mind that meteorological factors are but one of numerous effects of climate change. Environmental conditions are important modulators of vulnerability, and therefore shape the intensity and extent of phenomena detrimental to health. Communities in the developed world, who have appropriate services and resources, are able to deal with certain types of impacts without suffering major loss of life, though the property losses resulting from meteorological events can be similar in magnitude to those experienced in communities within developing countries.

These principles are universally applicable in evaluating adaptation strategies.

### Political and administrative factors affecting health

Present-day food production, as well as the positive results of “green revolutions” and improved food-preservation techniques, signals an enhanced capacity to provide an adequate supply of safe and appropriate foods.

The challenges of global warming, however, will require significant changes in agriculture, livestock-raising, fishing, and other areas of food production. Adaptations will be needed in these areas to prevent climate change from adversely affecting human health and the environment and to ensure an adequate and continuous supply of food, both to meet the needs of the planet’s current 7 billion inhabitants and to provide for the food and health needs of the approximately 9 billion people who the United Nations estimates will inhabit the earth by the year 2050.

Managing the food, agriculture, livestock, fisheries, and forestry sectors will require adaptation to the new climatic geography created by the global warming now under way. Only then will it be possible to achieve durable, sustainable production, particularly in regions with marginal soil quality, scarce water, and growing populations.

### **Hunger and malnutrition remain critical factors in the proliferation of disease and social unrest in many communities in the region.**

As mentioned earlier, human activities related to food production are affected not only by global warming but by the actions of people and groups responsible for decision-making, whether officially or in a private capacity. There is a broad and varied spectrum of activities linked in one way or another with agriculture and its effects on human health.

Land-use and other policy decisions designed to maintain the environmental patrimony of each country and region, beginning with those related to deforestation and the degradation of jungles and forests, have fundamental implications for human health.

As noted earlier, the loss of forest and jungle means the destruction of habitat for species that prey on the vectors and transmitters of disease. To address this issue, and in the interest of reducing CO<sub>2</sub> emissions, initiatives such as REDD (see Reducing Emissions from Deforestation and Forest Degradation at [www.un-redd.org](http://www.un-redd.org)) should be studied, as recommended in the Report of the Conference of the Parties to the United Nations Framework Convention on Climate Change.

REDD measures and related policies could also serve as the basis for national health policies in the region. Indeed, REDD has the potential to become an important catalyst for slowing deforestation and helping to eradicate poverty in jungle regions such as the Amazon, as well as in wooded and mountainous areas. Here, for example, mice from the temperate forests of South America would not invade populated areas if their original habitat were preserved, thus preventing the spread of hantavirus—a consideration worth bearing in mind, given the practice of burning forested and mountainous areas to expand the agricultural frontier, make room for urban development, and clear the way for road and highway construction.

Policy decisions should be designed to keep the natural landscape largely unaltered, particularly in environmentally fragile areas. At the same time, adaptation strategies should be developed to mitigate the effects of climate change on the nature and biological diversity of ecosystems. The IPCC's 2002 technical note on climate change and biodiversity contains information for decision makers working in the field of public health and establishes frameworks for understanding the links between health and biodiversity. The successive reports of the IPCC add updated information from each evaluation period on new discoveries and research on the relationship between the environment and human health.

The scourge of deforestation affects all forms of security (physical, hydrologic, food) associated with human well-being and the health of communities. Major disasters entailing loss of human life and property, exacerbated by extreme events such as storms, intense precipitation, large hail, tornados, heat waves, and drought, have made it clear that heavy deforestation, undertaken merely for profit, is an impediment to sustainable development, leading to the loss of essential resources such as soil and water.

The use of biomass as a direct or indirect input for producing biodiesel and ethanol for vehicles and agricultural and industrial equipment is widely recognized to have social and economic impacts that merit study, due to factors such as:

- higher prices for foods of plant origin;
- uncertainty about the total sequestration of the carbon dioxide emitted by the “new” biomass slated to replace the biomass currently used to produce biofuels;
- the fact that conventional (including thermoelectric) energy sources are needed to produce a fuel whose per-volume energy yield is inferior to that of fossil fuels;
- the displacement of agricultural production, often for basic foods in the popular diet such as beans and rice, which are staples for much of the region's population and as well as export products;
- increased scarcity of water, caused by the water requirements of crops used for biofuels, in areas where water shortages already exist and/or are expected in the future; and
- the shortage of fresh water and water suitable for irrigation.

A 2008 FAO study analyzes the pros and cons of this type of bioenergy production. The fact that over 1 billion human beings are undernourished, with 12 million dying of hunger each year, and that over 1.2 billion people lack access to safe water casts serious doubt on the assumption that biofuel production is an inevitable and reasonable consequence of the high price and scarcity of fossil fuels. Any proposal involving the generation of bioenergy must therefore be analyzed giving due consideration to local conditions, particularly since such production makes use of plants and seeds used for human consumption.

Another issue, mentioned earlier, is the uncontrolled use of agrochemicals. As far back as 1987, the Brundtland Report (90) highlighted the effects of chemical substances on human and animal health. Recent works, such as “*La problemática de los agroquímicos y sus envases. Su incidencia en la salud de los trabajadores, la población expuesta y el ambiente,*” (91) show the effect of poorly chosen, and even more poorly sprayed, agrochemicals on human health.

National and regional political action to consolidate environmental protection activities should be coordinated through: regional bodies in Latin America and the Caribbean, among them MERCOSUR, the Secretariat for Central American Economic Integration (SIECA), the Andean Community of Nations, and the Caribbean Commonwealth; national organizations, such as ministries and secretariats that oversee public health, social action, environment and development, water resources, and economics and finance; and participatory social movements and nongovernmental organizations. Such coordinated action would buttress social and economic factors and policy measures that promote good health.

Based on the information presented in the preceding paragraphs of this chapter and the references provided, the following policy actions to promote health security for the region's population are recommended.

## General health

Applying the Hippocratic principle to the idea that health is a function of the environment and the seasons:

- National and regional authorities should promote and support the preparation of morbidity and mortality studies and statistics linked with the relevant environmental characteristics and realities.
- Specifically, these authorities should identify the particularities of each region's and subregion's weather and climate in order to define the medical geography of each area within the territory.

With regard to the information that should be made available in public health centers, hospitals, and research and development institutes, the lead government health organization should:

- Coordinate work on the various effects of weather, climate, and water resources with meteorological and hydrologic services, research institutes, and public and private universities, viewing these aspects as interdisciplinary challenges bearing on the population's health, vulnerability, and adaptation potential.
- Carefully monitor air and water quality and their health effects, and track the general health of the population. Authorities should also promote interdisciplinary studies to examine the factors exacerbating air and water pollution, as well as soil contamination, in an effort to protect health and well-being.
- In coordination with the above-mentioned centers and institutes, develop models to predict conditions that could adversely affect health and well-being. Drawing on medical experience, studies should be undertaken to identify ways of preventing diseases linked with the environment.
- Develop a warning system for weather and climate events and processes capable of exacerbating specific health conditions (e.g., asthma attacks brought on by allergies due to phenological changes in plants or other allergens, or by ozonifying substances or increased surface ozone).
- Maintain up-to-date information on the quality and quantity of available water, and provide alternatives for effectively and fairly managing water supplies based on needs and availability. Such management should take the new tensions created by global warming into account.
- Promote the development of systems for monitoring environmental variables and for hydrometeorological surveillance and risk management; participate in disaster preparedness efforts; assist in coordinating public and private public health capabilities; and carry out specific tasks during and following disasters, drawing on existing environmental surveillance systems.
- Cooperate with government institutions in charge of air and water pollution measurement systems at the provincial, departmental, and municipal levels to assess related health concerns. Also, they should establish permissible levels of air and water pollution based on WHO guidelines.
- Promote the measurement of meteorological variables of public health concern in various urban and rural areas, with a view to setting criteria for health alerts and ensuring the necessary care during environmental alerts.

With regard to the management of agrochemicals and other pollutants, authorities should:

- Have communications systems in place to inform and educate the general public (with emphasis on the most vulnerable groups —workers, children, women, etc.), as well as health professionals, educators, and decision makers, about the harm caused by improper handling of agrochemicals.
- Provide complete information and thorough training in measures to prevent and protect against acute poisoning and chronic exposure to low concentrations of agrochemical pollutants.
- At all levels of education on health and environment, introduce diagnostic methods and promote the adoption of measures to prevent diseases associated with exposure to agrochemicals and their containers.
- Apply the above measures to the following types of pollution:
  - a) air pollution due to hazardous emissions, harmful gases caused by photochemical reactions, toxic spills, etc.; and
  - b) water pollution resulting from human activity (biological contaminants, chemicals, etc.) and natural pollution (arsenic, fluoride).

- Initiate lines of research to develop better environmental technologies and practices, and implement the operational and logistical changes necessary to ensure that protection measures are feasible and reliable, and that they will be executed without delay.
- Encourage the competent authorities to take the necessary steps to ensure the identification of bottles and other types of containers for agrochemicals and recommend that such containers be barred from reuse by families or communities (e.g., for household water storage).
- Coordinate treatment methods for final disposal of the containers, based on the nature of the materials they were used to contain. Particular attention should be paid to the chemical constituents of agrochemicals to prevent critical chemicals from entering groundwater flows or from being dumped indiscriminately into the environment.

Other factors involved in protecting physical safety include the following:

- The region's public health systems should promote laws and ordinances to:
  - a) prevent access to polluted water sources used for a variety of purposes associated with the public's physical and biological security—for example, fishing, irrigation, leisure, and recreation (e.g., immersion in polluted water during the summertime); and
  - b) reduce emissions of volatile organic compounds that are precursors of ozone formation in the surface atmosphere and are harmful to the health and well-being of humans, animals, and plants.

Efforts to identify and implement policies and measures to reduce the adverse health effects of agricultural activities face a number of constraints, such as lack of basic information (reliable data and statistics). Moreover, the classic science-versus-politics dichotomy, combined with a lack of communication with other areas of science, hinders the adoption and implementation of the health and surveillance measures required to deal with ongoing changes in the environment, while the political will needed to address these issues is sometimes lacking.

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## ■ Notes

- 1 Report of the Argentine Ministry of Public Health (MSP), Argentine Association of Environmental Physicians (AAMA), and Secretariat of the Environment.
- 2 The feedlot is a system for beef production that has been spreading in recent years, in which animals are confined in small spaces and fed with balanced rations, grains and/or preserved forage. The concentration of manure characteristic of these systems leads to the proliferation of flies and other insects that are foci for the propagation of some diseases and, most importantly, serious pollution of both surface and ground water.
- 3 See [www.rap-al.org](http://www.rap-al.org), 2011.
- 4 First Directing Council, 24 September - 2 October 1947. Last amendment approved by the 41st Directing Council of PAHO (Resolution CD41.R8, 30 September 1999)

# Work and health in the Americas

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## ■ Introduction

Over the past three decades, globalization and trade reform have impacted the world over, and the Americas in particular. Although an acknowledged major driver of economic growth, these phenomena have not been accompanied by a comparable increase in employment, as demonstrated by GDP growth, high unemployment rates (1), and substandard forms of participation in the labor market. The economic recession of 2009 not only laid bare the flaws in this business model but revealed the critical role of government in regulating the economy and providing the needed social security and health coverage to a growing number of new unemployed workers and people thrust into the informal economy. The structure and characteristics of the labor market in the Americas differ across countries and regions, reflecting the Hemisphere's diverse cultures and traditions and especially their social, economic, and political development. Also important is how the restructuring of production and trade reforms have been integrated into economic policies. These processes have been cited as a major social determinant of poverty and social inequities in employment and working conditions, impacting not only workers' health and well-being but society as a whole (2).

There are several definitions of social protection, but it is commonly understood as a range of measures designed to secure a basic income for people affected by unanticipated economic downturns, to protect human capital, and to ensure effective participation in economic production and/or provide basic services such as health care, education, and social insurance (3). These are fundamental human and social rights, and providing universal coverage, instead of coverage only for groups in need, is a challenge for most countries in the Region. Universal social protection implies solidarity pacts and the commitment of different levels, ranging from the State to society as a whole, supported by political will and institutions actively engaged in securing funding and other necessary resources and capabilities (4). Social insurance and/or health care are often provided to workers who contribute to a bipartite or tripartite system through specific taxes, with benefits usually limited to formal jobholders (i.e., individuals legally recognized and registered as salaried or self-employed workers). Not surprisingly, morbidity and mortality from work-related illnesses and injuries have increased in the Region, and estimates are higher than those for the developed countries (5). The same holds true for non-occupational illnesses and injuries (6). Therefore, a major challenge for social protection in the Americas is how to provide universal social protection for the unemployed, people who hold informal jobs, and people who toil in the informal economy with its wide range of substandard work, so common throughout the Region.

Our aim in this chapter is to summarize the main features of the working conditions, social protection, and health inequities affecting the poorer groups in the workforce so as to raise awareness about the importance of this issue and give it higher priority in health and social policies in the Region.

## ■ Labor and employment in the Americas

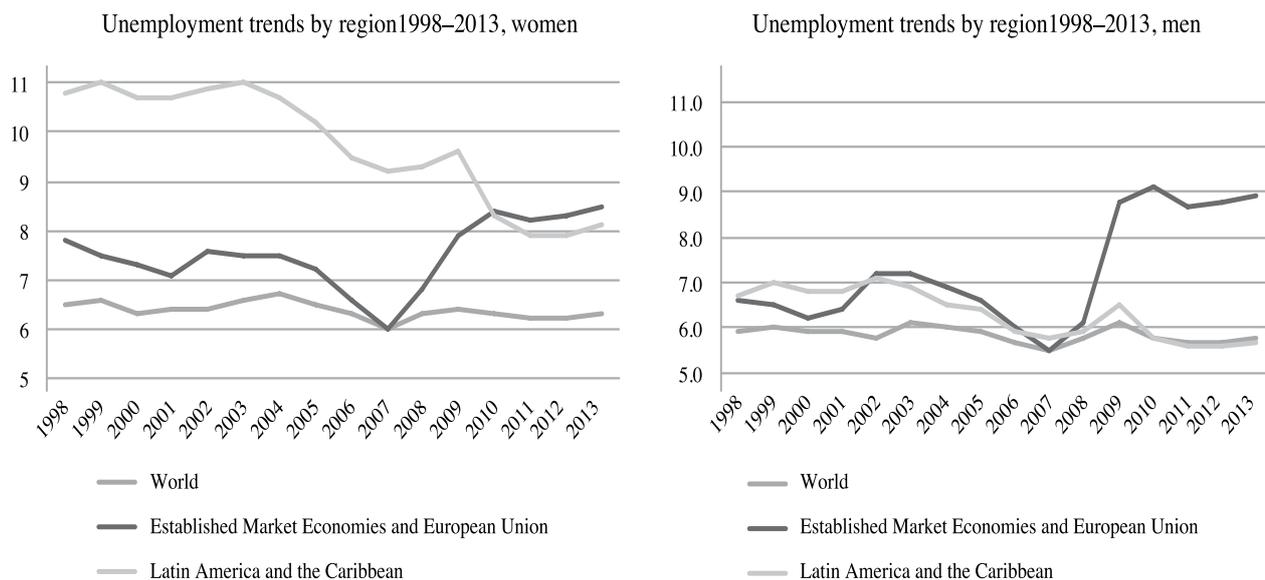
Global GDP was on the rise until 2007, when the economic crisis hit and caused GDP growth to fall from its level of 5.2% to 2.22% in 2009; this was followed by a transient recovery in 2010 (1). Expected GDP growth for 2013 was below 2.5%. A similar trend was observed in the Latin American and Caribbean region (LAC), where the average growth rate of 2.1% to 5.7% between 2003 and 2007 was followed by a rate of 1.6% in 2009 (1). While the decline in global GDP from 2007 to 2008 was steeper than in LAC, slower recovery was observed in the region subsequent years. The formerly positive economic trend in the region was followed by a reduction in unemployment from 8.5% in 1998 to 7.2% in 2007 (Figure 21-1); unemployment rose to 7.8% in 2009 (7), falling to its lowest level in 2012 despite the decline in the growth rate. In 2011, approximately 18.7 million workers in Latin America and the Caribbean were unemployed (33). In 2013, roughly 1.2 million workers are expected to have lost their jobs in these countries, harder hitting agriculture and industry, which are labor-intensive and involve mainly poor groups (8). The global crisis is also affecting male employment more than female employment, and while the global trend in the unemployment rate was roughly the same for men and women until 2012, the increase in the rate over the past two years has been higher among men than women (Figure 21-2).

**Figure 21-1.** Unemployment (%) trends in the world, established market economies, and Latin America and the Caribbean, 1998-2013



Source: ILO, [http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms\\_101461.pdf](http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms_101461.pdf) (8)

**Figure 21- 2.** Unemployment rate in the world, established market economies (EME), and Latin America and the Caribbean, 1998-2013, by sex.



The economically active population in the Americas is steadily growing, increasing the demand for jobs. Overall, employment in the Region grew from 1998 to 2012, increasing from 57.9% to 61.9%; however, among men, it fell from 75.4% to 75.1%, while among women, it rose from 41.2% to 49.4% (7). While the worldwide male employment rate fell from 80.5% in 1996 to 77.1% in 2012 (-3.4%), the decrease in Latin America and the Caribbean was greater, from 81.6% to 79.5%, a -2.1% change in the course of a decade (9). Among the economically active population in Latin America and the Caribbean, the proportion of wage and salaried workers increased by (61.6% to 64.2%) between 1996 and 2009 (1). In another direction, self-employed workers decreased among both men (37.5% to 35.7%, a variation of -1.8%) and women (32.5% to 31.6%, a variation of -0.85%), but no relevant changes occurred among contributing family workers in the region during this period.

## ■ Informal economy and other types of precarious work

A significant feature of the labor market in the Americas, especially Latin America and the Caribbean, is the informal economy, a heterogeneous group of unregulated and unregistered activities for the production of goods and services beyond State control and characterized by low levels of organization and based mostly on trust (7). In rural areas, it consists of most subsistence farmers and small-scale agricultural producers, while in urban areas, it is made up of street vendors, domestic workers, and home-based or family-owned businesses (3) involving quasi-legal, non-legal, or illegal activities (10). Nevertheless, the informal economy is closely tied to the formal economy, sometimes through linked production chains involving multinational corporations (11), and it has been associated with hazardous environments that affect workers' health (12). Workers in the informal sector usually lack social protection and have limited access to health care, compromising their health status. In terms of occupational health and safety, workers in the informal sector rarely benefit from labor inspections, which are commonly limited to registered businesses. Lack of training opportunities and weak unionization also reduce the bargaining power of workers to negotiate healthier, safer workplaces. Informal production is also recognized as a potential threat to the environment, due to the mismanagement of chemical hazards, waste, and natural resources.

The importance of the informal economy to regional wealth, working conditions, and workers' health is unknown. Because of its unregistered nature beyond State control, its contribution to GDP and even workforce participation is only partially estimated by the countries of the Region. Based on ILO data, Table 21-1 presents the trends in informal employment from 1984 to 2010, estimated as a percentage of the employed population. The proportion of these informal arrangements in the labor market was over one-third of the economically active population (EAP) in several countries in 2010, among them Honduras (40%), Paraguay (45%), and Peru (38%). Better situations with

proportions of informal workers below one-third of the EAP were found in Ecuador (31%), Mexico (25%), Argentina (18%), and the Dominican Republic (18%), and in the period for which data were available, most countries indicated a downward trend. In Brazil, where the role of the informal economy in the economy, working conditions, and health is a matter of concern for society and government alike, there was a well-documented decline in the number of informal workers from 1999 to 2008; however, when the global economic crisis erupted, this trend began to turn around (13).

**Table 21-1.** Informal employment (%) in Latin America, 1984-2010

Countries	1984-1990	1990-2000	2008	2009	2010
Argentina	42	39	21	19	18
Bolivia	-	68	43	39	-
Brazil	21	35	-	17	-
Colombia	31	49	14	14	13
Costa Rica	18	33	13	12	-
Dominican Republic	24	45	22	20	18
Ecuador	40	49	38	34	31
El Salvador	47	-	20	20	-
Honduras	-	52	38	36	40
Mexico	42	39	25	25	25
Nicaragua	-	-	21	-	-
Panama	15	30	19	17	17
Paraguay	-	-	46	44	45
Peru	-	-	41	38	38
Uruguay	22	-	8	7	6
Venezuela	27	44	-	17	-

Sources: *Panorama Laboral 2012 América Latina y el Caribe* (7);  
*Women and men in the informal economy: a statistical picture*, ILO 2002 (14)

Precarious work in the region is disproportionately found among Afro-descendant and indigenous workers, and within these groups, mostly women (15,16). Except in Uruguay, where the situation is better, the hourly wage of indigenous or Afro-descendant women is 80% of that of men from the same ethnic group and only 39% of that of nonindigenous or non-Afro-descendant men in six countries with available information (9). An example of precarious work can be found in some textile factories, where virtually all the workers are women, who often report racial discrimination, and the work is organized as piecework. Layoffs of pregnant workers are common, and it is not uncommon for those who retain their jobs to have contact with hazardous substances (9).

High underemployment and unemployment rates make occupational health a low priority for many workers and their organizations or unions, when they exist. Lack of good job opportunities drives individuals into the informal economy or to accept unregistered work contracts, fueling substandard living conditions and poor nutritional and health status. These conditions can result in greater worker susceptibility to the health effects of workplace exposures (9). Furthermore, despite the recent progress of successful initiatives, unacceptable types of labor, such as bonded or child labor, persist throughout the Region. Progress in this area is especially hard to achieve in rural areas, where law enforcement is weak and labor unions and social movements are scarce or poorly organized.

Child labor is considered a human rights violation. Apart from the short-term negative impact on school performance and the higher dropout rates that it entails, child labor damages health (17) and human and physiological capital. It has a long-term impact on the educational level of the population, thus impeding the social mobility of

future generations. Table 21-2 presents data on child labor for LAC countries and the world in 2000, 2004, and 2008. Child labor fell during the eight-year period, declining from 17.4 million in 2000 to 10 million. Correspondingly, the employment of children aged 5 to 14 was estimated at 16.1% in 2000, 9.9% in 2004, and 9.0% in 2008. This is better than the global situation, where child labor fell by only 17.5%. Among working children, boys predominate (Table 21-3), but girls commonly labor in occupations considered inappropriate for children (i.e., domestic employment). Although households would be considered safe work environments, there are reports that sexual abuse and violence against housemaids and nannies are common (17). Based on this evidence, Brazil has deemed household employment a hazardous occupation forbidden to underage children or adolescents (18,19).

**Table 21-2.** Number and proportion of child and adolescent workers aged 5-14 in LAC and the world

Region	Population (millions)			Number of paid workers (thousands)			Employment as percentage of the population (%)		
	2000	2004	2008	2000	2004	2008	2000	2004	2008
Latin America and the Caribbean	108.1	111	110.5	17.4	11.0	10.0	16.1	10.0	9.0
World	1199.3	1206.5	1216.8	211.0	196.1	176.4	17.6	16.2	14.5

Source: [http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms\\_126694.pdf](http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms_126694.pdf)

**Table 21-3.** Child labor as a percentage of the population aged 5-14 in Latin American and Caribbean countries, by sex

Countries	Total %	Male	Female	Source
Bolivia	26	28	24	ETI, 2008
Brazil	3	4	2	PNAD, 2009
Colombia	9	12	6	GEIH, 2009
Costa Rica	5	6	3	EHPM, 2002, UCW Project calculations
Dominican Republic	13	18	8	ENHOGAR, 2009-10
Ecuador	8	7	8	ENEMDU, 2008, UNICEF HQ calculations
Guatemala	21	-	-	ENCOVI, 2006
Guyana	16	17	16	MICS, 2006
Jamaica	6	7	5	MICS, 2005
Mexico	5	6	5	ENOE, 2009, UNICEF Mexico Country Office calculations
Nicaragua	15	18	11	DHS, 2001 data, UNICEF HQ calculations
Paraguay	15	17	12	EPH, 2004, UCW Project calculations
Trinidad and Tobago	1	1	1	MICS 2006, table produced at UNICEF HQ
Venezuela	8	9	6	MICS 2000 data, UNICEF HQ calculations

Definition: A child is considered to be engaged in child labor under the following classification: (a) children aged 5-11 who performed at least one hour of economic activity or at least 28 hours of domestic work during the week preceding the survey, and (b) children aged 12-14 who engaged in at least 14 hours of economic activity or at least 28 hours of domestic work during the week preceding the survey. Data differ from the standard definition or refer only to part of a country but are included in the calculation of global averages.

- No data available

Source: UNICEF, [http://www.childinfo.org/Labor\\_countrydata.php](http://www.childinfo.org/Labor_countrydata.php) (20)

Sexual exploitation is common and involves extensive networks of traffickers in Latin America and the Caribbean, which have become major suppliers for the sex-worker trade in developed countries. Migrants from LAC traditionally travel to the European Union, the United States, and Canada in search of better opportunities. Lately, however, there are flows to other countries in the Region, such as Mexico, Brazil, and Chile, where these migrants

endure poor living and working conditions, are largely unregistered, and receive no social security or health benefits due to their illegal status (9).

Antiquated agricultural production and landholding models have fueled rural conflicts, spreading violence and increasing the violent death rate among farm workers. These rural conflicts are common in remote regions and concentrated among bonded laborers and workers living under conditions of extreme deprivation. In Brazil, the Pastoral Land Commission of the Catholic Church reported 34,538 worker reports of slavery, with 17,983 individuals freed by labor inspectorate officers during the period 1996–2005. It is interesting to note that most bonded workers were found in high-tech agribusinesses, sometimes owned by well-known politicians. Because bonded workers are common in Brazil, malaria, yellow fever, and other infectious diseases in border areas near tropical forests and deforestation areas are work-related (21).

## ■ Occupational risks, illnesses, and injuries

Nearly all the countries lack statistics on employment conditions and workers' health, and when they exist, the data are underreported or difficult to compare because of different definitions (22). Because of their economic importance, labor market indicators are included in census data and other official statistics; however, the information on occupational illnesses and injuries is either unavailable, generally underestimated, or of poor quality, thus limiting their recognition as a priority in health policies and planning (8).

### Occupational risk factors and exposed workers

The lack of reliable computerized data on work-related risks and exposures is more pronounced, making it hard to implement prevention programs in the region. With data from the Global Burden of Disease Study, Murray and Lopez (3) reported that occupational risk factors account for 3.6% of DALYs in Latin American and Caribbean countries—below the figure for other, more developed regions such as established market economy (EME) countries in 2000. Table 21-4 summarizes the DALY contribution estimated in the 2004 study *Global Burden of Disease from Occupational Risks* for the Americas and by UN regions, contrasting it with that of the world and established market economies. The table shows that all proportions in the AMRO region were well below world estimates, except for carcinogens and airborne suspended particulates (24, 25).

**Table 21-4.** DALYs per 100,000 population in the Americas and the world. Global Burden of Disease Study, 2000

Occupational exposures	World		Americas		
	(000)	% Total	Total (000)	High income (000)	Low and middle income (000)
Risk factors for injuries	11612	0.8	772	95	677
Carcinogens	1897	0.1	181	81	100
Airborne particulates	6751	0.4	590	251	339
Ergonomic stressors	898	0.1	87	28	59
Noise	4509	0.3	314	123	191

Source: WHO (26).

Asbestos, known to be a significant occupational risk, is still produced in many Latin American countries, among them Argentina and Brazil, where its production and trade increased between 2007 and 2011 by 6% and 19%, respectively (27). Pesticides are known to be widely used throughout the Region of the Americas, but safe practices among rural workers and agribusiness in Latin America and the Caribbean are rare. Noteworthy is the

initiative to develop exposure matrices for application at the population level, like those created for pesticides in Costa Rica (28) and for silica in Brazil (29); these initiatives opened the way to monitoring exposure, developing prevention programs, and estimating their impact. Also worth noting are the ongoing efforts from 1996 to 2012 to develop a Latin American and Caribbean version of the Cancer Exposure job matrix, a component of the International Information System on Occupational Exposure to Carcinogens. An oft-forgotten occupational risk is hiring conditions, which can be understood as the way workers are inserted in the labor market and therefore eligible (or ineligible) for welfare, health insurance, and other indirect nonwage work related benefits.

## Occupational illnesses and injuries

Official epidemiological data on occupational illnesses erroneously indicates that occupational illnesses and injuries are not a priority in developing countries, whereas other health problems, such as infectious diseases and violence, rank high in public policies and health investments. Recent WHO data show that the quality of only 39.6% of the available mortality data from the Americas can be considered good (30). Health data are usually of poor quality or incomplete, and the situation is worse for occupational illnesses and injuries. In Brazil, for instance, a review of studies on fatal work injuries revealed underreporting as high as 95% (18). Most occupational illnesses are diagnosed as such only for workers covered by workman's compensation benefits (22). Only a few countries in the Region have structured compulsory notification of work-related illnesses and injuries; among those that do have registries, the infrastructure for enforcing labor law is inadequate, which contributes to underreporting. Moreover, workers with informal employment contracts are usually not covered by health information systems (22). In addition, the extent of the economic burden of occupational health risks is unknown. This lack of information decreases the social visibility of this public health problem, resulting in the low priority of prevention programs in occupational health and research on this issue, fueling a vicious circle. Unfortunately, business operators and employers are not fully aware that prevention programs can reduce risks and prevent injuries and illnesses, thus leading to greater productivity. Most of the available information on work-related illness comes from workers' compensation registries limited to prevention, which requires early diagnosis.

In addition, as a result of the chronic unfair management of labor protection, workers usually demand risk-related wage compensation rather than effective prevention programs or healthier, safer workplaces. The available health information systems reinforce these distortions while concentrating on ill-health data instead of data on occupational or environmental risks, which are rarely available or limited to a few major corporations (31). The belief that health risks are inherent to work or natural in the work experience is shared by workers, even in high-risk trades such as construction (32).

The Commission on Social Determinants of Health, a WHO initiative, noted the relevance of this type of poorly understood health risk. Table 215 shows some of the main findings of studies on the health effects of informal jobs conducted in Latin American and Caribbean countries. Data are limited to these countries because of differences in definitions and measurements. Although there are no statistically significant differences between formal and informal workers in terms of fatal and nonfatal work-related injuries, several studies found a relative excess of cases of mental disorders, particularly depression and minor psychological disorders, among women who hold informal jobs. Other conditions include chronic diseases, cirrhosis, and musculoskeletal disorders (33).

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**Table 21-5.** Main findings of studies on health effects of informal jobs

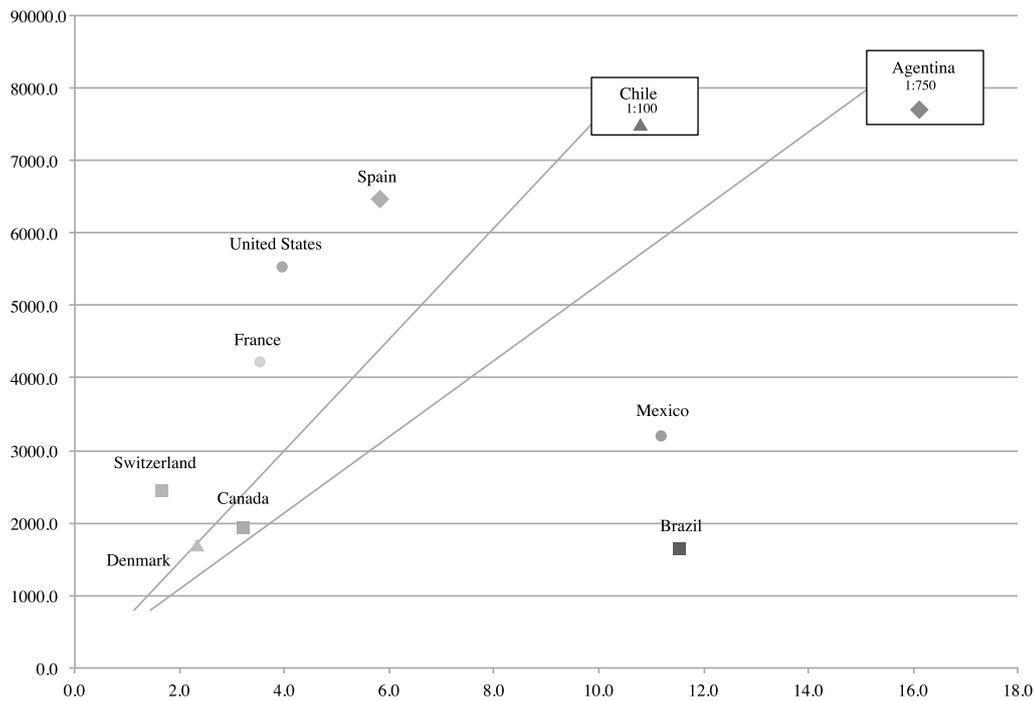
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<i>Authors</i>	<i>Place</i>	<i>Population/design</i>	<i>Findings</i>
	Nicaragua	National survey.	Formal jobs increase.
Hernandez <i>et al.</i> , 1996 (34)	Mexico, Mexico City.	Street vendors from selected farmers' markets. Cross-sectional.	Access to child care was limited for women street vendors who must leave children at home under the supervision of older brothers and sisters. The children of informal workers have a higher proportion of gastrointestinal diseases and injuries compared to the general population.
Santana <i>et al.</i> 1997 (35)	Brazil, Salvador	Cross-sectional study (534 households, 677 adult women).	Women with informal jobs have a higher prevalence of minor psychological disorders than their counterparts.
Sales, and Santana, 2003 (36)	Brazil, Salvador	335 women who have a paid occupation. Community-based survey.	"Sadness/fatigue," "poor concentration," "palpitations," and "aggressive behavior" were more common among housemaids, mostly informal workers (83%), than formal workers. The association was higher among those at young ages (age 14-26)
Santana, <i>et al.</i> , 2003 (37)	Brazil, Salvador	1,650 working women, community-based cross-sectional study.	Domestic workers with no formal job contracts were at higher risk (cumulative annual incidence=8.3%) of nonfatal occupational injuries as compared to formal workers working in the same job (5.8%), $p < 0.05$ .
Ludermir <i>et al.</i> , 2002 (38) Ludermir <i>et al.</i> , 2005 (39)	Brazil, Pernambuco	621 adults from a random sample of an urban area. Cross-sectional study.	The prevalence of minor psychological disorders among blue-collar workers was more than twice as high as in the control group (OR=2.21; 95% CI 1.1-4.5). In another analysis of the same study data, the authors report that this association is limited to women (OR=2.66, 95% CI 1.1-6.3).
Iriart <i>et al.</i> , (2002) (40)	Brazil, Salvador	Qualitative study based on in-depth interviews of 17 workers.	Workers reported considering formal jobs higher-status employment, stating that work in the informal economy undermines self-esteem but is not related to occupational injuries.
Noe <i>et al.</i> , 2004 (41)	Nicaragua, Managua	3,801 injured workers from emergency rooms.	Over 60% of all cases have a job outside formal workplaces.
Santana <i>et al.</i> , 2004 (19)	Brazil, Salvador	Cluster area sample of an urban area. Community-based cross-sectional study.	The incidence rate of nonfatal occupational injuries did not differ across informal 5.6/100 full-time equivalent workers (FTE) and formal workers (IR = 5.1/100 FTE).
Giatti & , Barreto, 2006 (42)	Brazil	National population survey of the six largest metropolitan regions in 2003 (n=39,925).	Informal workers were more likely to report poor self-perceived health, workdays lost, sick leave, chronic diseases, and medical consultations in the past 15 days than formal workers; They were also less likely to have medical consultations in the past 15 days or during the preceding year.

<i>Authors</i>	<i>Place</i>	<i>Population/design</i>	<i>Findings</i>
Giatti <i>et al.</i> , 2008 (43)	Brazil	National population survey of the six largest metropolitan regions in 1998.	The prevalence of depression was higher among part/full-time workers without social security coverage compared to full-time workers with coverage. Short- or long-term unemployed people were more likely to report depressive symptoms than the control group. Part-time workers covered by social security have a higher prevalence of tendonitis, arthritis and rheumatism, cirrhosis, and depression than full-time insured workers; part-time workers without social security coverage have a higher prevalence of arthritis and rheumatism, bronchitis/asthma, heart disease, cirrhosis, depression, and chronic diseases. The long-term unemployed were more likely to report arthritis and rheumatism, bronchitis/asthma, cirrhosis, and chronic diseases.
Da Silva <i>et al.</i> , 2006a (44) Da Silva <i>et al.</i> , 2006b (45)	Brazil, Rio Grande do Sul	Ragpickers and a nonragpicker neighborhood matched control group. Comparisons were also made with a sample of the city population (Pelotas, Brazil). Cross-sectional design.	Ragpickers more frequently reported repetitive tasks, and awkward postures, particularly squatting, than both control groups. The prevalence of lower back pain and pain in the upper and lower extremities did not differ from that of the neighborhood control group, but both estimates were higher than the prevalence in the general population. Women in the ragpicker group were more likely to report all symptoms under analysis than men, even after adjustment by age and marital status. The prevalence of minor psychological disorders was higher among ragpickers than in the neighborhood control group.

WHO has estimated that only 25% of work-related accidents and 5% of all occupational illnesses are recorded in the region (46). In total, Latin America reports 30 million work-related accidents every year, with an estimated 240,000 deaths, excluding those occurring in the informal economy. The ILO estimates the economic impact of work-related injuries and illnesses at 4% of GDP in the region (33). The construction, agriculture, mining, and chemical industries together are responsible for 140,000 work-related deaths each year. Low technology and a limited culture of prevention are concerns in the agricultural sector, where injury rates throughout Latin America are high (9).

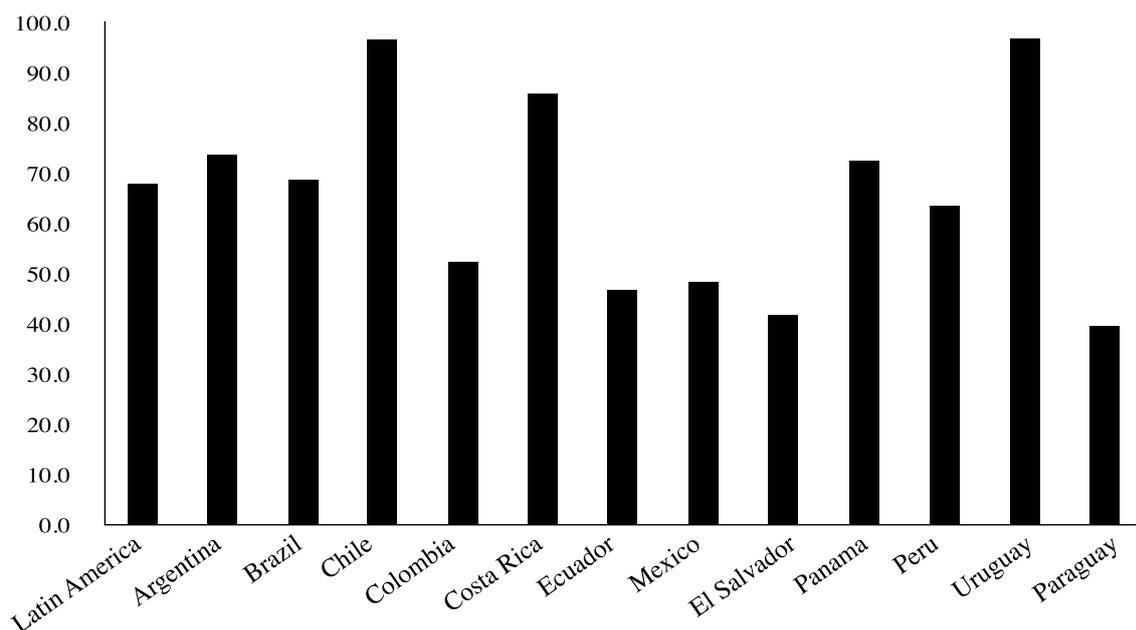
Figure 21-3 shows the official nonfatal accident rate in selected countries of the Americas and Europe (33). The Y axis shows the rate of work-related accidents, with Brazil and Mexico at almost the same level as Denmark and Canada and even below that of the United States and Spain. However, if we look at fatal occupational injuries, which are a sound indicator of safety conditions, the rates of the four Latin American countries presented are higher than those of the other countries. This figure also offers a way of estimating the nonfatal injury rate if the fatal injury rate is known. The two lines represent the expected nonfatal injury rate if it is assumed that each death represents 750 or 1,000 nonfatal injuries, as reported in the literature. The countries below these lines have problems with recording nonfatal occupational injuries, and the difference in the tick line represents the underestimation of accident rates.

**Figure 21-3.** Fatal and nonfatal occupational injury rate in selected countries 1991-2008

Using indirect methods to estimate the frequency of occupational illnesses, ILO has estimated that 300 to 500 of every 100,000 workers develop an occupational illness every year. This contrasts with official reports from the Latin American countries where records are available. For example, the cumulative annual incidence of occupational illnesses in 2005 was 35 per 100,000 workers in Mexico, 26 in Venezuela, and 79 in Colombia. However, in Argentina, the diagnosis of occupational illnesses increased from 20 per 100,000 workers in 1996 to 180 in 2007, a frequency similar to that reported in European countries. Most of the countries report hearing loss and pulmonary disorders as the main problems, which are more easily recognized than other chronic effects with long latency periods. Diagnosis of musculoskeletal disorders associated with new technologies is still rare, as is recognition of psychosocial effects (22).

## ■ Social protection

The closing decade of the last century marked a period of reform in the social security systems of certain countries in the Americas, whose models originally followed the employment-based Bismarck model developed in Europe in the late 19th century. In contrast to the developed countries, not all wage earners in poor countries are covered by health and social insurance. It is estimated that only 67.9% of the employed urban population is protected by social security, including health care and workman's compensation benefits. The worst situation was observed in Paraguay, where in 2006, only 40% of the employed population was covered by insurance, followed by El Salvador, with 42.4%, in contrast to the more than 80% coverage in Uruguay, Chile, and Costa Rica (Figure 21-4) (33).

**Figure 21-4.** Social security access in selected countries, 2011

Source: OIT, 2012 (7)

Several countries in the Region followed Chile's lead in setting up individual defined-contribution accounts as a replacement for state-run pension systems, based on the premise that there is no guarantee of the long-term stability of these systems in the face of new social needs. Other countries embraced mixed systems or have made individual accounts optional and supplementary. Workers' compensation plans were also redesigned in some countries, with Colombia representing the private model.

Over the past decade, the paradigms introduced in the 1990s have been called into question and modified. The challenges of an aging population increased unemployment, which, in turn, increased poverty, exacerbated the situation of migrant workers, increased informal employment, and heightened dissatisfaction with the portability of pensions, health coverage, and family protection —issues that were the subject of rancorous debate by critics before and after the reforms. For example, unemployment insurance is not widely available in poor countries, and it is usually limited to workers who lose formal jobs covered by this social benefit. However, wage earners account for less than half of the economically active population in urban areas, and the situation in rural areas is even worse. Access to health care is restricted to workers covered by private health insurance, and public health services are scarce (4).

Workers' protection against occupational hazards is governed by labor legislation that sets occupational health and safety standards. Unfortunately, compliance with regulations is rare and limited to the few registered companies and formally employed workers.

Certain countries, such as Chile and Argentina, have begun reviewing their pension systems in order to introduce new reforms that will guarantee the long-term sustainability of benefits and facilitate wider coverage. Chile has planned to reform the current system by improving it, without altering the national structure adopted in 1981. Argentina has recently approved an additional reform of its pension system, introducing improvements and defining the role of the system's public and private components. Mexico, in contrast, has continued to reform specific systems to integrate a social security structure with greater private participation.

Growth of the informal economy has increased the number of non-contributors and non-taxpayers, as well as evasion and underpayment of premiums, intensifying the crisis of formal social security systems. Furthermore, as a result of recurrent economic and political crises, most governments have been obliged to allocate resources to

programs to reduce poverty, child labor, unemployment, and informal employment and to extend social coverage to those excluded population groups. Not uncommonly, social security benefits are provided to low-income non-contributors. Welfare experts have voiced concern about the sustainability of this mixed-funding model, which combines contributions with general taxation.

Globalization has also affected social security systems. In Latin America, the Southern Common Market (MERCOSUR) has laid the foundation for a new wave of reforms and the harmonization of regulations. Another model of a community is the CARICOM Agreement on Social Security. The Ibero-American Multilateral Agreement on Social Security, still under discussion, will guarantee the security of migrant workers and their families in Latin American countries.

## Prevention

In nearly all Latin American countries, occupational health activities are the responsibility of three ministries: labor, health, and social security. The ministry of labor issues regulations on hygiene, safety, and occupational medicine and performs inspections through its regional units. The ministry of health, social security, and/or private services provides medical care for workers who are injured or develop occupational illnesses, and, in some cases, these ministries have surveillance programs for certain occupational illnesses. The ministry of social security and/or private insurance companies provide rehabilitation and compensation for affiliated workers. Despite a decline in the number of workplace injuries in recent decades, some studies have shown that working conditions have not improved and, on the contrary, have worsened in some trades. Changes in social security laws have discouraged the reporting of occupational injuries and diseases (47,48). In Brazil, occupational injuries and illnesses have been included in the national mandatory disease notification system since 2004, but these health problems are still largely underreported. Interestingly, once epidemiological information on the relative excess of health-related compensation benefits by specific trade was made available to occupational physicians at the country's National Social Security Institute, there was a substantial increase in the number of work-related diagnoses (49). A year after this system was implemented, there was an overall increase of 148% in work-related illnesses and health compensation benefits (50).

Enforcement is another problem in the Region. Officials, who are government employees, have trouble enforcing work regulations and labor laws. They generally have no professional training in occupational health, industrial hygiene, and/or safety, and thus, the successful application and implementation of control measures is limited. In Brazil, for example, there are reports showing understaffing of labor inspectorates and poor enforcement of mandatory workplace surveillance (51), as well as a lack of financial autonomy for company occupational health and safety programs (52). The legislation in most countries requires employers to comply with prevention programs based on the number of employees and the activities of each company, and it entails the obligation to form bipartite committees; furthermore, companies with 100 or more workers are required to have health and safety services.

Most insurance or mutual companies offer advice on implementing health and safety programs based on a diagnostic study designed to lower accident rates. Since they do not have enough experts to advise all of their clients, most insurers have sought to boost the capacity of their member companies. ART Prevention of Argentina has developed an e-learning system for all covered workers to intensify training activities in the area of occupational risk. AP Colmena in Colombia has also set up a training program targeting different levels of organizations to reduce and eliminate occupational hazards. Peruvian Pacific Life Insurance has interesting benefits involving visits to improve its services to companies and their insured workers. With mentoring by experts from the ACHS, it offers a risk prevention service program that includes technical visits to companies to identify workplace hazards. It also provides training for insured companies through lectures and seminars on occupational hazards for risk-prevention staff.

## ■ Research

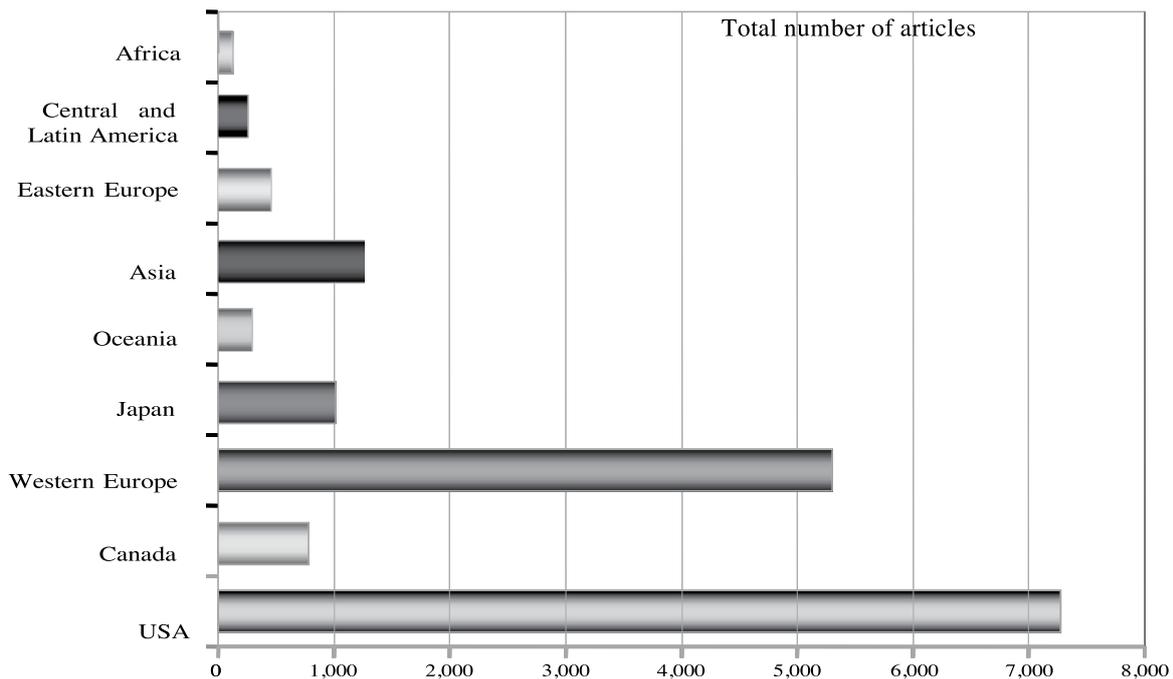
Occupational health research could play an important role in furthering our understanding of work and health problems in Latin America. Research can not only guide us toward recognition of the dimension and severity of health problems, but also their management and prevention. However, in Latin America, where occupational and environmental illnesses and injuries may play an important role in the burden of disease, research capabilities are poorly developed in comparison with those for infectious or chronic noncommunicable diseases; this is probably due to lack of knowledge about the actual dimensions and severity of work-related health problems and the chronic

absence of workers' health on the health policy agenda of Latin American and Caribbean countries. This not only affects access to occupational health care and services but also funding for research and, thus, researchers' motivation to study this area. This situation may be deteriorating even further owing to the reduction in the number of formal workers and the weakening of their representatives, labor unions, which clamor for scientific knowledge to support their demands for better workplace safety and health conditions. Scarce funding for occupational health research may trigger a vicious cycle, in which the lack of opportunities for research, practice, and education leads to a shortage of qualified personnel, research centers, laboratory facilities, and good-quality studies and publications.

Local research on workers' health is needed to furnish knowledge about health problems that are no longer of interest in industrialized countries, where workers benefit from better labor relations, working conditions, and respect for their social and human rights. Unregulated, ill-defined workplaces and informal employment contracts make it hard to conduct studies on a substantial portion of the workers in LAC countries. For example, domestic workers comprise the largest female occupational group in most LAC countries. Their working conditions are known to be poor; however, there are only a few studies to back this up, and no occupational health and safety programs have been devised for this group. In addition, basic work-related epidemiological data are scarce, limited to few insured workers, or largely underestimated because of underreporting.

With a few exceptions, there is a marked dearth of published occupational studies on potential hazardous exposures. Limited studies on occupational illness in agriculture, mining, and manufacturing suggest a high prevalence of work-related illnesses in the exposed populations. Well-known hazardous exposures in mining, construction, and nontraditional agricultural activities are still a problem. Although there is no need to repeat research to demonstrate what is already known, there are situations where interventions and their evaluation are needed more than original research. A detailed scientific evaluation and research on innovative risk control programs could foster better choices in terms of health investments, lowering costs and achieving greater effectiveness.

**Figure 21-5** Bibliometric analysis in the field of preventive and occupational/environmental medicine, 1995-2003



**Source:** Soteriades and Falagas (53)

Positive changes have recently occurred, with a growing number of indexed scientific publications from LAC countries on occupational health and safety. Several consolidated groups of researchers in Argentina, Brazil, Chile, Colombia, Cuba, Ecuador, and Mexico have contributed to the analysis of working conditions from the standpoint of social medicine (54). The growth of graduate programs in social or public health and the burgeoning of research groups and projects and international collaboration have intensified research efforts and outreach for the develo-

ment of workers' health development (55). Several groups have focused on the social determinants of illness and death, the impact of social policies such as privatization and public-sector cutbacks, occupational and environmental causes of disease, critical epidemiology, the mental health effects of political trauma, the impact of gender, and collaboration with local communities, labor organizations, and indigenous people. Some international multisite studies, such as those of the Fogarty Foundation International Training on Occupational and Environmental Health initiative, have also bolstered research and research capacity in the Hemisphere (56).

In some countries, occupational epidemiologists have contributed to recognition of the magnitude, severity, and costs of some of the problems in the Region. Some research groups have contributed to an understanding of working conditions and potential hazards in the Region, as in the case of the study on pesticide exposure, effects, monitoring, and control in Costa Rica (28,57,58). The enormous number of informal workers in Latin America has led to an increase in studies on this topic, as seen in Table 21-5. There is also a growing body of qualitative occupational health research that is yielding useful and important insights into workers' perception and understanding of health and risks (40), their view of disease, and exposure monitoring and control (59).

In addition to the contextual analysis of occupational health, there is a need for rigorous research on the inherent nature of occupational health in societies marked by deep social inequalities. Of particular interest is equity in the provision of occupational health care and safety measures—specifically, how to provide workplace surveillance and protection against occupational health risks to the entire workforce, achieving universal coverage and giving priority to the more destitute groups. Some countries are employing strategies that integrate occupational health and safety into primary health care, family health, or community-health practices. However, the feasibility and effectiveness of such strategies has yet to be evaluated. Workers' voices and involvement in occupational health and safety policies and programs are needed beyond the traditional collaboration with labor unions. Social movements, for example, have played a key role in banning child labor, and some churches are preventing violence against small farmers and rural workers. Small businesses, which represent the majority of enterprises, both formal and informal, require special innovative inspection and surveillance strategies. Little is known about their organization, management of occupational health and safety problems, occupational risks, or how to engage them in effective prevention programs.

Assessments of new hazards to a population with a history of endemic factors for ill health are required. The issue of financing is not a trivial one. Donor agencies usually set their own priorities, which do not always coincide with local priorities. Moreover, some ethics and autonomy issues could make it hard for researchers to secure external funding. Universities usually provide an unfettered environment; however, occupational epidemiology research should not be viewed as an academic exercise but part of a major undertaking to develop innovative occupational practices and foster major social change.

## ■ Challenges

The main challenges to workers' health in Latin American countries are related to social protection, ensuring universal occupational health and safety, and developing a culture of prevention. This means it is important not only to popularize knowledge about occupational health and safety but to instill values and daily practices that will help to anticipate health and safety problems and take serious steps to prevent them.

Not only must workers be involved, but entrepreneurs and other relevant social actors as well. The close link between environmental and health issues, particularly in the informal economy, has not been fully demonstrated, and proactive action is scarce and has not been evaluated. Initiatives like solidarity economics, cash transfers, or microcredit programs are not targeting occupational health and safety issues, and nothing is known about how these initiatives may affect workers' health. Social protection for workers is a prerequisite for improving occupational safety and health. In countries with informal economies like those in Latin America, universal health care and workers' health surveillance can improve the health status of workers.

The informal economy and informal workers have been targeted by alternative strategies to provide social protection, health care, and other services, using several mixed approaches that may work differently depending on the local and regional situation (4). Participants at a recent conference on how to extend social health insurance to workers in the informal economy included representatives from 25 countries. The final report of the conference noted the serious undercoverage of informal workers, which is already affecting society and public policies everywhere, and the need to put this issue on the global social development agenda. The report also acknowledged the difficulties of implementing a contributory funding system due to the operational problems involved in contribution

collection and service delivery. For successful initiatives to promote universal social protection and health care coverage, the strong political will, commitment, and legitimacy of governments is a *sine qua non* (3). Some Latin American and Caribbean countries have programs that reach out to informal enterprises and workers to provide health care through family health programs, integration with universal primary health care programs, and community and worker participation in general health and occupational health and safety programs (60), or through sectoral networks for multisectoral action.

Although it is known that today there are innovative initiatives to promote income generation, such as solidarity economics, alternative programs for expanding social security coverage and incorporating occupational health and safety activities for the working poor in primary health care, very limited evaluative research or nonacademic reports are currently available (2). These initiatives are valuable for raising awareness and giving greater voice to social movements in their struggle for better living and working conditions.

Health promotion on a micro scale can save lives and can be based on worker involvement, free association, awareness raising, and training in conjunction with the social responsibility of employers for healthy work environments. The deregulation of labor markets threatens the guarantee of healthy workplaces and access to labor protection and social welfare services. Improving knowledge about these issues and offering opportunities for decent jobs may increase the number of workers with an adequate income, thus alleviating poverty and expanding safe and healthy work environments. This is a major challenge at the international, national, and local level.

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# The generation and buildup of contaminants: Threats to health in the short and long term

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## ■ Introduction

Contemporary scientific output on environmental health and government policies in the health sector of some countries in the Region of the Americas has uncovered a relationship between population health status and the buildup of waste in the vicinity of industrial sites or, often, its disposal in inappropriate locations.

The U.S. Department of Health and Human Services defines hazardous waste as any chemical compound, element, or combination thereof that, because of its quantity, concentration, or physical or toxicological properties, may pose a present or potential hazard to human health or the environment when improperly used, treated, stored, transported, or disposed of.

The U.S. Environmental Protection Agency (EPA) stresses that hazardous wastes are dangerous or potentially harmful to health or the environment and can be found as liquids, solids, gases, or sediments ([www.epa.gov](http://www.epa.gov)). The EPA classifies hazardous wastes under four categories: a) ignitable (i.e., wastes that, under certain conditions, produce spontaneous combustion); b) corrosive (e.g., acids and bases — $\text{pH} \leq 2$  or  $\geq 12.5$ ); c) reactive (i.e., wastes that are unstable under normal conditions or can explode or emit fumes, gases, or vapors when heated, compressed, or exposed to water); and d) toxic substances (i.e., wastes that can cause acute or chronic poisoning and death). Biological and radioactive waste, generated mainly by health facilities such as hospitals, clinics, and research laboratories, can also be included in this classification and entail the additional challenge of a lack of guidance for their proper management in most countries (1,2).

The generation of industrial waste and the negative impact of that waste on the environment and population health are among the principal indicators of the unsustainability of the productive processes responsible for human development in the Region of the Americas and are important areas for research and surveillance in environmental health. Pollution is usually the result of a combination of chemical substances that can affect various aspects of the environment. The adverse effects of such pollution on the health of exposed segments of the population are usually asymptomatic and chronic, which hinders their diagnosis and the understanding of their association with environmental degradation.

The costs of environmental remediation and providing health care to the population affected by pollution are generally high. As a further challenge, in most cases, hazardous waste buildup is detected only once companies have gone bankrupt, a situation that hinders legal action to compensate victims, which is based on the “polluter pays” principle.

Regarding environmental health, hazardous wastes are involved in a range of high-risk situations, from their generation and transport—and it is paramount that there be policies for the prevention, assessment, communication, and management of such risks—to technologies for their treatment, storage, and mitigation of their effects on the environment and, consequently, health. In view of the ample scope of the subject, this chapter will focus on specific aspects of solid wastes that may be of interest to public health administrators and researchers.

## ■ Production processes, waste generation, and effects on health

Human development occurs through production processes that modify the environment and, consequently, the health profile of populations. As part of this development, the natural environment is altered because of production processes that subject nature to economic and social purposes, without consideration of the limits to the environment's survival and, especially, to the survival of human beings themselves (3). These processes include elements of production and consumption in which people, through their ability to work and use various tools and instruments, transform raw materials into goods.

This complex process consists of four main stages. The first is the acquisition of raw materials and their transport to the production site; the second is the transformation of the raw materials into goods, particularly at industrial plants; the third is the consumption of the goods; and, finally, the fourth, which is the focus of this chapter, is the generation of final waste. It should be underscored that waste generation occurs throughout these processes and not just in the final consumption stage.

Regarding production as such, countries are often concerned about major industry—which, *per se*, can generate vast quantities of hazardous waste—without recognizing that it is also critical to monitor small enterprises, which are usually numerous and, taken together, are equally capable of producing vast quantities of hazardous waste. By way of example, based on national data, a landmark study conducted in 1986 in the state of Massachusetts in the United States calculated that approximately 15,500 companies which, in isolation, produced quantities of waste below the threshold required for reporting to the Environmental Protection Agency together accounted for an output of nearly 53,000 tons of hazardous waste per year (4,5).

In order to determine its effects on population health, exposure to waste is generally described in terms of intensity, duration, and frequency (6). Dose is essential for characterizing exposure and its potential adverse effects on health. As noted by Philippus Aureolus Theophrastus Bombastus von Hohenheim (known as Paracelsus, 1493-1541), “All substances are poisons; there is none which is not a poison. The right dose differentiates a poison from a remedy.” A population's exposure to several waste-generating sources determines the cumulative dose or concentration of waste to which it is exposed, as does the target organism, organ, tissue, or cell, based on the multiple possibilities for the absorption of chemical substances through inhalation, ingestion, transdermal contact, or even prenatal transmission. This is particularly important when it comes to children's exposure to waste by virtue of their more frequent and intense contact with polluted environments due to the typical activities of childhood—such as playing, crawling, and eating dirt—and the greater degree of absorption per unit of weight (7). Again in Massachusetts, in 1986 the state's Department of Environmental Management launched a pilot outreach project to expand coverage of small businesses that generated waste, including auto body shops, which use solvents in paint jobs, equipment cleaning, and radiator repair and generate other types of chemical waste such as spent oil from oil changes, paint, brake fluid, and gasoline. The program, conducted through mailings, workshops, inspection programs, and technology transfer, increased the number of self-reports of waste generation from 650 to 1,200 (4).

Accidents and waste caused by the transport of hazardous substances can be associated with road and rail infrastructure, as well as with the modes of transport themselves—i.e., due to the overloading and poor maintenance of trucks (8), lack of driver education, and excessively long workdays. Health-sector administrators should be ready to respond to accidents involving hazardous materials and should have methods in place for the rescue and treatment of victims of such incidents, as well as a network of hospital emergency units for referring victims for medical care (9).

Urban landfills used for the disposal of other types of municipal waste have become a source of concern for municipal, state, and federal governments. Waste is being generated at unprecedented levels, increasing the exposure of waste collection and recycling personnel to chemical substances of varying toxicity, as well as to microbial pathogens, and the risk of trauma. In addition, the decomposition of such waste generates “leachate” or runoff, composed of countless toxic substances that can first affect waste collectors and other personnel who handle refuse

and ultimately, by polluting the various sectors of the environment, the general population. This problem should therefore feature among the main concerns of environmental health professionals (10,11,12).

Waste generation can also occur in the home, as household products (e.g., pesticides, paints and varnishes, medicinal products, auto fluid, batteries, lightbulbs, etc.) are a major component of waste. Another study in Massachusetts estimated that household waste accounted for nearly 5% of all industrial waste produced in the state (13). The authors interviewed a sample of 504 residents, who recognized the problem caused by their garbage and supported passage of a law to impose sanctions on homeowners who did not properly dispose of their waste, as well as a tax to fund the safe disposal of this waste.

Through a Pan American Health Organization project implemented in several Latin American countries (Technical Strengthening of the Pan American Network for Environmental Waste Management) it was observed that the final stage of several production processes took place within a household setting. Gold is found in powdered form, and mercury is employed for its extraction, forming an amalgam that is subsequently burned, releasing the mercury into the atmosphere. In Poconé (Mato Grosso, Brazil), the stage of this process that poses the greatest risk of mercury exposure often occurred outside the customary work environment—that is, inside the home. Câmara *et al.* (2000) observed that the average total urinary mercury content (HgU) of people who were not occupationally exposed ( $n = 365$ ) but lived near establishments that sold gold was four times higher than that of a rural control population (4.35  $\mu\text{g/L}$  and 1.25  $\mu\text{g/L}$ , respectively). In an even more dramatic case, 13 individuals from four families residing in areas not exposed to production processes involving mercury presented with HgU levels of between 7.2 and 86  $\mu\text{g/L}$ ; high concentrations of this metal were also found in soil and dust collected from their dwellings. These individuals reported that they prospected gold on their property and burned the mercury-gold amalgam in their kitchens.

Waste can also contaminate the food consumed by specific populations. For example, foods such as oysters and blue mussels in the Gulf of Paria along the coasts of Venezuela and Trinidad and Tobago (14) and fish in the Amazon region exhibit high concentrations of methylmercury, due to the contamination of river sediments (15,16). Ortiz Pérez *et al.* (17) concluded that, after domiciliary deltamethrin spraying in areas with high malaria prevalence in Mexico, levels of this substance in soil samples were slightly higher inside dwellings than outside of them. The authors also demonstrated the exposure of children in these areas by measuring the deltamethrin metabolites 3-phenoxybenzoic acid and *cis*-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropanecarboxylic acid in urine, finding elevated levels.

At all stages of production processes, people—both workers and other segments of the population at large—are exposed to different types of waste and can be subject to poisoning or chronic illnesses with varying mortality and case fatality rates. For example, exposure to persistent organic pollutants may be associated with higher rates of stroke, dyslipidemia, and thromboembolism (18). People are also exposed to illness and injuries stemming from the production and transport of raw materials and their products. Between 1993 and 2000, Shcherbatykh *et al.* conducted a study in New York State and compared stroke rates in households located in areas (delimited by ZIP code) containing hazardous waste sites. The authors concluded that, after adjusting for sex and ethnicity, the incidence of stroke in areas with waste sites was 15% higher than in areas without such sites (relative risk, 1.17; 95% confidence interval 1.04-1.31).

In El Paso, Mexico, Díaz-Barriga *et al.* (19) conducted a study on exposure to pollutants from a foundry closed 20 years before and found that children were most susceptible to the health impact of these wastes. Rosado *et al.* (20) studied 602 children aged 6-8 living within a 3.5-km radius of a metalworking complex in the city of Torreón, Mexico, and found an average urinary arsenic concentration of  $58.1 \pm 33.2 \mu\text{g/L}$ ; 52% of these children had a concentration of  $>50 \mu\text{g/L}$ . The authors also confirmed an association with cognitive delays. Carrizales *et al.* (21) evaluated soil lead levels and exposure of children in the vicinity of a foundry in the community of Morales, San Luis Potosí, Mexico, and found that 90% of soil samples contained lead and arsenic concentrations in excess of 400 mg/kg and 100 mg/kg, respectively. Children aged 3-6 had the highest blood lead levels: 90% of concentrations exceeded 10  $\mu\text{g/dL}$ . Urinary arsenic levels were higher in children aged 8-9, whereas the percentages of children with creatinine rates higher than the CDC recommendation of 50  $\mu\text{g/g}$  or the WHO recommendation of 100  $\mu\text{g/g}$  were similar across the different groups assessed.

## ■ Inequality of exposure to hazardous waste

It should be noted that, in these situations, social inequality and the vulnerability of different segments of the population confer different levels of risk, in terms of both the level of exposure to waste and the incidence of adverse

effects on health. Undoubtedly, in the majority of situations involving exposure to hazardous waste, an individual's health plays a key role in host defenses against exposure to highly toxic substances and a better recovery. Taking vulnerability into account, Ayres *et al.* (22) noted that the disease process is the result not only of a series of personal characteristics but of collective and contextual ones that are intrinsic to higher susceptibility and fewer resources of all types for an individual to protect himself.

These issues are described in detail by the United Nations Development Programme (UNDP) in its 2006 Human Development Report, which highlights the worldwide water crisis, emphasizing the ethically indefensible conditions of poverty, hunger, vulnerability, suffering, lack of citizenship, inequality of opportunity, and insecurity that affect a substantial portion of the population in several regions of the world, including Latin America. The indicators reveal that one-third of the global workforce is unemployed or underemployed, 900 million people live in slums, and 10.8 million children die before the age of 5 (850,000 due to nutritional deficiencies). This same report notes that some 1.8 million children under 5 die each year of diarrhea (4,900 deaths per day). Children under 5 account for less than 1% of deaths in developed countries, versus 20% in the rest of the world (<http://hdr.undp.org>).

The association between poverty and heightened exposure and risk of suffering the ill effects of hazardous waste is a fact. A study by the U.S. Government Accountability Office demonstrated a relationship between hazardous waste dumps and the dwellings of poor minorities in the country. This relationship was even more evident in the late 1970s with the landmark Love Canal case (23-25), which was instrumental in putting these issues on the agendas of public health and environmental protection agencies. The United States passed legislation on compensation for victims and decontamination (Cleanup Act), as well as the right to information about present or future hazards in a given neighborhood (Right to Know Act). A "Superfund" was created to fund research and credit programs for citizens to hire specialized technical expertise, and the Agency for Toxic Substances and Disease Registry (ATSDR) was created.

The origins of the Love Canal case date back to 1892, when William T. Love built a canal as an alternative shipping lane to bypass Niagara Falls. After a 1-km length of canal had been dug, the project was abandoned. Love Canal was used as a recreational area for swimming and canoeing up to the early 20th century and was subsequently sold at public auction. During the 1940s and 1950s, a chemical company dumped 21,000 tons of chemical waste (organic solvents, acids, pesticide, and their intermediary products) into the canal. Years later, the area was sold again, and low-income housing was built on it. This continued until 1978, when the lower-middle-class residents discovered that their homes had been built on a canal into which chemical, industrial, and military waste had been buried (23-25). Studies to evaluate mortality among former residents of the canal area did not detect any differences in comparison with other areas of the United States. However, the authors did not rule out the possibility of cardiac and neurotoxic effects, which suggests that serial follow-up of this population could have revealed a different health profile (26).

The Love Canal incident served as a warning for other communities in the United States, including African-American communities, which discovered that their homes had been built on land contaminated with wastes of varying toxicity; this led to movements denouncing "environmental racism" and subsequent calls for "environmental justice." (23-25) Regarding environmental justice, new technologies and production methods continue to affect the population unequally; many authors maintain that high-risk situations unfairly and disproportionately affect the more economically vulnerable social groups, and that this vulnerability is responsible for different levels of health in the population (27).

## ■ Hazardous waste risk assessment

When conducting risk assessments, one of the primary obstacles faced by the environmental health surveillance systems of Latin American governments is the lack of information about the number of polluted sites. In the United States, registration of sites contaminated with hazardous waste is one of the routine activities of ATSDR ([www.atsdr.cdc.gov](http://www.atsdr.cdc.gov)). In Mexico, although there is no national registry to indicate the number of such sites, the University of San Luis Potosí School of Medicine created a statewide program that identified 41 potentially dangerous sites, the majority of them (80%) located on the outskirts of populated areas or in rural zones. In approximately 30% of these sites, the pollution was directly caused by industrial activities; in 30%, by agricultural activities; and in the remaining sites, by landfills, small-scale industry, and natural contamination. Nearly 60% of the sites were contaminated by organic pollutants or a mixture of pollutants, and the remaining 40%, by inorganic elements. In Brazil, between 2002 and 2013, the Environmental Sanitation Technology Company (CETESB) of São Paulo state

recorded 4,771 polluted sites statewide (<http://www.cetesb.sp.gov.br>). Regarding the affected populations, between 2006 and 2014, the Ministry of Health's information system recorded 12,800 polluted areas, with an estimated exposed or potentially exposed population of 41,126,710 throughout the country (<http://portalweb04.saude.gov.br/sissolo/default.asp>). The other Latin American countries need to structure the sectors that monitor health to detect polluted sites, ensure that the health system provides care for exposed populations, and conduct surveillance for the adoption of health promotion, disease prevention, and care measures.

Although research on the risks of exposure to hazardous waste and its adverse health effects and the integration of environmental health into health systems in the Hemisphere are still ongoing, increased scientific output and information obtained through surveillance programs in some countries show that academia, research institutions, and the health sector are capable of conducting research and surveillance to support the detection, prevention, or mitigation of environmental risks caused by hazardous waste that can damage the health of the population.

Several countries in the Region use the method developed by the ATSDR for this purpose (28). This health assessment method takes into account relevant environmental information, data on health effects, and the concerns of communities living in the sites affected by hazardous waste release. The Agency recommends public health actions for residents or workers identified as exposed to hazardous waste in contaminated areas.

Implementation and development of this method in Latin America began in 1992 at the San Luis Potosí School of Medicine in Mexico, whose contributions include a paper published by Díaz-Barriga (29) through the Pan American Center for Sanitary Engineering and Environmental Sciences (CEPIS) that is now being used to identify and prioritize high-risk sites to which the ATSDR method should be applied.

Also important in some situations is the role of epidemiology, a discipline used to assess risk, generally by means of analytical studies in which the occurrence of a given event in two groups is compared in terms of their exposure and the presence of adverse effects on health. The EPA also characterizes the type of public health risks from exposure to hazardous substances, based on the following elements: hazard detection, dose response assessment, exposure assessment, and risk characterization. The product of this assessment is a numerical estimate of consequences to public health.

ATSDR assessments are based on quantitative and qualitative information, include methods for evaluating community concerns, and, at the same time, analyze environmental data and information on health effects. A guide is available that should be followed by a multidisciplinary team made up of professionals from the fields of health, environment, and human services. It is designed to facilitate information exchange and broaden the scope of the pertinent situation analysis.

Table 22-1 describes the stages, objectives, and type of information used for health assessment in locations with hazardous waste. Among its other benefits, this method contributes to health planning; expands registries of exposure data; develops toxicology profiles; produces morbidity and mortality statistics; supports surveillance activities and health education programs; generates indicators for surveillance; provides inputs for the formulation of health recommendations; contributes to the implementation of sustainable policies, producing politically relevant results that can be communicated to exposed populations; sets program priorities; and detects environmental health issues that warrant more in-depth research. The Annex to this chapter includes links to online resources for interested health professionals.

**Table 22-1.** Stages, objectives, and type of information used for health assessment in locations with hazardous waste, using the ATSDR method

<i>Assessment stage</i>	<i>Objectives</i>	<i>Types of information or analytic procedures used</i>
Obtain site information	Determine the historical and current conditions of the site and ascertain the community's health concerns.	Obtain a history of pollution, and basic information; ascertain the community's health concerns; collect data on demographic aspects, land and natural resource use, environmental pollution, and health effects.
Respond to community concerns	Obtain information on the community's health concerns and establish methods for responding to these concerns.	Identify the community members involved; ensure community participation in the assessment process from the outset. Ensure effective communication with the community and other participating groups through the implementation of activities. Request community input on the final health assessment in response to these observations.
Identify pollutants of interest	Identify the pollutants of interest by measuring concentrations at the site and evaluating the quality of environmental sampling data and the potential for human exposure.	Pollutants at and outside the site, concentrations of the pollutants in the environment, background concentrations in the environment, quality of the sampling data and analytical techniques, comparison with environmental assessment guidelines and emissions inventory or ATSDR toxicology profiles.
Identify and assess exposure pathways*	Ascertain each of the five elements of the exposure pathway and determine whether these elements are linked.	Five elements: a) sources of pollution; b) environment and mechanisms for pollutant migration; c) exposure points; d) exposure route; and e) receptor populations.
Determine public health implications	Associate the site's potential for human exposure with the health effects that can occur under these specific conditions.	Estimate exposures, compare the exposure estimates to health guidelines, determine exposure-related health effects, assess the factors that influence adverse health effects, determine the implications of physical and other health hazards.
Draw conclusions and recommend actions	Draw conclusions about the health implications of the site and formulate recommendations.	Draw conclusions and formulate recommendations. Categories: a) urgent public health hazard; b) public health hazard; c) undetermined public health hazard; d) no apparent public health hazard; e) no public health hazard.
*An exposure pathway is complete when all five elements of the pathway exist, linking the source of pollution to the receptor population. Regardless of whether the pathway is past, present, or future, the population is considered exposed in all cases where the pathway is complete.		

*Source:* Adapted from ATSDR, 1992.

In the United States, risk assessments of sites contaminated by hazardous waste are performed mainly by the agency that devised this method, the ATSDR. In Latin American countries, there are several challenges to performing this type of risk assessment. A particularly important one is the lack of environmental and health data, which must often be obtained through primary data collection. In Brazil, the Ministry of Health endorsed the ATSDR method as the tool of choice for assessing the health risks posed by waste in contaminated soils. Between 2001 and 2007, studies were conducted in five regions of Brazil as part of a Ministry of Health project to evaluate the applicability of the ATSDR method to the Brazilian reality. These studies were conducted at sites where the population was exposed to hazardous waste, and the studies conducted up to that point had not yielded any conclusions or recommendations for health interventions.

The five locations where the studies were conducted are described below (see also Table 22-2):

a) In Cidade dos Meninos, a plant that manufactured hexachlorocyclohexane (HCH) and compounded and stored other pesticides, such as dichlorodiphenyltrichloroethane (DDT), halted operations in 1964 but had accumulated nearly 29,700 tons of contaminated material in a 38,000 m<sup>2</sup> area (30). b) In the municipality of Santo Amaro da Purificação, a mining company operated from 1960 to 1993 and contaminated the entire surrounding area in a 1-km radius (soil, streets, houses, and farmland), as well as the sediment of the adjacent river and the local biota (mollusks), mainly with lead, cadmium, copper, and zinc. c) Condomínio Barão de Mauá, a housing complex, was erected on the former site of an industrial waste dump. In 2001, there was a methane explosion in a groundwater deposit. Testing confirmed that the underground waste consisted, *inter alia*, of volatile organic compounds, including chlorobenzene, toluene, and benzene. d) In 2002, in the municipality of Campinas, São Paulo state, chemical pollutants from a solvent recovery plant were detected on the grounds of Mansões Santo Antônio, a complex of four apartment buildings under construction. Finally, e) in the Baixada Santista metropolitan area of São Paulo state, a study was conducted of nine areas contaminated by the clandestine disposal of organochlorine waste, four of them in the municipality of Itanhaém and five in the municipality of São Vicente.

In the case of the exposed population of Cidade dos Meninos, located in the municipality of Duque de Caxias, Rio de Janeiro, the complete pathway of exposure to the pollutants of interest consisted of surface soil, water wells, food, and air (through the gastrointestinal, dermal, and respiratory routes). HCH and its isomers, DDT and its metabolites (in eggs, milk, water, soil, and household dust), and dioxins (in eggs and soil) were detected in the primary and secondary sites of pollution. Airborne exposure was evaluated indirectly by quantifying the pollutants in household dust collected from locations where waste had built up over time and which thus contained substantial amounts of pollutants. Although the exposure dose could not be calculated, as the volume of air was not measured, the inhalation route could not be ruled out as a pathway of exposure to the compounds.

The results obtained were sufficient to determine that the population of Cidade dos Meninos was “exposed to chemical compounds hazardous to human health” and that it might already be suffering harm from this exposure or come to do so in the future, even if the exposure were halted. The recommendation was, therefore, to conduct research and monitor the health of the residents, who were advised to evacuate the area (31). Analytical capabilities were drawn on to assess the risk and the recommendations, and other interventions are being implemented as part of a joint action plan between the Ministry of Health and the Municipal Health Departments of Rio de Janeiro and Duque de Caxias.

In Mexico, among the areas evaluated the following stand out: two areas polluted by heavy metals from mining and metalworking activities; an aquifer with naturally occurring arsenic and fluorine; an area affected by deltamethrin spraying to control vector-borne diseases; and an indigenous community in the Huasteca region affected by indoor air pollution (smoke from firewood). This latter case was included to emphasize that pollution is not always the result of industrial processes. Marginalization means that indigenous communities are exposed to pollution through their use of biomass in food preparation.

Table 22-3 shows the characteristics of these sites. This information illustrates the variables found in any type of assessment: multiple sites; mixtures of pollutants (organic, inorganic, and biological); vulnerable populations (all polluted sites were home to children, and several also had women of childbearing age among the residents); large populations (although some smaller places had hundreds of exposed children); marginalized communities (many of the sites are located in marginalized areas, which hinders the implementation of intervention programs); and a lack of physicians and other health care professionals trained to recognize the toxicological hazards posed by pollutants.

**Table 22-2.** Pollutants of interest, contaminated media, exposure pathways, and receptor populations by population studied. Cases: Cidade dos Meninos, 2001; Santo Amaro, 2003; Barão de Mauá, 2004; Santo Antônio, 2005; Baixada Santista, 2006

Case and characteristics	Cidade dos Meninos	Santo Amaro	Barão de Mauá	Santo Antônio	Baixada Santista
Pollutants of interest	HCH and its isomers (alpha, beta, gamma, and delta) Trichlorophenol; trichloroben-zene; dioxins DDT, DDE, and DDD	Lead, cadmium, zinc, and copper	Lead, cadmium, zinc, copper, barium, mercury, cobalt, total chromium, nickel, phenol, $\Sigma$ cresol, $\Sigma$ DDD/DDT/DDE, and polychlorinated biphenyls	Vinyl chloride, carbon tetrachloride, 1,2-dichloroethene, trichloroethene, 1,2-dichloroethane, benzene, trichloromethane, 1,1,2-trichloroethane, tetrachloroethene	Chloroform, carbon tetrachloride, 1,2-dichloroethane, trichloroethene, tetrachloroethylene, vinyl chloride, hexachloroethane, hexachloro-butadiene, pentachloro-phenol, tetrachloro-benzene, pentachloro-robenzene, and hexachloro-robenzene
Contaminated media	Surface soil Food (eggs and milk) Air: household dust	Surface soil Air: household dust Food (vegetables, mollusks, shellfish) Work clothes	Deep soil Air: dust	Soil Groundwater Air (past)	Surface soil (past) Food (aquatic biota) Air (past) Groundwater
Receptor populations	Residents	Residents in a 500-m radius of the company, fishermen, workers	Former construction workers who built the complex	Residents in a 500-m radius of the company and workers	Residents and workers in the contaminated areas
Total exposure doses exceeding the reference value	Exposure dose (2) Reference value	Exposure dose (3) Reference value	The calculated doses did not exceed the reference values	The calculated doses did not exceed the reference values	The calculated doses did not exceed the reference values
	$\Sigma$ HCH = 6.94059 $\Sigma$ DDT = 17.6758 Dioxins = 0.04434	Lead = 37.1 Zinc = 0.6821 PTWI ** 0.3			
	* 0.01 ** 0.5 * 1 x 10 <sup>-</sup>				

Reference value: MRL-C (\*): minimum risk level for chronic exposure (longer than 365 days); MRL-I (\*\*): minimum risk level for intermediate duration of exposure (15 to 364 days); PTWI: provisional tolerable weekly intake = 25  $\mu$ g/kg body weight (Joint FAO/WHO Expert Committee on Food Additives, 2000).

(1) For the adult population (>12 years) (2); all calculated exposure doses and reference values (MRLs) are presented as  $\mu$ g/kg/day (3); all calculated exposure doses, except for lead, and reference values (MRLs) are presented as mg/kg/day.

Lead: exposure doses estimated for adults and children in  $\mu$ g/kg/day. Reference values are for exposure over a 7-day (1-week) period.  $\Sigma$  = Sum total concentration of the contaminant: BHC = alpha, beta, gamma, and delta isomers; DDT = DDT + DDE + DDD.

**Table 22-3.** Selected characteristics of sample contaminated sites in the state of San Luis Potosí, Mexico

<i>Exposed population</i>	<i>Morales</i>	<i>Vila de La Paz</i>	<i>Cidade de San Luis Potosí</i>	<i>Huasteca</i>	<i>Tancuime</i>
Source of pollution	Metallurgy	Mining waste	Aquifer	Spraying	Burning firewood
Pollutant	As, Pb, SO <sub>2</sub>	As, Pb	Fluorine	Deltamethrin	CO, PAH, etc.
Average environmental concentration	Soil (mg/kg) Pb: 1,450 As: 791	Soil (mg/kg) As: 1,932 Pb: 932	Water (mg/L) 5.4	Soil (mg/kg) 16.4	Particulate PAH (not quantified)
Child exposure (geometric mean)	Pb in blood 14.8 µg/dL As in urine 50 µg/g creat.	Pb in blood 13.8 µg/dL As in urine 52.1 µg/g creat.	Fluorine in urine 6.5 µg/g creat.	Deltamethrin metabolites in urine 3-PBA: 35.2 µg/g creat. Br2Ca: 83.5 µg/g creat.	53% with COHb > 2.5% 1-OH pyrene: 17.1 µmol/mol creat.
Potential health effects	Lower IQ  Stunted growth	Lower IQ  Stunted growth	Lower IQ  Dental fluorosis	Skin irritation	Respiratory symptoms  Neurological effects
Number of exposed children	3,300	11,200	210,000	32,900	6,500
Reference	Carrizales <i>et al.</i> , 2006 (21)	Jasso-Pineda <i>et al.</i> , 2007 (32)	Grimaldo <i>et al.</i> , 1997 (33)	Ortiz-Pérez <i>et al.</i> , 2005 (17)	Torres-Dosal <i>et al.</i> , 2008 (34)
As, arsenic; Pb, lead; CO, carbon monoxide; PAH, polycyclic aromatic hydrocarbons; COHb, carboxyhemoglobin; 1-OH pyrene, a metabolite of the PAH pyrene.					

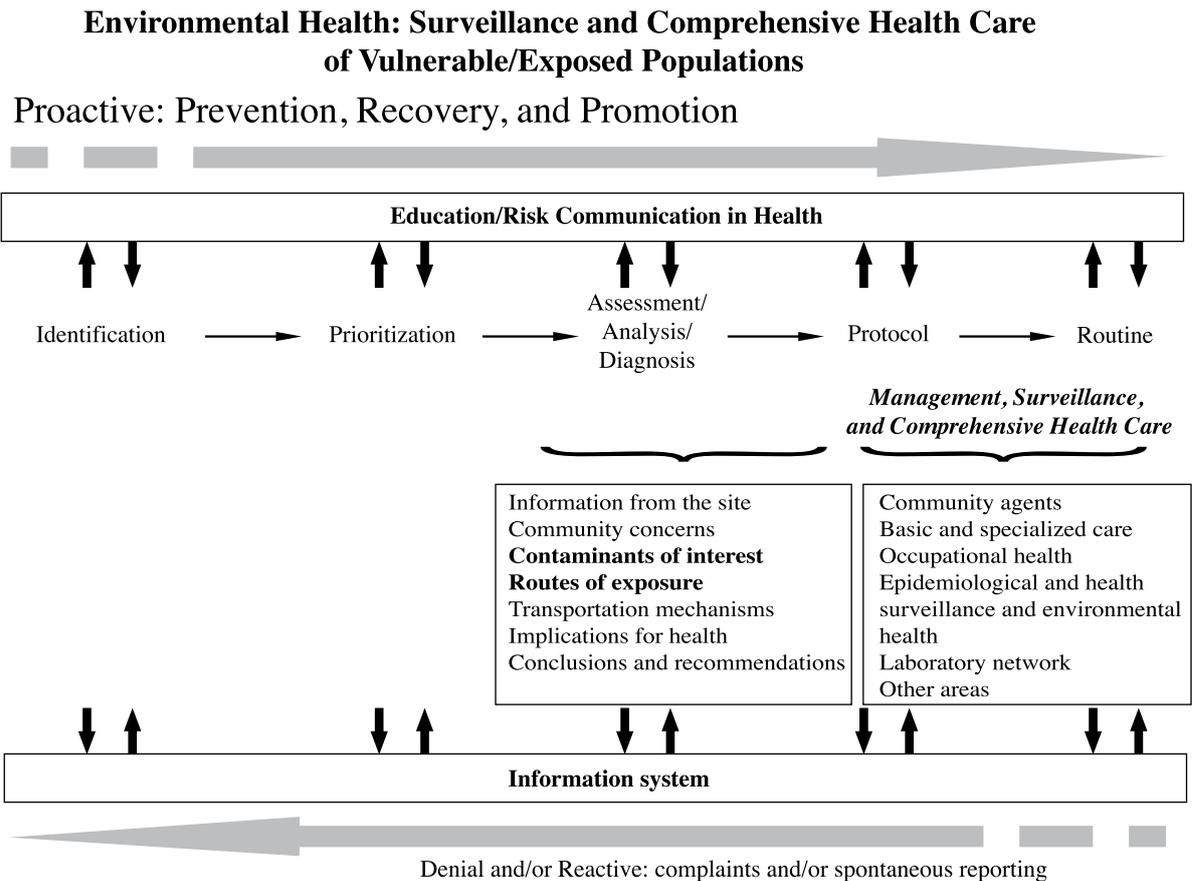
## ■ Proposal for health surveillance action

This proactive proposal, outlined in Figure 22-1, is based on the experience of the Brazilian Ministry of Health (<http://www.saude.gov.br/svs>), which prioritized surveillance of populations exposed to soils contaminated with hazardous waste under the Ministry's policy of environmental health surveillance. It also considers the work of Díaz-Barriga (29), which proposes criteria for the prioritization of contaminated areas.

Initially, areas whose populations have been exposed to contaminated soils can be identified using a form for collecting data in the field that can serve as a record in the country's information system. This database represents the starting point for implementing short-, medium-, and long-term activities in the health sector. For example, in the short term, the pathway of population exposure to the pollutant should be interrupted or supplementary information should be sought with the aid of other competent agencies.

Site definition and identification activities, preparation of the field form, and uploading of the information to the database can be performed by trained local government personnel.

**Figure 22-1.** Proposed model plan for comprehensive surveillance of and health care for exposed populations in contaminated areas



**Source:** Brazilian Ministry of Health, 2009 (<http://www.saude.gov.br/svs>).

During the second stage, areas detected and included in the information system are prioritized, indicating the parameters and subparameters. A total of 100 points is distributed across the following parameters: classification of the area; characterization of the population; toxicological assessment; presence of containment and control measures; and access to the site. Each area is subsequently assigned a priority level based on the score obtained. Priority 1 is assigned to the highest-scoring area, and priority 5 to the lowest-scoring area.

In the third stage, depending on the quality of the information compiled, the routes of exposure and pollutants of interest in the areas are defined to facilitate the development of medium- and long-term strategies of action; this can be done using the ATSDR method for assessing health hazards posed by exposure to hazardous waste.

However, given the technical complexity and the human and financial resources needed to undertake a comprehensive assessment of health hazards, intra- and intersectoral coordination at the local level is advisable so that consistent information can be compiled to elucidate the routes of exposure and pollutants in question. Such data are considered sufficient for developing population health monitoring protocols that include a comprehensive approach to health, rather than focusing on the presence of the resulting diseases.

The last phase includes the development and implementation of protocols for care and monitoring of the exposed populations. These instruments should target specific situations of human exposure and consider the timing of the exposure (past, present, and future). Protocols are instruments developed by health teams to guide the organization of the local health sector. Their purpose is to identify exposed populations and ensure health care delivery tailored to their specific needs to reduce morbidity and mortality and thus contribute to a better quality of life (see Ministry of Health website, <http://www.saude.gov.br/svs>).

Furthermore, in this model plan, two cross-cutting lines of action can coexist throughout the process. One consists of education and communication activities focused on health risks, and the other, of an online information system comprised of four modules: identification, prioritization, contaminants of interest, and exposure pathways, as well as the data obtained from monitoring the health of the exposed population to construct health surveillance indicators.

Finally, Figure 22-1 also shows the response pattern often observed in countries (denial or reaction). When pollution is denounced —typically by the press, campaigning politicians, or nongovernmental organizations— the authorities react, taking isolated, disjointed action inappropriate to the context to explain away, minimize, or deny outright its effects on both the health of the exposed population and the environment.

## ■ A proposal for management and practice

Based on the characteristics of each country, state/province, or municipality, spheres of authority must be formally defined. The responsibilities of administrators could include the coordination of a nationwide environmental health surveillance system consisting of activities and services relative to surveillance, which should include the monitoring of populations exposed to areas with contaminated soil. For this purpose, to start, environmental health agencies should be officially established in states and municipalities, particularly in the capitals and priority municipalities (defined by population, number of potentially polluting industries, amount of waste detected, etc.), followed by identification and training of the respective professionals and technical personnel.

Health sector administration agencies could establish priorities, targets, and the financial resources for national implementation, as well as for the continuous and systematic nationwide identification of populations exposed to contaminated soil. The phases of the model plan (see Figure 22-1) would then be implemented in subsequent years.

The identification of populations exposed in areas with contaminated soil requires professionals trained in the following areas: basic concepts, the collection of information from secondary sources, the completion of data collection forms, database management, the use of GPS devices, practical activities, case studies, and activities planning (35).

Before visiting a site, the health team should collect information on areas with soil contamination in the territory and prepare a work plan, which should include: a guide for field activities, intrasectoral partnerships among entities involved in health surveillance, occupational health, epidemiological surveillance, and primary health care, and intersectoral cooperation with local government and other public agencies that deal with the environment. Based on the initial information, the health team should coordinate and plan any emergency actions that may be required, such as securing access for people with disabilities, cutting off the water supply, and other measures to halt further exposure of the population.

During the visit, a pre-prepared work guide should be followed, especially for completion of the local activities form, which could include information on four topics (35,36):

- Site identification: name of the site, its address, geographic coordinates, size and distance from the capital, types of known and potentially present waste and contaminants of interest, and, finally, classification of the site as: inactive area, industrial area, agricultural area, supply and services unit, or area for final disposal of urban waste.
- Potentially exposed population: once the presence of people in the area (workers or residents) has been confirmed, the form should record the distance between the site and the nearest housing, the estimated exposed population (for example, within a 1-km radius), and its social status.
- Pathways of population exposure to environmental pollutants: the data to be collected are the presence of susceptible populations, activities implemented in the area and its surroundings, presence of bodies of water, type of water supply and its uses, and whether crops are grown in the area.
- Data sources and studies: the form may also be used to provide detailed information on the area, including studies conducted and sources of information on soil pollution, water pollution, air pollution, and human exposure, as well as the presence of mitigation measures.

The data obtained about the area could then be entered into the database for data analysis and validation and the development of a strategy and plan of action for each area detected. Local environmental health technicians

should be responsible for the preparation and enforcement of this plan of action, with the advice and support of state and federal agencies, when necessary. The strategy should include training for intrasectoral task forces (technical personnel from different areas of the health sector, representatives of society at large, victims' associations, etc.) to meet the specific health care and surveillance needs of the exposed population groups (children, pregnant women, adults in general, and workers). Intersectoral task forces made up of representatives of the health sector, environmental protection agencies, and local organizations charged with the management and mitigation of socioenvironmental effects can also be set up, especially for the purposes of environmental remediation (35,36).

Based on the plan of action, these task forces would develop a work program to be implemented and monitored, whose duration would be determined on a case-by-case basis.

The plan of action would be the product of a joint effort involving situational diagnosis and strategic planning. It would include emergency activities and short-, medium-, and long-term goals consistent with the proposed model of action and would include three major lines of action, as detailed below (37).

## ■ Surveillance and comprehensive health care for exposed populations: Intra- and intersectoral management

This line of action was conceived following the country health system guidelines for meeting the specific health needs of exposed populations for a period based on the toxicology profile of the pollutant (e.g., 15-30 years or more). The activities would include emergency measures to prevent further exposure, the development of a demographic and epidemiological profile of the affected population, strengthening and adaptation of local health systems to better serve this population, beginning with primary health care, a referral and counter-referral system, and a specialized care component, as well as procedures and tests of low, medium, and high complexity.

Health care and surveillance should consider the toxicological characteristics and long-term effects (carcinogenic or noncarcinogenic) of the pollutants found in the affected area, as well as past, present, and future exposure to them (38). The results of the health care provided to the exposed population would be used as instruments for health professionals to conduct initial assessment, follow-up, and surveillance of the health of the exposed population, and to include these actions under municipal health programs and plans. They could also include indications for specific procedures and care for subsets of the exposed population (children, pregnant women, etc.) at the various levels of the health system and include activities to buttress the existing health information system, adjusting it as necessary to take into account any findings gleaned from monitoring the health of these populations.

Regarding intrasectoral management, in some countries the health sector often lacks definition, coordination, and structure at the local, state, and federal levels. In many countries, it is essential that legal instruments designed to systematize and guarantee resources for health sector interventions aimed at populations exposed to areas of contaminated soil be drawn up, reviewed, promulgated, and published.

In addition to the intrinsic challenge that this activity poses for monitoring environmental health, it is neither disconnected nor separate from the actions of the health sector or any individualized and collective care provided to people exposed to additional health risks linked to pollutants.

In defining measures, activities, and objectives for the line of action concerned with management and coordination of the various health areas, the principles and guidelines of comprehensiveness, universality, and equity in the health sector should be followed.

One of the purposes of these measures is to evaluate coordination and management strategies, in addition to implementing the plans of action drafted for each case. When devising this process, advantage should be taken of the skills and expertise of environmental health surveillance technicians. It is also important to foster coordination among the participating areas, especially surveillance bodies, which often act only on request in an isolated manner or else, duplicate activities, making poor use of technical experience and resources (35).

These issues demand coordinated action to prevent population exposure to pollutants through the ingestion of contaminated food and water or air pollution. This action should include education and the communication of health risks, a census, and the identification of currently and potentially exposed populations. The local biota and contaminated areas should also be monitored before and after any mitigation procedures.

Based on the structure, organization, and even the existence of the local health system, steps can be taken to restore basic health services for the municipal population through primary care, health surveillance activities, management, social control, regulation, referrals, counter-referrals, and other measures.

Health action to meet the needs of the exposed population should be monitored for extended periods of life. Hence, the need not only to maintain a single population registry but to strengthen the health information system and create a surveillance system, bearing in mind that chronic health damage is expected in this population. Finally, all training activities for health professionals involved in the management and follow-up of this population should be ongoing, current, and geared to a comprehensive, coordinated approach by the different areas of the health sector.

Regarding intersectoral coordination, just as the response capacity of health surveillance agencies in the health sector is limited, so too is the sector's capacity to intervene on its own in the situations detected. Complex action, such as halting further population exposure, calls for the participation of a wide range of sectors together with local, state, and federal government intervention. For example, to keep the population from consuming locally grown food, there must be alternatives to generate income and food; to identify affected population groups, each individual must have an identification document of some sort; to halt exposure caused by contact with contaminated soil, area residents must evacuate (so that dust can be removed from their homes, as well as from streets, gardens, yards, etc.) and avoid eating any food grown or produced in the area.

From an environmental standpoint, there is a need for diagnosis of areas that have not yet been studied, surveillance of areas that have already been detected to prevent exposure of new population groups, and assessment of the results of any control or mitigation activities already carried out. These actions and activities will require partnerships and, often, guidelines for joint action. Many actions and activities will be possible only if the community is involved in the decision-making process and implementation of the decisions; thus, the participation of the social movements and public agencies working in areas such as social security, labor, justice, education, agriculture, animal husbandry, and social development is essential.

## ■ Human resources training, education, and the communication of health hazards

Training activities for health professionals and other health workers are designed to enable them to meet the specific needs of the affected population. They also include the implementation of programs for human resources education, health risk communication, and environmental education to raise public awareness about the problem and minimize exposure and damage to health, in addition to strengthening the population's capacity to organize and participate in this process.

In the specific case of human resources education, training methods for hazardous waste risk assessment are needed, given the heavy demand for training among federal and local government workers. In Brazil, PAHO funded a distance learning course coordinated by the Institute of Public Health Studies of the Federal University of Rio de Janeiro (IESC-UFRJ) and entitled "Online course on methods for assessing human health risks from exposure to hazardous waste." In addition to the team that prepared the course, the Ministry of Health's General Coordinating Office for Environmental Health Surveillance, the Health Education Technology Unit (Nutes), the Federal University of Rio de Janeiro, and technicians from the PAHO/WHO Representative Office in the country also took part (see Table 22-4).

## ■ Research

In some cases, studies and research by different national and international academic institutions can be consolidated and contribute to the risk assessment report, giving the health sector greater clarity and the ability to systematize information for understanding the problem and how best to address it (see databases such as MEDLINE, Lilacs, SciELO, etc.).

Availing themselves of these resources, technicians involved in developing the plan of action can suggest guidelines, studies, and research to provide scientific backing for interventions and decisions in the fields of knowledge relevant to the case at hand. Proposals can address social, anthropological, environmental, educational, neurobehavioral, and nutritional aspects, as well as areas such as health sector management, health care, toxicological analysis,

risk communication, harm prevalence and incidence rates (whether described in the literature or previously unreported) in subgroups of the exposed population, social control, and societal participation.

**Table 22-4.** On line course on methods for assessing human health risks from exposure to hazardous waste (Brazil)

<i>Curriculum structure</i>	<i>Content</i>	<i>Resources</i>
Module 1	Familiarization with the scope of the program Understanding of the conceptual and historical underpinnings of risk assessment studies in Brazil	Basic texts containing links to websites that provide further information
Module 2	Application of the risk assessment method Eight progressive stages: ≠ stages 1 and 8: general content ≠ stages 2, 3, 4, 5, 6, and 7: specific contents by knowledge area Individual and group exercises at the end of every stage	Specific instructors for each subject Problem-solving in multidisciplinary groups Supporting material, glossary, bibliography, and web links
Module 3	Final assessment	Individual solution of a problem scenario

## ■ Final considerations and recommendations for decision makers

Issues pertaining to health and the environment are a challenge for societies today. Moreover, environmental health as a discipline is a very recent phenomenon and, in most countries, its application is still in its infancy. The current body of experience demonstrates the complexity of these issues, reflected in the low, medium, and high-complexity requirements of health promotion, disease prevention, and health recovery at the micro- and macro-regional, intra- and intersectoral, local, state, federal, and international levels. This puts the spotlight on a wide range of opportunities for professionals, administrators, and researchers.

Regarding health promotion, in addition to intersectoral action, the countries of the Region must design and implement rapidly adoptable policies and guidelines for cleaner production; this will benefit not only the environment but economic development by sparing the countries massive future investments in technology and treatment. Furthermore, it will cut costs and boost productivity and competitiveness, thanks to more efficient resource utilization. All of this is consistent with the holistic concept of cleaner production endorsed by the United Nations Industrial Development Organization (UNIDO). This proposal consists of an integrated preventive strategy applied to the entire production cycle to boost productivity; ensure more efficient use of raw materials, power, and water; promote better environmental performance by reducing waste and other emissions at the source; and reduce the environmental impact of goods throughout their life cycle by designing products that are sustainable from an environmental and cost-benefit standpoint ([www.unido.org](http://www.unido.org)). In addition, the countries of the Region should strive to reach the target of “sound management of chemicals throughout their life cycle and of hazardous waste” by 2020 to minimize their adverse effects on human health and the environment, as stated in the Johannesburg Plan of Implementation ([www.rio20.gov.br](http://www.rio20.gov.br)).

Civil society organization and engagement are essential to the exercise of democracy. They foster the organized participation of new social stakeholders or agents —health system users, health workers, administrative institutions, agencies, communities, work teams, etc.— in administrative processes and make technical, political, or ethical contributions to public health planning and monitoring as active participants in the discussion, development, and enforcement of the policies adopted by public health agencies in each country. In Brazil, for example, the Unified Health System recognizes health councils and conferences as special venues for developing guidelines and paths for the exercise of the right to health (39).

Comprehensive health surveillance and care for populations exposed to polluted areas must include different sectors. The flow of surveillance and care activities includes health promotion, disease prevention, and treatment interventions that require the involvement of several areas of the health sector, important among them coordination of environmental health surveillance, epidemiological surveillance, health surveillance, occupational health, health care (especially primary health care as the point of entry), and public laboratories. An information system is

also necessary, as are support for training professionals, risk education and communication, and social mobilization activities.

Clear and well-defined work routines in all areas and at all levels of complexity in the health sector strengthen and facilitate the planning and implementation of intersectoral activities to guarantee the health and quality of life of populations exposed to contaminated soil.

Several general recommendations for decisionmakers should be emphasized, since, by virtue of their complexity, environmental health issues are not always evident or recognized by administrators and professionals; nor are there clearly established roles for the different areas of the health sector and other sectors, which, more often than not, represent distinct interests across different societal groups. These recommendations are:

Adopt an environmental health policy that covers prevention and reduction of hazardous waste generation, methods for assessing health hazards to populations exposed to such waste, management of hazardous materials transport, and procedures for the treatment, reuse, recycling, storage, and proper final disposal of such wastes, including their sequestration.

Contribute to the development of legal instruments for the detection and prevention of health risks associated with exposure to hazardous waste by drafting and adapting sectoral and intersectoral legislation at the country level to address environmental health issues stemming from hazardous waste.

Include the collection and analysis of data on sources of waste at the local, municipal, state/provincial, and national level in annual health plans and agendas, facilitating the identification of populations exposed in the past and present and, potentially, in the future.

Draw up guidelines for prioritizing and assessing public health in these areas. Implement, either sequentially or concomitantly, emergency measures to prevent serious harm to the exposed population.

Prepare a situational and strategic plan of action that includes immediate, medium-term, and long-term activities, considering, at the very least, the lines of action described earlier in this document: a) comprehensive monitoring and health care (promotion, prevention, diagnosis, treatment, and rehabilitation) for the exposed population; b) intrasectoral and intersectoral management; c) human resources education, risk education, and risk communication; and d) research.

Foster the development of technologies, instruments, and management strategies and the participation of social control agents to address environmental health issues.

Develop information systems or technologies for analyzing the existing information.

Strengthen the capacity of laboratory networks to analyze environmental samples and specimens of human biological material.

Forge intersectoral partnerships, particularly with environmental agencies, to permit mapping of polluted areas (past, present, and potential).

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39. Brazil. Ministério da Saúde, Coordenação Geral de Vigilância Ambiental em Saúde. Ministério da Saúde, Secretaria-Executiva. *O SUS no seu município: garantindo saúde para todos*. 2nd ed. Brasília: Brazilian Ministry of Health; 2009.

## ■ Annex: Websites

<http://bvsmms.saude.gov.br/php/index.php>

<http://www.cetesb.sp.gov.br>

<http://www.bvsde.paho.org>

<http://www.bireme.br/php/index.php>

<http://www.scielo.org>

<http://www.inchem.org>

<http://www.epa.gov>

<http://www.saude.gov.br/svs>

<http://www.saude.gov.br/svs>



# Air pollution trends in the Americas: Impact and policies

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## ■ Scale of air pollution in Latin America and the Caribbean

Air is a natural resource, freely shared by the entire population of our planet, and a basic requirement for human health and well-being. Poor air quality in the Latin America and Caribbean region causes premature deaths, jeopardizes the health of millions and produces major economic losses (millions of U.S. dollars) associated with medical care and lost productivity. Major cities in developing countries have experienced rapid growth over the past few decades, creating huge megalopolises where inhabitants are constantly exposed to air pollutant levels often exceeding those recorded in industrialized countries during the first half of the 20th century (1). The Pan American Health Organization (PAHO) estimates that over 100 million people are exposed to air pollutant concentrations above the maximum permissible levels established in the Air Quality Guidelines published by the World Health Organization (WHO). An estimated 45,318 people die and 998,778 years of life are lost per year from urban air pollution across the Region (2). Climate change, which is affecting weather patterns, is also believed to play an important role in the greater frequency and duration of poor air quality.

### Emission sources

The leading cause of urban air pollution in the Region is the intensive use of fossil fuels in industry and transportation. In Mexico City Metropolitan Area in 2010, for example, transportation was responsible for 12% of  $PM_{10}$  (particulate matter with a diameter of less than 10 microns), 30% of  $PM_{2.5}$  (particulate matter with a diameter of less than 2.5 microns), 5.06% of sulfur dioxide ( $SO_2$ ), 98% of carbon monoxide (CO), 79% of nitrogen oxide (NOx), 31% of volatile organic compound (VOC), 29.6% of toxic pollutant, and 51.4% of carbon dioxide ( $CO_2$ ) emissions (3).

In Bogota, pollution from motor vehicles has been reduced, and a battle is currently being waged to control industrial emissions in urban areas. However, air pollution is increasing in medium-sized or smaller cities, where control technologies and resources are scarcer and urban growth management is still inadequate (4).

Colombia has developed a diagnostic tool for environmental health that furnishes guidelines for comprehensive policy-making in environmental health, with special emphasis on air and water quality and chemical safety. Air quality assessments facilitate comprehensive management of this resource to protect public health.

In Chile, controlling vehicle emissions (vehicle control and certification) and reducing agricultural burning are two important measures for reducing emissions. Improving fuel quality in Metropolitan Santiago has also proved advantageous for the residents of this city, as pollutant levels have fallen (5).

In general, the growing use of unleaded gasoline and low-sulfur diesel fuel (gasoline and diesel) has steadily improved air quality across the Region (6).

### Trends in countries with monitoring networks

Good air quality management plans can contribute to a progressive reduction in air pollutant levels. However, most Latin American countries cannot keep pace with trends in implementation of the WHO recommendations. A series of effective measures have been adopted to reduce air particle concentrations in Mexico City Metropolitan Area. However, they have not been sufficient to reduce levels to comply with national standards. More alarmingly, air pollutant levels are well above the WHO recommendations; in the 2005 updated recommendations, Mexico fell well short of the recommended target levels (see Table 23-1). The same holds true for Chile, where average annual  $PM_{10}$  levels exceed both national standards and WHO limits. In Brazil, concentrations are within the maximum nationally permissible standards, but they, too, exceed the WHO recommendations (see Figure 23-1).

There is a clear need for better monitoring systems to analyze trends using more exhaustive, continuous, reliable, and complex data and methodologies that are comparable between countries, so that better intervention measures could be adopted to control air pollution.

**Table 23-1.** Air quality standards in countries of the Region (WHO and EPA-USA)

Standards (by country/city)	$PM_{10}$ ( $\mu\text{g}/\text{m}^3$ )		$PM_{2.5}$ ( $\mu\text{g}/\text{m}^3$ )		$O_3$ ( $\mu\text{g}/\text{m}^3$ )		$NO_2$ ( $\mu\text{g}/\text{m}^3$ )		$SO_2$ ( $\mu\text{g}/\text{m}^3$ )		CO (ppm)
	24hr	Annual	24hr	Annual	8hr	1hr	1hr	Annual	24hr	Annual	8hr
WHO	50	20	25	10	100		200	40	20		
EPA-USA	150		35	12	160	240		100	372	80	9
Mexico	120	50	65	15	157	216	395		288	66	11
Buenos Aires	150	150	65	15	157	235		100	365	70	10
Brazil	150	50				160	320	100	365	80	9
Chile	150	50	50	20	120		400	100	250	80	8.6
Colombia	100	50	50	25	80	120	200	100	250	80	8.8
Ecuador	100	50	50	15	100			40	125	60	
Peru	150	50	25		120		200	100	20		8.7
Bolivia	150	50				236	400		365	80	

WHO Air Quality Guidelines 2005 (7)

EPA: National Ambient Air Quality Standards (NAAQS). Air quality guidelines. (<http://www.epa.gov/air/criteria.html>)

Mexico: Mexican official standards., Secretaría de Medio Ambiente y Recursos Naturales.

Buenos Aires: Ley N° 1356. Calidad Atmosférica Jefatura de Gabinete de Ministros. Secretaria de Medio Ambiente y Desarrollo Sustentable Gobierno de la Ciudad de Buenos Aires.

Brasil: Companhia Ambiental del Estado de São Paulo, CETESB (8)

Chile: Instituto Nacional de Estadística (9) Biblioteca del Congreso Nacional de Chile (<http://www.leychile.cl/Navegar?idNorma=1025202>)

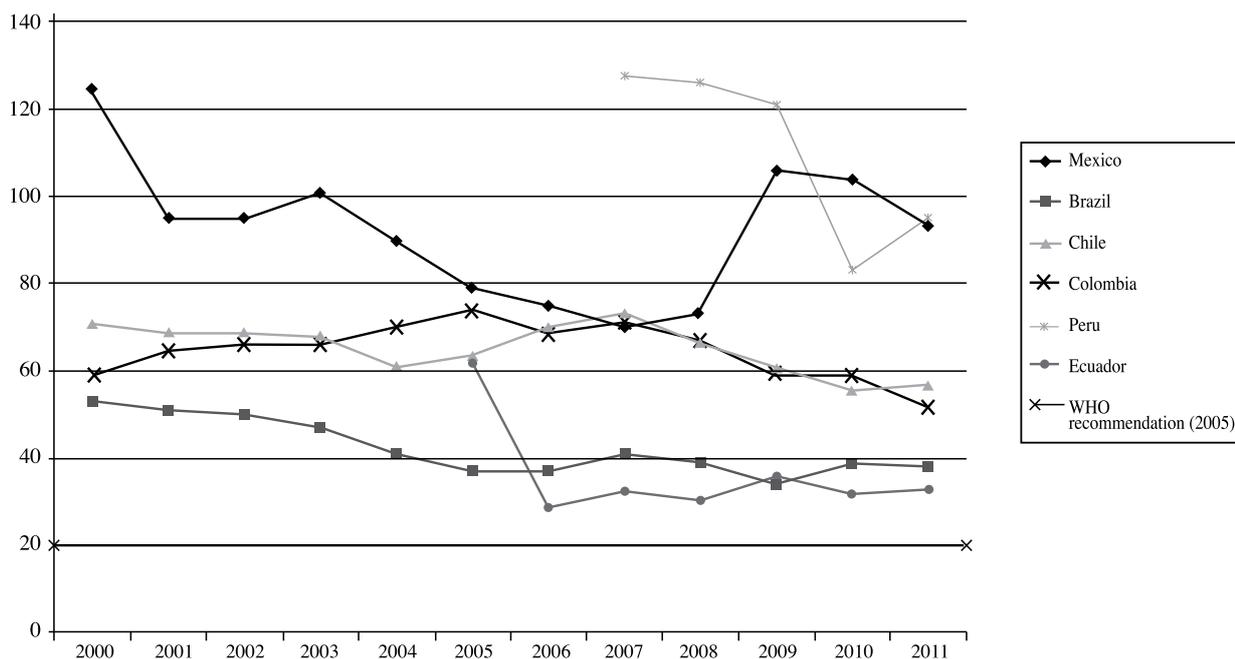
Colombia: Resolution 0601 (2006). Republic of Colombia, Ministry of Environment, Housing, and Territorial Development (<http://www.alcaldiabogota.gov.co/sisjur/normas/Norma1.jsp?i=19983>)

Ecuador: Informe anual 2011. Calidad del Aire. Quito, Distrito Metropolitano, 2011 (10)

Perú: Estándares Nacionales de Calidad Ambiental del Aire vigentes al 2014 (D.S N° 003-2008-MINAM) (11)

Bolivia: Informe Nacional de Calidad del Aire 2008-2009. Ministerio de Medio Ambiente y Agua 2010 (12)

**Figure 23-1.** Annual average PM<sub>10</sub> in six Latin American cities (Mexico City, São Paulo, Santiago, Bogota, Lima, and Quito)



Mexico: Data from Atmospheric Monitoring System (SIMAT) (3,13-16)

Brazil: Data from Air Quality Report in the State of Sao Paulo (CETESB) (2012) (8); 2010 Environmental Quality Report, Secretariat of the Environment (2010) (17)

Chile: Data from 2010 Annual Environment Report, INE (2010)(9)

Bogota: Data from Bogota Environmental Observatory. Available at (<http://oab.ambientebogota.gov.co/index.shtml?s=l&id=1&v=1>).

Peru: Data from General Directorate of Environmental Health, DIGESA; Environmental figures 2013. SINIA (2012) (18)

Ecuador: Environmental indicators, SUIA. Available at: [<http://suia.ambiente.gob.ec/ambienteseam/index.seam>].

**Note:** For 2008 in Mexico and for the Peru series, the annual average corresponds to the value obtained from the monitoring station with the highest annual average.

## Standards

The WHO Air Quality guidelines and the maximum levels set by the U.S. Environmental Protection Agency (EPA) constitute a very useful reference for setting standards and/or targets in the Region. Countries, by and large, have insufficient economic resources or only limited capacity to conduct the research needed to set standards based on their own scientific data.

Air quality guidelines are recommendations about air pollutant exposure levels indicating the risk of adverse effects. Standards refer to maximum permissible levels of air pollutants during a given period. These limits are set with a margin of protection against risks. The purpose of standards is to protect human health and well-being (primary standards), as well as ecosystems (secondary standards). Air quality standards are thus an extremely important component in the development of national policies to protect public health.

Air quality standards are generally based on the findings of toxicological and epidemiological studies that evaluate the relationship between exposure to a pollutant and its effects on health. Table 23-1 displays and compares the applicable standards in the countries of the Region.

We should note that the limits set by most countries across the Region exceed those found in the WHO guidelines (7), which may signify inadequate protection for the population, if permissible international limits are considered. Furthermore, only a third of these countries have set air quality standards or emission limits (19).

The last WHO Air Quality guidelines update (20) notes that there are no thresholds below which human health is protected, as the adverse effects of air pollution occur even at very low concentrations. This marks a clear shift toward even tighter regulations, such as those of the EPA in California, where maximum levels are lower than those

in the rest of the United States. WHO also points out that the trend across Europe is toward lower thresholds. In Mexico City Metropolitan Area, current data are being reviewed to formulate an air quality policy for the next 10 years, which will most likely involve lowering the limits permitted under national standards.

## Exposed population

According to the calculations for 2010, over 590 million people are living in the Region, which represents more than 8% of the world's population (19). Between 1987 and 2010, the percentage of the population residing in urban areas of the Region increased from 69 to 78%. This growth is generally driven by migration from rural areas to escape the relentless poverty and unemployment (21).

The United Nations calculates that in 2010, approximately 9.4% of the Region's population was aged 0-4 years and 6.9%, over 65 years (22). Considering that there are at least 133 cities with a population of over 500,000 across the Region (23) and that the highest concentration of pollutants occurs in large cities, almost 100 million people are living in areas most susceptible to air pollution. Table 23-2 shows the total population and the percentage living in cities with populations of over 100,000 in countries of the Region.

**Table 23-2.** Deaths per year due to ambient air pollution in countries of the Region

Country	Population (million)	% population in cities with pop. >100,000 <sup>A</sup>	Deaths per year due to outdoor air pollution <sup>B</sup>	Average PM10 µg/m <sup>3</sup> <sup>C</sup>
Argentina	40,370	93.11	1,676	78
Bolivia	9,995	66.39	383	72
Brazil	195,153	85.01	7,582	35
Chile	17,149	87.52	1,404	62
Colombia	46,448	78.51	1,583	42
Costa Rica	4,669	66.00	360	40
Cuba	11,298	77.40	1,673	38
Dominican Republic	9,907	68.56	1,560	36
Ecuador	14,490	65.00	382	34
El Salvador	6,218	60.29	219	48
Guatemala	14,334	57.22	1,383	60
Haiti	9,884	45.26	2,203	47
Honduras	7,619	50.49	536	69
Jamaica	2,741	51.99	506	43
Mexico	112,364	78.03	20,496	49
Nicaragua	5,813	58.33	183	32
Panama	3,474	68.73	117	58
Paraguay	6,458	61.42	112	103
Peru	29,272	73.37	1,996	62
Trinidad and Tobago	1,341	13.44	46	22
Uruguay	3,373	92.41	7,086	154
<b>Total</b>	<b>542,531</b>		<b>51,486</b>	

**Source:** <sup>A</sup> Anuario Estadístico de América Latina y el Caribe. ([http://interwp.cepal.org/anuario\\_estadistico/anuario\\_2012/es/contents\\_es.asp](http://interwp.cepal.org/anuario_estadistico/anuario_2012/es/contents_es.asp)) (21)

<sup>B</sup> Institute for Health Metrics and Evaluation. GBD Arrow Diagram. Deaths, Latin America and Caribbean (<http://www.healthmetricsandevaluation.org/gbd/visualizations/gbd-arrow-diagram>)

<sup>C</sup> Environmental burden of disease: Country profiles. World Health Organization, 2009 (24)

## ■ Intervention policies: Pollution control programs and their effects

### Air pollution control programs in the Region

#### Regional programs

The Regional Plan on Urban Air Quality and Health 2000-2009 (<http://www.cepis.org.pe/bvsci/e/fulltext/planreg/planes05.pdf>), proposed by PAHO, is a platform for addressing priorities in air quality management, improving coordination and cooperation among air quality programs in the Region, and raising funds and securing resources to support measures designed to improve air quality and prevent its further deterioration (25).

The Regional Plan proposes a series of programmatic areas that the countries of the Region should consider when planning activities, based on their capacities:

1. *Policies, standards, and regulations*: enacting national air quality laws and regulations, and endowing national and local institutions with powers to ensure compliance with such laws and regulations; incorporating air quality into regional, subregional, national, and local development plans and policies.
2. *Air quality management*: air quality monitoring, emissions control, air pollution prevention, and public information, training, and communication.
3. *Air pollution health impact monitoring*: periodic surveillance of morbidity and mortality associated with air pollution; risk assessments; effective information systems; and systems to estimate the social cost of air pollution for health.
4. *Education, training, and public awareness*: a concerted public awareness campaign targeting decision makers, political leaders, the business sector, and the general public on the importance of preventing and reducing indoor and outdoor air pollution, including such topics as air quality and health at the different educational levels.
5. *Financing*: short-, medium-, and long-term operations programs that would facilitate the self-sustainability of national and local air quality and health programs.

Furthermore, the Clean Air Initiative for Latin American Cities, sponsored by the World Bank (<http://www.cleanairnet.org/lac/1471/channel.html>) and run by the Clean Air Institute, is a program designed to improve air quality in the Region. The initiative is a coalition of cities, private-sector entities, and nongovernmental organizations that share information on air quality programs in major urban centers. It supports policy development and implementation and promotes education through training and technical assistance (25,26).

Activities to improve air quality have been documented across the Region, among them the Pure Air in Central America Program, covering Costa Rica, El Salvador Guatemala, Honduras, Nicaragua, and Panama and funded by the Swiss Agency for Development and Cooperation (COSUDE) (25). One of the legacies of this program, which concluded in June 2003, was the creation of monitoring networks in each country's capital.

Other global initiatives, such as the Air Management Information System (AMIS) (<http://www.cleanairnet.org/cai/1403/article-34274.html>) and the Global Environmental Monitoring System for Air Pollution (evolved from the World Health Organization (WHO) urban air quality monitoring), also facilitate information exchange for rational air quality management, which includes activities such as monitoring air pollutant concentrations, developing instruments to build emissions inventories and air quality models, estimating public health impacts through epidemiological research, and drafting detailed action plans to improve air quality.

Participation in AMIS automatically creates links among participating countries through a network of support, resources, and activities (25). Some cities in the Region, like Mexico City and Santiago, Chile, belong to the network. The AMIS system makes it possible to estimate how much, if any, progress is being made in reducing air pollution in cities all over the world. For example, comparing mean annual values of reference pollutants from 1986-1992 with those of 1993-2000, we see that  $PM_{10}$  concentrations rose by  $26 \mu\text{g}/\text{m}^3$  (20%) in low-income countries, while levels decreased in middle- and high-income countries (income classification based on World Bank indicators) (27).

## National programs

Despite the efforts made and steps taken, satisfactory air quality management in the Region covering all programmatic areas in the PAHO Regional Plan has not been achieved, and the differences from country to country and city to city are considerable. A monitoring network is one of the basic requisites of any proposal or program aimed at a gradual reduction in atmospheric pollutant emissions to levels that would ensure the protection of public health, especially the health of the most vulnerable groups. The absence of this basic element is the main obstacle for countries of the Region lacking the financial wherewithal and qualified human resources capable of creating and operating reliable monitoring networks. Although the Clean Air Initiative has to some extent helped overcome these obstacles, the lack of country networks is one of the greatest constraints to Latin America's developing an adequate environmental monitoring network that would facilitate more in-depth research studies across the Hemisphere.

According to a study on air quality management programs conducted in 27 countries of the Region, some cities in Brazil, Chile, and Mexico have good air pollution monitoring capacity and welldeveloped management programs (28), while Argentina, Bolivia, Colombia, Costa Rica, Cuba, Ecuador, Nicaragua, Peru, Trinidad and Tobago, Uruguay, and Venezuela have made progress in setting standards, monitoring pollution levels, or implementing management programs (28). Table 23-3 shows the principal components of air quality management and monitoring in some countries in the Region.

As an example of the measures or strategies included in the air quality control programs of some countries in the Region, Table 23-4 includes some of the proposals of Mexico's Air Quality Improvement Programs (PROAIRE) and Santiago's Prevention and Atmospheric Decontamination Plan.

In Mexico, PROAIREs are one of the main instruments employed to reverse poor air quality trends in the Mexico City Metropolitan Area. Developing a PROAIRE requires sufficient information from a monitoring network and a detailed inventory of emissions from fixed, mobile, and natural sources. A series of strategies and instruments are then designed and evaluated, a critical path is established for each measure, and stakeholders are identified.

The guiding principle of the new PROAIRE 2011-2020 is to promote an ecosystem approach to air quality management in the Mexico City Metropolitan Area. The area is analyzed as an open, complex, spatial ecosystem to understand the functional relationships among urban, economic, environmental, cultural, and social variables. PROAIRE proposes eight strategies (consisting of 81 measures and 116 actions) (29): expanding and improving health protection; structural reduction of energy consumption in the Metropolitan Area of the Valley of Mexico; quality and efficiency in all energy sources; mobility and the regulation of vehicle fleet energy consumption; technological change and emission control; environmental education, a culture of sustainability and public participation; management of green areas, reforestation and the planting of greenery in cities; institutional support; and scientific research. Some of the effects of the air quality management promoted by PROAIRE are shown in Figure 23-4, which describes the different interventions over the years and how they have affected air quality.

In Chile, the Prevention and Atmospheric Decontamination Plan (PPDA) for the Metropolitan Region (30), aimed at implementing plans to prevent public exposure to high pollution levels, has put permanent measures in place to control emissions and stipulated the preventive action to be taken during episodes of high pollution. This type of intervention is reducing both the number and the duration of critical episodes in the Metropolitan Region.

The strategies in place in each country are aligned with the activities proposed by PAHO in the Regional Plan on Urban Air Quality and Health. However, significant progress has not always been made, for a number of reasons: financial obstacles to maintaining monitoring networks or implementing control measures (31), insufficient human resources to operate monitoring networks, or lack of accountability systems or enforcement mechanisms.

**Table 23-3.** Air quality management and monitoring in countries of the Region

<i>Country</i>	<i>Air quality management</i>
Argentina	Since 2001, National Program for Air Quality Control and Health / Prevention of risks due to exposure to air pollution. National Air Quality and Health Network
Bolivia	National Air Quality Monitoring Network (Red MoniCA Bolivia) in Santa Cruz, La Paz, El Alto, and Cochabamba.
Brazil	Since 1989, National Program for Air Quality Control (PRONAR). National air monitoring network in Rio de Janeiro, Sao Paulo, Belo Horizonte, Porto Alegre. Dissemination of daily results in Boletim de Qualidade do Ar. Inventory of sources of air pollution.
Colombia	In 2008, guidelines were established for the formulation of a comprehensive Environmental Health policy, emphasizing air quality, water quality, and chemical safety (32). <ul style="list-style-type: none"> <li>• Coordinates policy and management in the area of environmental health</li> <li>• Creates a unified environmental health information system and strengthens training and research</li> <li>• Contains an assessment of the burden attributable to environmental conditions and the resulting cost in Colombia (including outdoor and indoor air).</li> </ul> In 2006, the National Intersectoral Technical Commission for the Prevention and Control of Air Pollution (CONAIRE) was created by government order, with implementing regulations (33). Air Quality Information System (SISAIRE), in development. Bogotá: 15 monitoring stations (4,34).
Chile	Since 1991, has prevention and decontamination plans for saturated and at-risk areas, such as: Copper smeltings saturated by breathable particulate material and/or sulfur dioxide. Cities of Temuco and Gran Concepción. The Metropolitan Region, with the Santiago Atmospheric Prevention and Decontamination Plan (35).
Ecuador	Since 2004, Municipal Corporation for Air Management in Quito and in Cuenca (CORPAIRE), Metropolitan Atmospheric Monitoring in Quito and Air Monitoring Network in Cuenca.
Mexico	National Atmospheric Monitoring Program, whose origins date back to the 1950s. Automatic atmospheric monitoring networks in 23 cities (not all of them measure all pollutants, nor with the desired frequency) Air Quality Information System (SINAICA), <a href="http://sinaica.ine.gob.mx/">http://sinaica.ine.gob.mx/</a> Metropolitan Area of the Valley of Mexico: 36 monitoring stations. Reference document: Programa para mejorar la calidad del aire en la Zona Metropolitana del Valle de México (PROAIRE) 2011-2020 (29).
Peru	Regulations implementing National Air Quality Standards (since 2001) Local action and air quality management plans

## ■ Programs in Europe, the United States of America, and other countries

### Minimum air quality standards and air pollutants

Minimum standards for air pollutants in the Region are often based on European or U.S. standards. In Europe, ambient air quality is monitored throughout the Member States using a variety of methods: measurements, mathe-

mathematical modeling, or a combination of these. Assessments are mandatory in areas with over 250,000 inhabitants or zones where pollutant concentrations are close to the ceiling (36).

**Table 23-4** Examples of measures or strategies in air quality control programs in the Region

***PROAIRE strategies for emission reductions 2002-2010 (37):***

- Reduction of emissions in industry and services
- Preservation and restoration of natural resources and prevention of continued urban sprawl
- Integration of urban development, transport, and air quality policies
- Prevention of public exposure to high levels of pollution through risk evaluation and communication
- Strengthening and enforcement of the regulatory framework
- Strengthening of environmental education, research, and technological development
- Co-beneficiaries through the reduction of urban pollutants and greenhouse gases.

***Lines of action included in the Santiago Atmospheric Prevention and Decontamination Plan (38):***

- Technological renewal and public transportation
- Emissions for heavy, light, and mid-size vehicles
- Emission reduction requirements for the industrial and commercial sectors
- Control of emissions from home heating
- Program to control indoor pollution
- Program to control the raising of dust; and creation of green spaces
- Program to control volatile organic compounds (VOCs) and ammonia
- Permanent surveillance and audit program
- Program to strengthen local environmental management
- Program for public involvement, citizen participation, and environmental education
- Operational plan to tackle critical pollution episodes

**Sources:** Metropolitan Environmental Committee (2002). Air Quality Improvement Program of the Metropolitan Area of the Valley of Mexico, 2002-2010; Government of Chile (2004). Reformulación y Actualización Plan de Prevención y Descontaminación Atmosférica para la Región Metropolitana (PPDA-DS.58/2004)

Air quality in Europe is regulated by the European Union (EU) based on an air quality criteria framework. Council Directive 1999/30/EC, known as the “First Daughter Directive,” includes ceilings for SO<sub>2</sub>, NO<sub>2</sub>, NO<sub>x</sub>, PM<sub>10</sub>, and lead, as well as the thresholds required to evaluate and manage air quality. The regulatory framework in the United States, in contrast, focuses on six pollutants, known as “criteria air pollutants:” CO, Pb, NO<sub>x</sub>/NO<sub>2</sub>, O<sub>3</sub>, particulate matter, and SO<sub>2</sub>. These chemical compounds were selected because they imply a risk to public health and the environment, are found across the country, and are emitted from multiple sources. One of the mandates of the European Environment Agency is to establish and update National Ambient Air Quality Standards for each criteria pollutant. Member states failing to comply with these standards must issue specific regulations to reduce locally generated emissions.

The European Union has recently adopted a new air quality directive: Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe. The first EU directive to include ambient air PM<sub>2.5</sub> limits, it proposes reducing PM<sub>2.5</sub> exposure in urban areas by 20% by the year 2020, relative to 2010 values. This new directive consolidates several earlier air quality laws in a single directive. European governments have two years from 11 June 2008 to amend their legislation to comply with the directive.

Although this new directive represents a serious effort to reduce air pollution in Europe, environmental scientists stress that the current scientific evidence calls for standards that are even more stringent. For example, the new PM<sub>2.5</sub> limits are not sufficient to ensure adequate protection of public health. Some of the limits in the new EU directive are more lenient than some current European legislation and do not comply with the 2005 WHO recommendations. Although they are neither standards nor legally binding, the recommendations do serve as a guide for

decision makers concerned about reducing the health effects of air pollution, based on expert evaluations of the current scientific evidence. Table 23-5 compares current air quality standards in Europe, the United States, and Japan.

**Table 23-5** Clean air targets set by various entities

	SO <sub>2</sub> (µg/m <sup>3</sup> )				NO <sub>2</sub> (µg/m <sup>3</sup> )			PM <sub>10</sub> (µg/m <sup>3</sup> )		PM <sub>2.5</sub> (µg/m <sup>3</sup> )		Ozone (µg/m <sup>3</sup> )	
	1 year	24hr	1hr	10min	1 año	24hr	1hr	1 año	24hr	1 año	24hr	8hr	1hr
WHO (20)		20		500	40		200	20	50a	10	25a	100	
European Union (39)		125	350		40		200	40	50b			120	
Revised EU standards		125	350		40		200	40	50b	25		120	
Japan (40)		105	262			113			100				118c
United States (41)	78	366			100			50	150	15	65	157	
California (42)		105c	655				470c	20	50	12	65	137	180c

**Source:** World Health Organization. Air quality guidelines. Global update 2005. Particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Copenhagen, Denmark: World Health Organization; 2006. a) Not to be exceeded more than three days per year; b) not to be exceeded more than 35 days per year and c) photochemical oxidants.

## Regulatory framework for air emissions

In Europe, the National Emission Ceilings Directive (NECD) imposes emission limits for four key pollutants (NO<sub>x</sub>, SO<sub>x</sub>, VOC excluding nonmethane [NMVOC], and NH<sub>3</sub>) that are harmful to both health and the environment. NECD is currently being reviewed and will set limits for the four currently regulated compounds and for primary PM<sub>2.5</sub> emissions that should be met by 2020. In this review, the existing legislation for the different categories of sources (such as the Euro 5/6 for vehicle emissions), the review of the Directive by the Intergovernmental Panel on Climate Change, and the European Council decisions of March 2007 (to reduce greenhouse gas emissions by 20% and to have 20% renewable energy by the year 2020) should be taken into account.

With a view to meeting NECD targets, current European Community legislation includes directives on reducing emissions from large combustion plants, vehicle emissions, gasoline and diesel quality, and the sulfur content of certain liquid fuels. There is also a directive on gasoline storage and distribution, and another on reducing industrial emissions of organic solvents, both aimed at reducing VOC emissions.

Internationally, air pollutant emission ceilings were set in 2009 with the United Nations Economic Commission for Europe-Convention for Long-range Transboundary Air Pollution (UNECE-CLRTAP). CLRTAP's Gothenburg "multi-pollutant" protocol establishes national emissions ceilings that are equal to or less ambitious than those proposed in the NECD.

In the United States, emission control measures are applied if levels of criteria pollutants are exceeded. Since motor vehicles account for a large proportion of air pollution, the federal level and California have standards to limit vehicle emissions of five pollutants: hydrocarbons (HC), NO<sub>x</sub>, CO, PM, and formaldehyde (HCHO). The EPA also sets the National Emissions Standards for Hazardous Air Pollutants (NESHAP) for a series of industrial pollutants (43). Table 23-6 shows the emission limits set by the NECD and CLRTAP.

## Success stories

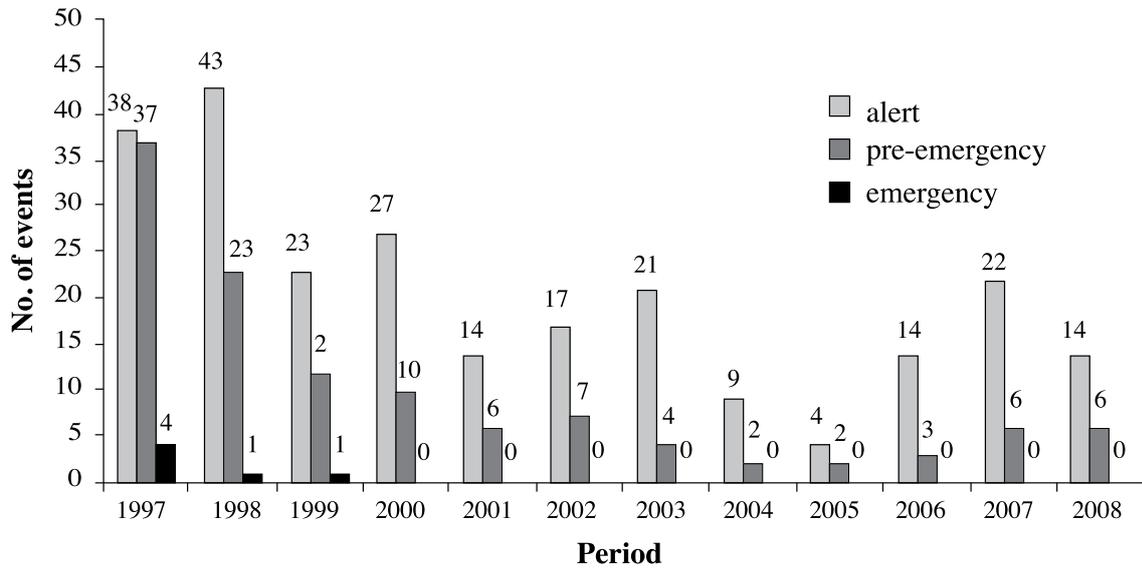
Over the years, Chile has presented evidence of lower emissions on days with critical episodes as a result of the interventions organized under the Prevention and Atmospheric Decontamination Plan of the Metropolitan Region (PPDA) (see Figures 23-2 and 23-3).

**Table 23-6** Air emission reduction targets. European Union and Member States

<i>EU Directive (NECD, 2000)</i>		<i>Required emission reduction</i>	<i>Time frame<sup>1</sup></i>
SO <sub>2</sub>	Total annual	77%	1990-2010
NO <sub>x</sub> (e.g. NO <sub>2</sub> )	Total annual	51%	1990
VOC (non-methane)	Total annual	58%	1990
NH <sub>3</sub>	Total annual	15%	1990
UNECE CLRTAP			
SO <sub>2</sub>	Total annual(1985) <sup>2</sup>	30% all <sup>3</sup>	1980-1993
	Total annual (1994)	62% EU	1980-2000
	Total annual (1999)	75% EU; 65% all l	1990-2010
NO <sub>x</sub> (e.g. NO <sub>2</sub> )	Total annual (1988)	0% EU; 0% all	1987-1994
	Total annual (1999)	49% EU; 44% all	1990-2010
	Total annual (1991)	30% all	1984/1990-1999
VOC (non-methane)	Total annual (1999)	57% EU; 49% all	1990-2010
NH <sub>3</sub>	Total annual (1999)	15% EU; 17% all	1990-2010
<sup>1</sup> First year of reference;			
<sup>2</sup> Year of protocol;			
<sup>3</sup> Countries that have ratified the convention			

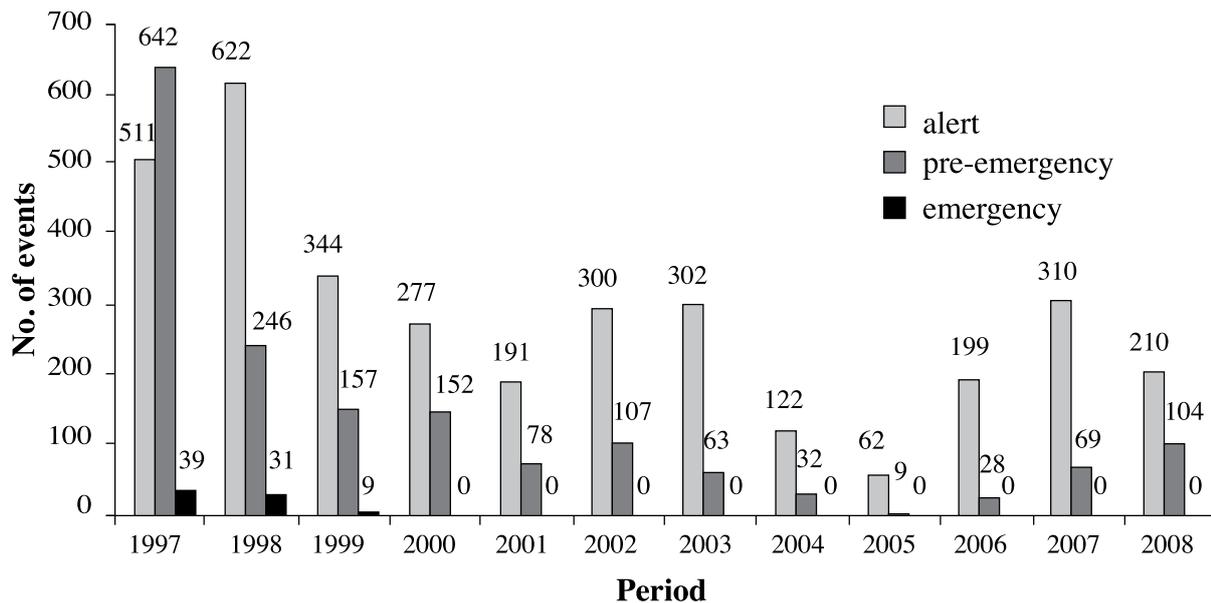
**Source:** National Emission Ceilings Directive (NECD, 2000); United Nations Economic Commission for Europe-Convention on Long-range Transboundary Air Pollution (UNECE-CLRTAP 1985-1999).

**Figure 23-2** Critical PM<sub>10</sub> episodes. Metropolitan Region of Santiago, Chile, 1997-2008



Source: CONAMA. (2009). "Planes de prevención y descontaminación".

Figure 23-3 Changes in the duration of critical PM<sub>10</sub> episodes in the Metropolitan Region of Santiago, Chile, 1997-2008



Source: CONAMA. (2009). "Planes de prevención y descontaminación".

The Cerro de Navia monitoring station is one of the most influential in the network, and if this station were excluded from the 2007-2008 comparative analysis, the results would be a 50% reduction in alerts, a 33% reduction

in pre-emergency alerts, and a 12% reduction in average concentrations throughout the period (1 April-31 August). If the Cerro de Navia station is included in the analysis, the comparison shows a 36% reduction in alerts, with no change in pre-emergency alerts, and an 11% reduction in mean concentrations for the period.

The various components of the Air Quality Management System promoted by the PROAIRE succeeded in reducing ozone levels in Mexico City Metropolitan Area, as seen in Figure 23-4. However, in 2007, Mexico's hourly ozone exposure limit was exceeded on 220 days, meaning that this substance continues to be a pollutant with potential adverse health effects.

## ■ Health impact assessment

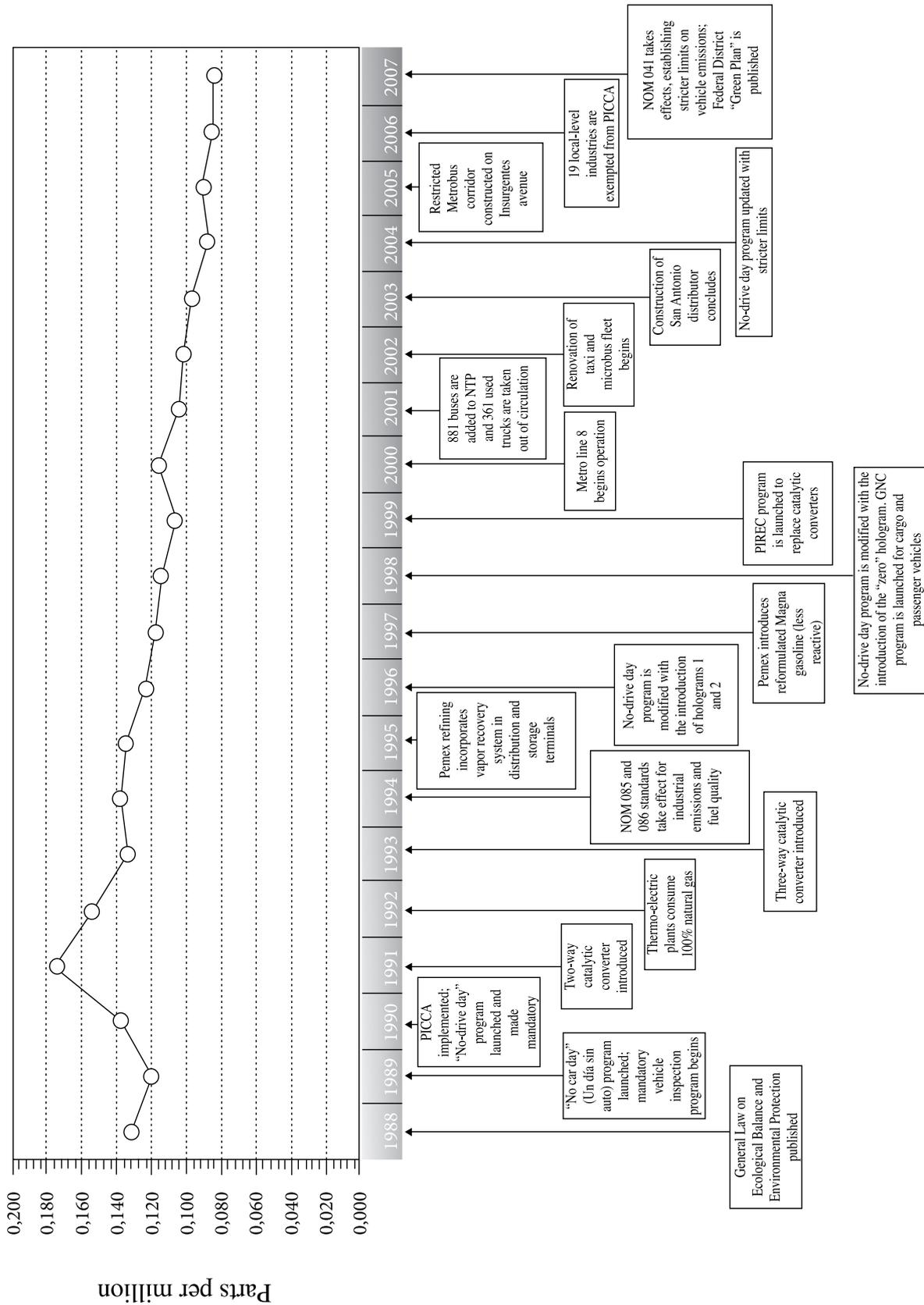
### Health impact of air pollution

The effects of air pollution on human health have been widely documented around the world. The Global Burden of Disease Study 2010 estimated that air pollution is the seventh leading cause of premature death worldwide, resulting in 3.2 million deaths per year and 72.3 million years of life lost. Longer life expectancy with improvements in air quality has also been demonstrated. In a study spanning 211 counties across 51 U.S. metropolitan areas, Pope, Ezzati *et al.* (44) calculated an increase in life expectancy of 0.61 years with a 10  $\mu\text{g}/\text{m}^3$  reduction in  $\text{PM}_{2.5}$  concentrations. These results are comparable to previous projections of life expectancy reductions when  $\text{PM}_{2.5}$  concentrations increase by 10  $\mu\text{g}/\text{m}^3$ : 1.11 years in the Netherlands, 1.37 in Finland, and 0.80 in Canada (45).

Acute and chronic exposure to air pollution is associated with higher mortality and morbidity from cardiovascular and respiratory problems (46,47), certain types of cancer, reproductive disorders, and neurological disorders (48). Exposure to air pollution during pregnancy and early life has been associated with preterm births, intrauterine growth retardation, low birth weight, sudden infant death syndrome, and infant mortality (48-51).

**Figure 23-4.** Air quality management – Ozone. Mexico City Metropolitan Area





Health effects can be classified as acute, chronic—excluding cancer—or carcinogenic (51). Alternatively, they may be classified according to the bodily system affected: respiratory disorders, cardiovascular disorders, cancer, reproductive and developmental disorders, neurological and neuropsychiatric disorders, mortality, infections, and other health effects. Epidemiological and animal studies indicate that the systems most affected are the cardiovascular and respiratory systems.

It is important to stress that air pollution levels in the major cities of the Region expose city dwellers—particularly children—to chronically high pollution levels that affect their long-term health, especially respiratory health (52,53). Table 23-7 lists the principal health effects associated with various air pollutants (54).

**Table 23-7** Health effects associated with ambient pollution and populations at greatest risk

<i>Pollutant</i>	<i>Population at risk</i>	<i>Clinical consequences</i>
Particles (PM10, PM2.5)	Children  Chronically ill (liver/ heart)  Asthmatics	Higher mortality due to cardiovascular and respiratory causes Higher mortality due to cardiovascular causes (chronic exposure) Increase in hospital admissions due to respiratory and heart problems Increase in respiratory symptoms Reduced pulmonary function Increase in asthma symptoms Higher prevalence of chronic bronchitis Higher risk of lung cancer Higher fibrinogen levels in blood Increase in inflammatory markers Lower heart rate variability
Sulfur dioxide	Healthy adults and patients with chronic obstructive lung disease  Asthmatics	Increase in respiratory symptoms Increase in mortality due to respiratory causes and increase in hospital visits due to respiratory illnesses Acute bronchoconstriction in asthmatics
Acidic aerosols	Healthy adults Children	Increase in respiratory illness Reduced pulmonary function
Ozone	Athletes, outdoor workers  Asthmatics (and others with respiratory illnesses)  Children	Increase in hospital admissions due to acute respiratory illness Increased asthma Increased bronchial sensitivity Reduced pulmonary function Lung inflammation Increase in respiratory symptoms Reduced exercise capacity (increase in hospitalizations)
Nitrogen dioxide	Asthmatic children	Increased morbidity due to respiratory causes Increase in the reactivity of respiratory passages Reduced pulmonary function Increase in respiratory symptoms
Carbon monoxide	Healthy adults Patients with ischemic heart disease	Increase in ischemic heart disease Reduced exercise capacity

**Source:** Romieu I, Hernández-Ávila M, Holguín F, “Ambient Air Pollution”, in Levy B, Wegman D, Sokas R and Baron S. *Occupational and Environmental Health: Recognizing and Preventing Disease and Injury*. 5th. ed. Lippincott Williams & Wilkins, Philadelphia, PA, 397-413, 2006.

## Health impact assessment

We now have sufficient epidemiological data to quantify the effects of air pollution on public health. One way to approach an environmental health problem such as air pollution is through a risk assessment. A risk is the likelihood of harmful effects to human health resulting from exposure to a danger or stressor, and a risk assessment can be defined as “a quantitative process carried out to characterize the nature and magnitude of the potential risks to public health from the exposure to hazardous substances, pollutants, or agents released from specific sites” (55,56).

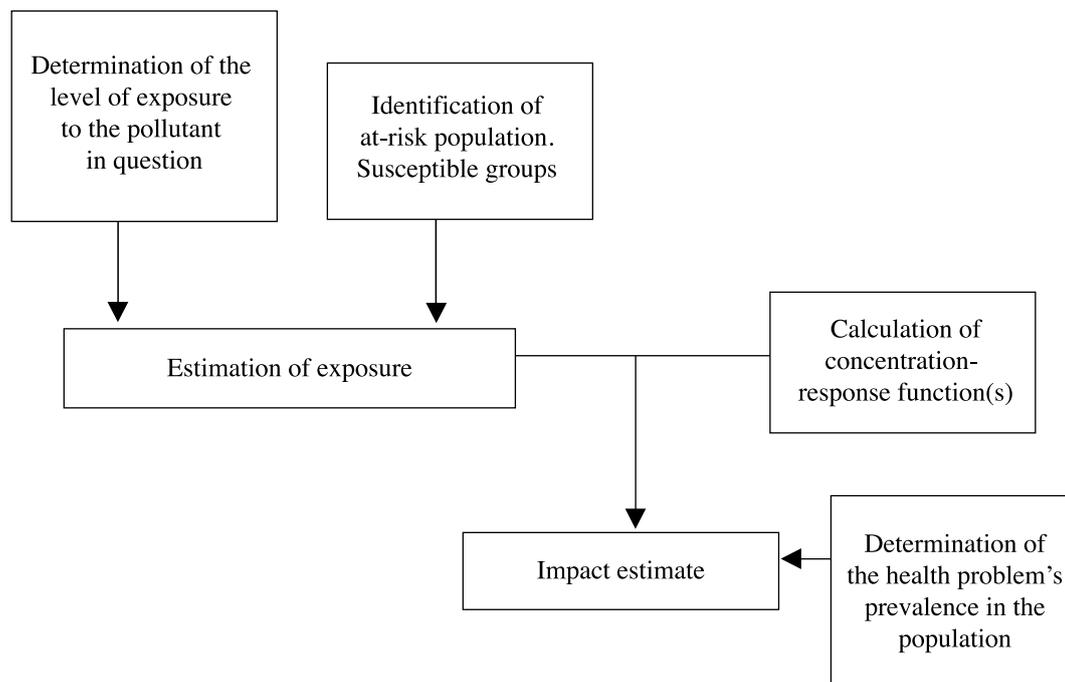
Various methodologies have been developed for risk assessments, such as those of the EPA (55,56) or the Agency for Toxic Substances and Disease Registry (ATSDR) (57).

Health impact assessment (HIA) is a methodology derived from the risk assessment approach. Defined as “a combination of procedures, methods, and tools through which a policy, program or project can be judged with regard to its potential effects on the health of the population” (58,59).

HIA is a tool designed to bridge the gap between research and decision-making and has been widely used throughout Europe and the United States in a range of fields, including environmental health. This tool is based on the use of methods to obtain the attributable fraction (60), which is the fraction of a health problem that can be attributed to a specific exposure or a change in exposure (compared to the reference exposure value). If the total burden of a health problem in a specific population is known, then the cases attributable to a given pollutant exposure can be calculated (60).

Figure 23-5 illustrates the principal stages of an HIA. Three factors are required to estimate attributable cases: a) the prevalence of the health problem in the population – in other words, the number of cases of a specific health problem (mortality or morbidity data) per year; b) the population’s exposure to the risk factor (air pollution data); and c) the quantitative association between exposure and the health effect (concentration-response function, or CRF) (60). In addition to these factors, health impact assessments are also conditioned by the defined study area, the choice of exposure measurements, the selection of health events, and the degree of uncertainty.

**Figure 23-5** Principal stages of a health impact assessment



Source: Adapted from WHO, 2005 (20).

## Health impact assessment in the Region

Following the methodology proposed by Ostro (61), WHO calculated the burden of disease attributable to environmental risks in each country. In the Region as a whole, outdoor air pollution is estimated to cause around 48,110 deaths per year. Table 23-2 presents the data from selected countries in the Region (24).

In 2006, Bell *et al.* calculated the impact of air pollution control policies on health in Mexico City, Santiago, and São Paulo (62). The results indicate that if the technology we now have were used to reduce PM<sub>10</sub> and O<sub>3</sub> emissions in the energy, transportation, industrial, and residential sectors, some 33,084 deaths could be prevented in Mexico City, 6,733 in Santiago, and 113,165 in São Paulo in the period 2000-2020. Likewise, 2,684, 385, and 735 deaths in children could be prevented in Mexico City, Santiago, and São Paulo, respectively, as well as almost 4 million cases of asthma, 300,000 pediatric medical visits, and 48,000 cases of chronic bronchitis in the three cities.

In a multicenter study of Mexico City, Santiago, São Paulo, and New York, it was calculated that in the period 2000-2020, approximately 64,000 premature deaths, 65,000 cases of chronic bronchitis, 91,000 hospital admissions, and 37 million person-days of lost work would be prevented if particulate matter and ozone emissions were reduced (by approximately 10%) through the adoption of greenhouse gas mitigation policies (63).

Three other studies on the effects of air pollution on health were conducted in Mexico, exploring different PM<sub>10</sub> and O<sub>3</sub> reduction scenarios: one study was an economic evaluation of the improvements in air quality in the Mexico City Metropolitan Area (64); another was on ambient air pollution in the Mexico City Metropolitan Area and human health (65); and the third study, published by Evans *et al.*, was part of the project “Integrated Program on Urban, Regional and Global Air Pollution: case study of Mexico City,” headed by Dr. Mario Molina (66). The economic evaluation study calculated an economic benefit ranging from \$717 million to \$1.1 billion for the year 2010 if ozone concentrations were reduced to comply with standards; and from \$3.0 billion to just under US\$5.6 billion if PM<sub>10</sub> concentrations were reduced to comply with standards (64).

The following is a brief description of a few recent studies evaluating the health impact of air pollution in the Region and of a case study in Riverside, California.

### Impact on mortality

The purpose of the ESCALA (Multicity Study of Air Pollution and Mortality in Latin America) study was to examine the association between exposure to outdoor air pollution and certain causes of mortality in the period 1997-2005 in the following cities: Metropolitan Area of the Valley of Mexico, Monterrey, and Toluca in Mexico; São Paulo, Rio de Janeiro, and Porto Alegre in Brazil; and Santiago, Temuco, and Concepción in Chile (67). This study ran from early 2006 to 2009, using a time-series design with the same analytical framework in all three countries to ensure comparable results. The analysis included an estimate of the percentage change in mortality risk with 10 µg/m<sup>3</sup> increments of PM<sub>10</sub> or ozone per individual city in each country. Statistical meta-analysis was employed. The ESCALA project also included an evaluation of the effects of socioeconomic status on the association between air pollution and mortality. For PM<sub>10</sub>, in the “all-age” group, there were positive and statistically significant increases in mortality from all natural causes (0.77%), cardiopulmonary diseases (0.94%), respiratory diseases (1.19%), cardiovascular diseases (0.72%), stroke (1.10%), and chronic obstructive pulmonary disorders (2.44%) (67). For ozone, an increase in mortality from cardiopulmonary (0.23%), respiratory (0.21%), and cardiovascular (0.23%) diseases was observed in the same age group (67). These results are similar to those of other multicity studies conducted elsewhere in the world. The investigators also reported patterns of greater risk of respiratory mortality among people in the lower socioeconomic strata, and increased risks of cardiovascular mortality among those in medium or higher socioeconomic strata, although the results were not consistent between cities (67).

### Health impact assessment: Metropolitan area of the Valley of México

An assessment of the health impact of air pollution in the Metropolitan Area of the Valley of Mexico conducted during the period 2009-2010 made it possible to estimate the number of deaths from various causes avoided by reducing ozone and PM<sub>10</sub> levels, as well as the impact on morbidity. For this assessment, concentration-response functions (CRF) were selected using various sources: international metaanalysis, other studies in Mexico City, and data from the ESCALA project. Three different PM<sub>10</sub> and three ozone reduction scenarios were evaluated and a geographic information system used to estimate population exposure to pollutants (68).

Using the CRF of the ESCALA project (Mexico City), it is estimated that 2,306 (95% CI: 1707-2899) deaths would be avoided if annual PM<sub>10</sub> concentrations were reduced to 20 µg/m<sup>3</sup>, the limit recommended by WHO (68). In the case of ozone, 389 (95% CI: 219-559) deaths would be avoided, if annual 8-hour average ozone concentra-

tions were reduced to 50 ppb, as recommended by WHO (68). Table 23-8 shows the results for the Metropolitan Area of the Valley of Mexico and the Federal District of Mexico. These findings were used as an information source for the health chapter of the Program to Improve Air Quality in the Metropolitan Area of the Valley of Mexico 2011-2020 (29).

**Table 23-8.** Total avoidable deaths per year according to hypothetical PM<sub>10</sub> and O<sub>3</sub> scenarios (68)

Exposed area/ Population	PM <sub>10</sub>				O <sub>3</sub>			
	FCR	Scenario	Preventable deaths	Confidence interval 95%	FCR	Scenario	Preventable deaths	Confidence interval 95%
Total 18,419,138	ESCALA (0.75%)	20µg/m <sup>3</sup>	2306	(1707-2899)	ESCALA (0.33%)	50ppb	389	(219-559)
		40µg/m <sup>3</sup>	1038	(767-1307)		60ppb	107	(60-153)
		50µg/m <sup>3</sup>	397	(293-500)		dism. 5%	90	(51-130)
	WHO (0.6%)	20µg/m <sup>3</sup>	1863	(1248-2473)	Ito and De Leon (0.53%)	50ppb	631	(441-796)
		40µg/m <sup>3</sup>	837	(560-1113)		60ppb	173	(121-218)
		50µg/m <sup>3</sup>	320	(214-426)		dism. 5%	147	(102-185)
Federal District 8,720,916	ESCALA (0.75%)	20µg/m <sup>3</sup>	1191	(882-1499)	ESCALA (0.33%)	50ppb	239	(134-343)
		40µg/m <sup>3</sup>	472	(349-595)		60ppb	79	(44-114)
		50µg/m <sup>3</sup>	108	(80-136)		dism. 5%	52	(29-74)
	WHO (0.6%)	20µg/m <sup>3</sup>	962	(644-1278)	Ito and De Leon (0.53%)	50ppb	387	(271-489)
		40µg/m <sup>3</sup>	381	(254-506)		60ppb	128	(90-162)
		50µg/m <sup>3</sup>	87	(58-116)		dism. 5%	84	(59-106)

### Case study. Preventing asthma-related events in children by improving air quality in Long Beach and Riverside, California

In Southern California (USA), Laura Pérez, an investigator at the Center for Research in Environmental Epidemiology, Barcelona (Spain), *et al.* conducted a study to evaluate the number of asthma-related outcomes that would be avoided if air quality were improved. They used concentration-response functions (CFR) data from epidemiological studies such as the Southern California Children's Health Study (CHS) on air pollution and respiratory health, which covered the Long Beach and Riverside areas (69). Table 23-9 shows some of the asthma-related outcomes (95% CI) attributable to air pollution per year in children living in Riverside, considering a scenario where NO<sub>2</sub> levels were reduced to 15 ppb and O<sub>3</sub> to 30 ppb in the annual 8hour average (levels in the cleaner coastal Southern California communities) (70).

**Table 23-9** Number of cases (95% CI) attributable to air pollution per year in children living in Riverside (70)

Pollutant	Evaluated event	Base estimates of the different events	Scenario (30 ppb O <sub>3</sub> ) *			
			Attributable to air pollution	Attributable to other air pollution-related causes in asthmatics	Total**	
					Number of cases that would be prevented	%
Exposure due to living near traffic in Riverside	Asthma cases	11,382	690 ***	n.a.	690	6.1
			(630-750)		(630-750)	(5.5-6-6)
O <sub>3</sub> in Riverside	Episodes of asthmatic bronchitis	4,405	3,100	80	3,200	72.6
			(170-4200)	(14-250)	(420-4,200)	(9.5-93.3)
	Asthma-related emergency room visits due to asthma	4,317	250	245	508	11.8
			(160-330)	(223-267)	(417-595)	(9.7-13.8)
	Asthma-related outpatient visits	8,560	220	250	490	5.7
			(20-410)	(220-270)	(410-580)	(4.8-6.8)
	Asthma-related hospital admissions	120	12	4	16	13.3
			(9-16)	(3-4)	(13-19)	(10.8-15.8)

\* This scenario involves lowering the annual average 8-hour ozone concentration to 30 ppb, i.e., reducing ozone exposure by 27 ppb.  
\*\*Not based on the sum of the other columns. Uncertainty distributions obtained through Monte Carlo simulations; n.a. = not applicable.  
\*\*\*Estimated number of asthma cases associated with living near a busy street

## ■ Data required to improve health impact assessments

### Monitoring

Air quality monitoring involves air sampling and the analysis of atmospheric pollutants. The primary purpose of the measurements is to quantify the concentration of the pollutants covered in the standards in each country. The substances in question are generally those commonly known as “criteria pollutants” and normally include: sulfur dioxide (SO<sub>2</sub>), carbon monoxide (CO), total suspended particles (TSP), particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>), ozone (O<sub>3</sub>), and nitrous oxides (NO<sub>x</sub>).

Among the current networks, those of Mexico City, Santiago, and São Paulo are at the forefront due to their degree of development, coverage, and importance. However, monitoring and network building in the countries are inadequate, with PM<sub>2.5</sub> monitoring virtually nonexistent, for example. The availability of data on the current situation and trends in pollutants is very limited, with efforts in several countries sporadic and of short duration. This lack of data continuity frustrates attempts to employ geostatistical pollutant dispersion models, whose use is becoming more widespread around the world. The Region must launch initiatives to develop appropriate models for determining exposure.

These new trends toward the use of geostatistical models to estimate exposure could prove very useful in countries with limited capacities or monitoring networks, as they make it possible to estimate variability in the dispersion air pollutants within urban areas.

### Evaluating exposure

One key issue in evaluating the health impact of a pollutant and ensuring adequate risk management is calculating exposure levels. Population exposure to an air pollutant is largely determined by the concentration of a pollutant in the microenvironments of a population and the length of time it remains in those environments. Several lines of research on the public health impact of exposure to air pollutants are currently being pursued. The

association between concentration and adverse effects continues to be established with ever-lower values; WHO has noted that there is no lower threshold, as there are risks with any concentration (7).

In epidemiology, various methodologies have been developed to evaluate population exposure to air pollutants. For many years, the principal method consisted of estimating exposure in terms of the radial distance from stations in a local monitoring network, with values calculated on the basis of the proximity of the subjects or study groups (68). However, these models for calculating exposure to particles or other pollutants have evolved considerably in recent years, driven largely by the computer software used for geographic information systems and geostatistical analysis.

Recent studies suggest that the concentration of pollutants in urban environments can vary widely, even in an area covered by the same monitoring station; (71) as a result, developing models to evaluate exposure to air pollutants in urban environments has become extremely important in recent research (72). Over the past few years, models based on geographic information systems, such as land-use regression models, have proven reliable for use in epidemiological studies for estimating exposure (71).

## Epidemiological data

To date, many health impact assessments have used suspended particles as the marker of ambient air pollution, particularly  $PM_{10}$ . Numerous epidemiological studies document the association between  $PM_{10}$  and different health effects in various age groups. Yet, there have been few such studies in the Region, especially those that explore morbidity and other factors, such as school absenteeism. Therefore, to estimate the effects of air pollution, the findings of studies conducted in other regions must be used, which leads to greater uncertainty in the estimates. Nevertheless, the data on the health impact of air pollution is sufficient to warrant measures and tighten air pollution control policies. The general trend is to obtain scientific evidence on the effects of smaller particles ( $PM_{2.5}$  or even  $PM_1$ ) or the chemical composition of particulate matter (i.e., sulfates, heavy metals, and polycyclic aromatic hydrocarbons), as well as on the effects of other substances (i.e., volatile organic compounds).

Reference values for the cases considered are necessary both for epidemiological studies and for health impact assessments. The lack of reliable systematized morbidity (and, to a lesser extent, mortality) data in most countries is a major drawback. Only with improvements in death certificate registries and a good epidemiological surveillance system that includes public and private health institutions and facilitates environmental epidemiological surveillance will it be possible to obtain the systematized information needed for quality studies.

## ■ Recommendations for intervention policies and programs

Air quality is one of the essential elements for a healthy environment. Both national and international conventions oblige States to respect, protect, and guarantee the human right to a healthy environment, especially because it is a right closely linked to the exercise of other basic rights, such as the right to health and a decent quality of life (73).

Many of the recommendations suggested in reports and documents from various Latin American countries apply to the entire Region. In this regard, some strategies of the PROAIRE for Mexico City (29) and the Prevention and Atmospheric Decontamination Plan in Santiago have already been discussed (38).

The following is a list of recommendations formulated by the Human Rights Committee of Mexico City (73) and the National Council on Economic and Social Policy (32), as well as others gained from experience. Thus, the following actions are advocated:

- Identify information gaps, weaknesses, and the technical requirements for strengthening epidemiological surveillance associated with air pollution.
- Evaluate the current spatial coverage of air quality monitoring systems, and ensure monitoring of recently developed regions.
- Expand monitoring to include toxic substances –more specifically, volatile organic compounds with carcinogenic potential.
- Promote or improve research on the health impact of air pollution through epidemiological studies and health impact assessments, as well as research on the influence of climate change on mortality and on the incidence of respiratory diseases associated with air pollution.
- Treat environmental management as a cross-cutting issue in public management. Coordinate infor-

mation from the environmental, energy, transportation, and health sectors. Make environmental issues key elements of development policies to ensure effective solutions to complex problems like air pollution.

- Include a specific chapter on accountability and compliance with standards in management reports.
- Promote the review, updating, or establishment of population exposure parameters, emphasizing human and ecosystem health. Spearhead initiatives to ensure compliance with national standards primarily, but with a view to meeting more stringent criteria, such as the WHO recommendations or the California standards.
- Prepare performance assessments of activities implemented by the State, which should be conducted by independent agencies. Air pollution prevention and control activities have been carried out in the Region, but in an isolated fashion and virtually without any evaluation of effectiveness. None of the achievements has been documented, and comparisons are difficult.
- Ensure that the resources obtained from environmental programs such as vehicle verification are allocated to improve, develop, and consolidate initiatives to prevent, control, and mitigate air pollution.
- Formulate policies to promote tax incentives, compensation, or awards for individual action to safeguard the right to a healthy environment.
- Propose and establish mechanisms to deter human activities that give rise to further pollution.
- Promote a public culture of environmental protection.
- Steer public policy towards significantly improving air quality through maximum energy saving and minimal waste.
- Support the creation of expert groups to conduct assessments, updates, and monitoring of interventions.

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# Violence and health: A challenging social issue

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Before getting started, a distinction must be made between violence and conflict. Conflict is a normal social phenomenon that reflects differences in ways of thinking, feeling, and acting among all members of a society. Conflict turns into violence when one party seeks to impose its will or viewpoint by force or intimidation. Violence and conflict are ancient phenomena (1) observed in all societies.

According to WHO estimates (2), each year, more than 1.6 million people around the world lose their lives as a result of violence. Of these deaths, 37% are homicides, 51% are suicides, and 11% are due to war and civil strife. Of the six regions into which the World Health Organization groups its member countries, the Region of the Americas, where the homicide rate was 16.4 per 100,000 population in 2004 (3), is the second most violent in the world, surpassed only by sub-Saharan Africa (4).

It is estimated that nearly 130,000 people die as a result of homicide in the Americas each year (5). Overall, the risk of death by homicide is 4.2 times higher among men than among women; in Latin America and the Caribbean, the relative risk is 8.9. Given these large differences, it is customary to analyze data for men and women separately.

Violence has reached epidemic proportions and is one of the leading causes of death in the population aged 15 to 44, accounting for 15% of global deaths in the male population and 7% in the female population (6).

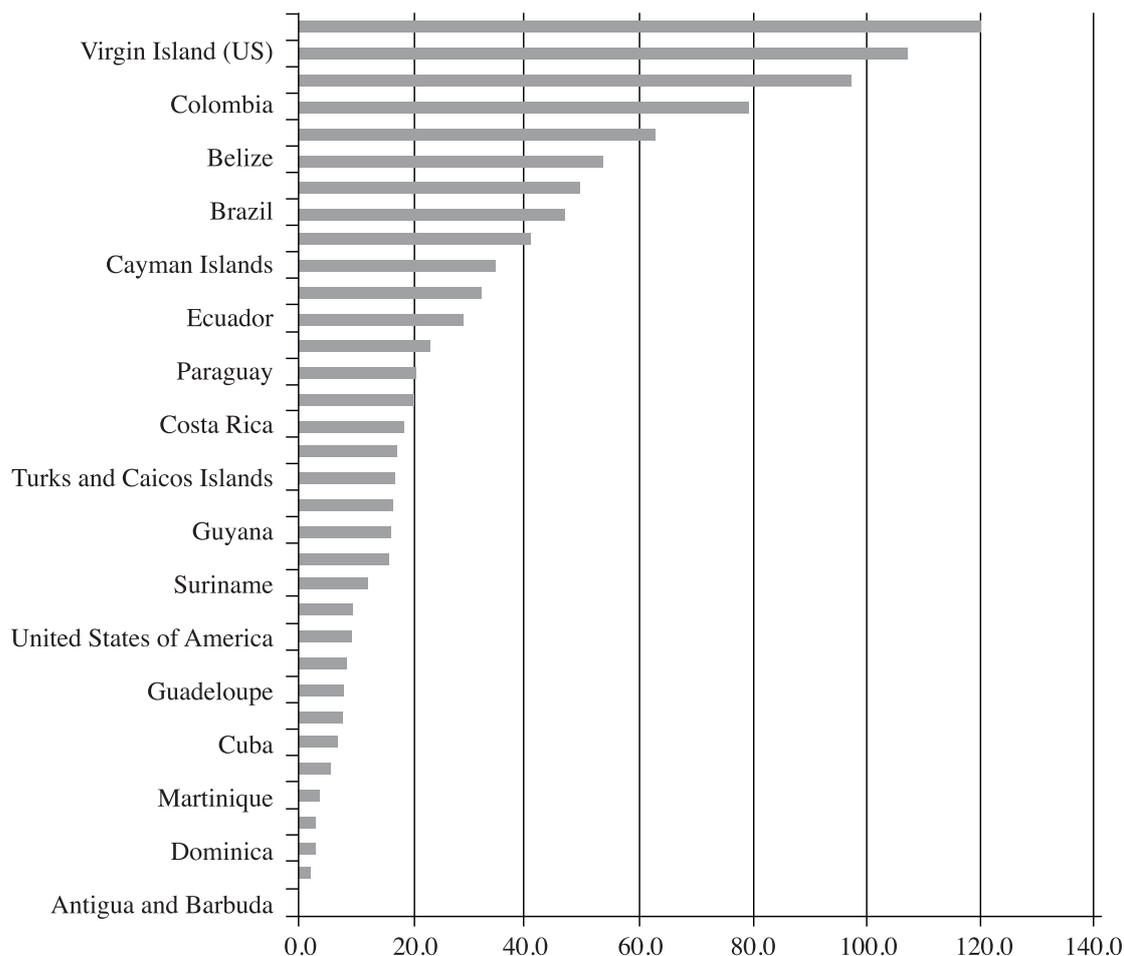
There are major differences in homicide patterns among the countries of the Region. As shown in Figure 24-1, the risk of a male dying by homicide in El Salvador, Guatemala, and Colombia is 44, 36, and 29 times higher, respectively, than in Canada.

In recent years, mortality from homicide in the countries of the Region has varied in both magnitude and trend. Figure 24-2 shows the trends in seven countries as reported in the past 25 years.

It is estimated that, in the year 2000, 14% of the Region's gross domestic product (GDP) was lost to violence (7). In many countries, violence is the leading cause of death among the general population, and in almost all, it is the leading cause of years of healthy life lost (disability-adjusted life years, or DALYs). It is calculated that 560,607 potential years of life were lost in Colombia in 2007 because of intentional violence, mostly among youth (8).

The rate of DALYs per 1,000 population due to assault and homicide is higher in Latin America and the Caribbean (11.0) than in Africa (9.2). On the other hand, when age-adjusted mortality rates are compared, the risk of dying from those causes is slightly higher in African countries (29.9) than in our region (25.5); this may be related to the greater number of people in Latin America who survive the initial assault but are left with disabling sequelae (see Table 24-1).

Violence and insecurity are the leading concerns of citizens across the Americas. In some nations, such as El Salvador, the United States, and Guatemala, most homicidal violence is the result of youth gang activity.

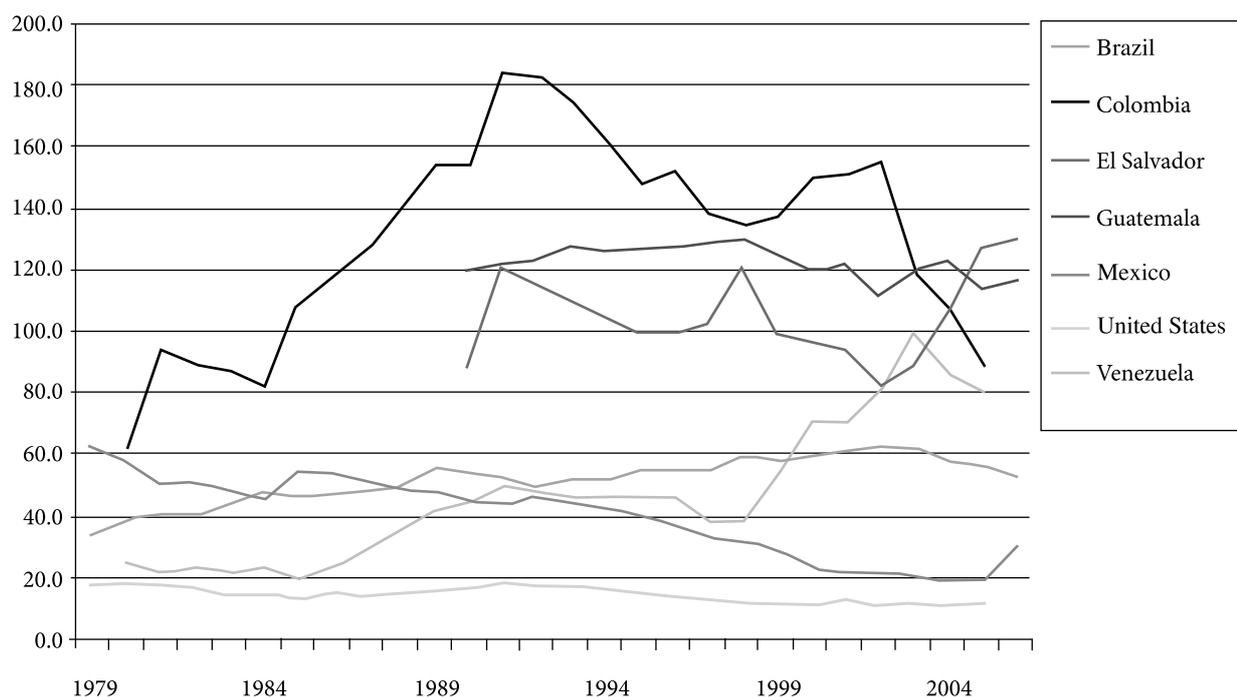
**Figure 24-1.** Age-adjusted male mortality from homicide: selected countries in the Americas, circa 2009.

Source: PAHO/WHO. Regional Mortality Information System, Washington, D.C., March 2013.

## ■ Violence and public health

Since Héctor Abad Gómez first proposed the application of epidemiological methods to the analysis of violence in Colombia (9), public health has taken an interest in violence prevention in the Americas (10). “Identifying violence as a public health issue is a relatively new idea,” wrote C. Everett Koop, the United States Surgeon General, in 1985 (11). In 1993, meeting in the Directing Council of the Pan American Health Organization, the ministers of health of the Americas adopted a resolution stating that violence was a public health priority in the Americas (12); the 49th World Health Assembly of the World Health Organization adopted a similar resolution (13).

Contrary to popular belief, public health and epidemiology are not merely the sciences that study infectious diseases. Epidemiology is a constituent part of public health that is devoted to studying the causes of diseases; although, in its early stages, it focused on diseases caused by infectious agents, it has since been applied to diseases caused by chemical agents or the physical environment and, more recently, to those of a social nature (14).

**Figure 24-2.** Age-adjusted trends in male mortality from homicide: selected countries in the Americas, 1979-2004.

Source: WHO. Mortality Database, several years. UN. Population projections, 2008.

**Table 24-1.** Deaths and disability-adjusted life years (DALYs\*) due to homicide in Africa, the Americas, and Latin America and the Caribbean, 2004.

	World	Africa	The Americas	Latin America and the Caribbean
Deaths (thousands)	600	182	155	138
DALYs* (thousands)	21.701	6.333	6.648	6.078
Mortality (age-adjusted), per 100,000 population	9.3	29.9	18.1	25.5
DALYs* (age-adjusted), per 1,000 population	3.4	9.2	7.9	11.0

Source: WHO, *Global Burden of Disease*, 2004.

## ■ The definition of violence

Violence can be defined in many ways: *by the person who experiences it* (violence against children, women, or the elderly); *by the nature of the aggression* (physical, psychological, sexual, etc.); *by the apparent motive or reason* (political, racial, etc.); or *by the setting in which it occurs* (domestic, occupational, urban, rural, etc.). There is no single definition that suits all interests and is generally accepted, but the one adopted by the World Health Organization (WHO) is possibly the most widespread.

WHO defines violence as “the intentional use of physical force or power, threatened or actual, against oneself, another person, or against a group or community that either results in or has a high likelihood of resulting in injury, death, psychological harm, maldevelopment or deprivation” (15).

This definition includes interpersonal violence, self-directed violence, and collective violence inflicted by political groups, terrorists, or the State. It clearly excludes cases such as falls, traffic injuries, etc., in which there is no intention of causing harm —i.e., incidents commonly known as *accidents*.

In this chapter, we will focus exclusively on interpersonal and collective violence.

*Interpersonal violence* is violence perpetrated by one person against another. This category includes both domestic and community violence.

*Domestic violence* consists of acts of physical, psychological, or sexual abuse, usually between family members or intimate partners, and tends to take place in the home, although not always (16). This category includes child abuse, an important form of violence with significant social repercussions, which is defined as “acts of commission or omission by a parent or guardian judged by a combination of community values and professional expertise to be inappropriate and damaging.” (17) Domestic violence also includes elder abuse.

*Community violence*, as defined by WHO, is violence that takes place outside the home between individuals who are not necessarily related, who may or not know each other, and that affects children in its multiple manifestations. This category includes youth violence—such as gang wars—, other forms of street violence, sexual abuse, and school violence. This latter is defined as interpersonal aggression that takes place within a school setting—including not only the school itself but also its athletic fields and access routes—and encompasses acts of violence committed by students against teachers, by teachers against students, and by parents against teachers.

*Youth and gang violence.* According to WHO, in the year 2000, 199,000 deaths by homicide (a rate of 9.2 per 100,000 population) among young people (10-29 years) were recorded. Homicide rates vary widely among regions and countries, with the Region of the Americas being the most violent (18). In 2004, Colombia (with a rate of 84.4 per 100,000) and El Salvador (with a rate of 50.2 per 10,000) were among the countries with the highest homicide rates recorded by WHO (19). In nearly all countries, homicide rates among males are much higher than among females (the male:female ratio is approximately 7:1), from which it follows that being male constitutes a demographic risk factor for homicide (20).

Most youth violence is the product of *gangs*, loosely defined organizations that play an important social role in young people’s normal process of achieving independence. Gangs can range from innocent groups of friends who congregate on a street corner up to highly structured organizations devoted to criminal activities. It is therefore hard to estimate the contribution of gangs to youth violence.

In the absence of a precise definition, the extent of the gang problem is hard to estimate. In 1995, it was estimated that, in the United States, there were approximately 25,000 gangs with 650,000 members, 54.6% of whom were African-American and 32.6%, of Latino origin (21). Some gangs deported from the United States keep their original names on arrival in their country of origin, among them the notorious and violent Mara Salvatrucha and Calle Dieciocho (18th Street) gangs in El Salvador (22).

According to the 1997 Caribbean Adolescent Health Survey, one out of 11 adolescents reported a current gang affiliation and another 10% claimed to have belonged to a gang in the past. Among youths aged 16 to 18, one in nine reported having taken part in a gunfight in the preceding year (23).

*Collective violence* is violence committed by people who identify as belonging to a group for the purpose of advancing a political, economic, or social agenda. WHO subdivides collective violence into social, political, and economic violence. The Latin American Center for Studies on Violence (*Centro Latinoamericano de Estudios de Violencia y Salud*, CLAVES) prefers to not use the term *social violence* as a subclassification of collective violence, since all violence is a social phenomenon. Instead, CLAVES breaks it down into the following categories: a) *structural violence* (violence committed in an attempt to maintain social, cultural, gender, or other inequalities); b) *cultural violence* (forms of discrimination accepted by society, such as racial discrimination); and c) *institutional violence*, which is manifested in operating rules and regulations that reproduce unfair social structures (such as rules governing patient access and management in public hospitals) (24).

## Public health and the study of violence

An important contribution of public health to the study of violence is the way it addresses the concept of causality. In epidemiology, causality is always interpreted *in terms of probability*— i.e., for a given factor to be considered *causal*, it is enough for its mere presence to increase (or decrease, if the factor is preventive) disease (25).

The concept of causality can be better understood by analyzing the example of cardiovascular disease (CVD), which offers a special analogy with respect to violence. It is known that CVD occurs secondary to the buildup of fat in the arteries due to an individual’s own genetically regulated metabolism. This genetic factor is, at least for the time being, impossible to control. It is also known that other factors (known in epidemiology as *risk factors*), such as diet, smoking, lack of physical exercise, and stress, increase the likelihood of CVD. Given the impossibility of addressing CVD’s genetic component, prevention campaigns have focused on modifying the most important

risk factors, such as smoking, saturated fat intake, sedentary lifestyles, and high levels of stress—a strategy that has achieved major reductions in mortality (26).

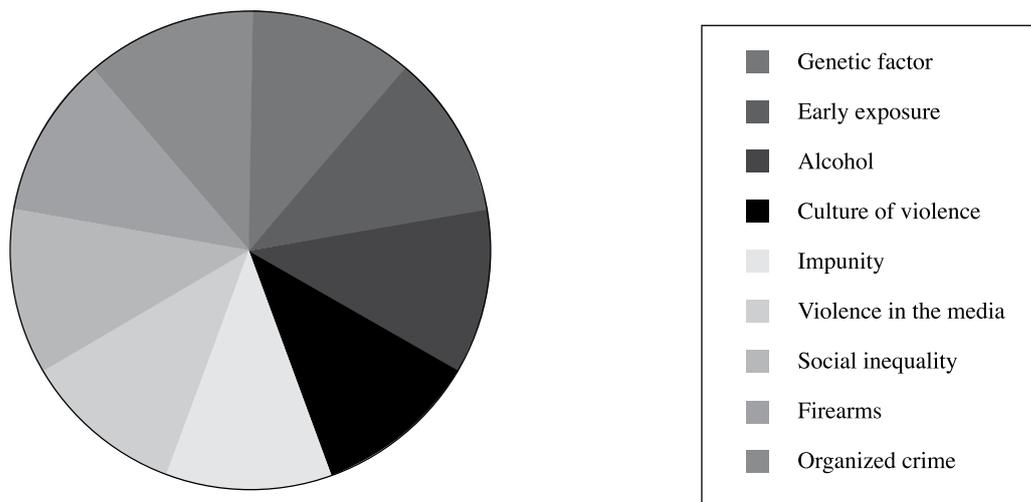
Like CVD, violent behavior in human beings (as in lower species) involves a genetic factor that promotes aggression and violence, as well as some risk factors that predispose to them. Much has recently been discovered about aggressive impulses: dynamic studies of brain function have made it possible to identify the anatomical sites where aggression lies, and we are beginning to learn about the nature of the chemical mediators (neurotransmitters) that permit its expression (27). For the time being, however, this knowledge has few practical applications.

Nevertheless, experience has shown that there are other risk factors that facilitate manifestations of aggressiveness as violent behavior. These include early exposure to domestic violence or violence at school, child abuse, alcohol abuse, and others (Figure 24-3). As in the case of CVD, the public health method recommends modification of the risk factors for violent behavior as a means of controlling it.

### Risk factors for violence

The paragraphs below analyze some of the most common risk factors, especially those observed in the Region of the Americas and those considered modifiable on the basis of empirical data. Figure 24-3 shows a theoretical model of the most important risk factors. As the model is theoretical, they are given equal weight, although in practice, some are more important than others. The weight of each risk factor—i.e., its contribution to the problem of violence (for instance, the contribution of organized crime or of culture)—varies from country to country.

**Figure 24-3.** Theoretical model of risk factors for interpersonal violence.



### Genetic factors

In rare cases, a genetic predisposition to violence has been found. This predisposition is dependent on the monoamine oxidase A gene (28), which, like a switch, activates or deactivates the enzyme that regulates brain chemicals. A deficiency in these chemicals predisposes to aggression, while their presence is a determinant of nonaggressive behavior. It is of special interest to note that the monoamine oxidase gene is expressed in environments that might heighten its effect; conversely, when children grow up in healthy environments, the likelihood of involvement in antisocial behavior is similar between those who have the activated gene and those who do not.

Neurobiology has demonstrated that the human brain has great plasticity and that permanent or chronic conditions are not necessarily irreversible, because positive social interactions can rebuild altered circuits and release brain chemicals whose deficiency predisposes to violent behavior.

## Early exposure to violence

A study conducted by the CISALVA Institute at Colombia's Universidad del Valle on a sample of heads of household from Bogotá, Cali, and Medellín found that 62% of parents admitted to yelling at their children, 27% to slapping them, and 17% to hitting them with a hard object (capable of causing harm) within the preceding month (29). Interestingly, if the same participants had been asked whether they had abused their children in the last month, they probably would have said "no." Although the harmful effects of child abuse have been known since ancient times, having been mentioned even in the writings of the Apostle Paul—"Fathers, do not provoke your children, lest they become discouraged" (30)—, violent methods of disciplining children are so deeply entrenched in Colombian and Latin American culture that the practices described above, which constitute a crime in many countries, are not considered child abuse in the Region, but viewed as necessary, appropriate, and desirable ways of "educating" children.

Individual behavior depends on the interaction of different factors, such as gender, temperament, age, neighborhood, and culture. Among these factors, neighborhood and culture are environmental, whereas age, gender, and temperament are intrinsic to the child. Each social experience changes brain chemistry and leaves an imprint on the neural circuits involved in it. Recurrent activation of the circuits of aggression enlarges and stabilizes them, thus establishing what could be called "neural formatting" or "neural highways," whereby altered cerebral circuitry and chemistry predisposes to chronic impulsive aggression (31). When children are raised with negative patterns of interaction with their parents, these patterns are expressed in disruptive behaviors that lead to rejection by peers and teachers; this, in turn, results in negative reinforcement of the disruptive behavior. This combination of factors, and their persistence, produces neurological changes that predispose to aggression (32).

Violent adults tend to have a history of early trauma. In other words, as a consequence of the neurological imprints of physical or emotional abuse, both those who themselves experienced violence as children—in the home or at school—and those who witnessed violence between their parents tend to become violent adults, because they learn that aggression is the natural form of conflict resolution. Thus, a spiral of violence that begins in the home continues at school, spreads across society, and is passed down from generation to generation.

According to Garbarino, the elements of a culture that subvert children's personalities and self-image cause boys and girls to feel incompetent, vulnerable, and threatened; impede or distort their moral reasoning; destroy their hope; and interfere with the development of the ideological and emotional foundations of their future performance in life, in what the author calls *social toxicity* (33).

The social toxicity factors that affect child development most keenly include exposure to traumatic experiences and to anything that destroys a person's sense of trust in the environment: collective fear; discrimination toward and rejection of minorities; domestic violence; parental rejection and abuse; lack of supervision and role models; a shallow and materialistic culture; tolerance of emotional violence; acceptance of abusive and depersonalizing language; and exposure to violence in the media (34).

## Alcohol

It is known that the consumption of alcoholic beverages, commonly known as *drinking*, causes significant metabolic changes in the body, especially in some of the neurotransmitters that play a role in violence, and that it is associated with nearly all forms of violent behavior, especially when the drinking is compulsive (known as *binge drinking*) and occurs in certain cultural settings (35). Drinking is therefore considered a risk factor for violence (36). Alcoholism in a male partner is associated with violence against women (37); several studies of homicide have revealed high alcohol intake among both the homicide victims (38) and their assailants or perpetrators (39). Data from the DESEPAZ program revealed that 56% of all homicides in Cali were recorded on one of the three days of the weekend as Monday was a public holiday, with one-quarter of them occurring on Sunday; furthermore, homicide rates rose on holidays, including Mother's Day, the Christmas season, and New Year's Eve, and on days of sports victories (40).

## Culture of violent response to conflict

Different societies have cultural patterns of conflict resolution marked by varying degrees of violence; thus, while in some countries, conflicts are rarely resolved through violence, elsewhere violence is considered a culturally legitimate solution. The guerrilla movements prevalent in Latin America and the drug trade have unquestionably helped legitimize violence and establish patterns of violent response to conflict. A study on cultural attitudes and

norms found that 40% of the population in Rio de Janeiro would approve of, or at least understand, having a daughter's rapist killed (41).

A large body of published evidence reveals that violent behavior begins in early childhood, and that educational practices and beliefs heavily influence such behavior.

### Impunity and ineffectiveness of the legal system and law enforcement

The choice of response to an affront is influenced by one's attitude toward other possible strategies (42). Public perceptions of the ineffectiveness of the legal system and the limited credibility of law enforcement are other risk factors that operate in many parts of the Region of the Americas, because they lead citizens to take the law into their own hands—i.e., to the legitimation of violence. DESEPAZ data for 1983 reveal that in only 6% of the homicides committed in Cali could the assailant be identified; data from Bogotá and Medellín showed similar results. Considering, moreover, that only a small percentage of the assailants identified are actually punished, it becomes clear that the extremely low likelihood of punishment can encourage aggressive behavior.

### Violence in the mass media

Given the ongoing controversy over the role of the media, we must emphasize that the depiction of violence in the media is only one of several risk factors that add to the effects of the aforementioned factors but do not exclusively explain violent behavior. There is no doubt about the existence of a causal relationship between the viewing of violent content on television and violent behavior (43) and that depictions of violence in the media stoke violent behavior, especially among young males, in what has been termed *observational* or *vicarious learning*. Through the media, children and young people learn to accept aggression as normal and regard it as an effective means of solving interpersonal problems. Just as air pollution affects physical health, repeated exposure to violent behavior is a form of social toxicity that has implications for personality development and can lead to death by suicide, homicide, drug abuse, and other self-destructive behaviors (44).

### Poverty, social inequality, and marginalization

Homicide rates in the United States—without racial distinctions—are 2.5 times higher in lower socioeconomic groups than among those at higher levels (45). Data from the DESEPAZ program in Cali also showed a higher rate of homicide among the lower socioeconomic strata of the population (46). However, other studies conducted at the national level have failed to find associations between poverty and homicide rates (47). There is no doubt that *intentional urban violence* occurs most frequently among the lower socioeconomic strata (48-50). Furthermore, the poor are at once the perpetrators and the victims. To some observers, absolute poverty matters less than relative poverty, which creates a sense of rejection, frustration, and powerlessness and leads to “free-floating anguish” that facilitates aggression (51).

The relationship between poverty and violence is difficult to interpret, given the multiple social and educational factors associated with poverty. In addition to low income, poor people experience multiple forms of deprivation, which can also be risk factors for violence (52). The only clear conclusion is that eradicating poverty and social and economic inequalities should be an integral part of any program to combat violence.

### Firearms

According to a 1994 report by the Carter Center, the high homicide rates observed in the United States in the 1990s were due to an increase in gun violence, since homicides attributable to other causes remained constant (53). According to the same Carter Center study mentioned in the previous reference, 80% of deaths by homicide among young people in the United States are committed with firearms. Some studies conducted elsewhere have identified the proliferation of firearms as a risk factor, especially as they make assaults more lethal, which is why restrictions on the sale and carry of firearms are recommended (54). It has been demonstrated that owning a firearm increases the risk of death of a household member 2.7-fold (55).

According to the Colombian Institute of Forensic Medicine, in 2007, 80% of homicides of men and 68% of homicides of women recorded in Colombia were committed with firearms (56). Similar figures are found in Cali and Medellín. Data from the Bogotá Metropolitan Police reveal that 31.3% of weapons seized during the commission of crimes had been sold legally by INDUMIL (*Industria Militar de Armamentos de Colombia*, the country's sta-

te-owned weapons manufacturer) and that a permit had been issued for 20% of them (57). According to data from the Bogotá municipal government, in 1994, 156,283 permits to own or carry firearms were issued in the city. If the illegal firearms and bladed weapons in circulation at the time are added to this figure, it can be deduced that, at the time, Bogotá was in the midst of an extraordinary proliferation of lethal weapons.

An evaluation of a disarmament policy in effect on selected weekends that was implemented in Cali in 1994 showed a substantial reduction in homicides by firearm, while no changes were observed in homicides by other means (58). These findings demonstrate that gun control helps reduce homicidal violence.

## Violence and human rights

Scholars of the history of civilization and violence agree that the issue of violence becomes relevant to a society as it begins to awaken to the concept of human rights. Violence has been present throughout human history, and even features in the biblical narrative in the crime of Cain against his brother Abel. However, it has only become a social issue in recent times with the appearance of modern societies. There is no doubt that crimes such as kidnapping and torture are especially relevant in the case of human rights violations and should be carefully studied.

The first charter on human rights was formulated in 17th-century England, through the so-called Bill of Rights, which affirmed the rights and freedoms of the English people and placed restrictions on the absolute power of the sovereign. Later, U.S. citizens, who had recently thrown off the mantle of colonial rule, incorporated similar freedoms and rights into the 1791 Constitution of the United States of America. Nevertheless, the key document in this domain is without a doubt the Declaration of the Rights of Man and the Citizen, issued by France's National Assembly in 1789 in the midst of the French Revolution. This declaration affirmed the freedom and equality of all men and demanded their natural and inalienable rights to liberty, property, security, and resistance to oppression. (As a curious aside, due to the historical conditions of the age, the Assembly rejected a declaration of the rights of women, proposed by the poet Olympe de Gouges.) (59).

The current Universal Declaration of Human Rights (60) was adopted by the United Nations General Assembly on 10 December 1948 and recognizes the civil, political, and social rights of the human family. In the field of civil rights, the declaration includes: *a*) freedom of expression, opinion, association, and movement; *b*) the universal right to life, which includes the respect for security of person, protection against torture and summary execution, and the abolition of slavery; and *c*) the right to a decent life, to social justice, and to well-being, regardless of sex, race, or nationality.

The Universal Declaration recognizes that deep-seated social injustices and inequalities are at the root of many problems; hence, the need to formulate and implement a basic agenda of economic and social rights for all humanity. That vision has been followed by a growing consensus that access to education, employment, health, and justice is also a human right.

The debate over human rights and, especially, respect for security of person gained momentum in the late 1970s, when the systematic violations of the rights of dissidents were made public and an international network of nongovernmental organizations founded to support human rights flourished.

Despite this progress, in many countries, inequalities continue to grow and serious forms of human rights violations persist, perpetrated by agents of the State or by organized groups in society—a phenomenon marked by death squads, summary executions, disappearances, lynchings, police brutality, and limited access to justice for the neediest population (61).

## ■ Effective programs for prevention

### Crime observatories

It is recognized in Latin America that the absence of reliable and timely information is a factor that holds back progress in defining the extent and characteristics of the various forms of violence and limits the monitoring and evaluation of programs and projects for their prevention and control.

To remedy this, various models have been created to improve data collection. One such model is epidemiological surveillance, a tool commonly used in public health, which is understood as a method for ongoing, timely, and organized monitoring of events or factors that cause disease or health problems in populations, used to devise appropriate responses for prevention. This method has also been applied to the study of violence and injuries.

One of the first such initiatives originated in the Cali municipal government in 1993 as part of the “Development, Safety, and Peace” (*Desarrollo, Seguridad y Paz*, DESEPAZ) Program (62), which focused on violence prevention and control as a component of municipal public administration. Subsequently, based on the experience of the DESEPAZ program, other activities were carried out between 1999 and 2001 under the auspices of the Departmental Secretariat of Health of Valle del Cauca (63), when the surveillance systems of 18 municipalities in the department were adapted to include violence in their coverage of the health situation. The greatest development of these surveillance systems, known as *Observatories*, took place in 2002, initially in Colombia, where the process was consolidated in 24 municipalities in nine Colombian departments through a partnership between the Universidad del Valle’s CISALVA Institute and the Colombia Program of Georgetown University.

This methodology was introduced in Central America in 2004, when the Inter-American Coalition for the Prevention of Violence (IACPV), through its Technical Secretariat based at PAHO, put together the project “Working with local governments in Central America: a pilot plan to reduce violence,” with financial support from USAID (64). Through this initiative, observatories were set up in municipalities across Nicaragua, Panama, El Salvador, Guatemala, Honduras, and Costa Rica, with encouraging results in the first three countries. It bears noting that in Honduras, there has been effective implementation of both a nationwide observatory and an observatory in the capital that operates out of the National Autonomous University of Honduras (UNAH), with technical support from the United Nations Development Programme (UNDP) and financial backing from the Swedish International Development Cooperation Agency (Sida). Furthermore, other regional technical and financial cooperation agencies, such as the Inter-American Development Bank (IDB), an active member of the IACPV, have promoted the establishment of violence and injury observatories in certain cities in Colombia, Guyana, and Trinidad and Tobago, as well as a national observatory in Peru, with technical support from CISALVA (65,66).

For observatories to function properly, the municipal governments involved in their creation must display leadership and political will. Technical capacity in the health, public safety, and transit sectors, which helped guide the development of the proposed activities, is also needed. In the early stages of the strategy, the continuous support of academia made the issue of violence a priority for municipal governments, adding to the backing and technical support they provided.

The following section presents three examples of effective action and policies adopted by some municipalities in Latin America based on the information collected by observatories.

### San Juan de Pasto (Colombia)

- The observatory has provided important input for municipal planning, since reviewing the information it generates is a mandatory step in the preparation of the Municipal Development Plan, which spells out the action to be taken by the mayor and his or her cabinet in all areas under their purview (health, education, welfare, safety, community living, economics, transportation, etc.).
- The observatory is used to prioritize the territories in which intervention or research programs (in health, education, transit, public safety, etc.) should be implemented because of their high risk for violent death and to reach agreements with local universities on research to study acts of violence.
- The information is a basic input for dialogue between the mayor and the community in venues known as “Community Living, Safety, and Justice Councils” (*Consejos Comunitarios de Convivencia, Seguridad y Justicia*).
- The observatory provides the input used to structure the Municipal Safety Plan, which is the joint responsibility of the Government Secretariat and public safety agencies.
- Based on the information provided, an alternative justice program was designed. In addition, the mayor made the problems of youth, who are the main victims of violence, a priority on his 2007 municipal agenda.
- With regard to transit, information from the observatory was an essential input for a study on traffic flows, with a view to reorganizing municipal transit.
- The Municipal Network for Suicide Intervention (*Red Municipal de Intervención en Suicidio*) was created as part of the observatory. Journalists were offered training on how to handle news stories involving cases of suicide, and a municipal roundtable of experts was created to discuss suicidal behavior.
- Information on gunpowder burns led to a decree prohibiting the use, production, sale, transport, and marketing of this substance. A program was simultaneously launched to replace gunpowder sales with alternative productive projects in December and Carnival season so that traditional gunpowder manufacturers and vendors could continue to generate income despite the ban.

## Santa Tecla (El Salvador)

- Public areas have been reclaimed for citizens through community drives to remove graffiti and gang tags from walls.
- Court procedures and services for youth gang members and their families were streamlined.
- Steps were taken at schools and educational centers to prevent the sale and distribution of psychoactive drugs and other factors that foster violence through a “school-for-parents” strategy and programs to address aggressive classroom behavior.
- To prevent traffic accidents, mini-terminals were built and put into operation to reduce disorder in the intercity transit system.
- Road safety education campaigns have been conducted for schoolchildren and other groups to increase awareness about driver and pedestrian responsibilities and rights.
- Analysis of the geographic location of accidents was used for decisions about the placement of ramps, speed bumps, traffic lights, walkways, protective barriers for pedestrians, and speed cushions, as well as to improve road signage and traffic controls.

## San Miguelito (Panama)

- Information obtained through the observatory made it possible to hold special workshops promoted by the CIPV and international conferences for sharing experiences at the regional level (Costa Rica).
- Significant results include a Technical Cooperation among Countries Agreement between Panama and Colombia and the procurement of breathalyzers for exclusive use in the district of San Miguelito to prevent traffic injuries.
- The identification of high blood alcohol levels in traffic accident victims led the municipal government to suspend the issue of new liquor licenses.
- Preventive police action was taken in the areas with the highest incidence of violence on specific days and hours of the week, along with preventive action targeting high-risk groups, such as youths and children.

## The case of Bogotá

In less than a century, Bogotá grew from a small, traditional town into a major metropolis with a population of nearly 7 million. This growth, spurred by multiple factors (rural unemployment, heavy migration from other regions, desire for a better life in the country’s capital, rural violence, etc.), forced the city’s new inhabitants to adjust to a strange new challenging urban reality, in which they could not find any elements of the cultural identity they left behind or abandoned and, thus, had no guidance for embracing the city and its codes.

In this environment it was only natural that citizens would become both agents and victims of violence: they had to fight to cross the street, failed to respect traffic lights, and altercations broke out between drivers and pedestrians, pedestrians and pedestrians, and drivers and drivers. Few people stood in line to take the bus; none were bothered by littering or cared about blocking sidewalks and platforms, shoving others, whistling, engaging in loud and unruly behavior, etc. Furthermore, crimes against property—including stick-ups and purse snatching—and against life—fights, assaults, and homicides—were rampant.

In the mid-1990s, the city recorded its highest-ever violent death rates: 80 homicides per 100,000 population in 1993 and 25 deaths from traffic accidents per 100,000 population in 1995.

At the start of his administration in 1995, Mayor Antanas Mockus made it a priority to restore safety and social harmony; to this end, he issued a special regulation, whose key components are described below (67).

## Crime observatory

Initially, the city signed an agreement with the Institute of Forensic Medicine and Forensic Sciences for the purpose of maintaining a continuous, georeferenced database of major crime in the city. Today, Bogotá has the Unified Information System on Violence and Crime (*Sistema Unificado de Información de Violencia y Delincuencia*, (SUIVD), CUIVD), whose members consist of the Institute of Forensic Medicine, the police, and the greater municipal administration. In addition to providing information on crime, the System conducts research on matters that affect safety and community living.

## Institutionalization of the topics of violence and crime

With a view to institutionalizing the management of community living and safety, a council was created that was eventually to become the Department for Community Living and Public Safety Affairs (*Subsecretaría para Asuntos de Convivencia y Seguridad Ciudadana*) in 1996. Today, a group of professionals is devoted to studying these problems and strengthening public policy on a daily basis.

## Cultural regulation of violence: Law, morals, and culture

According to Mayor Mockus, Colombian society is characterized by a high degree of separation between law, morals, and culture—i.e., inconsistency between the cultural regulation of behavior and moral and legal regulations. This inconsistency is manifested as violence, crime, corruption, illegitimate public institutions, the weakening of many cultural traditions, and a crisis or undermining of individual morals. Conversely, social harmony presupposes harmony among the three regulatory systems—law, morals, and culture—, which preserve their differences, but there is no moral justification for illegal behavior, except when the law itself is considered to violate universal ethical principles.

Within that framework, in 1995 the administration launched a series of programs, projects, and educational activities, such as using mimes to teach respect for traffic laws; teaching the importance of placing the common good above individual well-being; and respect for life and rejection of the violent actions of insurgent groups. Mayor Mockus played a leading role in all of these activities and became a great teacher of community living.

## Institution building: Improvement of law enforcement

To improve the operations of the Metropolitan Police, the District Administration adopted multiple strategies: it began modernizing communications, which led to a substantial reduction in response times to citizen calls and queries; it began expanding the fleet of police vehicles, doubling the number of patrols and motorcycles and improving police mobility; it allocated resources for training officers, deputies, and agents and signed contracts with private universities to educate these individuals in areas such as civil rights and the history of the city; and it reduced the number of administrative positions, reassigning administrative personnel to patrol duties.

The Metropolitan Police opened several Citizen Safety Schools (*Escuelas de Seguridad Ciudadana*), where the community receives training in safety issues to support the authorities in violence and crime prevention, and promoted the creation of Local Safety Fronts (*Frentes Locales de Seguridad*), organizations made up of different sectors and neighborhoods aimed at combating fear, apathy, indifference, and lack of solidarity in the face of violence and crime. A new type of police, the Community Police, was also created to forge closer ties between police officers closer and the community and promote a neighborhood culture of public safety.

## Institution building: Improvement of the justice system

To improve the management of conflicts stemming from intolerance, domestic problems, and disputes between neighbors, action was taken to strengthen and increase the number of Family Precincts (*Comisariías de Familia*) from 5 to 20 by the year 2000; 12 mediation and reconciliation centers were created; and several Houses of Justice (*Casas de Justicia*, facilities set up in the communities with the highest rates of conflict, where citizens can formally lodge complaints and obtain remedies for diverse legal conflicts) were opened.

To strengthen criminal justice, a Permanent Justice Unit was established, in which the Office of the Attorney General of the Nation, the National Institute of Forensic Medicine, the Metropolitan Police and Transit Police, and a police inspectorate participate. Open 24 hours a day, the Unit provides a venue where the Office of the Attorney General and National Institute of Forensic Medicine can quickly define the status of persons accused of crimes. In this same vein, the capacity of the District Prison was expanded from 450 to 1,100 inmates by means of a new modern building, and a rehabilitation program aimed at restoring dignity to prisoners and boosting their self-esteem was implemented.

## Attention to youths involved in violence and drug use

In 1998, the District Administration launched a project to mitigate the factors associated with youth violence. This project, which has reached more than 20,000 young people, has addressed issues such as education, the use of

free time, the possibility of earning money, and youth engagement. It has also conducted activities for young gang members in the process of rehabilitation, among them expedited high school diploma programs that emphasize community living, vocational training programs, the development of good habits and core competencies, cultural and recreational activities, and conflict management training for school settings.

### Reclaiming public spaces and improving critical sites

The Mission Bogotá (*Misión Bogotá*) program focused on reclaiming public spaces and improving safety and community living in critical locations. To this end, with the support of the Metropolitan Police, the program developed and implemented plans and activities to improve safety and strengthen the bonds between citizens and their community settings.

Through the Urban Renewal program, a project was carried out in the most violent area of the city, a street known as “El Cartucho,” where drugs and weapons were bought and sold and criminal activities were organized. This street had become an area rife with crime, and district and national authorities could do nothing about it until the decision was made in 1998 to replace it with a park. Bogotá drafted and implemented an ambitious urban renewal plan that included the construction of footpaths, pedestrian areas, bicycle paths, parks, public libraries, and the relocation of street vendors, at a cost of approximately \$3 billion.

### The “Carrot Law” and gun control

During the Mockus administration, limits were placed on the public sale of alcoholic beverages. As in Cali, these limits started at 2 a.m. on weekdays and at 3 a.m. on weekends. This schedule of “dry” hours was known as the “Carrot Law” (*Ley Zanahoria*) and was widely publicized and enforced by Mockus, who would often close establishments at the appointed hour himself.

The Bogotá municipal government issued a decree prohibiting the carry of firearms during certain periods, known as the civilian disarmament law. This measure sparked a judicial controversy over who had the authority to make such a decision—the Mayor’s office or the National Army. The courts held that, as agents responsible for law enforcement, Colombia’s municipal governments can restrict the carry of firearms in certain situations, thus ruling in favor of Mayor Mockus.

## ■ Conclusions and recommendations

The Region of the Americas is one of the world’s most violent regions. However, unlike other regions, where self-inflicted violence (suicide) predominates, violence in the Americas is mainly interpersonal, as manifested in high rates of homicide, assault, kidnapping, and other human rights violations.

Given the extraordinary diversity among the countries of the Region, finding a set of recommendations applicable to all of them is an unattainable goal. Thus, rather than search for a “magic bullet,” it would be better to find a method for identifying the necessary interventions. This method, as described above, consists of defining the problem, searching for its descriptive characteristics and risk factors, and, based on this information, devising interventions.

Despite the major differences observed among the countries, several lessons can be drawn from previous experience:

First, violence is preventable, and the Region of the Americas is not inexorably condemned to suffer it. Highly effective interventions with a very positive cost-benefit ratio, at both the family level (especially in early childhood) and the school setting, are available to address it.

Second, violence is multicausal. Accordingly, any policies adopted should cover the widest possible range of risk factors in each place. Violence can be controlled and prevented, but there is no single, simple formula to do so, because it is the result of a complex web of social interactions (risk factors) of a cultural, socioeconomic, and environmental nature. Measures of a social nature should be accompanied by other control interventions and activities to support the justice system and law enforcement.

Third, political will is needed on the part of local authorities, who should spearhead and manage efforts to solve the problem and adopt control measures that may be unpopular, such as gun control or restrictions on alcohol consumption.

Fourth, the authorities—whether mayors, governors, or ministers—should have timely and reliable information at their disposal to enable them to monitor violence and crime and evaluate the effectiveness of the measures adopted. The violence and crime observatories set up throughout the Region of the Americas are a practical, effective, and appropriate way of obtaining the necessary information. Special attention should be paid to the tendency observed in several areas to underreport violent deaths (especially suicides and homicides); several classification subterfuges are used in this practice.

Fifth, the continuity and permanence of such programs are paramount, since their purpose is to modify behaviors, attitudes, and situations that are entrenched in society and cannot be changed overnight. Prevention policies should be made State policies, instead of remaining the programs of the politicians in office, since, by the very nature of democracy, incumbents and policies change with each administration.

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# Road safety, health, and public policy

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## ■ Introduction: The severity of the problem in the Americas

The World Report on Road Traffic Injury Prevention (1), classifies traffic accidents as a public health problem, as every day over 3,000 people all over the world die from injuries sustained in traffic accidents, resulting in some 1.2 million fatalities and 50 million injuries per year on average. Roughly 85% of these deaths occur in low- and middle-income countries. Projections indicate that between 1990 and 2020, this figure will decrease by 30% in high-income countries but increase by 80% in low- and middle-income countries.

According to Kopits and Cropper (2) and Peden et al (1), mortality in Latin America and the Caribbean in 2000 was 26.1 deaths per 100,000 population, versus the world average of 13.0. Close to 130,000 people die every year in the Region and nearly 1.5 million are injured or remain partially or permanently disabled as a result of collisions and pedestrian accidents on public roads. These deaths and injuries cost the Region \$18,000 million per year, or about 1.5% of the regional GDP (3). Between 2000 and 2020, the number of deaths in traffic accidents is expected to increase by 48% (2). By 2020, therefore, mortality rates are expected to reach 31 deaths per 100,000 population, almost double the world average of 17.4 and four times the rate in high-income-countries, estimated at 7.8 deaths per 100,000 population. Analyzing the global burden of disease and injuries, Murray and López (4) predict that if no meaningful action is taken, injuries from road accidents will account for one third of that burden by 2020 in terms of the annual disability-adjusted-life-years lost figures. In general, Latin American countries lack a systemic and sustainable approach to road safety, a circumstance further compounded by a number of other issues: marked growth in private vehicle ownership; insufficient and inappropriate investment in road infrastructure, signaling, and inspection; poorly managed and poorly designed public roadways; decrepit and overstretched public transportation systems; growing social exclusion, leading to greater use of nonnotarized transport and more hazardous unregulated public transportation; the growth and densification of urban settlement with little or no planning; and an incomplete and somewhat arbitrary regulatory framework.

This chapter refers solely to land transport accidents occurring on public roads and involving pedestrians and drivers of both motorized and nonmotorized vehicles. Thus, subway or other rail, water, and air transport are excluded.

We selected five countries—Brazil, Costa Rica, Ecuador, Mexico, and the United States—representing diverse economic and social conditions and with recent attempts at improving road safety conditions in order to take a closer look at the current situation. Table 25-1 summarizes the data for all the countries in the Americas and the Caribbean and shows that, among the most developed countries, Canada has the lowest mortality rates (8.79) and, among the other countries (including all Latin American and Caribbean nations), Venezuela has the highest.

With the five countries selected, a number of important aspects are exposed that help broaden our understanding of the phenomenon. In the United States, for example, the problem commenced with the rapid and unprecedented increase in the number of cars on the road: in 1900, there were 8,000 and by 2006, the number had risen to a staggering 244 million (5). Consequently, there were 20 times more car trips in 2000 than in the 1920s (6). During the initial phase of this growth—1900 to 1930—the negative effects increased substantially. From 1913 to 1920, the number of traffic fatalities rose from 4-5 to 11.7 per 100,000 population, and from 1920 to 1930, from 11.7 to 26.7 per 100,000 population. Despite a series of efforts, this death rate continued to rise, reaching a record peak in 1937 with 30.8 per 100,000 population. Only with the major investments made after 1966 (Highway Safety Act) was it possible to dramatically reduce road deaths, so that by 2005 the figure had fallen to 15.4 (7).

**Table 25-1.** Mortality adjusted for underreporting and definitions, 2007

<i>Population (in millions)</i>	<i>Country</i>	<i>Fatalities</i>	<i>Population</i>	<i>Reported rate</i>	<i>Adjusted rate<sup>1</sup></i>
Over 60	United States	42,642	305,826,246	13.94	13.94
	Brazil	35,155	191,790,929	18.33	18.33
	Mexico	17,003	106,534,880	15.96	20.75
30 to 59.999	Colombia	5,409	46,155,958	11.72	11.72
	Argentina	4,063	39,531,115	10.28	13.73
	Canada	2,889	32,876,047	8.79	8.79
15 to 29.999	Peru	3,510	27,902,760	12.58	21.51
	Venezuela	6,218	27,656,832	22.48	21.81
	Chile	2,280	16,634,760	13.71	13.71
1 to 14.999 million	Guatemala	581	13,353,911	4.35	14.74
	Ecuador	1,801	13,341,197	13.50	11.69
	Cuba	994	11,267,883	8.82	8.56
	Dominican Republic	1,414	9,759,664	14.49	17.33
	Bolivia	1,073	9,524,568	11.27	16.74
	Honduras	974	7,106,001	13.71	13.50
	El Salvador	1,493	6,857,328	21.77	12.61
	Paraguay	845	6,127,077	13.79	19.68
	Nicaragua	522	5,603,190	9.32	14.22
	Costa Rica	710	4,467,625	15.89	15.40
	Puerto Rico	452	3,991,000	11.33	12.80
	Panama	425	3,343,374	12.71	12.71
	Uruguay	427	3,339,700	12.79	4.34
	Jamaica	350	2,713,779	12.90	12.31
Trinidad and Tabago	214	1,333,272	16.05	15.53	

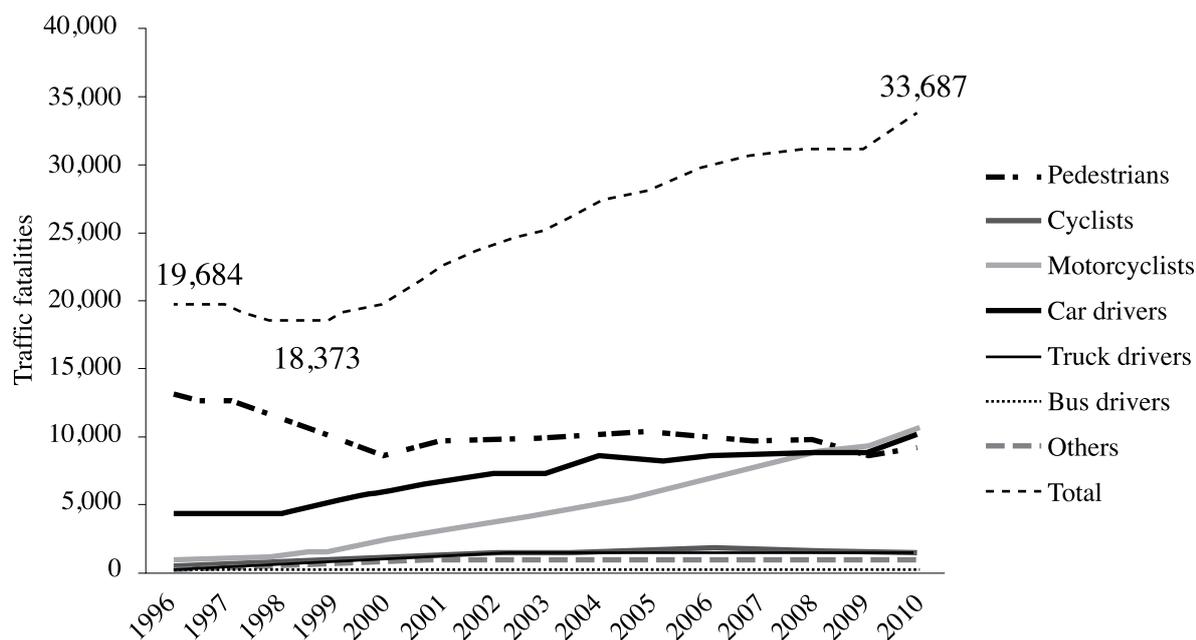
Population (in millions)	Country	Fatalities	Population	Reported rate	Adjusted rate <sup>1</sup>
Less than 1	Guyana	207	737,906	28.05	19.92
	Suriname	90	457,364	19.65	18.34
	Bahamas	50	331,278	15.09	14.48
	Barbados	38	293,891	12.93	12.25
	Belize	68	287,699	23.64	15.64
	Saint Lucia	30	164,924	18.19	17.58
	Saint Vincent and the Grenadines	9	120,402	7.47	6.64
	Virgin Islands	6	23,000	26.09	21.74

1. To facilitate the comparability of data provided by the countries, the World Health Organization used the following methods: a) adjusting to a 30-day definition of death post-accident; and b) use of a negative binomial regression model to correct the degree of integrity of the information. See the details in: <http://www.un.org/ar/roadsafety/pdf/roadsafetyreport.pdf>

In Brazil, the problem began to escalate in the 1950s, when the network of national highways and major city roadways expanded to accommodate the arrival of the automobile industry and the consequent increase in traffic. Between 1950 and December 2012, the vehicle fleet soared from 3.1 to 76 million units, most of them (89%) private cars and motorcycles. The motorization rate multiplied, going from 17 to 2.6 population per vehicle.

Data from the Brazilian Ministry of Health show that deaths from traffic accidents between 1996 and 2005 ceased to increase with the adoption of the new Traffic Code in 1998, only to rise again up to 2010 (Figure 25-1).

Figure 25-1. Road fatalities per transport mode, Brazil, 1996-2010



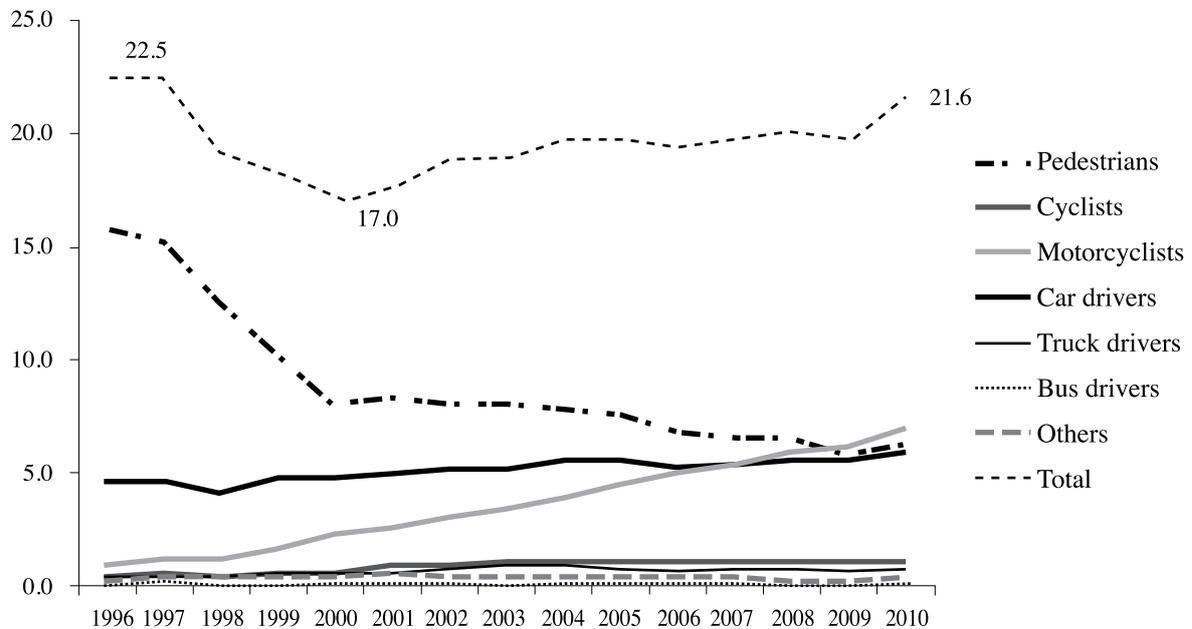
Source: Mapa da Violência 2012. Caderno complementar 2: Acidentes de trânsito. Tables 3.1 and 3.3.

Figure 25-2 shows that while pedestrian mortality has declined and stabilized, the number of drivers, motorcyclists, and cyclists dying in traffic accidents has risen. The total mortality rate in road accidents fell from 23 per 100,000 population in 1996, when the Traffic Code went into force, to around 17 per 100,000 in 2000, after the Code was approved. After 2001, the rate began to increase, reaching around 21.6 per 100,000 population in 2010. In 2006, 82% of traffic fatalities were male. Men aged 20 to 49 years accounted for 64% of the deaths, and for women this figure was 48%.

Another major problem is the exponential increase in motorcyclist deaths following the massive growth of the motorcycle fleet, which soared from 1.5 million motorcycles in 1991 to 20 million in December 2012.

In Mexico, there are two sources of information with national coverage: the first is a registry of traffic accidents occurring on federal roads (ATRCF) and the other is a registry of accidents in urban and suburban areas (ATZUS). Traffic accident rates began to increase dramatically in the mid-1970s and have continued to do so, as few steps have been taken to reverse the trend. From 1975 to 2007 (the year with the highest incidence in the period 2005-2010), the number of reported accidents quadrupled, jumping from 123,035 to 506,830, while in 2010 the figure dropped to 454,508.

**Figure 25-2.** Road fatality rate per transportation mode, Brazil, 1996-2010



**Source:** Mapa da Violência 2012. Caderno complementar 2: Acidentes de trânsito. Tables 3.1 and 3.3.

Depending on the sources consulted, in 2007 over 500,000 reported traffic accidents resulted in 11,652 fatalities (according to the Ministry for Health, the figure is 15,570 deaths, and if the 30-day definition is used, the figure would be higher still) and 192,790 injuries. However, these figures, which are already alarming enough, are only the tip of the iceberg as they are incomplete. As of 2010, only 65.6% of the 2,456 municipalities kept records on ATZUS, while the ATRCF data refer only to the federal network, which covers only 14% of the entire national network and 42% of the paved network. Therefore, there are no data from other areas. Mean annual accident growth rates, calculated over 5-year periods, reveal different behavioral patterns and correlate closely with the performance of the national economic policy, as seen in Figure 25-1. We see that in periods of economic prosperity, with increasing flows of passengers and goods, there is increased exposure to road risks and, hence, a higher number of accidents. Conversely, during times of recession, the mean annual accident growth rate decreases or grows at a slower pace. Thus, between 1975 and 1980, the rate was 8.1; from 1980-1985 and 1985-1990 the rates declined to 1.5 and 1.8, respectively, only to rise again to 2.9, 8.6, and 5.2 during the period 1995-2005.

In 1975, 75% of accidents were ATZUS. In 2007 and 2010, this figure rose to 94%, while the ATRCF figures dropped from 25% to just 6%. This, however, was not the result of prevention programs, but of a change in the way of road accidents were recorded— considering only those with fatalities or injuries—,so these data must be interpreted carefully to avoid misconceptions.

The socioeconomic data in Table 25-2 indicate that from 1997-2007, Mexican population growth was not as spectacular as that of its vehicle fleet, which doubled thanks to trade liberalization with the United States and Canada; that road accidents significantly increased, from 330 (per 100,000 population) in 1997 to 474.6 in 2007, and then fell to 405 in 2010; that the injury rate also increased, from 142 to 180, and then fell to 153 in 2010 (per 100,000 population); and finally, that the number of reported deaths increased from 15.7 in 1997 to 16 in 2005 and afterwards declined to 14.5 and 14.9 in 2007 and 2010, respectively.

Table 25-3 also points to another extremely important issue: unlike the situation in developed countries, where the highest percentage of deaths is among drivers, in Mexico, as in nearly all Latin American countries, a high percentage of accidents (28.5% in 2010) involve pedestrians. Interestingly though, most interventions implemented across Latin America still seem to pay greater attention to protecting drivers.

In Costa Rica, the motor vehicle fleet grew rapidly, from 507,000 in 1997 to 1,450,000 in 2012 (8). Considering only the past decade (2002-2012), this growth was about 116%, while population growth during the same period was about 15.7%, with the total population reaching 4,652,459 in 2012, according to Costa Rica's National Statistics and Census Institute (INEC) (9), for a current rate of approximately 3 vehicles for every 10 people. These changes are reflected in a reduction in mortality per 10,000 vehicles from 8.16 in 1996 to 4.8 in 2012. Regarding *in situ* fatalities and total deaths, the rate has held relatively steady, with an annual average of 322 and 658 deaths respectively over the past decade. However, during this period, the highest number of deaths was the 750 reported in 2008. In 2012, *in situ* deaths numbered 332 according to the Road Security Council Bulletin(10),with total deaths estimated at 679 (11).

According to the mortality figures in Figure 25-3, total deaths per 100,000 population decreased from 17.6 in 1999 to 13.9 in 2004. This period was only partly included in the Road Safety Plan 2001-2005, as described further on. The trend then moved upward for four years, reaching 17 deaths per 100,000 population in 2008, only to reverse itself, hitting its lowest value of about 13 in 2010 and 2011, as the second Road Safety Plan 2007-2011 was winding up.

Despite greater controls, the automation of equipment (centralized traffic light system and speed cameras), and the amendment of the 2008 Traffic Law (Law 8696), which substantially increased fines for traffic infractions, the beneficial effects of these actions (as reflected in 2009 to 2011 mortality rates) have partially been eclipsed by legal ambiguities and the lack of clear regulations. Thus, when fines or the use of cameras are challenged in the Constitutional Court, sanctions are often voided on the grounds of disproportionality or insufficient legal grounds. It can generally be said that the magnitude and gravity of accidents remains a serious problem, given the number of serious injuries and fatalities, and that young people are the most affected group. The estimated number of *in situ* fatalities among people aged 18 to 30 in 2012 was 30%, and 21% in the 31 to 40 age bracket. This means that over 50% of traffic fatalities involve people under 40, a large section of Costa Rica's economically active population (12).

Regarding the percentages per type of vehicle, by way of example, of the 760 fatal accidents reported in 2007, almost 50% involved light vehicles, followed by buses and heavy vehicles, and in third place, motorcycles, with 11%. Motorcycle use is increasing dramatically across Latin America, especially in urban areas. The impact of this phenomenon on mortality is clearly reflected in 2012 figures, where the highest percentage of the 330 *in situ* deaths involved motorcyclists (26%, or 87 deaths), surpassing pedestrians (24%) for the first time, while drivers accounted for 21% and cyclists 8%. It should be noted that in 2012, the number of *in situ* deaths of motorcyclists in traffic accidents increased by 61% over 2011 figures. In other words, vulnerable users (motorcyclists, bicyclists, and pedestrians) accounted for 58% of all *in situ* fatalities, exceeding the 41% (15% motorcyclists, 3% cyclists, and 23% pedestrians) WHO figure for the Region of the Americas (13).

Concerning the percentage distribution by type of accident in 2012, 47% of the *in situ* fatal accidents reported were due to collisions, with the second most common type of accident, at 26%, involving pedestrians (DGPT, 2013). The reasons for this include inadequate infrastructure for pedestrians, drivers' failure to yield to pedestrians, and lack of caution by pedestrians themselves.

In Ecuador, the total number of deaths from all causes in 2007 was 58,000 (426 per 100,000 population) (14) over 2,600 of which occurred on the streets and roads in traffic accidents—a very high rate (19.1 deaths per 100,000 population). According to the Directorate of Traffic Control and Road Safety (DNCTSV) and the National Institute of Statistics and Censuses (INEC), there were 2,049 deaths in 2011, for a rate of just over 14 per 100,000 population.

Many of these deaths involved public transportation, due either to mechanical failure or reckless driving. With regard to the vehicle fleet, car sales have continued to rise over the past seven years. In 2003, 55,456 and 17,095 new cars and motorcycles were sold, respectively; in 2007, 91,000 cars and over 100,000 motorcycles were sold in the country, with a value of over \$200 million, a national record for Andean countries (15); according to new vehicle sales data published by IHS Global Insight (16), Ecuador has one of the highest new vehicle growth rates.

One particular characteristic in this country is that accident deaths in the three largest cities, on average, account for one third of all traffic deaths across the country. While the overall trend from 2001 to 2007 was toward significant increases, the number of deaths held steady in Guayaquil and Cuenca and decreased slightly in Quito. One possible reason is that educational campaigns and traffic control measures are more concentrated in these three cities.

**Table 25-2.** General characteristics of traffic accidents in Mexico, 1997-2010 (24)

Category	1997	2000	2005	2007	2010
<b>Population (millions)</b>	93.62	97.48	103.26	106.78	112.33
<i>Vehicle fleet (million vehicles)</i>	12.58	15.61	22.15	26.55	31.63
<b>Accidents</b>	309,261	373,053	481,701	506,830	455,114
<i>Accidents per 100,000 population</i>	330.3	382.7	466.5	474.6	405.2
<i>Accidents per 100,000 vehicles</i>	2,458.4	2,389.8	2,174.7	1,909.0	1,438.9
<b>Deaths in traffic accidents—motor vehicle</b>	14,654	14,563	16,572	15,570	16,808
<i>Deaths in accidents per 100,000 population</i>	15.65	14.94	16.05	14.58	14.96
<i>Deaths in accidents per 100,000 vehicles</i>	116.49	93.29	74.82	58.64	53.14
<b>People injured in traffic accidents</b>	133,387	154,936	177,898	192,790	172,308
<i>People injured in accidents per 100,000 population</i>	142.48	158.94	172.28	180.55	153.39
<i>People injured per 100,000 vehicles</i>	1,060.31	992.54	803.15	726.14	544.76

**Sources:** Prepared with data from National Health Information System, SS. Land traffic accident statistics in urban and peri-urban areas, SIMBAD, and Interactive Data Consultation System, INEGI, several years. SCT traffic accident statistics and Federal Road Accident Statistical Yearbook, IMT-SCT, several years. Population and Housing Census 1990, 2000, 2010 and Population Count 2005, INEGI.

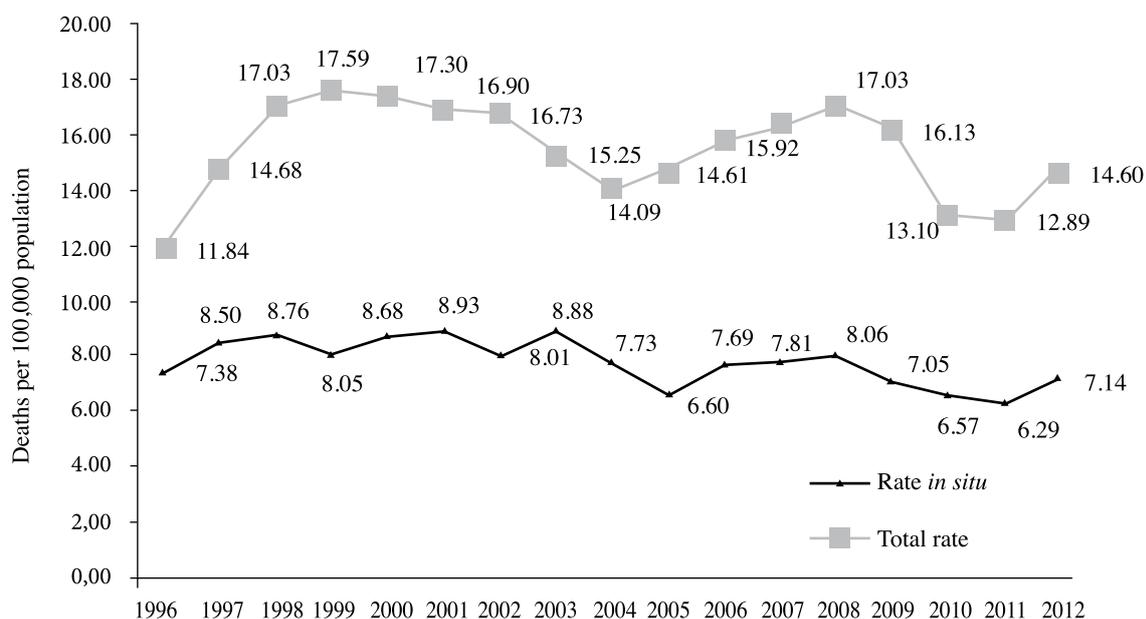
Table 25-3 shows the financial burden of traffic accidents in Mexico. Although these are only estimates and do not include indirect costs, the data reflect the magnitude of the costs incurred from these types of accidents: Mex\$110 billion, almost 0.8% of the national GDP in 2010.

**Table 25-3.** Estimated costs of traffic accidents in Mexico (17)

Accidents, mortality, and morbidity	Number	Estimated cost
<b>Accidents registered by INEGI 2010</b>	427,267	\$8,694,234,282
<i>Motor vehicle accidents (1)</i>	409,515	\$6,171,391,050
<i>Pedestrians injured by motor vehicles (2)</i>	17,752	\$2,522,843,232
<b>Total deaths reported by ATVM 2010</b>	16,808	\$54,886,524,000
<i>Driver and occupant deaths (3)</i>	12,011	\$39,221,920,500
<i>Pedestrian deaths (3)</i>	4,797	\$15,664,603,500
<b>INEGI estimate of victims injured, 2010 (4)</b>	144,033	\$47,032,986,000
<i>Fatal injuries (required hospitalization)</i>	4,258	\$36,948,186,000
<i>Nonfatal injuries (required only medical care)</i>	139,775	\$10,084,800,000
<b>Total estimated costs</b>		\$110,613,744,282

**Table 25-4.** In situ and total mortality in Costa Rica (1996-2012)

Year	Population	In situ fatalities	Total fatalities	In situ rate	Total rate
1996	3,502,866	260	417	7.38	11.84
1997	3,611,224	307	530	8.50	14.68
1998	3,699,939	324	630	8.76	17.03
1999	3,786,841	305	666	8.05	17.59
2000	3,872,349	336	670	8.68	17.30
2001	3,953,393	353	668	8.93	16.90
2002	4,022,431	322	673	8.01	16.73
2003	4,086,405	363	623	8.88	15.25
2004	4,151,823	321	585	7.73	14.09
2005	4,215,248	278	616	6.60	14.61
2006	4,278,656	329	681	7.69	15.92
2007	4,340,390	339	711	7.81	16.38
2008	4,404,090	355	750	8.06	17.03
2009	4,469,337	315	721	7.05	16.13
2010	4,533,894	298	594	6.57	13.10
2011	4,592,149	289	592	6.29	12.89
2012	4,652,459	332	679	7.14	14.60

**Figure 25-3.** In situ and total mortality in Costa Rica (1996-2012)

**Source:** COSEVI 2013, DGPT 2013, Judicial Branch and author's estimate of the total number of deaths in 2012 (based on the time series of the past decade). The population is that presented by INEC, calibrated according to census conducted in 2011.

## Analysis of policies and actions

In the Americas, road safety policies of different types have been introduced since the advent of mass motorization. The results have varied widely in practice, depending on the specific determinants in each country.

More-developed countries have the longest experience. This is especially true of the United States, where mass motorization began after the turn of the 20th century, while in other countries, the phenomenon began to appear only after World War II. Most of these nations have not had permanent road safety policies that have produced very positive results. We will now look at the experience of five countries—Brazil, Costa Rica, Ecuador, Mexico, and the United States—with an interesting variety of economic and social situations, historical determinants, and recent attempts to improve road safety.

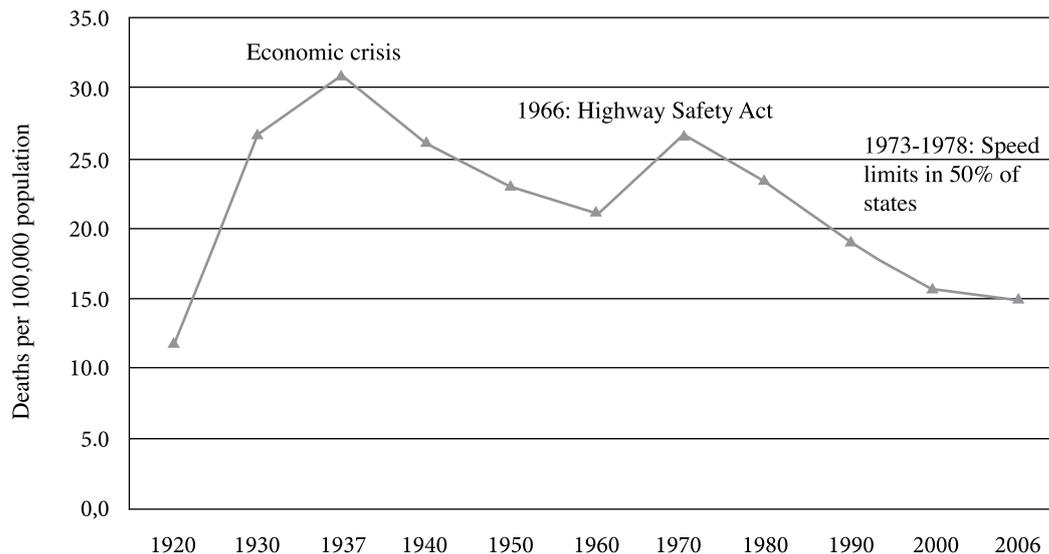
### *A matter of principles and priorities: Road safety as a public health problem*

The history of the developed countries, compared with that of Latin American countries, clearly shows that if a society fails to understand lack of road safety as a public health problem, the likelihood of effecting any significant change is low. This is because the problem is often perceived as the “*inevitable cost of progress*” or simply as a matter of “*human error*,” which hinders the search for and implementation of structural measures to tackle the problem. At some point in their history, several government and nongovernment entities in the United States and Europe altered their approach to the problem and acknowledged that traffic accidents are a matter of public health, deploying an extensive package of permanent coordinated measures. This shift in mindset has yet to occur in Latin America. However, there is now a greater onus on entities and individuals with the capacity to raise public awareness about the nature and severity of the problem.

One way of meeting the goal of reducing traffic fatalities and injuries is to legislate on citizens’ right to safety on public roads, following in the footsteps of Brazil in its 1998 Traffic Code and Ecuador in its Constitution of 2008, which underscores public responsibility for transportation, traffic, and road safety. The great advantage of these developments is that society can demand action to increase road safety—increasing the resources utilized—and traffic authorities can be hauled into court if they fail to address road safety issues. This is a very effective type of pressure.

### *Institutional strengthening*

In the United States, the soaring number of traffic accidents in the early 20th century was a serious national problem that led to the first National Conference on Street and Highway Safety in 1924, followed by several federal initiatives to create a uniform set of traffic laws. From 1924 to 1934, doctors and other workers from the health sector were invited to participate in a national program, and many technical committees on road safety were created. Following the failure of these committees to achieve satisfactory success rates (fatalities per 100,000 population had now reached 28.6), the next president (Franklin Roosevelt) enlisted the help of state governors to combat the problem. In 1936, a second national conference was held that proposed reducing speed limits, improving road lighting, and strengthening vehicle structures. These efforts also failed to produce satisfactory results, with the death rate reaching its peak of 31 per 100,000 population in 1937. After a decrease during World War II, the rate began increasing again and continued to climb until the 1960s (6). This was when the most significant change in road safety policy took place, with Lyndon Johnson’s signing of the *National Traffic and Motor Vehicle Safety Act* and *Highway Safety Act* in 1966. This legislation opened the door to the intensification of federal action to set safety standards for vehicles and highways. Later, the National Highway Safety Bureau, subsequently called the National Highway Traffic Safety Administration (NHTSA), was created and in 1970 was given the power to set vehicle safety standards. Furthermore, coordinated action was taken at the federal, state, and municipal level; road safety departments were created in states; and permanent funding was allocated to champion road safety measures. Studies on the effectiveness of these road safety systems put public health professionals in a position of strength to lobby for greater changes. The end result was a dramatic reduction in accidents and mortality rates, especially in the 1970s (Figure 25-4). In the United States, the decentralized political structure that gives great autonomy to the states makes it nearly impossible to draw conclusions about any single factor in decreasing mortality. The points discussed above are most likely those with the greatest impact.

**Figure 25-4.** Traffic mortality per 100,000 population, United States, 1920-2006

**Source:** National Safety Council (2013) and Dellinger *et al.* (2007). Historical dates marked by text coordinator.

Unfortunately, the same trend is not seen in Latin American countries. For example, in Brazil, federal initiatives to improve road safety have always been rather unambitious, due in part to the impotence of federal, state, and municipal institutions. There was no national traffic system prior to the 1998 Traffic Code, so there was no coordination among the different administrative levels. Most of the more ambitious attempts to create a national road safety plan failed in part because of insufficient resources or poor coordination among the different levels of government, but also because the problem was not considered a public health necessity. As mentioned earlier, the perception that traffic accidents are an act of “fate” still prevails. At the federal level, most of the resources have been allocated solely to communication programs to foster “good attitudes” and limited public awareness campaigns.

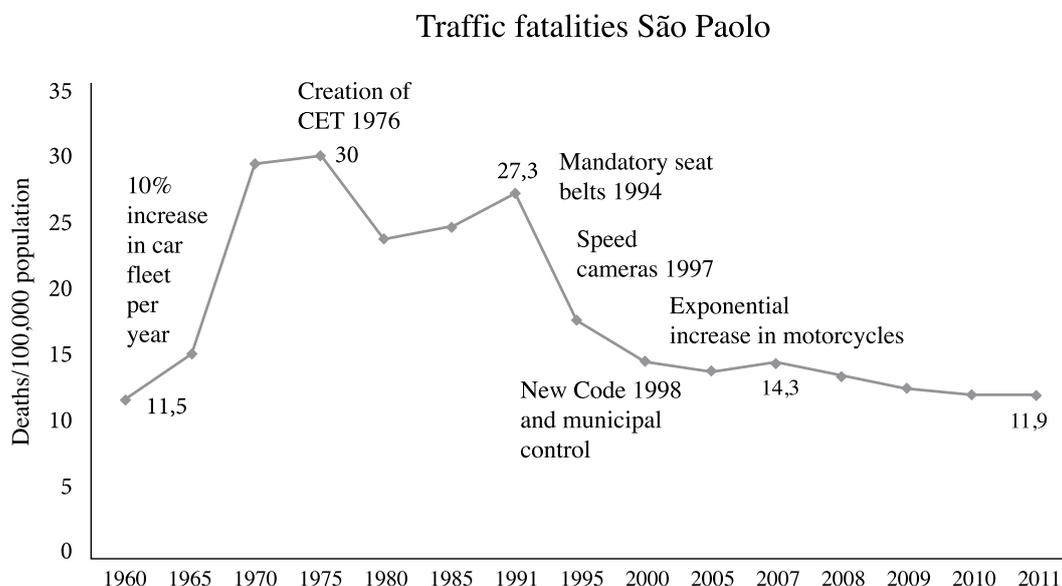
Conditions only began to change in 1992, when a civil society movement to pressure the National Congress began to push for changes in the outdated Traffic Code (issued in 1966 during the military dictatorship), which was clearly inadequate to the urban and political situation in the country. Under this code, traffic control was the responsibility of state administrative and police authorities, with municipalities having no jurisdiction in the matter. This civil society movement was initially spearheaded by the ANTP (National Public Transportation Association) and the Institute of Engineering in São Paulo. After a six-year debate in the National Congress, the new code was issued in 1998, leading to profound changes in institutional aspects of traffic in the country. The first step was the creation of the National Transit System (SNT), comprised of all legal authorities for traffic control (urban streets and highways) at the federal, state, and municipal levels. The spirit of the SNT was defined as “cooperation among all,” putting an end to centralized federal and state authority. The most important change was the municipal takeover of traffic matters, with mayors given the responsibility for civil planning, operation, and oversight of city traffic. The 1998 Code established the highest traffic regulatory authority (CONTRAN or National Traffic Council) and its executive branch (DENATRAN or National Traffic Department). It also created thematic groups charged with holding periodic meetings between public officials and society to discuss legal, technical, and educational aspects of road safety. Since it is impossible to observe mortality rates over time using national data, the historical curve of the city of São Paulo is shown (Figure 25-5). After extremely high numbers in the late 1980s, the rate fell sharply until the year 2000, when it again began to climb due to increased motorcycle use. Since 2008, rates have declined in the wake of measures such as the “Dry Law,” greater control of motorcycles, and special programs for protecting pedestrians. These are what have probably had the greatest influence in terms of decreasing mortality rates.

In Mexico, even though the institutionalization of road safety had already begun early in the last century (under the traffic engineering framework), it was only when the number of accidents, deaths, and injuries rose that the Secretariat of Health took the lead (1940s and 50s) and confirmed this as a serious health problem. In the 1970s, the enormous interest in natural disasters (as a reflection of events around the world) meant that road accidents were relegated to a secondary plane and inaptly described as a “social ill” that must be accepted as a trade-off for high levels of mobility and characterized as random or inevitable events, creating an environment that discouraged attention to them (who came up with and disseminated these ideas and what interests they served would undoubtedly warrant further inquiry). That is why the performance of the National Board for Accident Prevention, created in 1971, was mediocre at best and it was eventually dissolved. However, in 1987 it was revived and its influence grew throughout the 1990s, as Mexico encountered serious problems under the Free Trade Agreement when the United States prohibited Mexican truckers from crossing into U.S. territory, citing safety concerns. In 2000, the National Committee on Road and Highway Accident Prevention (CONAPREA) was created as a collegiate organ of the Secretariat of Communications and Transportation. The Committee has been rather ineffective so far, and some private groups even have established awards to encourage preventive action to promote road safety.

In Costa Rica, the institutional responsibility for road safety is clearly defined: the Ministry of Public Works and Transportation (MOPT) and its decentralized bodies, the Road Safety Council (COSEVI), the National Concessions Council (TNC), the Public Transportation Council (TCC), and the National Road Council (CONAVI), are responsible for activities related to transportation infrastructure and services, including road safety. Although COSEVI is the oldest decentralized entity with responsibility for road transport, it was originally created to administer the Road Safety Fund and not to exercise direct leadership or occupy a higher place in the hierarchy than other entities. Nonetheless, it was one of the direct leaders in the design of the Strategic Road Safety Plans 2001-2005 and 2007-2011 and a key player in setting the sectoral goals of the National Development Plans. The coordination of activities, budgetary planning, and policy discussion were shared with the Transportation Division of the MOPT, up to the passage of laws 8696 and 9078, the latter in 2012.

Finally, Ecuador is the latest country to modify its institutional definitions in road safety. Under its new constitution, the National Land Transport, Traffic, and Road Safety Commission became the regulatory agency, free of corporate influences and clientelistic political pressures. This was a major step forward, since associations of transport providers would no longer have a seat in its directorate, which is now made up of government representatives from the national (ministers or delegates), provincial (not advisers), and municipal (not aldermen) level, as well as the police. This directorate will oversee the entire package of transportation regulation and control activities, including driving schools and vehicle inspection centers. An advisory committee has been set up whose recommendations are not binding.

Figure 25-5. Traffic Fatalities, São Paulo, Brazil, 1960 to 2011



Source: Pinheiro Gawryszewski, V., and Prado de Mello Jorge, M. H. “Mortalidade violenta no Município de São Paulo nos últimos 40 anos,” *Revista Brasileira de Epidemiologia*, vol. 3, nos. 1-3, São Paulo, 2000 (up to 1985); and CET-Companhia de Engenharia de Tráfego, *Acidentes de trânsito em São Paulo*, São Paulo, 2012 (after 1991).

### Legal definitions

Specific laws and regulations, as well as effective control mechanisms, are necessary for improving road safety. There are too few cases of broad legislation in the countries of the Americas, giving the impression that while there may be many laws and regulations, they are often sporadic and inconsistent. The first major question is the degree to which laws are “nationalized” –in other words, whether there should be a national traffic code. In the United States, for example, while there are federal regulations, states have a certain degree of latitude to set local standards, such as the minimum age for drivers. Conversely, in Brazil and Costa Rica, most laws are federal with little or no flexibility at the state level. Finally, as in the case of Mexico, the different levels of legal and administrative authority (federal, state, and municipal) are in fact a stumbling block for harmonization of the legal instruments governing vehicular traffic. In this regard, each municipality can impose its own traffic regulations, each differing in terms of content, effectiveness, and scope of application (for example, concerning the use of seat belts or child safety seats, penalties for driving under the influence of alcohol, or third-party insurance).

Brazil is the most recent case of a country that has extensively nationalized its traffic laws. In the specific area of road safety, three critical decisions were reflected in the new 1998 Traffic Code. From a political and social standpoint, Article 1, paragraph 4 defines road safety as one of the rights of the Brazilian people, associated with the formal obligation of public agencies to guarantee road safety as part of their purview. This established the legal grounds for prosecuting authorities for failing to fulfill their obligations. Another essential element was the creation of FUNSET (National Traffic Safety Fund), primarily financed by 5% of all traffic fines imposed in the country by all authorities. Finally, the Traffic Code established a fine assessment structure—with very high fines for very serious infractions—and cumulative points for infractions up to a limit leading to the loss of a driver’s license.

Another very important decision was to set up national data systems, especially RENAVAL (National Motor Vehicle Registry) and RENAINF (National Traffic Infraction Registry), making it possible to fine a driver in a state other than the state in which the vehicle is registered. The Traffic Code also calls for mandatory use of seat belts by all car passengers and helmets by motorcyclists and bans the use of cell phones while driving. A full chapter is devoted specifically to the transport of hazardous substances.

Another major change—related to the municipal takeover of traffic control – was to grant municipalities authorization to set up their own traffic police forces to deal with traffic and parking infractions. This broke the monopoly of the military police and forced the two groups to coordinate efforts. This municipal takeover of traffic control profoundly changed urban transit planning and management in Brazil. By the end of 2012, 1,325 municipalities (of the country’s 5,600) had already organized their traffic sectors.

In Costa Rica, Traffic Law 7331, enacted in 1993, was amended by Law 8696 of 23 December 2008. This, in turn, was subsequently revamped by the new Law 9078 on Traffic on Public Thoroughfares and Road Safety, approved and signed into law by the Executive Branch after prolonged discussion in the Legislative Assembly, taking effect on 26 October 2012. The new text contains a series of changes that deal mainly with the following aspects:

- A point system for driver’s licenses: Points are removed when certain infractions are committed, up to a maximum of 12, at which point the license is suspended for one year; if the infraction is repeated, there is a two-year suspension and, with a third or subsequent infraction, the suspension is three years. Points can also be recovered with community service or driving courses.
- Traffic education has become compulsory content in preschool, general basic, middle, diversified, and technical professional or vocational education to instill an awareness in future drivers about road safety and education, with a view to gradually developing a road safety culture, in addition to preparing students for the written portion of the driving test.
- The consolidation of a unified traffic accident statistics and road safety research system under COSEVI, providing a more complete and reliable official database, where the number and type of accidents, as well as the number of *in situ* and subsequent deaths, can be verified—in other words, a single set of accurate statistics for the different agencies, which currently issue their own statistics independently with very little feedback.
- The classification of infractions considered reckless driving as criminal offenses, so that penalties can be imposed; such offenses include speeding and duly-confirmed driving under the influence of alcohol.
- Adjustment of fines by consensus with the Constitutional Court, so that they are not disproportionate or lacking sufficient legal grounds. The only infractions that will result in the removal of points are

those that jeopardize human life and are classified as Category A, with fines of \$555 (€280,000), and Category B, with fines of \$375 (€189,000). With Category A infractions, which include driving at over 120 km/hr or under the influence of alcohol, six points are removed.

- Changes in the composition of the COSEVI Board of Directors and in the components of the Road Safety Fund.

It should be noted that, for full implementation, several of these elements must be duly regulated.

In Ecuador, the essence of the new law debated and passed by the National Constitutional Assembly in mid-2008 is to sustain public responsibility for transportation, traffic, and road safety, improve the quality of life of Ecuadorians and visiting foreigners, and guarantee free movement. An example of this are the goals of protecting citizens and their property, putting public spaces at the service of the people, guaranteeing the safety, efficiency, and accountability of public transportation, educating the public about traffic and road safety, training transportation providers, administering public spaces and thoroughfares, and increasing citizen participation. These two basic instruments of the social compact will make it possible to intervene positively in the country's high accident rate.

## ■ The need for quality information and indicators

### Information

All the countries of the Americas have problems with the coverage and reliability of data on traffic accidents, but they are much more pronounced in the developing countries. Due to deficient information systems, the indicators available at the national level are often developed opportunistically, taking advantage of data collected for different purposes by various sources or for a specific population.

In Mexico, road accident data are obtained from the records of assorted public agencies: police, transportation agency, health sector, and the dataset of the National Institute of Statistics and Geography on fatal and nonfatal accidents. The data recorded are correlated with other details about the people involved in the accident, their injuries, and the outcomes. Details about the physical and social environment are also recorded, as is information on the type of vehicle, though less so. Here, it is important to point out that traditionally, nonfatal outcomes of injuries in Mexico were classified only by the nature of the injury or trauma. In other words, the only information provided on the roughly 350,000 people admitted every year to a public hospital due to the severity of their injuries is whether they suffered a fracture, amputation, dislocation, trauma, laceration, etc., but we do not know how many of these injuries were caused by a traffic accident, fall, or deliberate act. In fact, since 2003, the Ministry of Health has stated that around 1.2% of all hospital discharges are connected with road accidents. In other words, one out of seven (15.2%) discharges for accidental and intentional injuries (that is, 53,200 of the 350,000 admissions) is due to road accidents.

According to the National Health Survey 2006, 80% of people who suffered an accidental or intentional injury were treated in the public health services and 20%, in the private sector. Thus, if the aforementioned information system (which is limited to the public sector) accounts for 47% of the discharges, the figures represent only 38% of the discharges from injuries. Although it is impossible to extrapolate the results to the entire country, this is a more accurate estimation of the consequences of road accidents in the country.

Another change introduced in the way road accidents are recorded involves death certificates. In 2004, a space was included for physicians to indicate where the accident happened (home, street and number, kilometer and road, etc.). Like most death certificates involving accidents of this nature, they are generally completed by medical examiners, so it is assumed that there is more information. Experience shows that it takes at least two to three years to see the effects of a change in an information system, so the first good results would be seen in the 2006 or 2007 statistics.

As in other areas of public health, household surveys can reduce the selection biases of administrative registries, but they do not fully correct them due to the memory biases of the respondents and the fact that people are better able to remember more serious events. Nevertheless, surveys are an excellent source of information about the circumstances surrounding accidental injuries, risk factors, passive and active prevention, and the care-seeking process and its outcomes or consequences.

## Indicators

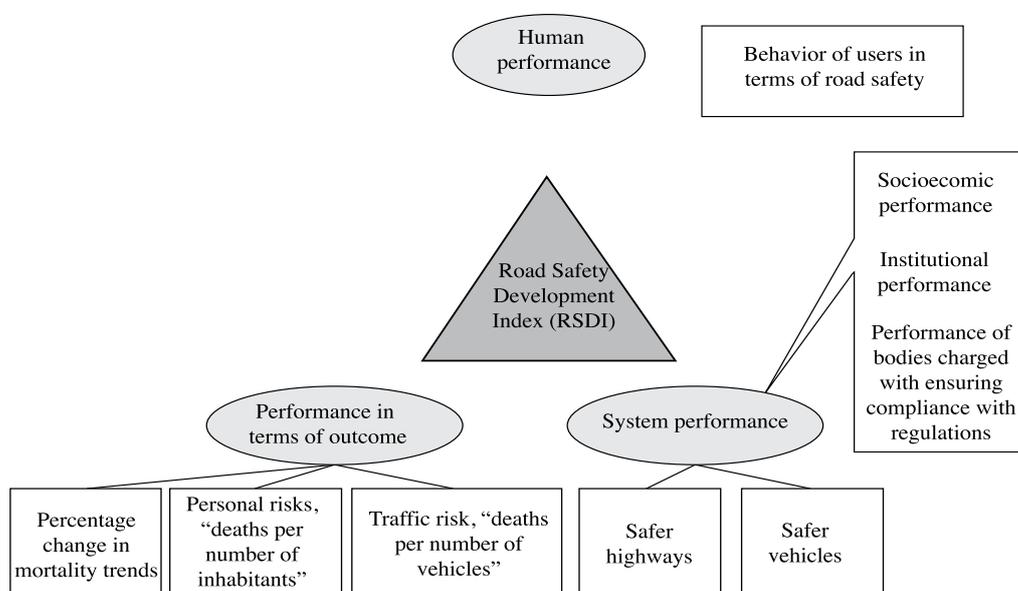
What information is needed to prevent road accidents? Data collection should be an exercise in consensus-building, which requires the leadership of one of the agencies involved and the willingness of the others to contribute to the construction and maintenance of the databank. It should also involve the coordination of efforts and harmonization of sources, as duplications in data collection and inconsistencies in the results are very likely. In practice, the effort should generate an indicator of the seriousness of the phenomenon that is at once sensitive, credible, consistent, and robust.

Although the mortality rate, also used to measure personal risk, is a widely accepted indicator for measurement and comparison, it is generally accepted that it must be used and interpreted with due caution. Furthermore, when speaking about a country's performance in road safety, other comparable measures, such as deaths per vehicle, per vehicle-km, or per passenger-km, have also been used. Interpreting these indicators can lead to ambiguous and even erroneous conclusions (ECLAC) (18), since divergent results may be obtained depending on the case. Moreover, when used in isolation they do not capture all the factors needed to provide a better and more accurate picture over time, which would improve understanding of the problem and the necessary action to take. For example, as seen in Mexico, a very characteristic bias in the information sources on traffic accidents is that they include only those involving serious human injury or material damage.

Therefore, setting specific mortality targets within a given timeframe in a development plan is not the best approach, nor is the use of mortality as the only reference indicator. Accordingly, an important line of research that should be adopted in Latin America would involve more open and systemic approaches to indicator development when the aim is to diagnose road safety, set sectoral goals, or perform comparative analyses of cities and countries.

For example, according to the proposed Road Safety Development Index (RSDI), designed by Al-Haji (19) (Figure 25-6), there is a more comprehensive approach that covers nine relevant dimensions and 14 indicators, namely: *a*) traffic risk: road fatalities per vehicle; *b*) personal risk: road fatalities per population; *c*) health index: combines both the severity (fatalities per accident) and life expectancy indexes; *d*) education index: percentage of adult literacy; *e*) vehicle safety index: new vehicles registered and percentage of two-wheel vehicles; *f*) road situation index: paved roadways and total road expenditure per vehicle; *g*) road user behavior index: percentage of traffic fatalities in alcohol-related crashes, percentage fatalities in speed-related crashes, and percentage related to the use of seat belts; *h*) standard of living: GDP per capita; and *i*) urbanization: percentage of the population living in urban areas. The figure below is a conceptual illustration of Al-Haji's Road Safety Development Index. Note that several indicators are taken into account in calculating the UNDP's Human Development Index.

Figure 25-6. Diagram of the stages in an intervention.



Source: Conpes, *Evaluación de Impacto de Programas Sociales*, Consejo Nacional de Política Económica y Social, 3188, Bogotá D.C., 31 July 2002.

## ■ National plans and programs

### Analyzing the context

Before devising any plans or programs, the social, legal, cultural, political, and geographical context of the traffic conditions in each country must be analyzed in detail so that the most appropriate and viable actions can be defined.

Regarding the social context, it is important to identify the characteristics of the people involved in traffic accidents. Thus, in countries highly dependent on private transportation (such as the United States), the main focus is on car drivers, while in less motorized countries, like most Latin American countries, the principal focus is on pedestrians, bicyclists, or public transportation users. Other characteristics, such as the age, income, and sex of the injured parties, must also be analyzed.

In the legal and political arena, an understanding of the country's legal structure and the autonomy of state or local authorities is indispensable for adopting rules and regulations. In smaller countries (most Latin American countries), central power is naturally dominant, while in larger countries (such as Brazil, Argentina, and Mexico), or those with a more liberal political tradition (the United States), there is greater distribution of political powers among the federal, state, and municipal spheres, which calls for the orchestration of shared actions.

In the cultural sphere, it is imperative to identify the level of education and access to information. In more developed countries, universal education permits more extensive and sophisticated forms of communication about traffic problems, while in countries with lower educational levels, these actions should be designed and targeted to specific social groups.

Finally, the geographic characteristics of the physical location where accidents occur should be analyzed, separating urban from rural environments.

In addition to these elementary needs, the real and dynamic context of each country should be taken into account. For example, in 1995 after signing the Free Trade Agreement with the United States and Canada, Mexico experienced huge growth in its vehicle fleet and the transport of cargo on its roads. The same phenomenon is now being observed in Brazil, where rapid growth of the motorcycle fleet is causing an exponential increase in fatalities and injuries among motorcyclists. In Ecuador, the urban transportation management model combines a semi-mass transit system operating at its limits, the heavy use of private cars, and unreliable service delivery marked, moreover, by flagrant violation of the traffic laws—all of which, in practice, has frustrated any attempt at modernization. There is a structural conflict with opposing interests in transportation that the legal and institutional systems have been unable to resolve in favor of the public interest: that for transport providers, this activity represents their income, while for users, it is a public service and a right. In a way, the State has been held captive by associations of transport providers and other allied interests, resulting in deficiencies in certain aspects of basic road safety regulation, if not their outright abandonment.

In 2010, a consortium of partners received funding from Bloomberg Philanthropies to conduct activities that would improve road safety in 10 low- and middle-income countries over a five-year period (2010–2014). Called the Road Safety in 10 Countries Project—or RS10 for short—this initiative is being implemented in Brazil, Cambodia, China, Egypt, India, Kenya, Mexico, the Russian Federation, Turkey, and Vietnam. The overall goal of the RS10 Project is to assist governments in the 10 project countries with the implementation of good road safety practices in line with their national road safety strategies. At least two risk factors were identified as priorities in each country: speed management and drunk driving.

### RS10 Consortium partners

The World Health Organization (WHO) provides financial and technical support for elements related to social marketing, legislative review and amendment, and the procurement of enforcement equipment in all 10 countries, as well as trauma care and data system improvement in two countries. The Global Road Safety Partnership (GRSP) is responsible for capacity building among different stakeholder groups, in particular through a series of workshops on particular risk factors and strategies to address in all 10 countries. The International Injury Research Unit at Johns Hopkins University (JHU) is responsible for ongoing monitoring and impact/outcome assessment of the program in all 10 countries, as well as the development of a capacity development package for health care workers. The Association for Safe International Road Travel (ASIRT) is responsible for engaging nongovernmental organizations in Egypt, Kenya, and Turkey and working with the media to promote road safety in three RS10 countries.

The WRI Center for Sustainable Transport (EMBARQ) is responsible for mass transit projects in India, Mexico, and Turkey. The World Bank, through its Global Road Safety Facility, is responsible for infrastructure assessment in China, India, and the Russian Federation.

## National plans

The *World Report on Road Traffic Injury Prevention (1)* issued a number of recommendations, the first of which was “Recommendation 1. Identify a lead agency in government to guide the national road traffic safety effort.”

Apart from the United States, which has had major national programs since 1966, Costa Rica has the most effective road safety plans. The National Road Safety Plan 2001-2005, promoted by the Ministries of Transportation and Health, was established by executive decree in March 2001. Its primary goal was to reduce the number of fatalities and injuries each year by 5% over the previous year for the next five years. Execution of the activities was overseen by a permanent high-level commission, chaired by the Minister of Transportation, and comprised ministers of Public Works, Public Safety, Public Education, and Health, as well as the executive presidents of the National Insurance Institute and the Costa Rican Social Security Fund.

The principal functions of the commission are to: provide active support for implementation of the Road Safety Plan by promoting the engagement of the State, civil society, and the private sector; make road safety a compulsory subject in primary and secondary education; implement road safety campaigns; raise the standards of the driver's licensing system; boost surveillance and control on high-risk roads; increase the number of traffic police to watch for people driving under the influence of alcohol; promote the building of infrastructure for pedestrian protection; gradually set up accident prevention and trauma centers in all hospitals; monitor and enforce the basic requirements for the operation of heavy trucks and paid transport for the general public and students; make the necessary adjustments in vehicle inspection processes; and include a road safety component in all projects involving the repair, maintenance, and construction of new roads. The high-level permanent commission would be responsible for coordinating all these activities through Local Road Safety Boards (COLOSEVI), comprised of the mayor, public health authorities, and representatives of civil society organizations.

To buttress the achievements of the aforementioned plan and guarantee the success of the strategic actions proposed in the National Development Plan 2006-2010, the executive signed the “Contract with the Public” 2007-2010, which guaranteed government support for fostering a culture of peace on the roads. The vision of the plan was that “Costa Rica would be recognized nationally and internationally as a country at the forefront in the adoption of road safety actions to reduce traffic fatalities and change the driving culture.” For this purpose, the National Strategic Road Safety Plan 2007-2011 was designed, with a view to strengthening and enhancing the measures included in the previous plan. In the case of COSEVI, a medium-term strategy was designed to implement the plan, establishing an indicator to set a concrete course of action and determine whether the strategy could meet its ultimate objective. This was a five-year plan with a target of achieving a 19% reduction in mortality over the 2005 figures by 2011. This meant a decline from 14.24 fatalities in 2005 to 11.53 in 2011, and 12.10 in 2010, the year in which the current administration's mandate and the National Development Plan were to end.

What happened in Brazil was quite different. The success of the 1998 Code was due more to the municipal takeover of traffic management than to any national plan. Despite their scope and ambition, the plans were not implemented as initially envisaged. This was due to political discord over who should bear the responsibility for implementing the plans and to the failure of the country's economic authorities to release the funds to the national traffic agency (DENATRAN) as a means of reducing State investments to lower the official public deficit.

## ■ Projects and actions

### Planning of actions

Road safety planning has been fragmented in most Latin American countries, skipping several intermediate phases and rendering the process less effective. Selecting interventions to prevent traffic accident injuries must be done very carefully, considering all stages, to ensure that implementation of the evaluation does not require substantial resources. Figure 25-6 presents a model that includes all the stages.

In the United States, the principal technical action stemming from the 1966 institutional definitions involved the creation of standards to protect vehicles in the event of collisions and improve postcrash survival, including

those governing brakes, tires, windshields, lights, doors, and gas tanks. These were complemented by two extremely important general actions: driver's education and surveillance, mainly of alcohol consumption. Concerning vehicle standards, improvements were made in a number of design features, which became standard: rollover protection, dual braking systems, seat belts, headrests, and safety glass. Drivers and passengers in vehicles with these features suffered 20% to 40% fewer fatal accidents than those in older vehicles. The principal changes in highway design involved the addition of central and side pavement markers with reflectors, illumination, and the use of breakaway signs, central barriers, and rough surfaces. Finally, national speed limits in the region saved 2,000 to 4,000 lives per year between 1974 and 1983 (6).

In the field of institutional and organizational action, the greatest advantages were based on the creation of an effective network for collaboration among traffic authorities. This was confirmed once there was a general awareness that road safety is a public health problem and the responsibility of the Department of Health and Human Services, which set the goals for 1990. Thus, both government and civil society entities began the ongoing analysis and implementation of actions to reduce accidents. In the 1960s, NHTSA, a Department of Transportation agency, promoted many of these efforts and since 2000 has had a staff of 3,500 and a budget of nearly \$26,000 million. An important aspect of these actions was the identification of specific groups of vulnerable users or aggressive drivers, for whom targeted measures were proposed. The medical community and motor-vehicle insurance institutes also participated. It is estimated that 250,000 lives have been saved by these actions since 1975.

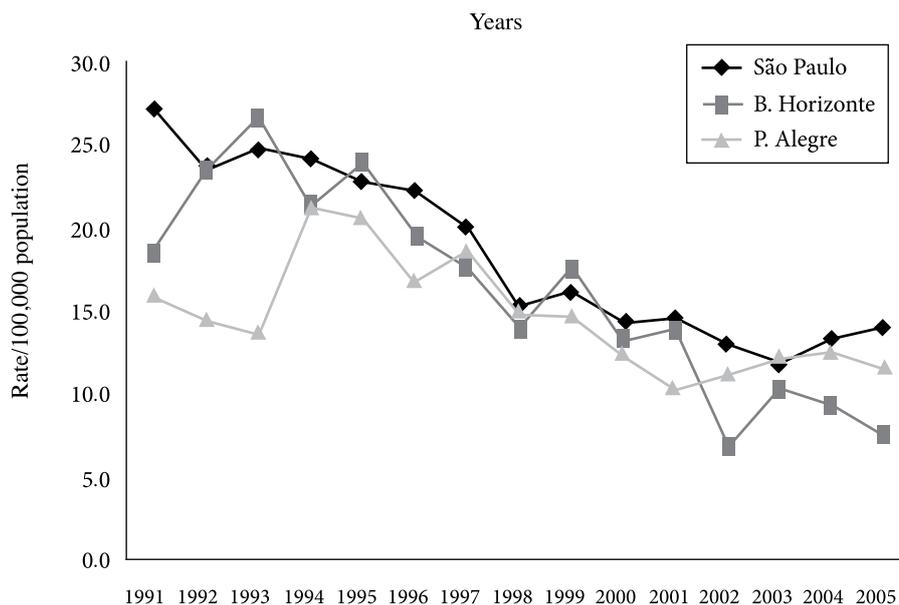
In Brazil, in addition to using mortality reduction (Figure 25-1), an important way to analyze the impact of the action taken is to look at the data from major cities with reliable information systems (Figure 25-7). The figures in the three cities did not change, even in the period prior to the 1998 Code, because they had already commenced the municipal takeover process by reaching agreements with state authorities and obtaining the guarantee of adequate human and material resources for traffic control. Intense action was taken in the areas of electronic speed monitoring, traffic stops by the new local civil police, and road and intersection repairs.

Another very important action was the change in the rules governing alcohol consumption. The 2008 "Dry Law" increased penalties for offenders and, within six months of its entry into force, produced a 28.5% drop in hospital admissions across the country (20). However, the need for concrete evidence enabled the majority of offenders to escape punishment by refusing a breathalyzer test, only to go back and repeat the infraction. The law was not amended until December 2012; it now includes other tests as evidence of blood alcohol levels (including police testimony, photographs, and recordings), once more opening up the possibility of significantly reducing infractions.

## ■ Action in Mexico

At a meeting in November 2003, the General Health Council published an agreement based on the Political Constitution of the United Mexican States, the General Health Law, and the Rules of Procedure of the General Health Council under which the following health policy measures applicable in the entire Mexican republic were established—measures that target motor vehicle users rather than pedestrians:

- Mandatory use of seat belts by passengers in public or private vehicles.
- Use of child safety seats.
- Children in rear seats in vehicles.
- Use of protective helmets by motorcyclists, whether the vehicles are for public or private use.
- Ban on driving under the influence of alcohol, drugs, or other toxic substances.
- Ban on the use of mobile communication devices, such as radios and telephones, which impair drivers' ability to react, jeopardizing maximum safety while driving.

**Figure 25-7.** Traffic mortality per 100,000 population, São Paulo, Belo Horizonte, and Porto Alegre, Brazil, 1991-2005

**Source:** CET - Companhia de Engenharia de Tráfego 2008 (São Paulo), Belo Horizonte ([www.bhtrans.gov.br](http://www.bhtrans.gov.br)), Porto Alegre ([www.epc.gov.br](http://www.epc.gov.br)).

Mandatory compliance with the legislation to reduce some of the risk factors for traffic accidents in Mexico demanded the passage of state laws to mirror the new standards, but in some cases the legislation was interpreted as each state saw fit. Differences between neighboring states were observed with respect to permissible alcohol intake, helmet use, fines, and when the state law was enacted (in some states within the year, and in others, up to four years). Furthermore, the penalties for drunk-driving, for example, ranged from revocation of the individual's driver's license in the State of Jalisco to a higher fine for jumping a red light under the influence of alcohol in Zacatecas, and even an indictment by the Public Prosecutor. Moreover, none of these states considered evaluating the importance of these interventions in terms of reducing injuries. This is often the case with isolated interventions of this type.

Regarding education and information in Mexico, the transportation and health sectors have conducted media campaigns since the 1990s, but they have been seasonal, separate from other interventions, and lacking consensus between the two sectors. The education sector recently included aspects of traffic accident prevention in primary school textbooks. Yet again, the common denominator in all these campaigns and sectoral efforts was that their effectiveness had not been evaluated. It is important to remember that:

- Education through publicity is a proven component of road safety programs that combine interventions.
- Education is more effective when combined with law enforcement monitoring.
- Increasing funding for educational media campaigns has reduced serious and fatal injuries.

Interventions to protect pedestrians have also been implemented, among them zebra crossings and traffic lights for pedestrians, speed radar, the designation of specific spaces to access public transportation, and pedestrian bridges, the most widely used intervention in cities such as Mexico City. Generally, these measures are based on technical criteria and fail to consider the population they target. There is no empirical evidence on the effects of these interventions, and while their effectiveness is worth noting, it is highly dependent on the context in which they are implemented. Research in Mexico suggests the need to reflect on the findings of other authors, who recommend that pedestrians be considered a basic factor in the definition of transportation policies, since vehicles and the growing need for highways often seem to be more important than the individuals who use them (21, 22). This way of perceiving and prioritizing pedestrians not only contributes to a safer physical environment for people who move about on foot but may also promote more respectful behavior among drivers and more personal responsibility among pedestrians.

Recent improvements have been made to the road infrastructure in some of Mexico's principal metropolitan areas, and the public transportation service has partially been restructured with the introduction of a service similar to the "Transmilenio" service in Bogotá. Examples include what has been done in Mexico City, Guadalajara, Monterrey, and León, where the mass transit service (Metrobús) has yielded such benefits as greater safety, an improved urban image, and a better quality of life. There is no doubt about the advantages of the Metrobús service, though it is important to point out the need for transportation systems that pay heed to long-term urban plans and flow dynamics not only in the city but in metropolitan and, in some cases, megalopolitan areas, as already occurs in the center of the country. We must begin to address the way in which we build our cities and transportation systems as a potential risk factor, since it is a source of the road risks and dangers of our streets.

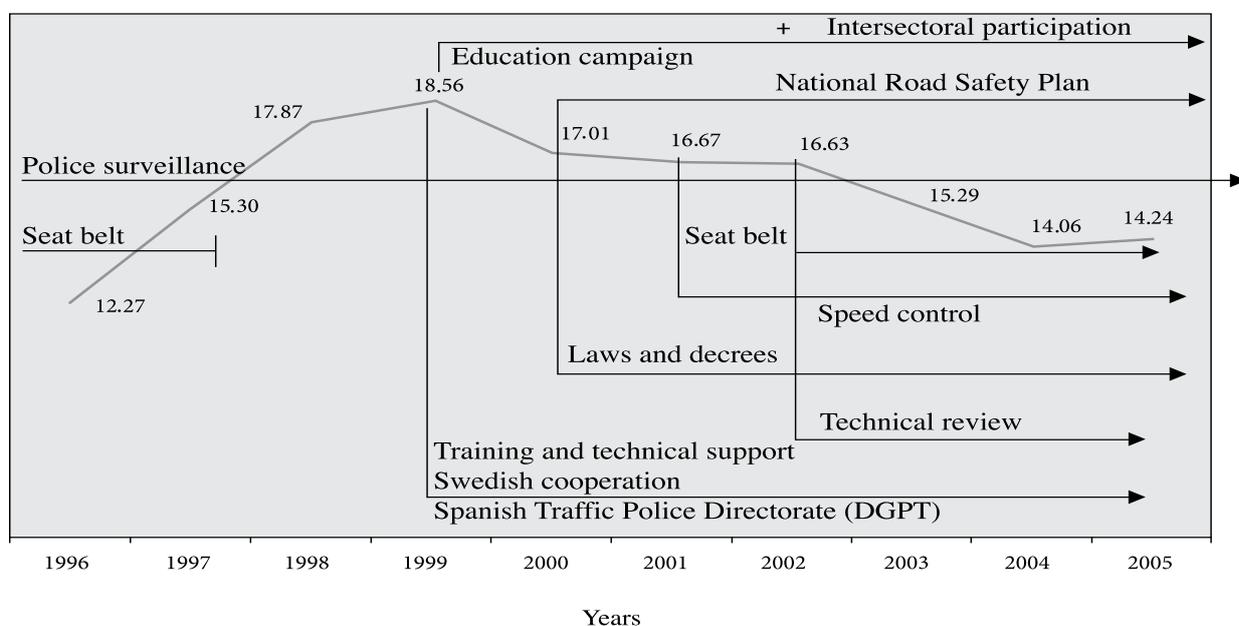
In 2008, through the National Center for Accident Prevention (CENAPRA), Mexico created the Mexican Road Safety Initiative (IMESEVI), a multisectoral program combining the efforts of CENAPRA (under the Secretariat of Health), the Pan American Health Organization (PAHO), and state governments with civil society to reduce injuries, disability, and deaths from traffic accidents (23). During the first phase, IMESEVI focused on alcohol use and the failure to use seat belts and child restraints as risk factors, developing six strategic elements or components (current situation, communication, training, legal framework, policing, and breathalyzer tests). The pilot cities for this road safety initiative are Monterrey (Nuevo León), Guadalajara (Jalisco), León (Guanajuato), and the Federal District (the country's capital), although expansion to the national scale is foreseen.

## ■ Action and results in Costa Rica

Figure 25-8 shows *in situ* and total mortality for the period 1996 through 2005. This figure, prepared by COSEVI with the data compiled, is a graphic representation of the principal interventions and programs implemented over the course of the first plan, 2001-2005. It should also be noted that the policy's goal of reducing mortality from traffic accidents by 18% over the five years was satisfactorily met: the reduction was 18.74 per 100,000 population. According to COSEVI (24), however, this figure is incorrect and appears to be a trend estimate, when in fact between 2001 and 2004, there was a 17.34% reduction (25), with the figure falling from 17.01 to 14.06 deaths per 100,000 population. In 2005, the rate rose slightly to 14.24 fatalities per 100,000 population.

One important aspect of these national strategies is ensuring that states or regions do not digress from the national actions agreed upon. This has happened in Mexico, where differences are observed between neighboring states with respect to drinking, helmet use, fines, and the year in which the state law was ratified. The same holds true for Brazil, where some states have failed to meet federal deadlines for entering their data in the national system.

**Figure 25-8.** Principal interventions of the Road Safety Plan 2001-2005 in Costa Rica



**Source:** COSEVI based on own data and data from the Institute of Statistics and Censuses (INEC) and Traffic Police Directorate (DGPT), Contreras-Montoya (26).

## ■ Action in Ecuador

### Quito Mobility Pact

September 2007 marked the signing of the Mobility in the Metropolitan District of Quito Pact, an agreement between governmental, private, and community organizations to discuss issues and reach consensus on mobility solutions. This agreement must result in a Mobility Master Plan, which is being publicized prior to its adoption as city policy.

### Compulsory Traffic Accident Insurance (SOAT)

As of January 2008, insurance to cover traffic accidents caused by the victims themselves, unidentified vehicles, or vehicles not covered by the system at the time of the accident became compulsory for all vehicles circulating in the country.

### Post-constitutional expectations and challenges

First, the aim is to transfer authority, bringing it closer to the people. The passage of the new law will further the transfer of responsibilities for transportation, traffic, and mobility planning and management to the municipal government of cities with populations of over 150,000.

Second, dialogue will be promoted for conflict resolution. In late November 2008, while associations of transport providers began talking about pressure tactics to obtain rate increases and amendments to the law to reduce penalties, the country's President reasserted his position on dialogue for settling disputes. The number of traffic fatalities underscored the need to enforce the law and retain the highest penalties for those responsible for the accidents.

### Vehicle inspections, renewal programs, and training

Vehicle inspections should be consolidated in cities where they already exist (Quito and Cuenca) and promoted in other cities. Worth mentioning are the program to repair or replace vehicles for public transportation (including the scrapping or physical destruction of old vehicles), promoted by the Ministry of Industry to upgrade over 23,000 public transportation units by the year 2010, and the decision to foster changes in the road culture among public transportation service providers and users alike.

## ■ Conclusions

The road safety policies implemented in the Region of the Americas have taken rather different courses as a result of broader, more participatory discussions and greater sharing of data and experiences. In general, they have been facilitated by initiatives such as the *World Report on Road Traffic Injury Prevention*, published by WHO in 2004 (1), the 2005 ECLAC report (18), and the PAHO *Road Safety in the Region of the Americas* report (27). These initiatives culminated the adoption in March 2010 of Resolution A/RES/64/255 by the United Nations General Assembly (28), which proclaimed the period 2011-2020 the Decade of Action for Road Safety, the goal of which is "to stabilize and then reduce the forecast level of road traffic fatalities around the world by increasing activities conducted at national, regional and global levels" (29).

It should be remembered that there are vast differences in the history, culture, and real traffic conditions between developed countries like the United States and developing countries such as those of Central America, South America, and the Caribbean. The social, political, cultural, and economic factors of the latter call for a diverse approach to road safety issues (30).

The WHO data presented in 2013 (13), which basically reflect the statistics compiled by countries during 2010, indicate that one of the rates representative of the phenomenon (deaths per 100,000 population) averaged 16.1 in the Region of the Americas, or 56% higher than the rate for the European Region, which exhibited the best performance at 10.3. However, the experience in developed countries—not only the United States, whose rate is 11.4, but also the European countries—shows that ongoing coordinated action can lead to profound changes in road safety conditions.

A summary of the most important points of studies around the world yields two basic conclusions. The first is that a structural change in road safety will only occur if there is a concerted, ongoing effort by national and local authorities, with strong civil society participation. The U.S. and Costa Rican cases are clear examples, with very significant benefits in both countries. The case of Brazil is also important, although the violence is still experienced by all and the expected benefits have-not yet been reported. This means that isolated action without proper planning or coordination between the public and private sectors may yield short-term political gains but the results are normally mediocre at best. In Mexico, where institutional sectoral action has been promoted for some time with poor results, the new IMESEVI (Mexican Initiative for Road Safety) implemented in 2008 is expected to result in significant and measurable changes. The challenge here is sustainability, so that the action continues when the current support from international organizations ceases. The second conclusion is that road accident reduction plans should set very clear objectives, timelines, and goals that will serve to evaluate their real effect, and that permanent financial support is needed.

### Most important action

Both international and Latin American experiences suggest that of the many actions that could be taken to improve road safety, the following are among the most effective:

- Coordination of efforts: as with the understanding that traffic accidents are a public health problem, proper institutional organization must be part of a strong, high-level policy-making component to orchestrate significant changes. Although this occurred in the United States and Canada several decades ago, there is still a lack of political will and coordination among the public agencies responsible for road safety in other countries—a phenomenon related to the more limited view of the problem mentioned earlier. Costa Rica and Brazil are showing signs of change, creating better conditions for a coordinated action network that can produce results in the short term (something that has already occurred in Costa Rica and is beginning to emerge in Brazil and Mexico). In Ecuador, measures such as comprehensive vehicle inspections have been adopted and implemented in Quito and Cuenca, and the interinstitutional action needed to take them national is now being coordinated. However, such changes have not yet occurred in the other cases analyzed.
- The creation of multidisciplinary forums for discussion and proposals with full legal and financial backing, such as decentralized councils with diverse agencies on their governing board. This experience was significant in Costa Rica, where the collegiate body, COSEVI, historically has included the Ministries of Transportation, Public Education, and Health, and, under the provisions of the new Law 9078 (2012), a representative from municipalities and professional associations (Federated School of Engineers and Architects), without compromising its partnerships with other stakeholders from the private, academic, and social sectors. Here, it is worth mentioning the experience of Argentina, where in 2008, Law 26.363 created the National Road Safety Agency (ANSEVI) as a decentralized agency of the Ministry of the Interior, with its own legal status and budget.
- The physical reorganization of traffic space to guarantee safe circulation of pedestrians and cyclists, including the construction of footpaths and bicycle lanes and the installation of effective signaling and signage systems, zebra crossings, bridges, pick-up or drop-off spaces, and pedestrian traffic lights.
- The adoption of more open and systemic approaches when determining the indicators to be used in development plans, especially when their purpose is to evaluate the road safety situation, propose sectoral goals, or make cross-comparisons between cities and countries. When setting sectoral goals, mortality rates per inhabitant should not be the only reference indicator but should be supplemented with other, broader indicators such as mortality per vehicle and kilometer.
- Control of speed limits with effective electronic or photographic equipment, road illumination, rough pavement, and centralized control of traffic lights.
- Rigorous enforcement of alcohol intake limits for drivers.
- Establishment of the requirements for obtaining a driver's license; use of a cumulative point system for traffic offenses (with high fines for perpetrators and the potential loss of their driver's license for the most dangerous infractions, such as speeding, driving under the influence of alcohol, passing on a curve, running a red light, and failure to yield to pedestrians); a ban on the use of cell phones; mandatory use of child safety seats and their location; and control of reckless driving.

- Use of seat belts by passengers and helmets by motorcyclists and their passengers; headrests and safety glass for windows; control of old obsolete vehicles; and the setting of vehicle protection standards.
- Offering of road education programs tailored to different age groups and types of users.
- Vehicle inspections by qualified entities with the independence to make the necessary decisions about the repairs needed for vehicles that fail inspections; this has been successfully done in the United States and Costa Rica, and partially in Mexico and Ecuador, but not in Brazil.
- The media: efforts should be made to ensure that the media have up-to-date, quality information that exerts a positive influence, giving preferential coverage to road safety issues. This has proven critical not only in the United States, but also in Brazil when the 1998 Traffic Code first came into force, and currently in Costa Rica, since the legislative change introduced in 2012.
- The participation of all stakeholders: in addition to high-level policy-making, another key element that is highly effective in achieving structural improvements in road safety conditions is the participation of all the public, private, and civil society sectors involved. This has been very clear in the case of the United States and, more recently, in the discussion and approval of the new Traffic Code in Brazil and the new Constitution in Ecuador. Only when all stakeholders participate in the plans and their implementation are significant results possible.
- Caring for the most vulnerable: an important question in Latin American and Caribbean countries when speaking about road safety is “safety for whom?” Most interventions to combat the problem of motor vehicle accidents have been designed in high-income countries; therefore, the most vulnerable stakeholders have nearly always been ignored: pedestrians, cyclists, and the users of public transportation. In Mexico, Costa Rica, and Brazil, pedestrians account for 21%, 24%, and 28% of traffic fatalities, respectively; these data exemplify the results of the 2013 report for the Region of the Americas. In our context, most of the interventions targeting vehicles have even increased the inequality and vulnerability of other users. Thus, a profound shift in road safety project priorities is necessary, focusing on the most vulnerable stakeholders. In other words, vulnerable users (motorcyclists, cyclists, and pedestrians) account for 58% of all *in situ* deaths, exceeding the 41% (15% motorcyclists, 3% cyclists, and 23% pedestrians) detected in the Region of the Americas by WHO (13).
- Guaranteeing human and financial resources: adequate human and financial resources are essential for changing the current situation. Human resources must receive specific technical training to work in the field of traffic accidents and include engineers, traffic police, and public health professionals. This requires ongoing training programs. As for financial resources, the challenge is to convince society that this problem merits large-scale State support. Ideally, there should be a specific road safety budget, as in the United States, in Brazil with FUNSET, and in Costa Rica with the Road Safety Fund created by law.

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# Toward a tobacco-free Hemisphere

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## ■ The smoking epidemic

The tobacco epidemic is one of the leading preventable causes of death worldwide. In 1999, the World Bank published a document (1) highlighting the growing trend in tobacco use and warning that this would produce a heavy burden of disease and premature death, especially in developing countries. Evidence of the health risks of smoking first came to light in the 1950s, and today, thousands of scientific papers have established a causal relationship between tobacco use, exposure to second-hand smoke, and the development of major diseases.

At present, 24% of the world's population smokes. In the Region of the Americas, there are approximately 145 million smokers, with the following distinctive characteristic: although smokers are predominantly male, differences between men and women are less pronounced than in other WHO regions and even less so among adolescents (2). The prevalence of smoking in the Region's adult population is 22%, with huge variations from country to country. In adolescents aged 13 to 15, the prevalence is 16% (3) and this, too, varies greatly across countries.

Tobacco is responsible for almost 6 million deaths per year worldwide. Around 1 million of these occur in the Region of the Americas, where tobacco is responsible for 15% of deaths from cardiovascular disease, 26% of deaths from cancer, and 51% of deaths from respiratory disease (4). Smoking threatens the health of users, critically compromises the health of those exposed to second-hand smoke, and is a threat to public health. It therefore constitutes a world public health catastrophe and, as such, requires a global response.

This epidemic has been further facilitated by a series of cross-border effects, such as the liberalization of trade, direct foreign investments, transnational cigarette advertising, promotion and sponsorship, and the illicit trade in tobacco products worldwide. Thus, in addition to being a health problem, tobacco use also has major economic, social, and environmental consequences, and many of the measures needed to curb it are beyond the scope of the health sector alone, which means that a multisectoral approach is required.

Within this context and given the serious threat to public health, the economy, and the environment caused by the growing smoking epidemic, the Forty-eighth World Health Assembly in 1995 called upon the Director-General to report to the Forty-ninth World Health Assembly on the feasibility of developing an international instrument, such as guidelines, a declaration, or an international agreement, for tobacco control. This marked the birth of what would ultimately become the WHO Framework Convention on Tobacco Control (WHO FCTC) aimed at combating the globalization of the tobacco epidemic (5).

## ■ Who Framework Convention on Tobacco Control (WHO FCTC)

In May 2003, at the Fifty-sixth World Health Assembly, the 192 WHO Member States adopted the FCTC as the first global public health treaty negotiated under the auspices of WHO. This Convention brings together all strategies that have proven effective in controlling the tobacco epidemic, which can be summarized as a package of measures aimed at reducing the supply and demand for tobacco products. It adopts an innovative approach to the issue of addictive substance use, as it not only focuses on controlling consumption but envisages other strategies to reduce both supply and demand (6). Today, over 170 countries have formally ratified and are Parties to this Convention (7).

The main provisions of the Framework Convention for reducing tobacco demand are found in Articles 6 through 14 and can be categorized as:

- pricing and tax measures to reduce the demand for tobacco products, and
- nonpricing measures to reduce the demand for tobacco products, namely:
  - protection from exposure to tobacco smoke;
  - regulation of the content of tobacco products;
  - regulation of tobacco product disclosures;
  - packaging and labeling of tobacco products;
  - education, communication, training, and public awareness;
  - tobacco advertising, promotion, and sponsorship;
  - demand reduction measures related to tobacco dependence and smoking cessation.

The main provisions addressing supply issues in the Convention are found in Articles 15 through 17 and entail:

- illicit trade in tobacco products;
- sales to and by minors;
- support for economically viable alternative activities.

Later, the Conference of the Parties (COP) to the Convention prepared and approved by consensus guidelines for the implementation of several articles of the Convention designed to assist countries with the practical implementation of the different articles (8). Furthermore, the Protocol to Eliminate Illicit Trade in Tobacco Products was approved at the fifth COP meeting. This is currently open for signature and ratification by the Parties (9).

With the aim of effectively reducing tobacco demand, WHO developed the MPOWER measures to help fight the smoking epidemic (10). These are:

**Monitor:** Monitor tobacco use

**Protect:** Protect people from tobacco smoke

**Offer:** Offer help to quit tobacco use

**Warn:** Warn about the dangers of tobacco

**Enforce:** Enforce bans on tobacco advertising, promotion, and sponsorship

**Raise:** Raise taxes on tobacco.

## ■ Exposure to second-hand smoke

For over 30 years now, scientific studies have been demonstrating that exposure to second-hand smoke causes serious health problems. It was not, however, until relatively recently that this was recognized as a major public health concern, largely due to the social acceptance of tobacco. Moreover, the tobacco industry has devoted considerable effort to generating controversies in this area. Yet, the scientific evidence is irrefutable, as confirmed by the U.S. Surgeon General in his 2006 report: second-hand smoke causes disease and kills (11). The debate is over.

## Health consequences

The only effective way to protect people from exposure to tobacco smoke is to create 100% smoke-free environments, and the scientific evidence is very conclusive. This is also the only way to protect a people's right to defend their health and to avoid the risks associated with exposure to second-hand smoke. Furthermore, smoke-free environments help smokers reduce their consumption and encourage former smokers to remain abstinent. Exposure to second-hand smoke kills about 603,000 people per year across the planet, 166,000 of whom are children and 281,000 are women (12).

Estimates in the United States indicate that tobacco leads to the death of one nonsmoker for every eight deaths of smokers (13). Here, the risk of death from passive smoking is 600 times higher than the risk of death from exposure to all other hazardous environmental contaminants combined (14).

Figure 26-1 lists the diseases for which an unequivocal causal relationship with passive smoking has been established (15). Many other diseases are being investigated and will most likely be added to this list as there are already causal links.

In general terms, in nonsmokers exposed to second-hand smoke in the home or workplace, the risk of lung cancer increases by 20% to 30% and the risk of cardiovascular disease, by 25% to 30% (16).

## Environmental consequences

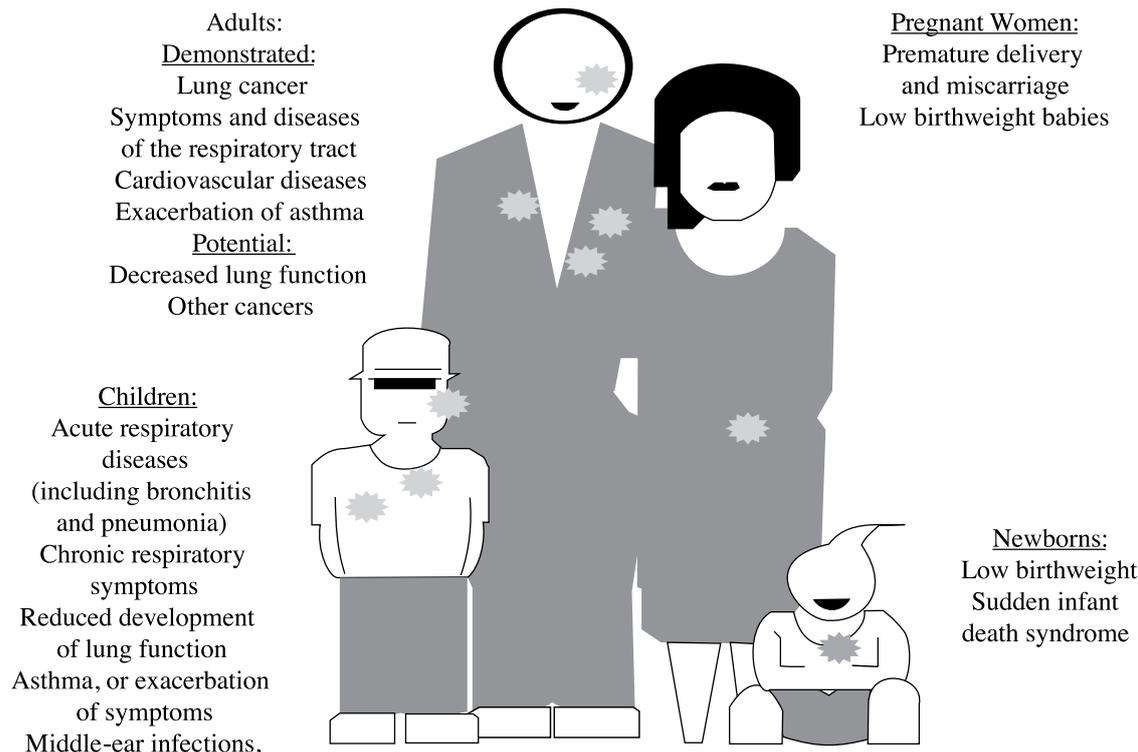
Over 4,000 chemical compounds have been identified in tobacco smoke, at least 250 of which are toxic or carcinogenic. The U.S. Environmental Protection Agency and the National Toxicology Program, as well as the World Health Organization's International Agency for Research on Cancer (IARC), have classified second-hand smoke as a recognized human carcinogen; the U.S. National Institute for Occupational Safety and Health (NIOSH) has classified it as an occupational carcinogen.

Studies in the United States and Canada show that if smoking were banned in the hospitality sector, small particle air pollution could be reduced by 90% and the presence of airborne carcinogens, by 95% (17). In Uruguay, thanks to the legislation on smoke-free environments, air pollution in enclosed public spaces was reduced by over 90%. This was determined by detecting the concentration of respirable suspended particles (less than 2.5 microns) and nicotine concentration in the air (18,19).

There is no level of exposure to second-hand smoke that does not involve risks, because even very low levels can be harmful to our health. The only way to protect the health of nonsmokers is to ensure totally smoke-free environments. Strategies to separate smokers from nonsmokers in the same environment, clean the air, or provide ventilation, which are generally the strategies advocated by the tobacco industry, are not effective solutions for protecting people's health (20).

Although many toxic chemicals (arsenic, benzo(a)pyrene, cadmium, chromium(VI), polonium-210, etc.) in tobacco smoke are recognized and individually regulated as carcinogens and industrial toxic substances, workplace contamination by tobacco smoke is rarely considered.

Figura 1-26. Diseases causally related to passive smoking



## Economic consequences

The economic repercussions of tobacco use have been extensively investigated. The World Bank calculates that tobacco-related health care accounts for 6% to 15% of the total annual health care costs in high-income countries (21), whereas in low- and middle-income countries, where the epidemic is still in its early stages, there is possibly a complete lack of awareness of the economic burden that this will imply for health systems in the near future, and even less awareness of the financial costs of exposure to second-hand smoke. Some studies indicate that the specific costs of second-hand smoke are also high.

In an international review, the effects of passive exposure to tobacco smoke were analyzed, and the financial costs of this exposure were calculated in several countries (22).

## Exposed populations

According to WHO data, over half the world's children are exposed to tobacco smoke (23). Children are especially sensitive to this exposure because they absorb comparatively more toxic substances per unit of weight. In the Region of the Americas, Global Youth Tobacco Survey (24) data show that, in general, more than half the young people surveyed are exposed to tobacco smoke in public places.

A report by the International Labour Organization points out that smoking constitutes an occupational health and safety risk (25). Studies conducted in the United Kingdom show that this risk is higher in certain sectors, among bar and restaurant staff, for example. Scientific evidence shows rapid and significant health improvement in employees in this sector after the introduction of smoke-free environments (26,27). Studies conducted in Spain prior to the amendment of the legislation that permitted smoking areas, show that employees' health improved only where smoking was completely banned (28,29).

## Evidence in favor of smoke-free environments

As more and more countries are introducing smoke-free environments, more positive scientific evidence is being generated about the benefits of such measures.

### Health impact

Several countries and jurisdictions that have passed laws to establish smoke-free environments have observed health effects that can be verified rapidly. Studies conducted in the United States (30,31) and Italy (32) show a significant reduction in the incidence of acute myocardial infarction after 100% smoke-free environments were mandated. In Uruguay, after smoke-free environments were mandated in March 2006, there was a 22% decrease in hospital admissions for acute myocardial infarctions (33). According to studies conducted in Ireland (34) and Scotland (35) on the respiratory health of bar and restaurant staff, fewer respiratory symptoms and increased well-being were reported by these workers after the smoking ban.

The study conducted in Spain shows that in the 100% smoke-free areas, respiratory symptoms in hospitality staff decreased by 72% and their saliva cotinine (a biological marker of exposure to tobacco smoke) levels fell by 55.6%.

### Economic impact

As already noted, one of the tobacco industry's favorite arguments to pressure governments not to adopt these types of measures is the economic losses for the hotel, restaurant, and leisure sector in general. In 2002, Scollo et al. (36) reviewed all studies published on the economic impact of smoke-free environments on revenues for this sector. Results from the better-designed studies, which calculated earnings using objective measurements and were published in peer-reviewed journals, showed no losses and even a slight increase in revenues for the sector. All the studies showing losses had been financed by the tobacco industry. Research in Argentina and Uruguay showed no economic losses for the hospitality sector following the implementation of the smoke-free environment legislation (37).

We must remember, however, that, unlike other public health situations, the smoking epidemic is driven and sustained by a multinational industry that continues to put profits above people's lives and health.

## ■ The role of civil society in the Region

As a multifaceted problem involving all social stakeholders, global control programs are necessary to curb tobacco use.

A global program consists of a diversity of strategies and activities with a common goal, conducted with an integration and mutual support approach across various sectors of society. One such example is the participation and integration of nongovernmental organizations in the work of public and private health sector institutions. Numerous examples exist to demonstrate how joining forces achieves far better results than the sum of individual efforts. Civil society involvement is essential to achieving the proposed goals.

According to the Union for International Cancer Control (UICC), the implementation of global programs must have the support of major coalitions that include participants from various sectors of society (38) and assimilate new activities into preexisting ones. However, it is important that each entity preserve its identity. It is particularly important that NGOs maintain their freedom to act, feel free to disagree with government policies, and can motivate the political system to promote the measures of the Framework Convention.

NGOs have proven effective in conducting promotional activities, including meetings with policymakers to get laws passed and regulations issued, attracting media attention to guarantee coverage of smoking prevention activities, and convincing celebrities and opinion leaders to participate as role models for smoking prevention. They have also played a key role in monitoring compliance with the tobacco control regulations in force.

Comprehensive tobacco control programs have been shown to reduce the prevalence of tobacco use and improve public health. Such programs should include the following actions:

- raise public awareness about the problems associated with tobacco use;
- enlist public support for the implementation of tobacco control measures;

- prevent people from starting to smoke; and
- promote smoking cessation.

These options can be categorized according to the main objectives: awareness, protection, prevention, and cessation. For these actions to be undertaken, a proper institutional framework is necessary together with sufficient financial support and training for those involved.

## ■ Interference from the tobacco industry

The tobacco industry profits by marketing a product that kills or sickens people while at the same time contributing to world poverty. Direct and indirect advertising of tobacco products has further exacerbated the smoking epidemic, especially among young people.

For many decades, the industry concealed the truth about the risks of tobacco use, denied its addictive nature, created controversy and uncertainty about rigorous scientific data, and systematically opposed effective tobacco control measures implemented in countries around the world. It resorted to all sorts of tactics: proposing less-effective alternative measures, offering to collaborate with control measures, offering to implement voluntary agreements, pushing for approval of less stringent laws when the passage of legislation was imminent, or filing appeals against regulations already in force.

The table below summarizes the principal arguments used by the tobacco industry in opposition to the implementation of some articles of the FCTC and the response from the health sector.

<i>FCTC measure</i>	<i>Tobacco industry argument</i>	<i>Response</i>
<b>Article 8. Protection from exposure to tobacco smoke</b>	Smokers and nonsmokers should share public spaces through adequate ventilation systems.	Methods based on technical solutions (ventilators, etc.) are ineffective. The only effective protection is SFEs*.
	SFEs damage the economy.	Evidence unequivocally demonstrates that SFEs have no negative economic impact in any sector.
	SFEs lead to increased tobacco consumption in the home.	Evidence shows that children's exposure to tobacco smoke in the home does not increase, but actually decreases.
	An individual's right to smoke is violated.	Constitutional or legal rights, such as the right to health and to life, are protected.
	SFEs violates the right to employment.	Only environmental conditions and behavior in the workplace are regulated; access of smokers to employment is not.
	SFEs discriminate against smokers.	What is prohibited is the act of smoking. Smokers are not banned from entering the protected spaces.
	SFEs violate property rights.	States can regulate certain activities, even when they occur on private property, to protect people's constitutional right to health and life.
	SFEs negatively affect commercial freedom.	Jurisprudence exists whereby limitations on commercial freedom are legitimate if proportional to the goods being protected (in this case, health).
<b>Article 11. Packaging and labeling of tobacco products</b>	Health warnings limit tobacco manufacturers' freedom of expression.	Health warnings provide truthful information on the harmful effects of tobacco use and exposure to smoke, as required by the Framework Convention.
	Health warnings violate international agreements on trade and intellectual property and expropriate trademarks.	The fact that a measure affects the use of a trademark does not violate these agreements, as they do not force States to permit use of trademarks as their owners might wish but, rather, protect the right to exclude unauthorized use of the trademark by third parties.
	To implement the warnings with images, tobacco companies need more time than stipulated by law.	When governments remain steadfast in their decision, tobacco companies meet the stipulated deadlines, as seen in many countries.

<i>FCTC measure</i>	<i>Tobacco industry argument</i>	<i>Response</i>
<b>Article 13. Banning tobacco advertising, promotion, and sponsorship.</b>	TAPS** is directed only at adult smokers.	Advertising costs and internal industry documents show that marketing has been consistently and consciously targeted specific populations, such as young people, as this is the market sector that will yield greater long-term profits.
	TAPS is aimed at maintaining the market share of each brand and not to increase total consumption.	There is ample evidence demonstrating that TAPS has little effect on which brand is purchased. Conversely, it suggests that product advertising has a greater effect on impulse purchases than on the choice of brand.
	Freedom of expression includes the “right” to advertise a legitimate product.	There are several precedents whereby advertising of hazardous or potentially hazardous legal substances is restricted or banned (e.g., weapons or pharmaceutical products).
	Banning advertising will negatively affect the advertising industry, and banning sponsorship will affect art, sports, and other activities.	TAPS represents only a small part of the entire advertising industry, so any negative impact can be recovered. Also, other sponsors will fill the gap left by the tobacco companies.
<b>Article 9. Regulation of the contents of tobacco products</b>	Regulating tobacco products will cause job losses.	A study by the World Bank shows that, except in a few cases, there would be no net job losses. Economies will have years to adapt to the drop in demand. Furthermore, if the demand declines, the money not spent on tobacco products will be invested in other goods and services, generating jobs elsewhere.
	Sugar and other additives do not affect the toxicity or addictive nature of tobacco products.	From a public health standpoint, the issue here is that the sugar and other additives make the product more attractive, giving it a more pleasant flavor.
	Banning the addition of sugar will mean that certain types of tobacco cannot be used, causing losses to farmers.	Internal industry documents and the experience in Canada show that this is untrue.
<b>Article 12. Education, communication, training, and public awareness</b>	The industry tries to sponsor educational programs for smoking prevention in young people.	Industry documents show that the aim of these programs is to present an image of responsibility, while at the same time gearing their marketing to young people. These programs are ineffective at best and, at times, harmful.

\* SFEs: Smoke-free environments

\*\* TAPS: Tobacco advertising, promotion, and sponsorship

**Source:** Manual for Developing Tobacco Control Legislation in the Region of the Americas. PAHO, 2013.

This fundamental clash between the interests of the tobacco industry and public health policies makes it necessary to adopt global measures to counteract the activities of this industry. United Nations Member States reiterated this in the Political Declaration of the High-level Meeting of the General Assembly on the Prevention and Control of Noncommunicable Disease (39). Countries must remain ever vigilant to identify early signs of attempts to sabotage measures that protect the health of their citizens.

As established in Article 5, paragraph 3 of the FCTC and the guidelines for implementation adopted by COP 3 (40), the following recommendations are provided for countries:

1. Raise awareness about the addictive and harmful nature of tobacco products and about tobacco industry interference with Parties' tobacco control policies.
2. Establish measures to limit interactions with the tobacco industry and ensure the transparency of those interactions that occur.

3. Reject partnerships and nonbinding or nonenforceable agreements with the tobacco industry.
4. Avoid conflicts of interests for government officials and employees.
5. Require that information provided by the tobacco industry be transparent and accurate.
6. Denormalize and, to the extent possible, regulate activities described as “socially responsible” by the tobacco industry, including but not limited to activities described as “corporate social responsibility.”
7. Do not give preferential treatment to the tobacco industry.
8. Treat State-owned tobacco industry in the same way as any other tobacco industry.

We know that some countries are already taking steps to control tobacco industry interference in their tobacco control programs. In one case, for example, the minutes of meetings with the tobacco industry are posted on the Ministry of Health webpage. In Uruguay, representatives of civil society organizations involved in tobacco control attend any meetings held at the request of the tobacco industry, while in Brazil, interviews with representatives of the tobacco industry are duly documented through minutes and recordings (see next section).

In recent years, the tobacco industry has deployed new strategies to slow progress relative to the Framework Convention by filing lawsuits at the national and international levels.

Trade liberalization fosters the expansion of tobacco industry activities toward new markets, especially in developing countries. In this context, the industry endeavors to counteract tobacco control measures through agreements States have reached to protect their investments or regulate international trade.

In some instances, the tobacco industry has turned to investment protection agencies, such as the World Bank's International Centre for Settlement of Investment Disputes (ICSID); in others, it has taken the dispute to the World Trade Organization (WTO) and filed complaints with the Technical Barriers to Trade Committee. It has also alleged that trade agreements, such as the Agreement on Trade-related Aspects of Intellectual Property Rights (TRIPS) or the General Agreement on Tariffs and Trade, have been violated.

Resort to these agreements by the tobacco industry threatens the sovereign right of States to adopt the public health policies that they deem necessary to protect the health of their population; tobacco control is essential because it is directly related to the protection of basic human rights: the right to health and the right to life.

## ■ Implementing the FCTC in the Region of the Americas

In June 2013, 29 countries of the Region of the Americas were Parties to the WHO FCTC. Substantial progress has been made in the implementation of national legislation aligned with WHO FCTC mandates, albeit somewhat haphazardly depending on the country and the articles of the Convention.

Regarding taxes on tobacco products, two countries in the Region levy tobacco taxes that represent at least 75% the final retail price. In recent years, countries like Brazil, Costa Rica, Ecuador, Mexico, and Panama have made progress by enacting legislation designed to raise taxes on tobacco and, in some cases, by mandating that a certain percentage of the monies collected with these taxes be allocated for specific tobacco control activities or health purposes in general.

At present, 17 countries in the Region have enacted national legislation (or subnational legislation covering at least 95% of the population) to require totally smoke-free environments in at least all enclosed public spaces, workplaces, and public transportation<sup>1</sup> (FCTC, article 8).

In 20 countries, the law states that the outer packaging and labeling of tobacco products must carry health warnings, must not mislead consumers about the characteristics of the product, and must include qualitative information on contents and emissions.<sup>2</sup>

Finally, with respect to the prohibition of tobacco advertising, promotion, and sponsorship, five countries<sup>3</sup> have a total ban, while the others allow a certain number of exceptions. However, 24 countries have not placed bans on tobacco advertising that cover at least television, radio, and printed news media.

## ■ Successful examples of tobacco control in the Region of the Americas:

### Case: Uruguay

When a country decides to require smoke-free environments as a health policy, it faces considerable challenges. Once it meets its objective, however, significant changes in health and social and cultural behavior can be achieved. This is all part of the process and the underpinning of the objective of improving the health of the population. We must always bear in mind that the scope of the measures and the changes that they bring about will depend on the magnitude of the health problems caused by tobacco use in the country.

In Uruguay, the tobacco control process underwent a substantial change in 2000 with the creation of the National Partnership for Tobacco Control, a partnership of public and private agencies and NGOs, working together initially for ratification of the FCTC and then its implementation. The critical goal was the creation of smoke-free environments. In 2004, all health care institutions were declared 100% smoke-free by law, and in 2005 this mandate was extended to all public offices.

Finally, on 1 March 2006, Uruguay became the first 100% smoke-free country in the Americas by means of the following decree: "Every enclosed public space and every workplace, public or private, designed to be shared by people shall be a 100% smoke-free environment."

Before this law went into effect, there was a preliminary preparatory stage to provide information and raise awareness, which proved key to the success of the measure.

During this initial phase, there was a carefully planned public awareness campaign about the tobacco epidemic in general and daily contacts with the press during the six months prior to the law's entry into force. The objective was both specific and ambitious. The aim was to inform the public and show how people were exposed to tobacco smoke on a daily basis and the risks that this implied. Another aim was to ensure that nonsmokers understood that, in most cases, the smoker is the victim of an addictive disease, and thus no punitive measures would be adopted against smokers.

Two lines of action were established for this preliminary period:

1. Dialogue with businesses explaining that implementation of the measure was inevitable and that the onus was on businesses owners, office or factory managers, etc., to ensure compliance with the law, and that inspections would be conducted and infractions would carry very high fines. This ensured that the process was both regulated and fair.
2. The second line of action worked towards thanking smokers who, once the ban came into force, refrained from smoking in enclosed places. To this end, a campaign to collect signatures was carried out, called "A Million Thanks." One month after its launch by the President of the Eastern Republic of Uruguay, over 1,200,000 signatures had been collected.

Six months after the implementation of smoke-free environments, a survey showed that 80% of the population supported the measure, including 63% of smokers, and that 92% believed that second-hand smoke was hazardous to nonsmokers.

Objective elements demonstrate changes in air quality in enclosed spaces. Measurement of suspended particles in the air before and after the advent of smoke-free environments yields the values shown in the table below.

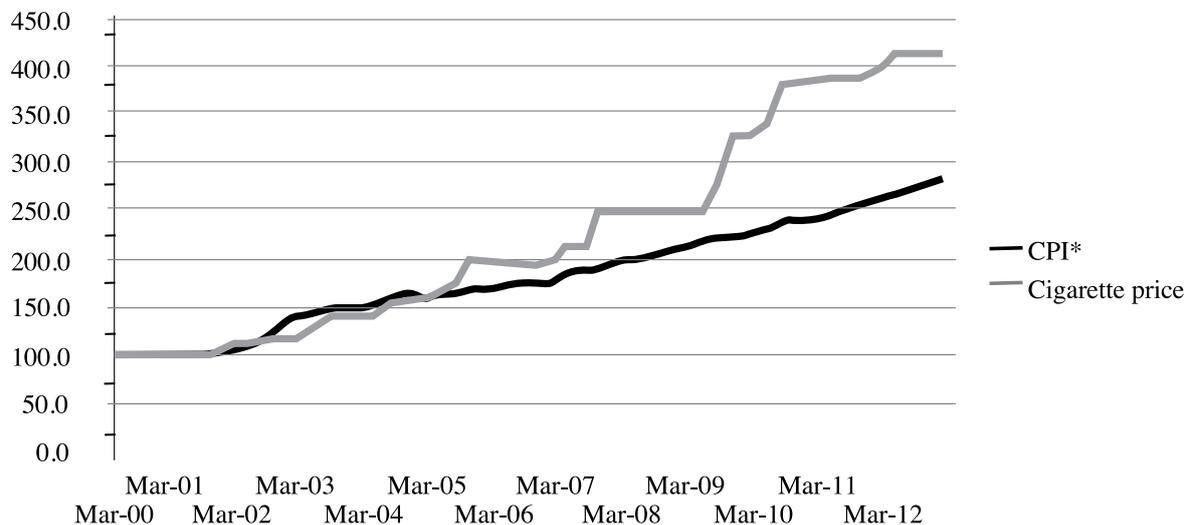


Once the ban was in force, systematic inspections were conducted as well as others in response to complaints. The information was computerized and hefty penalties imposed for infractions.

In Uruguay today, there is a high degree of compliance with the smoke-free environment regulation. This country has also made significant progress in implementing other WHO FCTC articles.

Article 6 of the Framework Convention refers to increasing the price of tobacco products through higher taxes. Since 2005, Uruguay has had a tax policy consistent with the provisions of this article, namely: taxes on tobacco will steadily increase, in the understanding that this measure is very effective in reducing consumption among young people and the lower-income population. Consequently, the price of tobacco products has substantially increased, well above of the consumer price index.

Figure 26-2. Consumer price index and cigarette price index



\*CPI = consumer price index

Source: Figure provided by Dardo Curti, with data from the National Statistics Institute of Uruguay.

Article 11 of the Framework Convention refers to the packaging and labeling of tobacco products. As more and more countries ban advertising, product packaging becomes increasingly important for the tobacco industry as a means of promoting its products and transmitting information to deceive consumers about the effects of tobacco use. Since 2009, tobacco product packaging in Uruguay must carry the health warnings approved by the Ministry of Public Health. These must cover 80% of the back and front surfaces of the pack and 100% of one of the sides and provide information on contents or emissions without stating quantities. The health warnings are rotating and contain images together with a clear direct message. This measure has proven effective: 44% of smokers indicated that they had thought about quitting as a result (GATS 2009). The tobacco industry has attempted to evade or to undermine the effect of the health warnings through different strategies, such as publications in newspapers and offering alternative images to replace those approved by the health authority.

Concerning WHO FCTC Article 13, under Law 18.256 Uruguay prohibits all forms of tobacco advertising, promotion, and sponsorship in the media: radio, television, newspapers, public thoroughfares, and other print media. Before 2014, this ban was broad but incomplete, because the places where these products were sold were excluded. On 8 July 2014, Uruguay's Parliament passed a law banning all advertising, promotion, sponsorship, and display of tobacco products at points of sale, without exception. Uruguay had thus arrived at a total ban.

WHO FCTC Article 14 refers to treatment for tobacco dependence. In line with this article, access to such treatment in Uruguay, including medications, is free and universal. There is a National Guideline for Tobacco Management, and all medical records must indicate whether a patient is a smoker. Patients who smoke are counseled briefly on cessation and treated or referred for treatment. Some 32.7% of former smokers quit within four years of the implementation of this system (between 2005 and 2009).

At the last Conference of the Parties to the Framework Convention in November 2012, the first Protocol to the Convention, aimed at eliminating the illicit trade of tobacco products, was approved. Uruguay signed and ratified this Protocol.

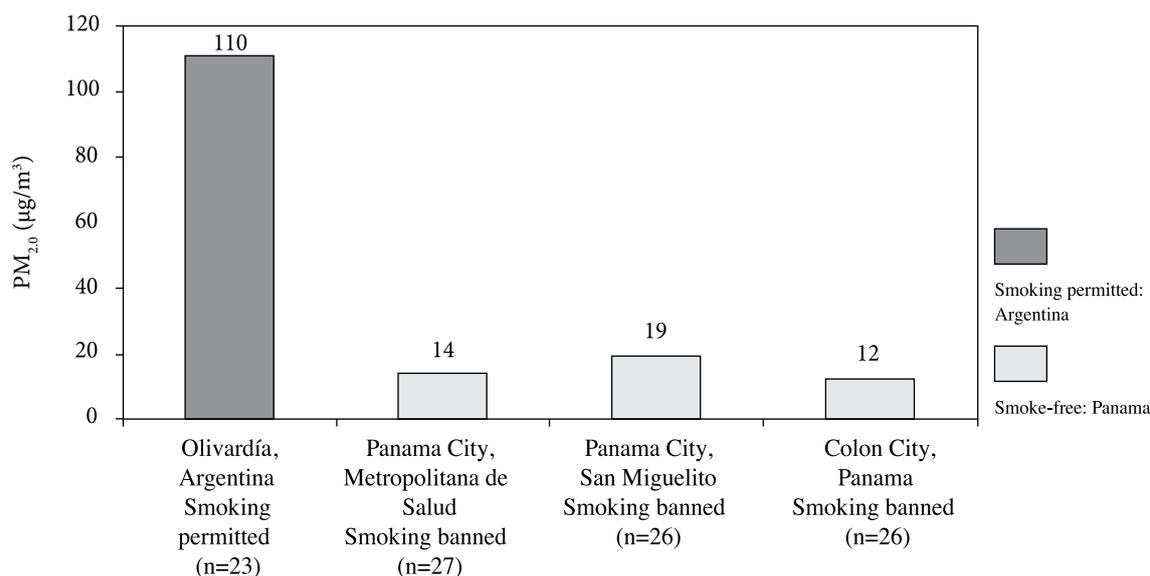
As a result of the process outlined above, tobacco control policies have had a rapid and remarkable impact in Uruguay: consumption in the population aged 15 or older declined by 3.3% per year between 2005 and 2011, while in consumption among adolescents decreased by 8% per year between 2003 and 2009 (41).

### Case: Panama

On 25 January 2008, the *Official Gazette* published Law 13 “that adopts control measures for tobacco and its harmful effects on health,” whereby smoking in enclosed work environments and other specific areas was totally prohibited. Passage of this legislation took almost four years. During that time, a variety of strategies were implemented, many of them promoted by nongovernmental organizations working to promote tobacco control. The media acted as facilitators to raise awareness among the Panamanian population about the importance of 100% smoke-free environments. Scientific evidence obtained from national studies on the issue of tobacco consumption and addiction in young people (13-15 years), environmental nicotine measurements in enclosed areas, and orientation for managers of establishments where smoking is prohibited and for civil servants responsible for monitoring compliance with the law (health inspectors, police officers, magistrates, etc.) all contributed to the approval and effective implementation of the total smoking ban in enclosed environments, and even in some open venues used for sporting activities. With a view to evaluating the effectiveness of the measure, the Ministry of Health, with technical assistance from the Roswell Park Cancer Institute's Department of Health Behavior, Buffalo, USA, participated in a multicenter study to measure tobacco-related air pollution in different workplaces.

This study was conducted in May 2008 and revealed that policies banning smoking in public workplaces dramatically reduce exposure to second-hand tobacco smoke and help improve the health of workers and business people.

Figure 26-3. Average fine particle air pollution in cities in Panama and Argentina, 2008



Air pollution levels in enclosed smoke-free areas in the sampled sites were 86% lower at sites where there were no smokers. The difference was statistically significant ( $p < 0.001$ ) using the Mann-Whitney U test.

**Source:** Global air monitoring study: a multi-country comparison of levels of indoor air pollution in different workplaces. Results from Panama. Roswell Park Cancer Institute. New York.

### Tobacco advertising, promotion, and sponsorship

With regard to the regulation of advertising, promotion, and sponsorship, since 1947 the Panama Health Code has had legal provisions to regulate advertising and publicity through the Ministry of Health's Advertising Commission. Prior to ratification of the WHO Framework Convention on Tobacco Control, other related regulations consisted of general, ambiguous provisions that were very ineffective in combatting the advertising, promotion, and sponsorship of tobacco products.

After ratification of the FCTC, by Executive Decree 17 of 2005, a partial ban on tobacco advertising, promotion, and sponsorship was approved, including the sponsorship of children's events. However, advertising was permitted at points of sale, in magazines, and at movie theaters, as was advertising, promotion, and sponsorship targeting the adult population. All advertising had to carry the Ministry of Health's health warning.

Finally, after four years and several public demonstrations, Law 13 (2008) was passed, making Panama the first country in the Americas to totally ban all tobacco advertising, promotion, and sponsorship, even cross-border advertising.

Implementing a total ban on all tobacco advertising, promotion, and sponsorship is essential for combatting the deceptive nature of tobacco marketing, young people's exposure to that marketing, the lack of effective self-regulation by the tobacco industry, and the ineffectiveness of partial bans.

Current legislation in Panama clearly indicates what constitutes a violation of the law and the applicable sanctions. One important point here is the regulation of other tobacco products (apart from those that are smoked), whose consumption is increasing across the country, and the use of water pipes. These products are subject to the same Convention provisions on advertising, promotion, and sponsorship and the packaging and labeling of tobacco products. Article 26 of Law 13 of 2008 lists the following as violations of this law:

1. Smoking in places where it is totally prohibited.
2. In establishments where the sale of tobacco products is authorized, failure to display visible signs prohibiting the sale of tobacco to minors and warning about damage to health caused by tobacco.

3. Failure to display signs prohibiting smoking at the entrance to the establishment.
4. Allowing smoking in places where it is totally prohibited.
5. Handing out or distributing samples, whether free or not, of any tobacco product.
6. Selling or giving minors tobacco products or imitation tobacco products that may lead to smoking, or that are shaped like tobacco products and may be attractive to minors.
7. Marketing tobacco products using the name, trademark, logo, or any other distinctive sign of any other good or service other than those permitted by this Law.
8. Selling, giving away, or supplying tobacco products under circumstances other than those permitted by this Law.
9. Advertising, promoting, and sponsoring tobacco products in any communications medium.

Sanctions are enforced incrementally depending on the health risk, the offender's ability to pay, the social impact or repercussions of the offense, the benefits to the offender, whether the affected party is a minor, or if it is a repeated offense.

In the case of advertising, Article 28 of Law 13 (2008) states that sanctions shall apply to those responsible for the advertising—in other words, to both the advertising firm and the beneficiary of the advertising, the latter understood as the owner of the advertised trademark or product, as well as the owner of the establishment or space in which the advertisement appeared.

Furthermore, offenses or violations of the Law must be reported to the competent authority, in this case the Ministry of Health, and the penalties imposed shall comply with the provisions of the Health Code. The revenues obtained from fines are allocated to the implementation of tobacco prevention and control activities.

Penalties are enforced by level of authority in the Ministry of Health's public health management network. Authorities at the base level can impose fines of up to \$500 and confiscate articles or goods; the regional network can impose penalties ranging from \$501 to \$5,000, confiscate or destroy items or goods, and temporarily shut down facilities, while the Directorate General of Public Health can impose penalties of up to \$100,000 and permanently shut down facilities, when appropriate.

In addition, the marketing of electronic cigarettes and other nicotine delivery devices is prohibited in Panama. These products raise several issues when it comes to implementation of the Framework Convention: they violate Article 16, they do not discourage social acceptance of consumption, they are advertised with messages contradicting efforts to guarantee smoke-free environments (i.e., "smoking everywhere"), and there is no evidence that they help people give up smoking; on the contrary, they deliver nicotine to maintain the addiction.

Moreover, the tobacco industry has already expressed an interest in these products and will undoubtedly use them as an innovative advertising ploy.

On 3 June 2010, Decree 230 (2008) containing the regulations under Law 13 was amended, as it was necessary to enforce a total ban on tobacco advertising, promotion, and sponsorship. This specifically meant that the display of tobacco products would now be prohibited at points of sale. Approval of this Decree was a recognition of the global evidence that the exposure of smokers to tobacco marketing is significantly lower in countries where the display of tobacco products is banned at points of sale and the guidelines for the application of FCTC Article 13 have been complied with. This is a very effective measure for reducing compulsive purchases of cigarettes and other tobacco products, and it naturally provoked a response from the tobacco industry. The industry resisted and refused to comply with the measure, claiming that it needed more time to change the dispensing machines. It appealed to the American and Panamanian Chambers of Commerce and to the United Kingdom's Embassy in Panama. At no point was implementation of the measure suspended, and it was effectively complied with.

Furthermore, the tobacco industry is increasingly convinced that packaging and labeling are the only options available for advertising in countries where complete bans have been imposed. It now targets consumers and potential consumers, particularly young people and women, with "innovative" designs to reduce the effectiveness of the health warnings.

There have been health warnings on packaging since 2005. Pursuant to Law 13 (2008), the warnings cover 50% of both the front and back surfaces, and any misleading term, such as those listed below, has been removed:

1. Citrus thrill enhanced by menthol exhilaration
2. Spicy excitement powered by menthol exhilaration
3. Special Edition by the menthol authority
4. Freezing Point

5. Filter King Box
6. Midnight Blast
7. Rich Tobaccos
8. Filter Kings
9. The phrase “Extra Long Filters” should be removed from menthol cigarettes.
10. In Marlboro cigarettes, the highlighting of the word “Ice Mint” and “Fresh Mint” should be removed, just leaving “ice mint/fresh mint” in small letters underneath “Marlboro,” without any special design. With Marlboro Gold (new packaging), the word “original” should be eliminated, while the word “gold” may be left, as long as it is not emphasized and has no design.
11. L&M: The following phrases should be removed from all L&M cigarette packs (red, light blue, and green): Quality Tobacco, Total Harmony in Taste, Luminous Mark.
12. Next: The design of the brand’s letters must be changed, because they represent flagrant advertising.

The tobacco industry is increasingly resorting to the courts, both national and international, in an attempt to obstruct the continued implementation of effective tobacco control measures.

Panama has been taken to court by the tobacco industry on four occasions. The first case was to appeal virtually all the provisions of Law 13, but the Supreme Court of Justice of Panama found in favor of public health. The second lawsuit was filed in opposition to the banning of packaging with subliminal designs, while the third and fourth cases were filed when the display of tobacco products at points of sale was prohibited. The provisions of this Law have been successfully complied with and constitute good practices, as envisaged by the guidelines for implementation of Article 13 of the Framework Convention.

The challenges before us now include improving surveillance systems to monitor compliance with the tobacco advertising, promotion, and sponsorship ban. Of particular importance is the display of actors smoking in films, on television, or on the Internet as well as other cross-border content. The Global Tobacco Survey found that exposure to tobacco advertising, promotion, and sponsorship has declined in Panama.

## Case: Canada

“I think I help because I put a face to cancer. There are lots of statistics out there, but I am a person, and I think that helps people understand that this is a real problem!”

*Heather Crowe*



Heather Crowe, a waitress for over 40 years and diagnosed with lung cancer although she had never smoked, became the public face for the establishment of smoke-free environments in Canada. Health Canada’s media campaign with her story resonated across the country and created a surge in awareness of the dangers of second-hand smoke.

Through a partnership with Physicians for a Smoke-Free Canada, a nongovernmental organization, Health Canada further helped Heather share her story with Canadians. Her courage and leadership impacted Canadians and helped her lobby decision makers at the municipal, territorial and provincial levels for a ban on smoking in public places. As a result of her efforts, all 10 provinces and three territories in Canada have now passed smoke-free laws that restrict smoking in public places.

In order to assess the level of protection afforded by these laws, Canada’s nongovernmental organizations have developed a “Gold”, “Silver” and “Bronze” standard. The “Gold” standard prohibits smoking in all public places. In Canada, 85% of the population lives in a jurisdiction with Gold Standard protection from second-hand smoke in public places, and 81% is protected in both public spaces and workplaces”. (42)

Nova Scotia is considered to exceed the Gold Standard, with the strongest laws governing restaurants, bars, and the workplace. It has further banned smoking in all outdoor patios and most recently, the town of Wolfville was the first in Canada to ban smoking in cars where children are present.

The provinces of Newfoundland, Labrador, New Brunswick, Quebec, Ontario, Alberta, and British Columbia are protected at the Gold Standard level through their bans in all restaurants, bars, and workplaces, and Ontario recently became the first province to ban smoking in cars with young passengers.

It is estimated that as many as 830 deaths can be attributed to second-hand smoke in Canada each year (43). The combined efforts of the federal, provincial, and territorial governments, together with communities, advocacy groups, and public health stakeholders, continue to ensure that Canadians are protected from the dangers of second-hand smoke.

### Case: Argentina<sup>4</sup>

In mid-2003, the Ministry of Health of the Argentine Republic launched the National Tobacco Control Program, based on the adoption of a comprehensive approach to the problem of smoking in line with suggestions of the WHO Framework Convention on Tobacco Control (FCTC) approved by the World Health Assembly that same year.

#### Building national capacity for tobacco control

At the start of the Program, the Ministry of Health implemented a communication strategy designed to make smoking a priority issue on the national agenda. When the President signed the Framework Convention (FCTC) in September 2003, the Program was organizing events, training journalists, and carrying out campaigns to raise public awareness about the risks associated with tobacco use and the right to breathe clean air, while promoting 100% smoke-free environments. Training for the human resources of nongovernmental organizations was introduced in 2004, and soon thereafter for provincial teams, with a view to setting up tobacco control programs and enacting legislation on smoke-free environments in every province in Argentina. Programs were rapidly created in 22 of the country's 24 provinces, and the awareness raised among lawmakers resulted in a new wave of legislation to establish smoke-free environments.

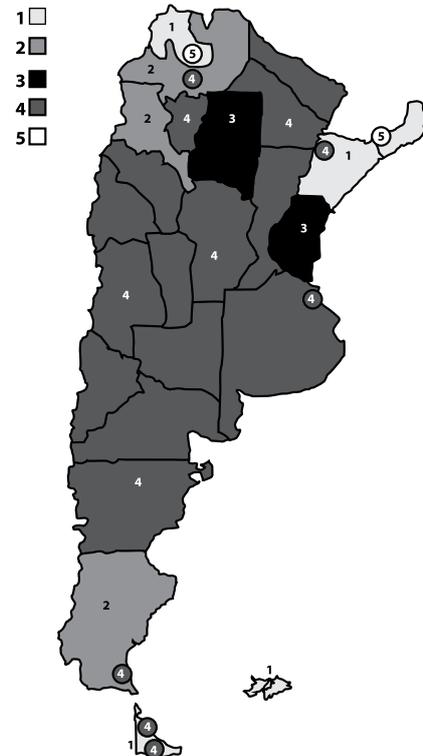
In 2004, the Executive Branch submitted the proposal to ratify the FCTC to Congress, and in 2005 submitted a bill that closely followed the measures contained in the Framework Convention. However, there was a great deal of resistance to both national initiatives from sectors associated with tobacco production and lawmakers in tobacco-producing provinces. Even though this sector is a relatively small part of the domestic economy, Argentina is the world's eighth largest tobacco exporter. In the northern provinces (especially Jujuy, Salta, Misiones, and Corrientes), the new legislation was viewed as a threat to tobacco production and, consequently, to regional economies. Unlike the experience in Brazil, in Argentina it was not possible to debunk this very popular myth, espoused by political sectors in that region, which is still used as grounds for opposing ratification of the FCTC.

Nevertheless, action by lawmakers, national governments, and civil society (in a coalition of over 80 organizations mobilized to support ratification of the Convention) was the driving force behind passage of the National Tobacco Control Law in 2011, whose regulations were issued in early 2013.

#### Smoke-free environments

Legislation on smoke-free environments in Argentina has moved forward at the national, provincial, and municipal levels.

Since 2011, under National Law 26.687, public places and workplaces are 100% smoke-free environments. Similar legislation has been in force since 2005 at the local level: at present 15 provinces are 100% smoke-free (dark gray (4) on the map), 2 exempt gaming venues (black (3) on the map) from the ban, and 7 still permit areas to be set aside for smokers or have not updated their legislation. It should be pointed out that, in these



provinces, several municipalities are 100% smoke-free—for example, the two cities containing most of the population of Argentina's southernmost province, Tierra del Fuego, as well as the provincial capitals of Salta, Corrientes, and Santa Cruz.

The time between the passage of the laws and regulations and full implementation of the smoking ban in public spaces was generally taken advantage of to inform the public and owners of establishments patronized by the public and varied from province to province.

Once the laws were passed, as soon as implementation commenced, public controversy ensued. Most complaints came from the hotel, bar, and restaurant sector, as well as gaming venues, whose representatives were quick to respond. Very soon after the measures were introduced, there were complaints about the difficulties encountered in implementing the measures and significant economic losses.

A 2007 study on bar and restaurant income across the country showed that the impact of the legislation in the four pioneering provinces (Santa Fe, Tucumán, Córdoba, and the City of Buenos Aires) did not adversely affect business (44). In Córdoba, Santa Fe, and the City of Buenos Aires, establishment owners and others petitioned for writs of *amparo* (remedy for the protection of constitutional rights). Another lawsuit alleging the unconstitutionality of the legislation was filed in 2009 against the Province of Santa Fe by one of the multinational tobacco companies.

Nevertheless, the precautionary measures did not gain much ground and surveys showed that public support for smoke-free environments was very high. This key factor has translated into a high degree of compliance with the ban, considering that use of the control mechanisms varied from province to province.

#### Packaging and labeling of tobacco products

Law 26.687 established 10 warnings for packaging and labeling, complete with images covering 50% of one of the main surfaces and text covering 50% of the other side. It also stipulated that information on the free smoking-cessation helpline be displayed on one of the side surfaces and prohibited use of misleading terms such as smooth, light, or low nicotine or tar. The warnings were implemented by Resolution of the Ministry of Health in October 2012 and had a major impact, substantially increasing the number of calls to the helpline.



### Tobacco advertising ban

National legislation prohibits tobacco advertising, promotion, and sponsorship except at points of sale and when directly targeting adults over the age of 18. Recent regulations severely restrict these legal forms of advertising and promotion, regulating the size and location of posters, requiring health warnings, banning the distribution of free samples, etc. Some provinces, such as Santa Fe, Neuquén, and San Luis, have also placed major restrictions on advertising.

### Access to tobacco products

Even though they are heavily taxed (around 70% of the sale price), cigarette prices are still very low in comparison with other countries in the Region, which increases consumption. Recent legislation regulates points of sale and prohibits sale to minors, the sale of individual cigarettes or packs of less than 10 units, and sale in vending machines.

### Smoking cessation treatment

In 2005 and in formal consensus with experts, the National Program drew up a National Guideline for the Treatment of Tobacco Addiction, which was updated in 2011. This provided training for health teams in all provinces and set up a free telephone helpline for smoking cessation, accessible from any location across the country. It also set certification standards for intensive treatment services and certified services in the different provinces. The network of services offering short-term treatment is constantly expanding. Some provincial public services and social security entities cover the cost of such therapies; however, they are not yet covered by Social Security's Compulsory Medical Program.

Furthermore, in 2011 the Ministry of Health prohibited the importation, marketing, and advertising of electronic cigarettes throughout the country.

### Smoking surveillance

Smoking surveillance is part of the surveillance of noncommunicable diseases. It consists mainly of conducting national surveys on risk factors that include a module on smoking in adults (ENFR 2005, 2009, 2013) and in adolescents (Global school-based student health survey [GSHS] 2007, 2012), as well as specific surveys on smoking in adults (MS 2004, GATS 2012) and in adolescents (GYTS 2007, 2012). It is supplemented with the surveillance of economic, legislative, smoke-free environment, and advertising variables, conducted on a regular basis by the National Program.

### Results

During these 10 years of the intervention (2003–2012), despite the absence of national legislation and the low cost of cigarettes, smoking prevalence has declined significantly among both adults and young people. Among adults, the figure fell from 29.7% in 2005 to 27.1% in 2009 and 22.1% in 2012 (ENFR 2005 and 2009 and GATS 2012), while in young people it went from 24.5% in 2007 to 19.6% in 2012 (GYTS). The smoke-free environment regulations were extended to the majority of provinces, high levels of compliance have been reached, and exposure to second-hand smoke has decreased in all provinces.

### Challenges

The recent regulations issued under the National Law are opening up a new chapter in tobacco control. Some of the main challenges facing the national tobacco control policy are getting all the provinces on board, strengthening control mechanisms, and ensuring full compliance with legislation. Other major challenges include increasing taxes on all tobacco products and ratification of the Framework Convention.

## Case: Brazil<sup>5</sup>

Article 5, paragraphs 1 and 2 of the WHO Framework Convention on Tobacco Control (FCTC) addresses national coordinating mechanisms for tobacco control programs.

In Brazil, the design of a national governance mechanism for tobacco control took shape during the 1990s with the consolidation of a network of partnerships that included state and municipal health secretariats and was coordinated by the Ministry of Health through Brazil's National Cancer Institute (INCA). This network coordinated anti-smoking campaigns. It went around to schools, health units, and workplaces organizing educational activities on the risks of smoking and how smoking can be reduced by means of smoke-free environments and banning advertising. It also provided information on ways to promote cessation. This process, which was largely responsible for creating a critical mass at the national level and a favorable social environment for tobacco control in Brazil, gained a great deal of ground in the mid-1990s, and since 2000 has included coordination with nongovernmental organizations. In 1999, the government tobacco control network was buttressed with the creation of the National Health Surveillance Agency (ANVISA), one of whose responsibilities is the regulation of tobacco products.

The intersectoral approach began to acquire clearer parameters when negotiations on the WHO Framework Convention on Tobacco Control (FCTC) got under way. Brazil was the second country to sign the Convention, doing so on 16 June 2003. Shortly thereafter, a National Commission (*Comissão Nacional para Implementação da Convenção-Quadro* or CONICQ) was created by Presidential Decree, tasked with implementing the Framework Convention and its Protocols (45). The advisory capacity of its predecessor, the National Commission for the Control of Tobacco Use (CNCT), thus acquired executive authority, as the role of CONICQ was to ratify the Convention and promote its implementation at the national level.

Thus, the first challenge facing CONICQ was to promote ratification of the Framework Convention by the National Congress. As Brazil is a major tobacco producer, the transnational companies that control tobacco production across the country mounted strategies to keep the State from becoming a Party to the Convention.

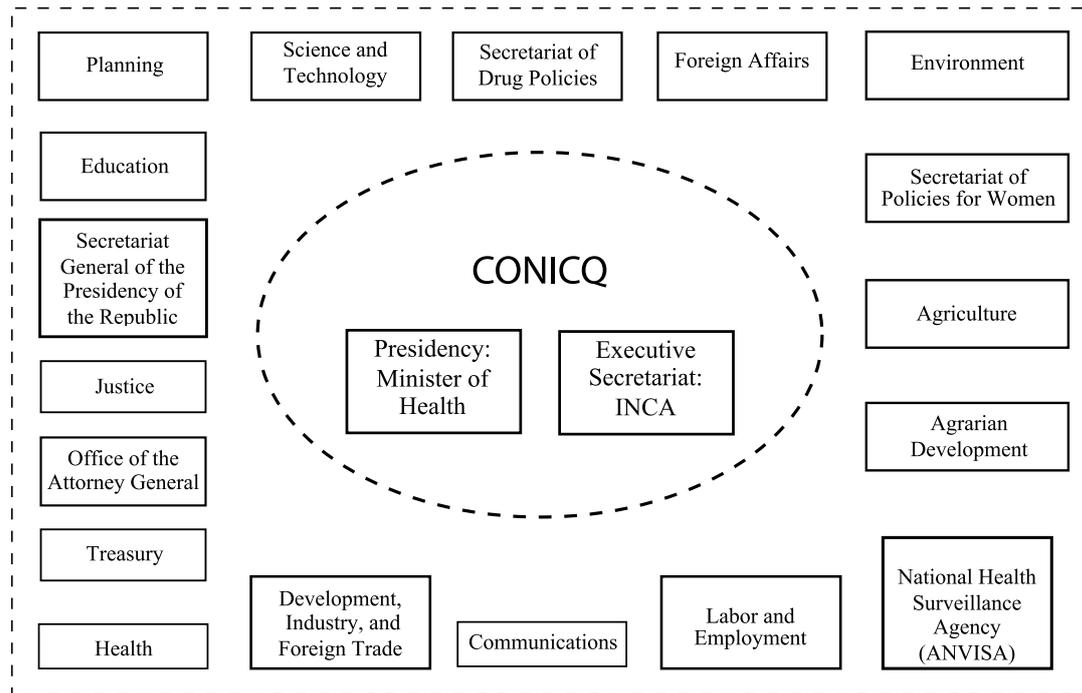
CONICQ members, together with several associations in the national smoking control network, worked tirelessly to deconstruct the myth invented by the tobacco industry: that the FCTC would destroy the tobacco production sector and would therefore threaten the survival of 200,000 tobacco farmers and their families. As a result, the Convention was ratified by Brazil only after two years of intense public debate in the tobacco-growing regions to explain that the FCTC would confer protection and would not threaten the livelihoods of tobacco farmers because it would promote economically viable alternatives (Article 17) (46,47).

In November 2005, Brazil finally ratified the FCTC. From that point on, national implementation of the FCTC was a State policy: the National Tobacco Control Policy (PNCT). The Commission charged with implementing the Framework Convention (CONICQ) assumed responsibility for coordinating an intersectoral national program for its implementation. (48,49)

### CONICQ's role in governance of the National Tobacco Control Policy

The National Commission charged with implementing the Framework Convention (CONICQ) is a government forum responsible for applying FCTC measures in Brazil. It is made up of 18 Ministries and Secretariats of the Federal Government (Figure 26-4). The Minister of Health occupies its Presidency and INCA is responsible for its Executive Secretariat.

Figure 26-1. Federal Government Ministries and Secretariats in CONICQ



The main functions of CONICQ, as announced in the Presidential Decree creating it in 2003, are the following (50):

- I. To advise the Brazilian Government on decisions related to the formulation of national policies for ratification of the Framework Convention and on effective compliance with the obligations stemming therefrom;
- II. To advise the Brazilian Government on the negotiation and adoption of supplementary protocols, annexes, and amendments to the Framework Convention, as well as other related matters;
- III. To coordinate organization and implementation of the intersectoral government program to ensure compliance with the provisions of the Framework Convention;
- IV. To promote the development, implementation, and evaluation of strategies, plans, and programs, as well as policies, legislation, and other measures, in keeping with the obligations of the Framework Convention;
- V. To identify, promote, and facilitate the mobilization of financial resources for its operations and support compliance with the Framework Convention;
- VI. To promote relevant studies and research with regard to the Framework Convention;
- VII. To open a dialogue with national and international institutions and entities whose aims and activities could provide relevant input on matters under its purview;
- VIII. To request, as appropriate, cooperation and information from competent government agencies, national or international nongovernmental organizations or agencies, and experts in matters related to its areas of interest;
- IX. To consider, as appropriate, the adoption of other measures necessary to meet the objectives of the Framework Convention; and
- X. To exercise any other appropriate functions to ensure compliance with this Decree.

## Duties and responsibilities

For the implementation of the Convention, each sector of the government represented in CONICQ has a function that could involve direct or shared responsibility in the implementation of specific measures of the Convention. These are:

- Pricing and tax policy applicable to the tobacco sector (Framework Convention, Article 6). This is the responsibility of the Ministry of Finance.
- Supervision of tobacco control legislation and the regulation of tobacco products (Framework Convention, Articles 8, 9, 10, 11, and 13). ANVISA is the agency responsible for this.
- Surveillance and monitoring (Framework Convention, Article 20). INCA (Epidemiology Division)<sup>6</sup>, the Ministry of Health's Secretariat of Health Surveillance Monitoring<sup>7</sup> and the Ministry of Justice's Secretariat on National Drug Policies<sup>8</sup> all share responsibilities in the implementation of this article.
- The National Program for Diversification of Production in Tobacco-growing Areas. Set up in 2005 under the Ministry of Agrarian Development, the aim of this program is to integrate Articles 17 and 18 of the Framework Convention into the rural development policy.
- Educational activities (FCTC, Article 12). This is an area that spans all sectors. The World No Tobacco Day and National Day to Combat Smoking (*Dia Nacional de Combate ao Fumo*) campaigns are coordinated nationally by INCA, together with state and municipal health secretariats.
- The fight against the illicit trade in tobacco products. The Ministries of Finance (Federal Revenue)<sup>9</sup> and Justice (Federal Police) act jointly in this area.
- Smoking cessation (FCTC, Article 14). This includes the free stop-smoking helpline “*Disque Saúde*<sup>10</sup>/*Pare de Fumar*<sup>11</sup>” operated by the Health Ombudsman's Office of the Ministry of Health, with INCA support (51), and free smoking cessation therapies dispensed through the public health network under the coordination of INCA together with state and municipal Health Secretariats (52).
- Defense of the tobacco control policy against legal challenges (Article 5, paragraph 3). The Office of the Attorney General, also a member of CONICQ, has closely followed legal challenges and defended the policy.
- International cooperation and Brazil's participation in Convention-related working groups. This area consists of joint action by the Ministry of Foreign Affairs and the Ministry of Health (International Advisory Services and Executive Secretariat of CONICQ/INCA) to maintain the dialogue between CONICQ and the Secretariat of the Convention, PAHO/WHO, and other countries.

## How CONICQ operates

CONICQ meets regularly four times a year. Restricted to members, the purpose of these meetings is to discuss, prepare, and evaluate sectoral or joint action and policies that respond to the various obligations established in the Framework Convention. Special meetings may be held whenever this is deemed necessary. The Commission may invite representatives from public administration, civil society, the legislative or judicial branches, or the Public Prosecutor's Office to participate in its activities. These agencies and representatives of civil society or interested economic sectors may also request a hearing with CONICQ to address matters in connection with the National Tobacco Control Policy. Commission members will consider hearing requests and state their opinion about whether to approve, reject, or put them on the agenda of the next general meeting.

CONICQ is also responsible for formulating the positions to be taken by the Brazilian delegation at the FCTC Conferences of the Parties (COP) (53). When preparing for these Conferences of the Parties, seminars open to civil society are held to compile information that would help define Brazil's stance.

The Commission can also set up special working groups to analyze and draft recommendations on specific points of interest for the National Tobacco Control Policy. There are currently two working groups: one coordinated by the Ministry of Agrarian Development and responsible for the implementation of Articles 17 and 18, and another coordinated by the Office of the Attorney General and responsible for analyzing legal matters related to tobacco control.

On 12 May 2011, the Minister of Health, through Ordinance 1.083, officially approved the Commission's Rules of Procedure and, more specifically, established its standards of operation as well as the duties and responsibilities

of its members (54). According to these Rules of Procedure, CONICQ members are obliged to sign a declaration on conflicts of interest.

Commission members are also bound by a Code of Ethics, officially published by the Ministry of Health under Ordinance GM/MS No. 713 on 17 April 2012 (55). The Code is based on FCTC Article 5, paragraph 3, and on the “need to adopt measures to ensure that the National Tobacco Control Policy can be applied in a pressure-free environment and to guarantee the integrity and impartiality of the CONICQ’s work, avoiding any situations in which interests that oppose the objectives of tobacco control can influence efforts to this end.”

With a view to making available all the information and relevant national data needed to monitor how well the Framework Convention is being applied nationally through a single virtual platform, CONICQ has also set up the National Tobacco Control Policy Observatory (56).

Every two years, the CONICQ Secretariat oversees the drafting of a report on the management and progress made in the application of the Framework Convention in Brazil (57).

### CONICQ’s strengths and weaknesses

This Commission offers an opportunity for dialogue, the alignment of visions, and convergence of the efforts of the various government sectors charged with national implementation of the Convention. One of its missions is to promote consistency in implementation of the Convention by the different government sectors.

Communication strategies and the exchange of information across sectors have been fundamental to strengthening the framework for intersectoral cooperation in tobacco control.

Furthermore, in a country that is the second largest producer and biggest exporter of tobacco, conflicts within the government itself are bound to occur, because the Convention represents a public health action whose objectives are diametrically opposed to those of the tobacco economy. From this perspective, one of CONICQ’s missions is to defend the Convention against government sectors that share the belief that the tobacco production chain should be strengthened and support this chain’s interference in the measures established in the Convention.

One such example is the Technical Chamber of the tobacco production chain, which is one of the sectoral chambers of tripartite production chains operating under the Ministry of Agriculture<sup>12</sup>. Although the purpose of these chambers is to provide an opportunity for dialogue between the manufacturing sector and the government, in the case of the tobacco sector chamber, this space has been usurped by tobacco companies as the front line in their fight against implementation of the Framework Convention in Brazil (58-62).

Despite the tensions, the overall balance of CONICQ activity is positive. As a legitimate entity officially created to promote implementation of the FCTC, in general its activities have made it possible to maintain a uniform government position aligned with the obligations assumed by the Brazilian State as a Party to the Framework Convention on Tobacco Control (62,63).

### Case: New York City

The New York City Department of Health and Mental Hygiene’s comprehensive tobacco control program has used a five-point plan comprised of taxation, legislation, cessation, education, and evaluation consistent with the World Health Organization’s 2008 six-pronged tobacco control package, MPOWER.

To protect people from tobacco smoke, the city passed the Smoke-Free Air Act (SFAA) in 2002. The SFAA, which went into force on 30 March 2003, resulted in smoke-free environments in virtually all city workplaces, including more than 20,000 restaurants and bars. The SFAA protects both workers and patrons—including local residents, visitors, and the nearly 1 million commuters who work in New York City but live elsewhere.

Prior to enactment of the SFAA, the New York City Department of Health and Mental Hygiene and other departments launched an educational campaign to garner support and communicate key messages, holding meetings with legislators, business owners, and the general public to present evidence of the effectiveness of smoke-free laws and to respond to public concerns. Building effective coalitions and working with supportive local partners was critical to successful passage of the SFAA. Public discourse over passage of the SFAA in New York City centered on two critical issues: first, that smoke-free workplace laws save lives, and second, that smoke-free workplace laws do not hurt businesses.

Once the SFAA was passed, implementation of the law focused on business owners, not smokers. The city government provided clear guidelines for business owners, explaining the components of the law, including the prohibition of ashtrays and the requirement that prominent signs be displayed. Enforcement of the law was rigo-

rously pursued, focusing at first on education rather than punishment, and then dealing more harshly with repeat violations.

To demonstrate the results of the SFAA, New York City released a one-year review of the economic and health impact of the law (63).

Today fewer New Yorkers are smoking and more are making their homes smoke-free. In 2008, 80% of nonsmokers and 42% of smokers in New York City had made their homes smoke-free, compared to 70% of nonsmokers and 27% of smokers in 2002.

Moreover, the city's SFAA has not hurt local businesses. In fact, since implementation of the SFAA, restaurant and bar employment has increased by 18%, restaurant and bar tax receipts have risen by 66%, and compliance with the law has been at or above 97%.

## ■ Recommendations

Future lines of action in the field of tobacco control are clearly outlined in the WHO FCTC and its implementation guidelines, as well as in the recently approved Protocol to Eliminate Illicit Trade in Tobacco Products. It is now a priority for more countries to protect their citizens from the harmful effects of tobacco use and exposure to second-hand smoke, which can only be achieved by integrating all WHO FCTC measures into the national legislation of every country. The Protocol, in turn, will enable countries to fight illicit trade in tobacco products, which undermines the effectiveness of the other measures by keeping the price of tobacco products low and generating tax losses for States.

According to scientific evidence, as well as the successful experiences outlined in this chapter, the basic principles for curtailing and reversing the tobacco epidemic are:

- Policies for the implementation of WHO FCTC measures (smoke-free environments; ban on tobacco advertising, promotion, and sponsorship; price increases and taxes; etc.) should be established by law, as policies of a more voluntary nature have proven ineffective.
- Legislation should be simple, clear, and binding.
- All people must be equally protected by law.
- Proper planning and allocation of sufficient resources are necessary for implementing, monitoring compliance, and evaluating the legislation.
- Civil society has a key role to play, especially in supporting and ensuring compliance with the measures, and should be an active partner in the drafting, implementation, and enforcement of the law.
- As necessary, tobacco control measures will have to be broadened or strengthened through the passage of new laws, the amendment of existing laws, improved compliance, and other measures that reflect new scientific data and new evidence garnered from case studies.
- It is critical to protect tobacco control measures from the commercial or other interests of tobacco companies and their partners by monitoring industry activities and strictly applying the provisions of WHO FCTC Article 5, paragraph 3.
- It is important that the Protocol enter into force without delay; for this to happen, it must be ratified by at least 40 States Parties to the WHO FCTC.

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## ■ Notes

- 1 ARG, BAR, BRA,\* CAN, CHI, COL, COR, ECU, GUT, HON, JAM, PAN, PER, SUR, TRT, URU, VEN (\*regulation and/or implementation pending).
- 2 ARG, BOL, BRA, CAN, CUB, , CHI, COL, COR, ECU, ELS, HON, JAM, MEX, NIC,\* PAN, PER, SUR,\*  
URU, USA,\* VEN, (\*regulation and/or implementation pending).
- 3 BRA, CHI, COL, PAN, SUR.
- 4 Document prepared by Mario Virgolini, coordinator of the National Tobacco Control Program in Argentina between 2003 and 2013.
- 5 Tânia Cavalcante, Mariana Pinho, Felipe Mendes, Cristina Perez, Érica Rangel, Rosa Vargas, Alexandre Ribeiro, Rita de Cássia Martins: staff of the Executive Secretariat of the National Commission for Implementation of the Framework Convention on Tobacco Control/National Cancer Institute/Ministry of Health, Brazil  
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- 6 Ministry of Health/INCA, Surveillance of Cancer and Its Risk Factors  
<http://www1.inca.gov.br/vigilancia/>
- 7 Ministry of Health/ Secretary of Health Surveillance  
<http://portalsaude.saude.gov.br/portalsaude/noticia/12595/785/pesquisa-inedita-vai-mapear-doencas-efatores-de-risco-a-saude.html>  
[http://portal.saude.gov.br/portal/saude/profissional/area.cfm?id\\_area=1521](http://portal.saude.gov.br/portal/saude/profissional/area.cfm?id_area=1521)
- 8 Ministry of Justice/Secretary of Drug Policies  
<http://portal.mj.gov.br/senad/main.asp?Team=%7B7D6555C3%2D69A4%2D4B66%2D9E63%2DD259EB2BC1B4%7D>
- 9 Ministry of Finance/Internal Revenue. Illegal trade in cigarettes: general guidelines  
<http://www.receita.fazenda.gov.br/DestinacaoMercadorias/ProgramaNacCombCigarroIllegal/Orienta.htm>
- 10 Ministry of Health/Ombudsman. Health helpline:  
<http://www.brasil.gov.br/sobre/saude/atendimento/disque-saude>
- 11 Ministry of Health/Ombudsman of the Brazilian Health System:  
[http://portal.saude.gov.br/portal/saude/visualizar\\_texto.cfm?idtxt=24509](http://portal.saude.gov.br/portal/saude/visualizar_texto.cfm?idtxt=24509)
- 12 Ministry of Agriculture. Sectoral, and Thematic Chambers. Tobacco  
<http://www.agricultura.gov.br/camaras-setoriais-e-tematicas>

# Environmental and technological disasters and emergencies

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## ■ Introduction

Environmental disasters and emergencies can harm the environment and pollute different aspects of it, such as water, air, soil, and biodiversity; alter daily activities and cause disease, disability, and death in humans; disrupt the continuity and compromise the quality of financial, trade, energy, communications, transportation, water, waste management, food, education, and health services; jeopardize payment capacity, increase defaults, and impoverish the affected population; and affect political action, potentially impacting governance, transparency, participation, and social inclusion. They can also cause conflict and threaten security, alter the habits and customs of traditional cultures, and jeopardize peaceful coexistence among citizens and social classes, leading to violence and insecurity. In short, they engender losses to individuals, families, society, and the State and may have negative repercussions for national development.

Since 1998, the WHO Center for Research on the Epidemiology of Disasters (CRED) has maintained a Disaster Database (EM-DAT), whose main objectives are to assist humanitarian action at both national and international levels and to rationalize decision-making in disasters. EM-DAT (1) records on loss of life from disasters and their economic impact show that from 1980 to the present, the economic impact and number of people affected by disasters have continued to grow, while, inversely, from 1960 to the present, the number of people killed in disasters has fallen significantly. Disasters such as the tsunami that ravaged Indonesia in December 2004 and the 2010 earthquake in Haiti broke this trend and caused 165,708 and over 200,000 deaths, respectively,—three times the number of expected deaths from all natural disasters worldwide in those years.

In April 2009, a variant of the influenza A(H1N1) virus containing a unique combination of human, swine, and avian viruses appeared in Mexico. Capable of causing disease in humans and easily transmitted from person to person, this virus caused the first pandemic of the 21st century.

In early 2010, two major earthquakes had different effects in two countries in the Americas. On 12 January 2010, Haiti suffered the most devastating disaster in its history when it was struck by a shallow earthquake with an epicenter about 20 km from the capital. Measuring 7.0 on the Richter scale, a magnitude not seen in Haiti in the previous 200 years, it killed some 217,000 people and injured another 300,000. The economic impact exceeded 100% of the country's gross domestic product. Port-au-Prince was almost completely destroyed, with the collapse of most public buildings, including the Ministry of Health, severely affecting the Haitian Government's ability to act. The already poor water and sanitation conditions were exacerbated and, one month after the disaster, only 5% of the affected population had access to latrines. The population in towns increased as a result of internal displacement, and then a cholera epidemic, caused by *Vibrio cholerae* O1 serotype Ogawa, broke out, spreading to the Dominican Republic and then to Cuba.

On 27 February 2010, Chile was rocked by an earthquake registering 8.8 on the Richter scale. Although three times deeper than the Haiti quake and some 330 km from the capital, this earthquake resulted in 512 deaths, 16 missing, and 800,000 homeless. Between 2010 and 2014, 14 earthquakes of different magnitudes struck the country, but the number of deaths did not exceed a few dozen.

In March 2011, a magnitude 9 earthquake occurred 130 km off the coast of Japan—the most powerful ever recorded in this country, and the fourth most powerful in the world—resulting in 15,883 deaths, 2,681 missing, and more than 6,000 injured. The earthquake triggered a devastating tsunami that damaged a nuclear power plant, creating a secondary technological emergency.

That same year, severe floods hit six countries in South America and Central America, causing loss of life and affecting large numbers of people.

In October 2012, Hurricane Sandy struck Jamaica, Haiti, Cuba, the Bahamas, and the eastern seaboard of the United States, which was the most affected country, where it turned into a super storm, converging with the first snowstorms of the season and resulting in enormous numbers of victims.

Due to the major economic impact of disasters, methodologies for calculating it have become more sophisticated, putting the cost of these events in recent decades at several hundreds of billion dollars: the cost of the Kobe earthquake reached \$150 billion; Hurricane Katrina and other tropical storms, \$182 billion; the earthquake in Chile, US\$31 billion; the earthquake in Japan, US\$214 billion; and Hurricane Sandy, US\$50 billion.

According to EM-DAT data (CRED CRUNCH, December 2011, produced by EM-DAT and funded by USAID), 46% of worldwide losses from disasters in 2011 were in Latin American countries. Current challenges largely involve coordination and the management of funding and determining the costs of humanitarian aid, something still difficult to contextualize.

According to a study on the economic impact of disasters (2), the total economic damages reported in the period 1990-2005, by continent and type of disaster, came to \$1.192 trillion. During this time, Asia was the continent most affected, with losses amounting to \$577 billion, followed by the Americas, with losses calculated at \$430 billion.

With regard to technological environmental emergencies, the growing and rapid development of science, technology, and industry, together with globalization, have increased the movement and handling of chemical products and waste, resulting in accidents. These are a cause of concern because of the dangers inherent in these materials (flammability, toxicity, and corrosiveness) and because such accidents are preventable with proper management. Data from the European Chemicals Agency (ECHA) indicate that more than 100,000 chemicals circulate in Europe, only 1,500 of which have been classified as very concerning. Latin America and the Caribbean have extensive coastlines and borders, which thousands of substances cross every day; these substances are misused for various reasons, such as lack of information, low educational level, and customary use deeply rooted in cultures. All these substances have short- and long-term health effects, some of which are irreversible and can cause death and damage to public and private property. They also have serious environmental impacts – e.g., soil, air, and groundwater pollution, which can compromise the quality of water resources and food. This issue is the object of ongoing study, and the related health risks and economic damage are being examined in depth.

This chapter explores *environmental and technological disasters and emergencies*, as well as their relationship to sustainable development and environmental health, through a common thread focused on a risk management approach.

At the same time, it seeks to raise awareness about the need to move toward the integration of environmental emergencies (3) and disasters, issues with different bodies of knowledge, where progress needs to be made in the standardization of definitions and the integration of processes in the various phases of disasters and chemical emergencies.

## ■ Definitions and their relation to health and sustainable development

### Definitions

The history of emergency management has revealed the need for standardized definitions. In this regard, in 2004, the International Strategy for Disaster Reduction (ISDR) of the United Nations Office for Disaster Risk Reduction (UNISDR) drafted consensus-based definitions on disasters, whose main elements are presented in Box 27-1 (4).



## BOX 27-1. UNISDR DEFINITIONS

**Acceptable risk:** The level of loss a society or community considers acceptable given existing social, economic, political, cultural, technical, and environmental conditions.

**Disaster:** A serious disruption of the functioning of a community or a society causing widespread human, material, economic, or environmental losses that exceed the ability of the affected community or society to cope using its own resources.

**Disaster risk management:** The systematic process of using administrative decisions, organization, operational skills, and capacities to implement policies, strategies, and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This comprises all forms of activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards.

**Early warning:** The provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response.

**Emergency management:** The organization and management of resources and responsibilities for dealing with all aspects of emergencies, in particularly preparedness, response, and rehabilitation. Emergency management involves plans, structures, and arrangements established to engage the normal endeavors of government, voluntary, and private agencies in a comprehensive and coordinated way to respond to the whole spectrum of emergency needs. This is also known as *disaster management*.

**Hazard:** A potentially damaging physical event, phenomenon, or human activity that may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation. Hazards can include latent conditions that may represent future threats and can have different origins: natural (geological, hydrometeorological, and biological) or induced by human processes (environmental degradation and technological hazards).

**Land-use planning:** Branch of physical and socio-economic planning that determines the means and assesses the values or limitations of various options in which land is

to be utilized, with the corresponding effects on different segments of the population or interests of a community taken into account in resulting decisions.

**Mitigation:** Structural and non-structural measures undertaken to limit the adverse impact of natural hazards, environmental degradation, and technological hazards.

**Preparedness:** Activities and measures taken in advance to ensure effective response to the impact of hazards, including the issuance of timely and effective early warnings and the temporary evacuation of people and property from threatened locations.

**Prevention:** Activities to provide outright avoidance of the adverse impact of hazards and means to minimize related environmental, technological, and biological disasters. Depending on social and technical feasibility and cost/benefit considerations, investing in preventive measures is justified in areas frequently affected by disasters. In the context of public awareness and education, related to disaster risk reduction, changing attitudes and behavior contribute to promoting a “culture of prevention.”

**Resilience/resilient:** The capacity of a system, community, or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures.

**Risk:** The probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted, or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions.

**Vulnerability:** The conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards.

**Source:** International Strategy for Disaster Reduction (ISDR). Terminology: Basic terms of disaster risk reduction. [http://www.unisdr.org/files/7817\\_7819isdterminology11.pdf](http://www.unisdr.org/files/7817_7819isdterminology11.pdf)

However, these definitions do not include the concept of “technological emergencies,” which come from different technical areas and are presented below.



### BOX 27-2. DEFINITIONS RELATED TO TECHNOLOGICAL EMERGENCIES

**Technological accident:** A usually sudden occurrence involving hazardous materials and equipment that adversely affects the normal activity of a system or process related to the capacity of the affected community to respond and control adverse consequences to people, materials, the environment, or the economy. This produces negative

consequences for people, materials, the environment, or the economy. Technological accidents occur primarily in the form of spillage, leakage, escape, fire, and explosion.

**Technological emergency:** Situation produced by accident or by deliberate action that involves hazardous materials and equipment and requires mobilization.

*Source:* CNE, Costa Rica, Procedimiento y protocolo interinstitucional para la atención de emergencias tecnológicas en tierra, at <http://helid.digicollection.org/es/d/Jcne03/>.

**Definition of environmental emergency:** An environmental emergency is a sudden threat to the public health or the well-being of the environment, arising from the release or potential release of oil, radioactive materials, or hazardous chemicals into the air, land, or water. These emergencies may occur from transportation accidents, events at chemical or other facilities using or manufacturing chemicals, or as a result of natural or man-made disaster events. While there are many other environmental problems with which the United States Environmental Protection Agency (EPA) is concerned, its activities are focused generally on immediate threats (6).

This integration of concepts, preparedness, and actions is needed, because those responsible for responding to environmental emergencies have been in situations marked by a vacuum in accountability or guidance. The extensive experience of organizations working in disaster preparedness and response can help coordinate and strengthen a more integrated emergency response. This integration is also important from a conceptual standpoint, since technological hazards are one of the different types of hazards, as seen in Table 27-1 (7).

To be clear about these concepts, it is necessary to consider the stable equilibrium on Earth for thousands of years that enabled life and development to exist and to be aware that there are times when this equilibrium is disrupted by the interaction between what is known as a hazard and vulnerability, resulting in situations that may turn into emergencies or disasters.

**Table 27-1.** Types of hazards related to disasters

<b>HAZARD</b> A potentially damaging physical event, phenomenon, or human activity, which may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation.	
<b>NATURAL HAZARDS</b> Natural processes or phenomena occurring in the biosphere that may constitute a damaging event and cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation.	
<b>Origin</b>	<b>Phenomena (examples)</b>
<i>Hydrometeorologic hazards</i> Natural processes or phenomena of atmospheric, hydrological, or oceanographic nature, which may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation.	<ul style="list-style-type: none"> <li>• Floods, debris, and mudflows.</li> <li>• Tropical cyclones, storm surges, wind, rain, and other severe storms, blizzards, lightning.</li> <li>• Drought, desertification, wildland fires, temperature extremes, sand or dust storms.</li> <li>• Permafrost, snow avalanches.</li> </ul>
<i>Geological hazards</i> Natural earth processes or phenomena, which may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation.	<ul style="list-style-type: none"> <li>• Earthquakes, tsunamis.</li> <li>• Volcanic activity and emissions.</li> <li>• Mass movements, landslides, rockslides, liquefaction, submarine slides.</li> <li>• Surface collapse, geological fault activity.</li> </ul>
<i>Biological hazards</i> Processes of organic origin or those conveyed by biological vectors, including exposure to pathogenic microorganisms, toxins, and bioactive substances, which may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation.	<ul style="list-style-type: none"> <li>• Outbreaks of epidemic diseases, plant or animal contagion, and extensive infestations.</li> </ul>
<b>TECHNOLOGICAL HAZARDS</b> Danger associated with technological or industrial accidents, infrastructure failures, or certain human activities that may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation, sometimes referred to as anthropogenic hazards. Examples include industrial pollution, nuclear release and radioactivity, toxic waste, dam failure, and transport, industrial, or technological accidents (explosions, fires, spills).	
<b>ENVIRONMENTAL DEGRADATION</b> Process induced by human behavior and activities (sometimes combined with natural hazards) that damage the natural resource base or adversely alter natural processes or ecosystems. Potential effects are varied and may contribute to an increase in vulnerability and the frequency and intensity of natural hazards. Examples include soil degradation, deforestation, desertification, wildland fires, loss of biodiversity, land, water, and air pollution, climate change, sea level rise, and ozone depletion.	

**Source:** Living with Risk: A Global Review Of Disaster Reduction Initiatives. Vol. I, Chapter 2, Understanding the nature of risk. Available at: [http://www.unisdr.org/files/657\\_lwr1.pdf](http://www.unisdr.org/files/657_lwr1.pdf)

Definitions by themselves do not suffice, because technological emergencies and disasters do not just happen; rather, they are related to underlying vulnerabilities, such as poverty, limited access to power structures and resources, economic systems, ideological clashes, and some systems-related aspects that interact with dynamic pressures. These latter include the lack of an institutional structure and local capacity, consumption trends, deficient or nonexistent education, skills, local investment, labor and product markets, and macroenvironmental forces, such as population growth, urban growth, migration, and environmental degradation.

These vulnerabilities are compounded by conditions of insecurity, such as a fragile physical environment, a weak economy, people living in risky or hazardous locations, the existence of unsafe buildings or infrastructure,

threatened livelihoods, a preponderance of low incomes, weak financial organization, and crises that create the need to save by downsizing staff or changing processes.

These conditions of vulnerability are cumulative and require a triggering event—i.e., the presence of a natural or man-made hazard of sufficient magnitude to cause a disaster, such as an earthquake, prolonged rains, or lack of rain, leading to floods, droughts, or landslides; forest fires; accidents during production, storage, transportation, or marketing; war or civil strife; and financial crises.

### Technological emergencies, disasters, and their link to health and development

The link between hazards, risks, and disasters and health and development is the product of multiple factors. Hazards are part of nature, and we live with them in our daily lives. The dynamics of hazards and their interaction with different subsystems are observable, measurable variables, enabling us to gain insight into what is happening in the environment, the return to normalcy, or the exacerbation of the hazards.

Before a disaster strikes, vulnerability, hazards, risk, and the likelihood that it will actually happen can be identified and estimated using different methods. This information is very useful for saving lives and should be used to take action. However, experiences during disasters in countries with different levels of development and organization have demonstrated that this information was not available in a timely manner or was not sufficiently disseminated, that the countries lacked the capacity and resources necessary to mount a response, or that, having all this, a decision was not made in time, in some cases because it was not a priority, resulting in social and political costs.

Once an adverse event has occurred, the magnitude of its impact is measured using “damage assessment and needs analysis” criteria. These have evolved and become quite specialized in recent years, consisting primarily of epidemiological criteria, such as mortality and the number of people injured and affected.

Characterization of the type of human impact varies with the different types of natural hazards and is something that should be considered in both the preparedness and response phases. Table 27-2 shows the short-term effects of different types of disasters.

Turning to concrete examples, with regard to flooding, this last decade saw floods in La Paz, Bolivia, in 2002, where heavy rainfall over a brief period caused the deaths of 72 people, with relatively few people affected and injured, and floods in Brazil and Colombia in 2011, which together caused more than 1,000 deaths and affected 2 million people.

The Region has also been stricken by droughts: in Costa Rica and Brazil in 1999; in Argentina, Chile, and Paraguay in 2008; in Guatemala in 2001 and 2009; and, more recently, in Bolivia, Paraguay, and Chile. It is worth examining the drought that hit Guatemala in 2009, when climate change with water stress and drought, Tropical Storm Agatha, and the eruption of the Pacaya volcano all converged, destroying crops and covering those that remained with ash, with serious repercussions in 21 of the country’s 22 departments. Following this episode, the real estate bubble in the United States burst, reducing the remittances sent home to families by Guatemalan migrants, a situation that exacerbated the situation and resulted in a sharp deterioration in nutritional status, leaving 24.8% of women with acute malnutrition and high rates of severe child malnutrition. All these events led the government, with support from PAHO/WHO, to take steps to provide subsidies, strengthen disease prevention and control measures, and improve sanitation, while at the same time take steps to reduce crime and generate income (8).

El Niño and La Niña are sporadic weather phenomena. The El Niño episodes in the Americas in 1982-1983 and 1997-1998 were the most intense recorded to date and had a devastating impact on Pacific Basin countries that was felt around the world (9). Studies by the World Meteorological Organization (WMO) calculated that there were more than 24,000 fatalities worldwide from El Niño in 1997-1998, due to high winds, flooding, and high waves caused by severe storms. Furthermore, more than 110 million people were affected and 6 million displaced due to the loss of community infrastructure such as dwellings, food storage facilities, transportation, and communications. Direct losses exceeded \$34 billion. Latin America experienced the greatest economic losses, totaling \$18 billion. Basic sanitation and health were seriously affected, with higher-than-expected numbers of malaria, dengue, and yellow fever cases, while excess or scarce rainfall increased the number of cases of diarrheal diseases and caused outbreaks in some of the affected regions (10).

**Table 27-2.** Short-term effects of major disasters

<i>Effect</i>	<i>Earthquakes</i>	<i>High winds (without flooding)</i>	<i>Tidal waves/ flash floods</i>	<i>Slow-onset floods</i>	<i>Landslides</i>	<i>Volcanoes / lahars</i>
Deaths	Many	Few	Many	Few	Many	Many
Severe injuries requiring extensive treatment	Many	Moderate	Few	Few	Few	Few
Increased risk of communicable diseases	Potential risk following all major disasters (probability rising with overcrowding and deteriorating sanitation)					
Damage to health facilities	Severe (structure and equipment)	Severe	Severe but localized	Severe (equipment only)	Severe but localized	Severe (structure and equipment)
Damage to water systems	Severe	Light	Severe	Light	Severe but localized	Severe
Food shortage	Rare (may occur due to economic and logistic factors)	Common	Common	Rare	Rare	
Major population movements	Rare (may occur in heavily damaged urban areas)	Common (generally limited)				

**Source:** Natural Disasters: Protecting the Public's Health (PAHO, 2000, 126 pp.), at <http://new.paho.org/hq/dmdocuments/2010/9275115753.pdf> (11).

The lack of rains due to El Niño and La Niña in 2012 affected crops and livestock in Paraguay (which impacted its GDP). Also affected were northern Argentina, southern Brazil, central Chile, and southeast Bolivia, where production fell sharply, impacting the health and nutrition of the population.

In its 2012 report, *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (12), the Intergovernmental Panel on Climate Change (IPCC) indicates that extreme events caused by disasters are a reality and that events associated with disasters and existing natural and technological hazards will become more frequent and have effects of greater magnitude. This report complements the *fourth assessment report on climate change* (AR4) published by the IPCC in 2007, which presents data on the effects of climate change on human health in different regions of the world resulting from rising global temperatures (the lowest scenario [B1] projects a probable range of 1.1°C to 2.9°C; and the highest [A1FI], a probable range of 2.4°C to 6.4°C). A 4°C increase could raise sea levels and shrink glaciers, leading to desertification or flooding in different ecoregions, changes in crop production from water stress, drought, and extreme temperatures, and changes in the behavior of disease vectors (10). Consequently, the impact on the environment and human health could be substantial and affect survival.

The main approach to addressing climate change has been the mitigation of emissions through environmental education, clean technologies, and financial incentives. However, despite these measures, emissions continue to rise, and there is a growing need for adaptation measures to adjust systems so as to mitigate harm or take advantage of the opportunities created by climate change. Adaptation measures integrate the knowledge and experience gained in disaster preparedness and response to tackle the new challenges from extreme events caused by climate change, climate variability, and global warming. Although this issue has become important in terms of political will, despite the efforts and progress in setting priorities, concrete action has still not been taken due to financial consi-

derations—that is, the cost to more developed countries from the obligation to acquire carbon-market certificates based on the volume of their emissions and, in some cases, from clean development through concrete measures to improve processes by sector. Moreover, the financial crisis has had an impact on this issue, so that although more concrete actions are necessary, the question is how to fund them and whether they are a priority, even when they are of interest. Developed countries link climate change to development and the creation of new jobs. Energy conversion using clean energy (solar, wind, and electric) offers business and employment opportunities as well as an alternative to lack of work through workforce retraining.

Technological advances in the chemical field lead to the development of thousands of products every year that are widely used by modern society. The chemical products trade in Latin America is worth over \$100 billion per year and is growing, given its significant expansion in Argentina, Brazil, and Chile. Average growth of 4.2% between 2005 and 2015 is anticipated. While technological and industrial emergencies and disasters are less frequent than natural disasters, they should not be underestimated, given the growing industrialization of this region.

In the case of man-made hazards, it often happens that activities, construction works, or projects created for a particular, usually beneficial, purpose (except those created expressly to cause damage and destruction), are affected by some unforeseen or uncontrolled situation that leads to an incident, either major or minor, resulting in damage and losses.

The health effects of technological emergencies depend on the type of substance involved and are related to its intrinsic properties, in addition to the time and type of exposure involved, which means that they require specialized management. Effects can range from nonspecific, self-limiting symptoms that emerge over a few minutes without any consequences, to those of single or repeated exposures that can produce moderate to severe short- or long-term effects and cause different types of cancer or malformations, to single, very short exposures that cause death immediately.

The situation is actually worse when we realize objectively that the countries have minimal capacity to deal with such incidents. One of the worst technological emergencies recorded in the Region was a liquefied gas spill followed by several explosions at an oil refinery in Mexico City in 1984, resulting in 600 dead and nearly 7,000 injured. Others include mixed disasters in which natural and technological hazards interact, such as the one in Cubatão, São Paulo (Brazil), where landslides on the slopes of the Sierra del Mar damaged an ammonia pipeline, releasing ammonia and requiring the evacuation of 6,000 people to prevent mass poisoning.

Some Latin American countries have gone the nuclear power route since 1960 (13); there are nuclear power plants in Argentina (previously, two; now, four), Brazil (previously, two; now three), and Mexico (previously, two; now, four). New plants were scheduled to come online in Mexico and Brazil between 2010 and 2015. Venezuela has also stated its intention to build new nuclear power plants. Several of the plants mentioned have reached the end of the useful life for which they were designed, maintenance and operating costs are high, they produce waste that can cause adverse health effects, and there is a history of nuclear accidents that have caused disasters, so it is important to not neglect this aspect. The world's worst nuclear technological disaster occurred in Chernobyl (then in the Ukrainian SSR) in 1986, when an explosion in the reactor of its nuclear plant sparked a fire and a series of additional explosions, leading to the deaths of 56 people from radiation exposure and contaminating the environment of Chernobyl and surrounding towns and countries. Radioactive rain fell on the former Soviet Union, Eastern Europe, Scandinavia, and the United Kingdom, impacting their economies because of restrictions imposed for public health reasons on the marketing of products from that region and affected areas. The permanent effects of this accident can still be seen today. It is estimated that more than 4,000 people have died from radiation exposure, primarily from solid organ cancers (such as breast and prostate cancer) and leukemia.

The accident in Goiania, Brazil (September 1987), was the most significant radiological incident in the Americas and one of the worst in history. However, it had similarities to other accidents, such as those in Mexico City (1962), Algeria (1978), Morocco (1983), and Ciudad Juárez, Mexico (1983). In fact, the last of these bore a striking resemblance to the Goiania accident. However, easily accessible information sources contain very few reports on such accidents, which means that they are often overlooked and valuable information is lost on how to prevent them and appropriately respond when they do occur.

Environmental emergencies and disasters have obvious adverse effects on health and development. Therefore, risk reduction is critical to ensuring a greater healthy life expectancy and should be integrated, on an ongoing, systematic, and regulated basis into policies, planning, decision-making, and the promotion of actions before, during, and, after a destructive incident occurs. Risk reduction should not be a matter of isolated actions or situational responses but should be mainstreamed into all the activities of a state, sector, or organization as part of a comprehensive development and strategic planning process.

This process should include actions to identify, reduce, or eliminate cumulative risks and to holistically prevent the creation of new risks in future activities.

## ■ Technological environmental emergencies and disasters and their relevance to health and sustainable development in the Americas

### Disasters

People only understand risks once they have lived through a disaster or, although more difficult, if they have learned from the experiences of others. There is international consensus that disasters have been increasing over the past 10 years, whether from environmental degradation or human activity. Agencies such as ISDR/United Nations, the Intergovernmental Panel on Climate Change, and the Red Cross anticipate that, far from decreasing, disasters will increase in the years to come (14).

Some reports show that the impact of disasters has tripled in the past 50 years. In the last decade (2000-2012), the Americas were hit by 922 natural disasters, which killed more than 247,000 people, affected over 82 million others, and caused at least \$487 billion in economic losses. The Americas were the second most-affected continent, after Asia, in terms of the number of disasters and people killed. However, the region had the largest share of economic losses during the decade (46% of worldwide losses) (15).

This period has also seen epidemics and pandemics that have led countries to declare states of alert or disaster from these hazards. In 2009, the Region of the Americas was the first WHO region affected by the influenza A(H1N1) virus, making it imperative to quickly gather data and share it globally so that decisions could be made about prevention and treatment strategies. For 16 months, the virus spread across the globe, causing at least 600,000 cases and more than 18,000 deaths worldwide. In the Americas alone, the pandemic resulted in at least 190,000 cases and 8,500 deaths and sparked a demand for health services that was overwhelming. The virus circulated with greatest intensity in the Hemisphere's temperate zones, at times stretching health systems to their capacity (16).

The 2010 earthquake in Haiti was followed by an outbreak of cholera, which spread as a result of population displacement, lack of services, and unusually heavy rains. From week 42 of 2010 to week 2 of 2013, the Haitian Ministry of Public Health reported a total of 6,389,610 cases, 353,288 hospitalizations, and 7,962 deaths, with a hospital case-fatality rate of 1.4% that was falling. In the second week of 2013, 1,379 cases were reported, 905 of which were hospitalized. The number of deaths dropped from 100-150 per day in 2010 to 2 per day in 2013; however, higher case numbers were reported in 2012 than in that same period (17,18).

The earthquake that struck Chile that same year initially affected O'Higgins, Maule, and Biobío. It was followed by a strong tsunami, which laid waste to the Chilean coast and destroyed or devastated several towns (Constitución, Iloca, Duao, Pelluhue, Talcahuano, Dichato, and San Juan Bautista). Nationally, 114 water systems were damaged, 49 of them severely. Lack of communication, compounded by the destruction of roads and bridges, hampered decision-making in the early days. There was looting and initial coordination and leadership problems due to the lack of communication, coupled with access problems due to the mass destruction of highways and bridges. However, these were overcome thanks to the institutional capacity and solidarity networks that were formed to aid those affected (19).

The region was hit by severe floods in 2011: in Brazil, the toll was 850 deaths and 1.2 million affected; in Colombia, 207 deaths and 1.3 million affected; in Bolivia, 56 deaths and 75,000 affected; in Guatemala, 43 deaths and 528,753 affected; and in El Salvador, 35 deaths and 300,000 affected (15).

As it passed through Jamaica, Hurricane Sandy killed one person and left 237 people injured; 51 health facilities and a hospital sustained minor damages, while Annotto Bay Hospital, with 100 beds, was more severely damaged. After the earthquake, and then Tropical Storm Isaac, hit Haiti, the number of cholera cases increased and continued to rise after Hurricane Sandy, due to the severe impact on sanitation conditions. In Cuba, the hurricane affected 61,000 families in Santiago de Cuba and 615 health facilities in six provinces (34 hospitals, 122 pharmacies, and 128 primary health care centers); reservoirs were damaged and precautions taken to control communicable diseases (cholera, diarrheal diseases, mosquito-borne diseases). In the United States, the most affected country, the hurricane turned into a super storm, affecting millions of people and causing 165 deaths. New York City experienced intense flooding, which led to forced evacuations and major road closures, in addition to leaving 530,000 people without electricity. In some of the affected areas, the hurricane converged with the first snowstorms in several towns,

many of them already without power. Most hospitals remained open, but 180 patients were evacuated during the storm due to lack of power and flooding (20).

According to the International Disaster Database (21), in the Region of the Americas, there were 922 disasters in the period 2000-2009, 124 more than the 798 reported in the decade 1990-1999. Based on the number of deaths per 100,000 population, the five countries most affected by disasters were Haiti (229.9), Grenada (3.9), El Salvador (2.7), Guatemala (1.6), and Belize (1.5). However, the number of affected people as a percentage of the population was greater in Cuba, making it the most affected country, since 8.8% of its population was affected, followed by Grenada, Guyana, Haiti, and El Salvador.

The magnitude of the impact of events such as the floods and landslides in Venezuela in 1999, mainly in the state of Vargas (30,034 deaths), and tropical storms and Hurricane Mitch in 1998, which left a toll of 20,000 deaths and set the economic development of Honduras back by 20 years, pale in comparison with the magnitude of the 2010 earthquake in Haiti, where more than 200,000 deaths were reported. According to the International Disaster Database, the principal impact in the Region in 2012 was economic losses, which came to \$5.8 billion, with 5 million people affected (the third most affected region, after Asia and Africa, in terms of the number of people affected) (21).

In the period 2000-2008, 54% of disaster-related deaths were due to floods in Colombia, Brazil, and Bolivia, and 11% to changes related to the drop in temperatures in Peru, Argentina, and Bolivia. In the Caribbean, 47% of the deaths were related to floods and 52% to tropical storms; 99% of the deaths from floods and tropical storms reported in this period (6,552) occurred in Haiti. In 2010, the earthquake in Haiti was the most devastating event in the Caribbean and the one that caused the greatest mortality. In 2011, 64% of deaths were caused by floods, followed by tropical storms (21).

According to the International Disaster Database, during the period 2000-2008, natural disasters are estimated to have caused \$205 billion in damages, well above the global estimates for disasters in the late 20th century. In 2011, regional financial damages came to \$11.4 billion, the highest since 1977 (22).

In the Region of the Americas, the greatest damages to relative GDP have occurred in the poorest countries and, although the wealthiest countries reported more losses, their response capacity and resilience in the face of these disasters is greater, which means that poverty is continuing to grow in the poorest countries, impeding their development.

**Table 27-3.** Number of disaster deaths in the periods 1990-1999, 2000-2009, and 2010-2012 in Latin America, the Caribbean, the United States of America, and Canada.

Subregion	Period		
	1990-1999	2000-2009	2010-2012
South America	48,543	6,018	4,179
Caribbean	2,126	7,761	229,931
Central America and Mexico	24,259	5,301	1,147
United States of America and Canada	3,699	4,358	1,057
<b>Total</b>	<b>78,627</b>	<b>23,438</b>	<b>236,314</b>

**Source:** Authors, based on information from EM-DAT 2012. Patients with acute and chronic diseases—in particular, cancer and HIV/AIDS—who could not receive treatment for more than six weeks.

## ■ Technological emergencies

Down through history, major accidents have occurred in the Americas, as shown in Table 27-4.

The accidents described earlier clearly show the gravity of the situation in Latin America. The following information provides a basis for analyzing the situation with respect to chemical emergencies (23):

- Approximately 40% of the global trade in chemicals in developing countries takes place in Latin America.
- Seventy percent of the Latin American chemical industry is concentrated in Argentina, Brazil, Chile, and Mexico.
- In most countries, industrial plants are located in densely populated areas or very close to disadvantaged communities.
- In some countries, business, government authorities, and the community commonly lack a clear perception of the risks to human health and the environment.
- There are no reliable data on the damages caused by chemical accidents, making it hard to correlate these events with the appearance of diseases and effects on the environment.

**Table 27-4.** The most important major chemical accidents in the Americas

<i>City, country</i>	<i>Year</i>	<i>Event</i>	<i>Impact</i>
Bogota, Colombia	1967	Contamination by parathion, a pesticide	88 fatalities and 600 people poisoned
Buenos Aires, Argentina	1967	Fire caused by liquefied petroleum gas	Destruction of nearly 400 houses, with 100 victims
Rio de Janeiro, Brazil	1972	Explosions of liquefied petroleum gas storage tanks	38 fatalities, 53 additional victims, approximately \$5 million in damages
Cartagena, Colombia	1976	Explosion in fertilizer factory, causing an ammonia spill	21 fatalities and 30 other people poisoned
Cubatão, Brazil	1984	Rupture of gasoline pipelines followed by fire in residential area	93 fatalities and nearly 500 displaced persons
Mexico City, Mexico	1984	Liquefied petroleum gas leak in refinery, followed by several explosions and a massive fire	600 fatalities and nearly 7,000 injured
Iquique, Chile	1986	Explosion at chemical depot	28 fatalities
Guadalajara, Mexico	1992	Gasoline spill from underground pipelines, followed by explosion and fire	Nearly 300 fatalities and more than 600 injured
Tejerías, Venezuela	1993	Flammable gas leak and subsequent explosion	75 fatalities and nearly 100 injured
La Guaira, Venezuela	1999	Mud flows in port area	30,000 fatalities and damage to 600 containers with various chemical products
Guayaquil, Ecuador	2000	Road accident causing spillage of 7,000 kg of sodium cyanide	Evacuation of surrounding community and closure of several roads
Pipiral, Colombia	2002	Tanker truck crash, causing an oil spill	Severe environmental pollution of a body of water
Cataguases, Brazil	2003	Failure of dam with waste from paper industry	Contamination of over 200 km of a body of water and lack of water for over 200,000 people for 20 days
Lima, Peru	2005	Several accidents involving rupture of liquefied natural gas pipelines	Evacuation of surrounding communities and impassable roads
United States	2010	Oil spill in the Gulf of Mexico	Environmental pollution of coastal and beach areas, in addition to impact on local industry and tourism

**Source:** Prevenção e resposta a acidentes químicos: situação na América Latina e no Caribe, *Acidentes Industriais Ampliados*, Editora FIOCRUZ, Rio de Janeiro, 2000, pp. 267-275 (24).

- There are few programs geared to community preparedness, either in prevention or response to chemical emergencies.
- Agencies in charge of dealing with chemical emergencies are inadequately prepared and lack material resources to manage these situations.

This situation has alerted authorities to the need for effective action to prevent chemical accidents and prepare government agencies to respond appropriately to potential emergencies in order to safeguard public health and safety, the environment, and public and private property.

## ■ Combined natural disasters and technological emergencies

According to official data (25,26), the earthquake that struck Japan in March 2011 (with a magnitude of 9 on the Richter scale and an epicenter 130 kilometers off the coast of Japan) resulted in losses of \$198 to \$309 billion. The greatest devastation was caused by the tsunami that followed the earthquake. Waves reaching 40 meters in height overwhelmed protective measures (10-meter-high dikes, tall buildings, evacuation routes, shelters) in Iwate and Miyagi prefectures, making it impossible to prevent the loss of many lives. The force of the waves caused the collapse of the largest breakwater wall in Kamaishi (63 meters high from the sea floor and 1,960 meters long).

Japan's Port and Airport Research Institute calculated, however, that the wall did reduce wave energy by as much as 40% and that without it, the flood-waters would have been twice as high as they actually were and caused much greater damage. The combined death toll and number of missing exceeded 25,000 as of June 2011. The earthquake and tsunami caused fires and disrupted transport and communication systems. The coastal area of Fukushima Prefecture had not been considered as vulnerable to tsunamis as were Iwate and northern Miyagi, but it was the area that was hardest hit, with flooding over approximately 400 square kilometers. Many of the affected cities were home to elderly populations that were unable to escape in time, as the first tsunami waves arrived within 30 minutes of the earthquake.

Most visible to international media audiences was the battle to gain control of the seriously damaged nuclear power plants in Fukushima. Even though the reactors automatically shut down seconds after the initial earthquakes, the tsunami damaged the cooling systems in the six core reactors that contained a mix of uranium and plutonium as well as radioactive waste. Residents within a 30-km radius of the plants were evacuated as radiation in the atmosphere rose to dangerous levels.

## ■ Analysis of policies, interventions, programs, and their outcomes

### Disasters

The Region of the Americas had progressed very little in disaster preparedness until the earthquake that struck Mexico on 19 September 1985. According to Mexico's Civil Defense Office, at magnitude 8.1 on the Richter scale (considered one of the strongest earthquakes recorded in Latin America in the last century), this seismic event left 6,000 fatalities (27), 20,000 injured (28), and wholesale destruction of infrastructure and services. The earthquake had serious consequences for Mexico's development and an estimated economic impact of \$4.5 billion, with administrative, social, and political repercussions. It also yielded many lessons, which became one of the key elements in strengthening health services in Mexico and Latin America.

On 13 November of that same year, Colombia was stricken with a crisis after the Ruiz volcano erupted and caused part of the glacier to melt. The ensuing mudslides destroyed the city of Armero, leaving a toll of 23,000 victims. Images of these catastrophic events on television gave people a vivid and heartbreaking look at the human suffering caused by disasters, aroused the public, and awakened authorities to the real dangers that natural hazards pose to the population, sparking growing interest in this issue in several countries in the Region.

Disasters such as these and others around the world made evident the need to make this a priority issue, raise awareness about it, and take concrete action. In response, the United Nations, through Resolution 44-236 of 1989, designated the 1990s the International Decade for Natural Disaster Reduction (IDNDR), aimed primarily at prevention and the strengthening of national disaster response systems, especially in the components of regulation, institutional framework, structure, and early warning at the local and national levels.

In 1999, the decade concluded, seeming to have gone by faster than expected due to the results achieved (important according to some and less important according to others due to the increase in the number of disasters and people affected). The United Nations saw the need for greater sustainability of the decade initiative, and so it became today's International Strategy for Disaster Reduction (ISDR) (29). ISDR has become the main promoter of disaster-resilient communities and facilities, furthering their development by raising awareness, promoting coordination, and ensuring synergies around disaster risk reduction in the context of sustainable development and the implementation of the Hyogo Framework for Action (30).

The ISDR is implemented through international, regional, and national entities called "platforms." Some of the countries' achievements within the framework of the Decade include the strengthening of national civil defense agencies; the creation of national committees by the health sector in many countries with intersectoral participation; greater coordination, development, and dissemination of programs of action on prevention and preparedness; the development of projects to increase the effectiveness of early warning systems; increased awareness and projects on mitigation and its benefits among civil society; and better coordination of regional cooperation.

As part of institution building, national authorities created political and technical entities at the highest level. They developed regulatory frameworks for the creation of national emergency response or disaster reduction systems, seeking better disaster management before, during, and after the event by mainstreaming a risk-based approach and professionalizing management. Furthermore, they better defined the role of the armed forces (which up to that point, with some exceptions, had been the main actors in response activities), promoting greater participation by different sectors through national committees with a coordinating and decision-making role, for which purpose they received technical and financial support from multilateral organizations, development banks, and other countries.

At the same time, there was an effort to create and strengthen supranational entities by subregion, which has contributed to technical and political capacity building in the countries, leveraging the strengths of the regional integration bodies to which they belong. These bodies include the Central American Coordination Center for Natural Disaster Prevention (CEPREDENAC), under the Central American Integration System (SICA) (31); the Caribbean Disaster Emergency Response Agency (CDERA) (32), under the Caribbean Community (CARICOM); and the Andean Committee for Disaster Prevention and Relief (CAPRADE) (33), under the Andean Community (CAN). Both Central America and the Andean area have regional strategy documents containing guidelines for their countries, a sign of substantial progress made in making these issues a subregional priority and developing response mechanisms. The Southern Common Market (MERCOSUR) (34) has prioritized the preparation of guidelines for joint action and the updating of existing disaster prevention and mitigation mechanisms, emphasizing the creation of rapid response teams to meet the needs of the most vulnerable populations. Integrated under the ISDR framework, these entities have become subregional platforms that collectively contribute to the hemispheric platform headed by the Inter-American Committee on Natural Disaster Reduction (IACNDR), based at the headquarters of the Organization of American States (OAS) (35), which connects the Inter-American system, the United Nations (UN) (36) system, and subregional intergovernmental organizations for the purpose of jointly developing and implementing coordinated policies and programs.

Even before the term "risk management" was in use, the health sector played a key role in promoting preparedness, prevention, mitigation, and response within countries through technical cooperation from the Pan American Health Organization (PAHO) (37), which became an important partner in the development of the national systems promoted by the United Nations Development Program (UNDP).

In education, including disaster prevention in the undergraduate curriculum of the schools of health sciences was encouraged, and, seeking to influence future generations, work on prevention was done with school children through the Health-promoting Schools Initiative—action that was subsequently taken over by the education sector and ISDR (38). Preparedness plans were drafted in communities located in vulnerable areas, promoting local civic engagement through the preparation of risk maps and local plans coordinated with the health, water, and sanitation services. Preparedness was institutionalized to ensure sustainability of the operations of basic services such as water systems. This initiative was supported by the PAHO Emergency Preparedness and Disaster Relief Program (PED/PAHO), the Regional Technical Team on Water and Sanitation (ETRAS) (formerly the Pan American Center for Sanitary Engineering and Environmental Sciences—CEPIS), and the United Nations Children's Fund (UNICEF). Initiatives for the health sector have also been undertaken with these entities. One such example is the "Hospitals Safe from Disasters" initiative, aimed at reducing the loss of hospitals from disasters using the hospital safety index (which collects information on hospitals, their context, and their vulnerability, making it possible to determine their level of risk and, if necessary, take steps to reduce it, and improve structural safety to enable them to remain

open in the wake of a disaster). Moreover, development of hospital disaster response plans was promoted and, more recently, the expansion of preparedness and a risk approach designed to protect critical health sector infrastructure, such as laboratories and blood banks, in disasters. Furthermore, these initiatives were critical for developing instruments that standardize damage assessment, needs analysis, situation reports, and the systematization of joint interinstitutional appeals. This process is the result of painful lessons learned, such as those from the earthquake in Mexico, which revealed the importance of protecting hospitals and the urgent need for their continued operation. According to information from PAHO/WHO, approximately 50% of the 15,000 hospitals in Latin America and the Caribbean are located in high-risk areas. In the past 20 years, more than 100 hospitals and at least 1,000 health centers in the Region were damaged in disasters. Current regulations in the Region governing the design and construction of health facilities are being amended, reorienting them toward *mitigation* of hospital vulnerability, with the ultimate goal of protecting the lives of patients, staff, and other occupants and ensuring that facilities can continue to operate during and after a disaster (39).

These coordinated efforts among countries and institutions led to the creation of a critical mass of professionals from different levels and institutions that began working in a more coordinated and strategic manner to construct an international and regional platform with multilateral and bilateral cooperation agencies. These agencies, influenced moreover by the United Nations, established a joint action framework in which functions were defined according to experience.

This entire process of capacity building to deal with disasters occurred over a period of some 10 years, from 1995 to 2005. During that time, new hazards emerged that required attention, among them bioterrorism and the SARS and influenza pandemic, which in turn led to additional preparedness efforts, further strengthening the capacities and coordination that constitute the basis of response. Despite the difficulties that countries encountered in coping with the influenza A(H1N1) pandemic, their efforts since 2006 to develop preparedness plans for an influenza pandemic proved very useful. Furthermore, PAHO provided direct support for country response through multidisciplinary field teams made up of medical epidemiologists, laboratory technicians, infection control specialists, and physicians. It also provided material support in the form of laboratory equipment, reagents, and personal protective equipment. The 2009 pandemic yielded many useful lessons, such as the importance of preparedness, increased laboratory capacity, and better surveillance of severe influenza cases. More importantly, the pandemic showed that countries must integrate emergency preparedness and response into their current activities to ensure that they have the means to effectively manage the next public health emergency.

Other epidemics—cholera, for example—have reemerged in the Region. Haiti experienced an explosion of cases and a high case-fatality rate, especially in hard-to-reach areas, such as remote rural communities and urban slums. The Dominican Republic, in turn, reported clusters of cases around the most populated areas, but the case-fatality rate was low and did not exceed the capacity of local health services to manage the outbreak. The action taken in Haiti, with ample support from the international community, included strengthening surveillance, improving case management by training health workers, and community education. These measures succeeded in reducing case-fatality rates within four months of the outbreak's appearance.

This cholera outbreak led the countries of the Region to bring their preparedness and response plans up to date and strengthen surveillance systems for the early detection of outbreaks. The most sustainable investment to protect people from cholera and other diarrheal diseases is still the improvement of water supply and sanitation systems. The risk of a reintroduction of cholera in the Region (40) is directly related to deficiencies in country water supply and sanitation systems.

The earthquake and tsunami that struck Chile brought out the best and the worst in Chileans. Lack of communication, limited access, lack of coordination, and delays in aid resulted in looting and strife. The highly centralized institutional structure and experience with emergency and disaster relief, as well as the deployment of the armed forces, were instrumental to the appropriate response. Communities that had some capabilities got to work and responded on their own. International aid, whose role was clearly defined by the national authorities, helped provide an orderly response.

Hurricane Sandy impacted the countries in its path to varying degrees. It worsened sanitation conditions in Haiti, recently stricken by the earthquake and Tropical Storm Isaac, the latter of which also hit Cuba and the Bahamas, further eroding existing conditions. This highlighted the need to strengthen disease prevention and control measures, primarily water treatment and disinfection. Health facilities were particularly hard hit, especially in countries with fewer resources.

With regard to disaster response, regular preparations, simulations, and drills are conducted and have markedly strengthened the capacity of health care providers.

Every year, floods render thousands of children victims of recurrent disasters in the Region, especially in Brazil, Colombia, Bolivia, and Guatemala. Due to these problems, ISDR designed the Regional Strategic Framework for Disaster Risk Reduction Education, whose thrust is to promote a culture of prevention in the educational community, both to raise awareness among the public about the dangers to which it is exposed and about what can be done in schools, the community, and the environment, and to guide efforts to inform the public and reduce, eliminate, or manage emergencies or disasters by mainstreaming “learning to prevent” across the curriculum. Children are aware of the dangers around them, and they get anxious when they do not know how to protect themselves. They feel safer and respond better to incidents if they receive training. This initiative also provides minimum standards for the construction of safe schools to protect future citizens. This initiative receives its primary support from the Disaster Preparedness Program of the European Commission’s Humanitarian Aid and Civil Protection department (DIPECHO) (41) and has implemented projects in Bolivia, Peru, Ecuador, and Costa Rica. This type of experience should make us think about the significance of the community’s role in the initial response and the importance of children and the elderly, not only as vulnerable groups but as social actors. In the context of sustainable development, it is important to consider that people should not only be the focus of discussion, but should also be involved in activities at all levels, regardless of sex and at all ages throughout life.

One of the most significant long-term advances for both preparedness and response geared to sustainable development is the value that knowledge management has acquired in the Region with the creation of the Regional Disaster Information Center—Latin America and the Caribbean (CRID) (42). This specialized online library is an exceptional resource for research, policy-making, and human resources education and is (and should be) used by decision makers, relief workers, and the public at every level. Access to information and the ability to adopt information-driven measures are essential for sustainable development and risk reduction. Experience has demonstrated its usefulness in saving lives and making people free and independent.

For several years, various types of lessons learned have been documented in the Region. It is important to see the contrasts in the management of different situations at different times and places to underscore the fact that only preparedness and prevention are unquestionably important elements in reducing the magnitude and consequences of adverse events. Every year, even relatively safe countries that have all the necessary resources, technology, and management systems are stricken by major disasters, but they move forward and restore and rebuild, adhering to the established standards. Furthermore, with communications technologies, everyone can receive real-time alerts about weather conditions or other risks. Some countries, such as Cuba, lack many resources, yet are able to respond rapidly to hurricanes. According to data from the United States National Hurricane Center (NHC-NOAA), one of the most violent hurricanes in the last 57 years was Hurricane Michelle, which swept across Cuba in November 2001, destroying 10,000 homes yet causing only five deaths (43). This experience calls for reflection about what can be achieved with proper planning, an effective civil defense system, and a trained population; having these elements permitted the evacuation of 700,000 people to emergency shelters and the implementation of plans for search and rescue, emergency health care, and prevention measures, such as cutting electricity to prevent electrocution, protecting aquifers and treatment plants to prevent water pollution, implementing measures to protect wastewater (an innovative aspect), and rapid street cleaning. These measures were important and prevented a considerable loss of lives, underscoring the comprehensiveness and intersectoral nature of the response (44).

In contrast, the tragedies in the department of Vargas (Venezuela) in December 1999 and the 2010 earthquake in Haiti were of such magnitude that they exceeded all response capacity. To strengthen capacities in the Region, PAHO and partner organizations, including UNICEF, ISDR, USAID, and the Red Cross, have created a number of self-learning resources on health, environment, and disasters:

The online Health Library for Disasters, accessible in English, Spanish, and French, contains more than 650 full-text documents, including technical guidelines, manuals, field guides, disaster chronicles, case studies, emergency kits, newsletters, and other training materials. It has the support of the United Nations (UNHCR, UNICEF, and ISDR), the Red Cross movement through IFRC and the ICRC, the Sphere Project, and other organizations. For more information, visit: <http://helid.digicollection.org/en/>.

The Electronic Library on Water, Sanitation, and Hygiene in Emergencies and Disasters is a collection of technical and management tools compiled from different institutions to guide efforts to improve the health conditions of populations affected by adverse events. Available only in Spanish at: <http://www.bvsde.paho.org/dvddes/main.html>.

Hospitals Safe from Disasters. This initiative offers guidelines, lessons learned, resources, good practices, technical recommendations, and methodology. The Hospital Safety Index provides a snapshot of the probability that

a hospital will continue to operate in a disaster. Available in English and Spanish at: <http://safehospitals.info/index.php?lang=en>.

The Disaster mitigation in drinking water and sewerage systems website contains training and outreach materials on system vulnerability analysis and basic mitigation measures to deal with the most common natural hazards in Latin America and the Caribbean. Available in English at: <http://www.disaster-info.net/watermitigation/i/publications.html>.

The Hospital Disaster Planning Course includes methods and materials for preparing hospital emergency response plans. Available only in Spanish at: [http://portal.proteccioncivil.gob.mx/prog\\_hosp\\_seg/phd\\_2005/files/index.htm](http://portal.proteccioncivil.gob.mx/prog_hosp_seg/phd_2005/files/index.htm).

*Leadership During a Pandemic: What Your Municipality Can Do* is a guide prepared for the local level that addresses issues related to coordination, communication, preparedness, and response (USAID-PAHO-Links Media). Available in English at: [http://www.paho.org/disasters/index.php?option=com\\_content&view=article&id=1053:leadership-during-a-pandemic-what-your-municipality-can-do&Itemid=937&lang=en](http://www.paho.org/disasters/index.php?option=com_content&view=article&id=1053:leadership-during-a-pandemic-what-your-municipality-can-do&Itemid=937&lang=en).

## ■ Technological disasters

Given the increasing frequency of chemical accidents and human chemical contamination, in 1980, WHO, together with the International Labour Organization (ILO) and the United Nations Environment Program (UNEP), created the International Program on Chemical Safety (IPCS). WHO is the executive agency of IPCS, and its main function is to establish the scientific basis for the safe use of chemicals and build national capacity to promote chemical safety.

WHO/IPCS assesses chemicals, preparing a description of the risks of exposure to these substances, based on scientific consensus. These descriptions are published in assessment reports and other related documents and are used by governments and national and international organizations as the rationale for adopting measures to prevent adverse health and environmental impacts. For example, these documents are often used in developing guidelines and parameters for chemical use and drinking water and can assist in the drafting of international agreements, such as the Global Harmonized System of Classification and Labeling of Chemicals (GHS). Chemical safety sheets are available at <http://www.inchem.org/>.

Following several catastrophic incidents related to the chemical industry, including the disasters in Seveso (Italy) in 1976, Mexico City in 1984, and Bhopal (India) in 1984, a number of international institutions geared their efforts to creating support programs to enable countries to prepare not only to prevent but to respond to accidents exacerbated by chemicals. These programs are listed in the Annex.

In 1988, several technological disaster experts from UNEP created the Awareness and Preparedness for Emergencies at Local Level program (APELL, <http://www.unep.org/apell/>), whose main purpose is to prepare communities, government, and industry to act appropriately in chemical accidents and thus reduce the number of casualties and damage to property and the environment. The program requires the participation of local governments, industries, and communities.

In April 2010, an explosion on a British Petroleum drilling rig and its subsequent sinking off the coast in the Gulf of Mexico set off one of the greatest oil spills in history. In the ensuing weeks, the spill continued to spread unchecked, polluting the waters and coastline and harming the region's fishing and tourism industries, with a severe economic impact. The spill was halted in late July 2010. An estimated 53,000 barrels of oil per day had been leaking, for a total of approximately 5 million barrels, making this incident the largest oil spill accident in world history (45,46).

In Brazil, the Brazilian Chemical Industry Association (ABIQUIM) translated the APELL manual when the program was implemented in Cubatão (São Paulo) in the early 1990s. Other Brazilian cities where the program is in place are Duque de Caxias (Rio de Janeiro), Maceió (Alagoas), Betim (Minas Gerais), and São Sebastião (São Paulo). The APELL program was also successful in Argentina (Bahía Blanca, 1995) and in Peruvian mining companies (2004), reducing the number and severity of industrial and transportation accidents, respectively. In addition to Argentina, Brazil, and Peru, the APELL program has been implemented in Canada, Colombia, Costa Rica, Chile, Ecuador, Mexico, the United States, and Venezuela.

The imposition of increasingly stringent measures for environmental licensing of potentially polluting activities led to the emergence of risk assessment studies and risk management programs, which have become essential instruments for preventing major accidents in industrial and other activities where chemical substances are invol-

ved. These tools provide the assistance necessary for the detailed identification of potential failings that could cause serious accidents, as well as the potential consequences of these events, making it possible to institute risk reduction measures and prepare accident contingency plans.

Nevertheless, very few Latin American countries use risk assessment for the prevention of chemical accidents. For example, Brazil uses environmental licensing, which makes it possible to quantify the risk of a facility and subsequently compare it with the risk tolerance criteria set by states or the federal environmental agency. Thus, a new industrial plant will be authorized only if the risk from its activities is within acceptable parameters. This approach seems appropriate, since there has been no recent history of major industrial accidents that have caused fatalities in the community living in the vicinity of such plants. The concepts used in industrial risk assessment and the phases of a study of this type can be found at: <http://www.cetesb.sp.gov.br/gerenciamento-de-riscos/emergencias-quimicas/10-conceito-de-risco>.

The Government of the State of São Paulo, through the São Paulo State Environmental Company (CETESB), launched a major initiative in the 1990s when it implemented the Risk Prevention and Management Program in 16 chemical and petrochemical terminals along the state coastline. The program required risk assessment studies that included measures to fight chemical spills at sea; the result was far fewer accidents in participating facilities and improvement in the quality of the companies' emergency response.

The World Health Organization (WHO) has an Emergency Preparedness and Disaster Relief Program (PED), whose main objective is to support the creation and institutional strengthening of national disaster programs in ministries of health and their coordination with all sectors involved in disaster reduction. The program provides training in this area and also helps countries in the Region of the Americas respond to emergencies.

In 1992, CETESB was designated a WHO Collaborating Center for chemical emergency prevention, preparedness, and response in Latin America and the Caribbean. As such, CETESB, together with PAHO/Brazil, has conducted two major activities in the Region:

- **Course on prevention, preparedness, and response to disasters caused by hazardous chemicals.**  
This 40-hour course covers topics in medicine, toxicology, environment, chemical safety, and desk and field simulations, in addition to specific topics requested by local authorities in the host country. Its target audience is professionals from civil defense, ministries of health and of environment, fire departments, traffic police, poison information centers, universities, the army, and other sectors involved in response to chemical accidents. From 1999 to 2003, the course was offered at CETESB headquarters in São Paulo, Brazil. However, to encourage greater participation by other Latin American countries, it was also given in countries that expressed an interest to PAHO. More than 800 professionals have taken the course, which has become a regional model for chemical emergency preparedness and response.
- **Survey of the chemical emergency prevention, preparedness, and response system.**  
This effort helps countries identify their own chemical emergency response capacity. CETESB, as a Collaborating Center, and PAHO/Brazil use technical questionnaires and visits to the main country institutions involved in chemical emergency prevention, preparedness, and response to collect information on their duties, responsibilities, and competencies, as well as their infrastructure, customary operating systems, training programs, human resources, and available materials. A technical report is then prepared that presents the findings and any suggestions for improving the country's institutions and existing system.

In its role as a Collaborating Center, CETESB, in conjunction with PAHO, gave the Self-instruction Course in Prevention, Preparedness, and Response to Emergencies and Chemical Disasters, available online in Spanish, Portuguese, and English (<http://www.bvsde.paho.org/cursode/i/bienvenida.php>). The course provides elements of theory and practice, as well as the methodology to use in national and regional settings and activities involved in chemical emergency preparedness and response in Latin American and Caribbean countries.

In many Latin American countries, entities such as fire departments, civil defense, and the police received training and material resources through partnerships with the United States, given the need for preparedness to respond to potential acts involving the use of chemical weapons. This led to the adoption of procedures that then became part of chemical emergency response measures.

Government and nongovernment institutions that offer training on chemical emergencies include CETESB in Brazil (<http://www.cetesb.sp.gov.br/institucional/cursos-e-treinamentos/79-apresentacao>), and three institutions in the United States: the Environmental Protection Agency (EPA) (<http://www.epaosc.org/>) and <http://www.epaosc.org/>

*main/training.aspx*); the Transportation Technology Center, Inc. (TTCI) in Pueblo, Colorado (<http://sertc.org/courses/>); and Texas A&M University (<https://teex.org/Pages/fire-and-emergency-services.aspx>).

In order to integrate and regulate the transport of hazardous substances by road, the MERCOSUR member countries (Argentina, Brazil, Paraguay, and Uruguay) enacted specific laws on this issue in 1996, resulting in the opening of markets to providers of services for emergency response and the rehabilitation of polluted sites. However, public agencies in these countries still lack coordinated plans to respond to chemical emergencies.

In 1998, the government of Brazil enacted Federal Law 9605/98 on environmental crime, containing provisions on criminal and administrative sanctions for behavior and activities harmful to the environment. The constitutional basis for this law is the fact that natural and legal persons can be subject to criminal and administrative sanctions for behavior or activities harmful to the environment, regardless of their obligation to make restitution. Consequently, environmental liability for private-sector activities increased, causing the sector to improve preventive and remedial aspects connected with chemical accidents.

Furthermore, in Brazil, following a major accident linked with a pulp and paper company (Cataguases), the Ministry of the Environment, in conjunction with several other ministries and environmental agencies from all the Brazilian states, put together the National Plan for Prevention, Preparedness, and Rapid Response to Environmental Emergencies Caused by Hazardous Chemicals, popularly known as P2R2. The plan was established by presidential decree in June 2004 and is structured around several groups, giving specific powers to federal institutions involved in this area (Ministries of Environment, Health, and National Integration, which Civil Defense is under), as well as to states, which are authorized to form organized groups to work on chemical emergency prevention, preparedness, and response, for which they must prepare plans and protocols. The plan is conceptually good but should emphasize the creation of state commissions to ensure that objectives are met.

These efforts were expanded to other countries in the Region to learn more about the chemicals situation. From 1998 to 2008, National Chemical Profiles were prepared and updated with support from the WHO/UNITAR International Program on Chemical Safety. Argentina, Brazil, Bolivia, Chile, Costa Rica, El Salvador, Mexico, Peru, and Uruguay completed these profiles.

In 2006, the Andean countries (Bolivia, Colombia, Ecuador, Peru, and Venezuela) held a subregional seminar on the prevention of and response to emergencies caused by hazardous chemicals and radioactive materials. A plan to address these emergencies was prepared, which was published in February 2008. This plan included a series of measures to be adopted in the context of each country and subregion for reducing the risks and impact of accidents; this would be accomplished by promoting technical cooperation and institution-building policies, strategies, and plans to prevent and mitigate chemical emergencies, prepare to address them, and respond to them (47).

Despite all these initiatives, it is worth mentioning that few countries have well-established structures and regulations for chemical disaster prevention and response, or even response plans, and that this issue is under discussion in many of them.

Some of the countries with plans in place are Peru (National Disaster Prevention and Relief Plan) (48), Paraguay (National Chemical Management Plan) (49), and Panama (Contingency Plan for Terrorist Actions and Chemical Incidents) (50).

Some of the countries that have organized systems are Nicaragua (National System for Disaster Prevention, Mitigation, and Relief—SINAPRED) (51), Colombia (National System for Disaster Prevention and Relief—SNPAD) (52), Honduras (Permanent Contingency Commission – COPECO) (53), and Ecuador (National Committee for Hazardous Chemical Management) (54).

Specifically, to adopt chemical emergency response measures, it is essential to know and respect the responsibilities and functions of the institutions charged with taking action in emergencies. The main responsibilities of public authorities and health agencies are summarized here (55):

- Raise awareness among all sectors of society about the need for disaster prevention, preparedness, and response measures.
- Develop a clear and coherent monitoring framework.
- Defend the community's right to know to ensure that the potentially affected public has access to appropriate information on the risks to which it is exposed.
- Create emergency preparedness programs, including drills.
- Ensure the availability of emergency and disaster alert systems to notify the potentially affected public.
- Facilitate and promote the dissemination of information and sharing of experiences in disaster prevention, preparedness, and response.

To fulfill these responsibilities, national and local public authorities, including the health authorities, must have a duly trained technical team and adequate resources. However, some responsibilities are specific to the public health authorities, namely:

- Develop health-sector disaster response plans, including disasters caused by chemical terrorism, and define roles in the plans.
- Standardize the basic elements of the response plan, including the following:
  - Determination of the roles of all parties involved in emergency and disaster response.
  - Guarantee of the availability and provision of antidotes.
  - Assessment of information needs: basic libraries.
  - Use of poison information centers and chemical emergency response centers.
  - Identification of toxicology and environmental surveillance and quality laboratories.
  - Creation of a system for reporting emergencies.
  - Provision of alternative sites for the treatment of victims.
  - Establishment of systems for intake and management of large numbers of patients (triage).
  - Design of a system for alerting health professionals.
  - Creation and implementation of training programs for health professionals that include simulations.
  - Communication with the public.
  - Promotion of research.
  - Creation of international cooperation mechanisms.

## ■ Needs assessment and proposals

### Disasters

National risk reduction and disaster response systems are now a reality in Latin America and the Caribbean, and the challenge has shifted to the importance of ensuring that they operate more professionally and effectively while respecting an ethical framework. In this process, creating a regulatory framework and allocating financial resources in national, sectoral, regional, and local preparedness, vulnerability mitigation, and response budgets are and should be considered some of the major advances in the Region, followed in importance by the shift from simply national preparedness to local preparedness that involves the authorities, men, women, the elderly, youth, and children who have received training on how to deal with the hazards that surround them.

Risk maps are raising awareness in the Region about natural and anthropogenic hazards at the national, regional, and in some cases, local level, improving the ability of national agencies to target their preparedness plans and vulnerability mitigation activities. These plans have made it possible to better target efforts and resources toward areas at greater risk that have a history of disasters. However, given climate variability, growing urbanization, and differences in poverty, plans must be regularly updated and analyzed, since hazards change dynamically and pose threats at an ever-growing scale. In this regard, the Metropolitan Bureau of Territorial Planning in Quito, with support from the *Institut de Recherche pour le Développement* (IRD), is engaged in an interesting effort with local stakeholders to draft technical urban development policies, strategies, and guidelines, based on satellite risk maps. Risks such as climate change pose the need for satellite surveillance on a larger scale at the local level to deal with diseases such as dengue and malaria, which are among the main vector-borne diseases related to climate phenomena. Tele-epidemiology, that is, the application of satellite capabilities designed by France's National Center for Spatial Studies (CNES) (56) to the study of disease transmission, makes it possible to identify environmental risk factors associated with the presence of transmitting vectors or viruses, bacteria, or parasitic causes of disease. Satellite information is already being used today and constitutes an important medium that holds great promise for the future. The National Oceanic and Atmospheric Administration (NOAA), which conducted a study of the different hazards and disasters in the Region, has also made a valuable contribution.

The extent of the problem of emergencies and disasters has spurred countries to develop policies on disasters, organization, and the need for coordination to respond as a State and not only as relief workers; thus, the role of the health sector here is key. However, civil defense still plays an essential and weighty role in some countries, which

creates coordination problems that reduce the efficiency of preparedness efforts and in some cases pose an obstacle to the response.

The different types of disasters have shown that there is competition for financial resources among cooperation agencies, country institutions, and the expanding nongovernmental sector. This competition creates resistance to coordinated intersectoral efforts, which means that not many countries have integrated policies, programs, or projects and that their approach is still sectoral. With regard to interagency coordination, the United Nations has advanced with its humanitarian reform platform (57), which is an essential mechanism for coordinating and implementing emergency and disaster response measures. It is therefore necessary to increase knowledge about the reform and promote its implementation by country agencies.

In some disasters, donor support has become the core of the response due to lack of national leadership. This is not good for the country, because it does not promote the principle of subsidiarity—i.e., self-reliance in a given situation—and is something that cooperation agencies should constantly bear in mind. This aspect is somewhat difficult to gauge, because, on the one hand, the goal is to increase self-reliance and promote the principle of sovereignty. On the other, however, in major disasters, the need for immediate action to save lives and alleviate suffering is paramount. This results in situations such as those seen after the tsunami in South Asia and Hurricane Mitch in Latin America. In these cases, unfortunate situations arose with the arrival of many humanitarian aid agencies working in an uncoordinated fashion in an environment in which national capabilities had been completely overwhelmed, mobilizing inflated and unnecessary quantities of resources that arrived too late, along with inexperienced response teams. These agencies' excessive pursuit of visibility was another unfortunate aspect (58).

*Undefined risks and unprioritized risks.* A hazard can be present at all times; however, as long as it has not been perceived as such, necessary prevention measures, not to mention response activities, will not be implemented. This is what happened with the blizzards in Spain in 2009, which led to a collapse of response capacity in cities such as Madrid. Despite all its available resources and personnel, the city had not anticipated that such a snowfall could affect it and therefore lacked a contingency plan—a problem that was later corrected. Worse than not identifying risks is knowing that they exist and not doing anything, whether from lack of confidence in the studies conducted, lack of historical precedent, not wanting to cause panic in the community, or, simply, not to be alarmist. A counterpoint to this is the lack of prompt decision-making, which has resulted in disasters with numerous victims, as in the cases of the Ruiz volcano eruption in Colombia and Hurricane Katrina in the United States.

Disasters are extreme situations whose response demands highly-skilled personnel. Over the years, the countries' human resources have achieved a certain level of expertise in risk and disaster management, but staff turnover is common in Latin America and occurs regularly with every change of government. This results in poor disaster response at the beginning of a government's tenure and improvement as time goes by, with the hope that a major disaster will not occur in the interim. The situation in the civil defense force is even more complex, since in some countries it is part of the armed forces; postings last for a certain period, which militates against the professionalization of personnel. With the governments in some LAC countries scheduled to change in the next few years, it is necessary to promote the continuity of these valuable human resources.

The changeable disaster picture is becoming increasingly complex and increasingly warrants an intersectoral response to traditional and new hazards. During the 2003 SARS epidemic, a large number of cases occurred among Canadian health workers due to poor infection-control practices in hospitals, leading to the need for cooperation among government agencies and, particularly, between labor and health authorities. After reviewing the SARS experience, the Ontario Ministry of Labor formalized a health and safety partnership with provincial health officials to improve occupational health and safety practices in health facilities. The program includes an internal accountability system, which requires health workers to report any health or safety hazard arising in the workplace.

Moreover, weaknesses in the response of the United States to Hurricane Katrina in 2005 forced the Department of Health and Human Services to forge operational ties with local authorities to ensure better hurricane preparedness in 2006. This preparedness included a study of evacuation and shelter needs and requirements for vulnerable groups. According to experts, this was the first time there had been such a detailed and coordinated planning process among state and local agencies (59).

With regard to climate change, there is sufficient evidence that it is real. The Latin American and Caribbean region is already experiencing its impact, which, according to the IPCC, will increase in the coming years. Thus, capacity must be built to integrate climate change adaptation and mitigation, addressing disasters and the environment together, integrating working groups that follow the guidelines of the Hyogo Framework for Action with groups that operate according to the United Nations Framework Convention on Climate Change – i.e., groups focused on science and the environment and groups focused on disaster preparedness and management. This lends additional

weight to this chapter in this publication because of its potential contribution with respect to the environmental determinants of sustainable human development. It is therefore necessary to begin conducting local research and situation analyses, creating early warning mechanisms, monitoring food and water quality, and implementing comprehensive surveillance to safeguard human health and safety.

Several issues must be addressed: malnutrition caused by periodic droughts is currently responsible for 3.5 million deaths annually, a number that will increase in regions facing water stress; a greater number of storms and floods, which will increase the already high mortality, in addition to producing outbreaks of vector-borne diseases due to the proliferation of breeding sites and water pollution from poor sanitation; droughts and floods, which will increase diarrheal diseases, currently the second leading cause of death in children; heat waves, which increase morbidity and mortality in elderly people with cardiorespiratory problems, as well as asthma attacks from pollen; and variations in temperature, humidity, and rainfall, which will alter the distribution of insects that transmit diseases such as dengue and malaria (60).

Greater knowledge of local epidemiology, early warning systems, and local technology use is needed to save lives in the face of different hazards. The methodology in these cases may not always be the best, but saving lives is very gratifying. Field epidemiology programs from several countries (e.g., United States, Spain, Peru, and Brazil) are working on this in the Region, but further capacity building is needed.

## ■ Examples of disaster-related environmental epidemiology

During Hurricane Mitch, two agrochemical factories and two companies with toxic-agrochemical warehouses in Honduras (all in the Department of Choluteca) were washed away by floods. Experts from the French Civil Defense and health services reported 60 cases of pesticide poisoning (61). This was validated by experts from the U.S. Centers for Disease Control and Prevention (CDC), which conducted a study that found high concentrations of chlorinated pesticides in soil samples and in the blood and urine of 45 adolescents (Istoca neighborhood, Department of Choluteca), but not in drinking water, leading to the assumption that these chemicals had been carried by floodwaters and ingested by this population (62). Furthermore, it was found that the groundwater had been polluted by these chemicals, necessitating prevention and control measures.

During the El Niño phenomenon affecting Peru, Ecuador, and Bolivia, drinking water quality was poor, requiring interventions using safe water-storage containers and onsite disinfection with liquid chlorine solution to improve water quality in flooded areas and provide well-water in drought-stricken areas. During volcanic eruptions in Quito (Ecuador), clouds of ash blanketed the city; air quality monitoring resulted in the suspension of outdoor activities and the protection of water storage and treatment plants.

Specialized centers, such as the International Research Center on El Niño (CIIFEN), the National Oceanic and Atmospheric Administration (NOAA), and the Emergency Events Database (EM-DAT), provide information that can be used for analysis. Changes in the behavior of dengue and malaria vectors are assessed with vector-density studies and new technologies such as tele-epidemiology. Work in this area should therefore be geared more to problem solving than research for research's sake.

There is no guarantee that the Region will not fall victim to major disasters again, which means that existing mechanisms must be strengthened and new mechanisms for observation, technical assistance, and action must be created to deal with any situations that arise, especially given the lack of coordination and the marginalization of national institutions and authorities.

Environmental health administrators must learn more about risk management and disaster preparedness and response and define their roles and responsibilities in this new scenario.

It is important to link health and environmental surveillance systems for environmental risk factors, such as climate and pollution, as is the case in many countries. It is also necessary to work at increasingly smaller scales to obtain data that will make it possible to take concrete steps to address climate change at the local level, the best way of thinking globally and acting locally.

## ■ Technological disasters

There is little basic information in the Region of the Americas for assessing the impact of technological accidents on human health (number of people exposed, injured, and dead) and the environment (pollution of soil, surface water sources and groundwater, and air, and contamination of the food chain). The consequences of the

lack of data are directly reflected in the ability to calculate the human, environmental, and financial costs of these accidents and, hence, the ability to develop broad, effective, and appropriate public control and prevention policies, especially with the participation of the health and environment sectors (63).

For example, there are very few epidemiological studies of chemical accidents in Latin American countries. In the United States, the Agency for Toxic Substances and Disease Registry (ATSDR) developed the Hazardous Substances Emergency Events Surveillance (HSEES) system, with the goal of installing capacity in U.S. state health departments to develop and maintain a surveillance system for high emissions of hazardous substances and implement appropriate prevention activities. The purpose of the surveillance system is to obtain data to be used to reduce the morbidity and mortality from chemical emergencies among first responders, workers, and the general public. Several U.S. states have been using this protocol since from 2004 to 2009. Annual reports with the compilation of relevant data are available at <http://www.atsdr.cdc.gov/Hs/HSEES/>.

There have been several efforts in Latin America to adapt environmental health surveillance systems for chemical events. One example is Brazil, which, through an initiative launched by the Ministry of Health in 2001, created a national environmental health surveillance subsystem with several areas of activity, including environmental health surveillance following accidents involving hazardous substances. In that context, a model was developed for environmental health surveillance of human exposure to accidents involving hazardous substances, which is used as a reference in several Brazilian states.

Both the U.S. protocol and the Brazilian model can serve as references for Latin American and Caribbean countries intending to create their own environmental health surveillance system for chemical emergencies, given the lack of public policies on accident prevention and control strategies.

Latin America and the Caribbean have a very limited number of chemical emergency response centers; only Argentina, Brazil, Colombia, Chile, Mexico, and Venezuela have them (64). A directory of these centers is available in Spanish at the following website: <http://www.bvsde.paho.org/bvstox/e/guiamarilla/guiamarilla.html>. These centers have functions that include technical assistance to response teams regarding the risks created by an emergency; the provision of information about chemicals, the recommended isolation distance around the zone, and evacuation; and support in mobilizing institutions and resources, to name a few. It is therefore essential for government or the private sector to encourage the creation of these centers.

Latin America and the Caribbean have more than 130 poison information centers (<http://www.bvsde.paho.org/bvstox/e/guiamarilla/guiamarilla.html>) that, in general, have rarely been used in chemical emergencies. Many operate 24 hours a day, 365 days a year and can make a valuable contribution to chemical emergency prevention and response when they follow the recommendations of the World Health Organization's International Program on Chemical Safety (<http://www.inchem.org/>).

These centers are usually located in hospitals and universities and are managed by experts, largely physicians with training in toxicology, pharmacists, chemists, biochemists, and biologists, who have access to reliable information sources and can therefore provide toxicology information on chemicals to other institutions involved in emergency management. Some centers have antidote banks (65,66). Consequently, it is essential to encourage the participation and integration of poison information centers in chemical emergency prevention, preparedness, and response measures.

The response to a chemical accident calls for the involvement of different institutions and experts with diverse training. Institutions such as fire departments, civil defense, the police, and the environmental and health agency are usually involved in emergency response. The health agency will be responsible for providing prehospital and hospital care after a chemical accident. However, as a rule, this work has often been done with little knowledge about the real risks in a chemical emergency, since response teams do not always follow safety protocols to the letter.

Various examples can be seen of failure to observe safe procedures in caring for the victims of a chemical accident, in which the rescue team is often exposed to the chemical in the course of its work. Similarly, in hospital care, once victims reach health services, different types of problems occur, such as a lack of protocols for managing these cases (e.g., lack of decontamination procedures), undertrained personnel, lack of laboratory equipment or diagnostic reagents, testing done outside the country, and lack of antidotes, all of which render the situation more complex.

In addition to this training, an investment in appropriate material resources that ensure performance is necessary, as is full coordination with the other institutions that deal with emergencies in order to achieve the desired result. It is both possible and necessary to develop protocols with the fire department, for example, for cases where victims must be rescued in areas with chemical risks.

Dealing with chemical emergencies poses a series of problems, beginning with the lack of information on the product involved. Every intervention that is safe and employs suitable procedures for the situation at hand is a direct

result of a proper assessment that includes a determination and understanding of the risks posed by the chemical in question. This information can be found on the website of PAHO's Virtual Library of Sustainable Development and Environmental Health (<http://www.bvsde.paho.org/sde/ops-sde/bvsdeeng.shtml>). At the initiative of CETESB, Brazil created a chemical database containing information on 1,013 products that is used as a reference by the entire country. This database can be consulted at: <http://www.cetesb.sp.gov.br/gerenciamento-de-riscos/emergencias-quimicas/258-manual-de-produtos-quimicos>. Thus, it is important for countries to create a database with information on frequently used chemicals as an essential tool for dealing with chemical emergencies.

Notwithstanding all of the above-mentioned initiatives in Latin America, health sector involvement in chemical emergency prevention and response is still rather limited. As a rule, the plans and programs in place should include the health sector as the essential element it is, because that way it can get involved in investigating the causes of chemical accidents and their impact on human health, an area in which information is currently lacking.

Another issue for which a technically feasible solution is still but a distant goal is treatment of the hazardous waste produced in chemical emergencies. This is the case in most of Latin America. Several countries in the Region have no sites or technologies for treating and permanently disposing of this waste. In Brazil, only a few states have several options for proper final disposal. It is therefore necessary to plan for the management of waste produced by the response to chemical emergencies. This involves ensuring that measures adopted include minimizing waste during work on the ground, searching for temporary disposal sites, and transporting the waste to treatment and final disposal sites.

Furthermore, the Latin American countries should identify facilities that pose a potential risk to the environment and draw up maps of chemical production, handling, and storage sites. These maps should characterize the area around these facilities in terms of human occupation and the presence of fragile or vulnerable environments—e.g., bodies of water and agricultural areas. Colombia already has a good initiative of this type with its Aburrá Valley Chemical Risk and Hazardous Substance Transport Maps (67). This document provides a methodology for individualizing risks and presents the situation regarding chemical industry and transport risks in the region in question. It also makes recommendations to help public authorities and the private sector minimize the frequency and consequences (human, environmental, and property) of technological accidents in surrounding areas. Likewise, the Association of Paint, Ink, Resin, and Chemical Manufacturers in Ecuador and the major mining companies in Peru prepared risk maps of the main chemical transportation routes, examples that should be replicated throughout the countries in question and in other countries as well.

One problem faced by some Latin American countries is the disjointedness of public policies, clearly visible in the failure to disseminate and update the National Chemical Profiles, whose purpose is to provide information on a country's infrastructure in this area and to serve as an analytical tool in the decision-making of organizations linked with the industrial sector.

Due to the needs of each country and region, initiatives in the field of chemical emergency prevention, preparedness, and response are very diverse. Experts in these fields should be encouraged to share their experiences, as it will improve the measures adopted by institutions. Important in this regard is the Latin America and Caribbean Chemical Emergency Network (REQUILAC), created in 2008 and administered by PAHO/Brazil and CETESB. This network, in Spanish, English, and Portuguese, is open to all stakeholders.

Given the importance of this type of interaction, membership in REQUILAC should be encouraged. The opportunity it will provide to share experiences with teams not only from one's own country, but other countries as well, will lead to institutional strengthening. Joining REQUILAC is quite simple and can be done by registering at its website: <http://www.bvsde.paho.org/requilac/e/requilac.html>.

## ■ Conclusions

### Environmental and technological disasters and emergencies

Environmental emergencies and disasters are increasing, making it necessary to build regional and national preparedness, prevention, and response capacity and to work operationally on their coordination at different levels.

## Environmental health and sustainable development

Emergencies and disasters have negative consequences for environmental health and pose a threat to sustainable development. Experience over the years has shown that all emergency and disaster personnel must work together proactively at all levels, with an eye to anticipating future scenarios that will make this increasingly necessary.

### Climate change and climate variability

Climate change is a reality. The effects of climate change and climate variability should be monitored nationally and regionally, and mitigation and adaptation measures should be more widely embraced. Also essential is the mapping of existing risks at the local and zonal or neighborhood scale, because this is where action should be taken to truly benefit the population.

Climate change adaptation and mitigation measures with specific budgets should be mainstreamed into all programs, and joint working groups should be formed that integrate the variable of preparedness into environmental health.

### Regional aspects

Subregional political integration agencies have developed joint agendas and regional programs that work at the technical and political level with ministries of foreign affairs and cooperation agencies. This has increased regional political support for the efforts of national technical entities at different levels and with different actors, yet integrating all sectors. These mechanisms must become widely known and used to benefit the population.

The Region also needs to encourage the formation of prospective intelligence teams that investigate what is happening at the regional level and learn about experiences in other regions and continents contending with extreme scenarios (e.g., water shortages, epidemics, chemical accidents). It is also imperative to create a regional databank to lay out and analyze potential similar scenarios in the Region and draft proposals for their comprehensive study (examining political, social, cultural, technical, and safety aspects), to review good and poor practices, and to promote a regional action strategy for extreme scenarios.

At the operations level, regional and subregional rapid response teams of experts from institutions in the Region have been formed that can be mobilized rapidly to support countries stricken by disasters. These teams must be strengthened with expertise in technological disaster response to improve their coordination and response to large-scale chemical emergencies in Latin America and the Caribbean. Since technological emergencies require far more specialized management, it is suggested that countries follow global guidelines and good practices and obtain assistance from PAHO, the Regional Technical Team of Water and Sanitation (ETRAS), and CETESB.

Other areas of environmental health that these teams should study are: *a*) the immediate provision of safe water; *b*) the creation and operation of shelters; *c*) the provision of quality food; *d*) vector control; *e*) excreta and waste management and the promotion of personal hygiene; *f*) air quality monitoring and personal protective measures in emergencies involving air pollution; and *g*) chemical emergency response. Organizations working in the Region have acknowledged strengths in these areas that do not need to be duplicated. Rapid mapping would be a good idea, as would initiating coordination and conducting joint disaster preparedness and response exercises, making them part of an environmental health and sustainable development approach.

### Policies and plans

We must not underestimate hazards or the course an emergency or disaster may take, but always keep the worst-case scenario in mind. Human life is too precious to do nothing because of politics, indifference, or negligence.

History and the number of people who have died or been affected remind us that it is vital to not underestimate any hazard and is essential to take proactive steps for timely decision-making with technical, political, and social support.

The countries of the Region have made great strides in developing emergency and disaster prevention and response policies and in institutional development. Work is still needed to improve civil defense and sector technical expertise, propose more effective ways to improve the work of regions and municipalities under the decentralization currently under way in the countries, and work more in terms of the International Health Regulations and

pandemics, integrating technological emergencies into these efforts. With regard to technological emergencies, it is important to know where chemical emergency prevention, preparedness, and response are addressed in the legal framework to identify any gaps and needs. This will require supplementing the analysis with National Chemical Profiles and linking it to broad policies on the integrated management of these substances and compliance with international agreements, such as the Basel Convention on the Control of Transboundary Movements of Hazardous Waste and the Stockholm Convention on Persistent Organic Pollutants, to ensure a comprehensive analysis. Furthermore, this analysis should not rule out the possibility of mainstreaming this aspect into sensitive areas such as water and land, for example; instead, it should consider the legislation governing land use and occupation and delimit industrial zones and their safe distance from inhabited areas.

The planning of preventive and remedial control policies is essential for the adoption of risk management programs designed to prevent accidents and minimize risks to human health and safety, as well as damage to the environment and to public and private property.

In addition to knowing the risks, organization and coordination with different national stakeholders are necessary in the various phases of the disaster cycle. The importance of considering health and the environment together should be underscored, especially in areas such as water and food supply, excreta disposal, environmental surveillance and control, healthy housing, and more specifically, climate change, toxicology, chemical accident control, and pandemics.

It is therefore important to devise plans for dealing with different hazards using an integrated approach based on the individual, the family, and the community. Such plans should involve all institutions (civil defense, fire departments, Red Cross, and health, education, water supply, energy, and other sectors), define their roles and responsibilities, and include action and simulation protocols aimed at integration.

### **Personnel involved in actions**

Technology, experience, and observation in the field should all be taken into account. Thus, guaranteeing the continuity and expertise of personnel in the organizations involved in disaster preparedness and response is important, as it will ensure the most appropriate action.

Making the disasters an area in the university curriculum has produced a critical mass of experts working permanently in the countries and has ensured sustainability by educating future managers or personnel who have the requisite training when they assume key positions and by fostering the creation of networks.

Health sector personnel have begun to give priority to their own preparedness and response training and organization, based on the lessons learned from adverse situations they have experienced. Recent years have witnessed a growing demand for hospital preparedness and contingency plans, and continued training and dissemination of information on toxicology, chemical emergencies, and environmental epidemiology are needed.

### **Financial resources**

It is necessary to conduct high-quality financial impact assessments for all disasters and to detail the costs of humanitarian assistance.

### **Information and communication technology (ICT) and information management**

The online disaster library and CRID offer the Region's professionals timely access to information, which aids in response. The use of ICTs and satellite-based georeferencing tools for preparedness is a reality that better directs resources and saves lives. Thus, more people need to know about their benefits and be capable of managing this information and applying it in decision-making. The use of mobile telephone technology in support of health programs and projects is also a reality. The Region has high coverage rates for these technologies. Progress needs to be made in using them to access knowledge, supervise the personnel and organizations involved, monitor local environmental conditions, and promote measures, technologies, and interventions.

### **Creation of technological hazards**

Society is aware that technology development means accepting certain risks. However, it expects public authorities and the private sector to conscientiously manage those risks.

It is imperative to ensure continuity of the work of all sectors, especially the public authorities who are charged with safeguarding the environment and the health and quality of life of the population.

## The health sector

With few exceptions, the lack of unified health systems in the countries of the Region produces fragmentation that is evident in emergencies and disasters. In the long term, these aspects must be addressed in the general legal frameworks governing health; furthermore, coverage and benefits, including those for the most frequent hazards, must be reviewed—or, better yet, there should be movement toward a unified system.

The essential functions of national disaster programs must be guaranteed to reduce the health effects of emergencies and disasters. These functions are:

- Planning and implementation of prevention, mitigation, preparedness, response, and early rehabilitation related to public health.
- A multipronged approach to the damages and etiology of all potential emergencies and disasters, given the country's situation.
- Involvement of the entire health system and broader intersectoral collaboration to reduce the health effects of emergencies and disasters.

While progress toward safe hospitals has been increasing, the majority of the Region's hospitals are not safe. In many cases, hospitals that are safe from a seismic standpoint do not have safe water, even in operating rooms, revealing the need for a comprehensive interdisciplinary approach to prioritize environmental sanitation at sites where health care is provided. Moreover, from the standpoint of chemical emergencies, hospital facilities must be improved so they can properly receive, decontaminate, and treat victims.

The expansion of the Safe Hospitals Initiative to the Safe Schools Initiative is a real step forward. However, more progress is needed in prevention, which should be expanded to other sectors and areas. In some countries, the Healthy Housing environmental health initiative has been expanded to disaster situations, rendering housing in risk areas healthy and safe.

It is also necessary to establish mechanisms and incentives for the participation of technological information centers on chemical emergencies and implement environmental surveillance programs related to health for such events.

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## ■ Annex Websites

- Humanitarian Assistance Reform. <http://www.humanitarianinfo.org/iasc/pageloader.aspx?page=content-template-default&bd=87>

Humanitarian reform seeks to increase the effectiveness of humanitarian response, so as to ensure predictability and boost capacity for accountability and joint effort. It is an ambitious effort by the international humanitarian community to reach more beneficiaries based on an approach to support grounded in effective and timely protection of their needs.

- Regional Disaster Information Center (CRID). [http://www.cridlac.org/ing\\_index.shtml](http://www.cridlac.org/ing_index.shtml)

CRID is an initiative sponsored by six organizations that decided to join forces to ensure the compilation and dissemination of disaster information in Latin America and the Caribbean.

- The International Disaster Database (EM-DAT). [www.emdat.be/Database/](http://www.emdat.be/Database/)

This database of different types of disasters around the world was developed by the Center for Research on the Epidemiology of Disasters (CRED).

- International Strategy for Disaster Reduction (ISDR). <http://www.unisdr.org/>

ISDR is an interinstitutional secretariat of the United Nations whose mandate consists of coordinating, promoting, and strengthening disaster risk reduction globally, regionally, nationally, and locally.

- Emergency Preparedness and Disaster Relief Area of the Pan American Health Organization. <http://www.disaster-info.net/>

Disaster-info is the front page to websites of many disaster organizations, particularly in Latin America and the Caribbean. All websites are hosted in their original language.

- Directive 82/501/EEC—European Community (CD82/501/EEC). <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31982L0501&from=EN>

The countries of the European Community issued directive 82/501/EEC, best known as the “Directive of Seveso,” to prevent, prepare for, and respond to major industrial accidents, with a view to minimizing the consequences for workers, the population, and the environment.

- Community Awareness and Emergency Response (CAER). <http://www.caer.ca/>

The CAER Program is coordinated by the Canadian Chemical Manufacturers Association (CCMA) with the objective of developing local chemical emergency response plans in which industries, government agencies, and communities participate.

- Prevention of Major Industrial Accidents Convention. [http://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100\\_INSTRUMENT\\_ID:312319](http://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_INSTRUMENT_ID:312319)

A program of the International Labor Organization focused on the prevention of major industrial accidents, aimed at helping countries control the handling of hazardous substances and protect workers, the population, and the environment.

- Responsible Care. <http://www.icca-chem.org/en/Home/Responsible-care/>

This program was launched by the Canadian Chemical Producers Association (CCPA) in 1985 and introduced in the United States in 1988 and in Australia and England in 1990. Its aim is to foster improved management of chemical companies and their value chain; to safeguard the environmental, economic, and social sustainability of their processes and products; and to contribute to ongoing improvement of the quality of life of society. The following countries in Latin America are part of the program: Argentina, Brazil, Colombia, Chile, Ecuador, Mexico, Venezuela, Peru, and Uruguay.

- Emergency Management Act. <http://laws-lois.justice.gc.ca/eng/acts/E-4.56/>

The Government of Canada passed this law in 2007 to improve and strengthen its emergency management measures and assign responsibilities to the ministers of State in the prevention, preparedness, response, and recovery phases. The objective of the act is to unify and standardize different federal, state, and municipal regulations on the subject. It addresses, *inter alia*, components of the country's chemical accident response system (including chemical weapons); the regulatory environment; the setting of prevention, preparedness, and response parameters; training; and action strategies.

- Integrated Urban Air Toxics Strategy. <http://www2.epa.gov/urban-air-toxics/integrated-urban-air-toxics-strategy>

A U.S. Environmental Protection Agency (EPA) strategy containing measures to control chemical emissions, in both normal and emergency situations.

- The Emergency Planning and Community Right-to-Know Act. <http://www2.epa.gov/epcra>

Under this U.S. law, known as the "Superfund Amendments and Reauthorization Act (SARA)," Title III, 1986, companies must provide information on chemicals and spills in their facilities. Upkeep and use of this information for developing emergency plans and gathering all information that should be provided to the public are the responsibility of local and state committees made up of different community institutions, along with health agencies, fire departments, and the emergency response team.

- Risk Management Plan (RMP) Rule Guidance. <http://www.epa.gov/oem/guidance.htm#rmp>

This program is coordinated by the U.S. EPA and requires companies to evaluate their worst-case scenario for chemical accidents, anticipate potential dangerous distances for the population, and help develop emergency plans.

# The potential impact of nanotechnology and nanoparticles on human health and the environment

William Weissmann

## ■ Introduction

Richard Feynman (1918-1988) announced in 1959 that there were no theoretical impediments to the reconstruction, even atom by atom, of small devices on a molecular scale. The idea, embraced and developed by Eric Drexler (1955 -), was bolstered by the discovery of scanning tunneling microscopy (1) and the subsequent development of various branches of science and technology beginning in the 1990s (2,3). It should be noted that the term “nanotechnology” was first used in 1974 by Professor Norio Taniguchi, of the Science University of Tokyo, to accurately describe the production of nanoscale materials (4).

Today, a nanotechnology platform has been erected. Nanotechnology, which involves processes, systems, and materials that operate at the scale of one billionth of a meter, indeed make it possible to reformulate various segments of production (5). However, it is important to distinguish between ancient and present-day nanotechnology. Colloidal gold was used in China and Egypt four to five centuries before Christ for aesthetic and curative purposes. Carbon black was also used thousands of years ago as black dye. Lead sulfide was already used in Egypt in hair dye during the Greco-Roman classical period (6). From the Middle Ages through the Renaissance, techniques involving the use of films with metallic oxides and salts at the nanoscale created shiny porcelain and glass surfaces (7). Many of the cathedrals from that period contain stained glass with colors ranging from red to blue tones, though painted with colloidal gold at nanoscale (8).

Nanoscale compounds may have properties that differ from those they have when they are larger. In nanoscale, relatively more atoms remain on the surface, and the surface area for the same mass is larger, allowing for greater chemical reactivity. Small dimensions can facilitate quantum effects, changing the behavior of optical, electrical, and magnetic properties. Nanomaterials can be shaped to provide a better ratio between mass and strength, as well as greater solubility, adhesion, softness, mechanical strength, and heat resistance (9,10,11,12).

Nanomaterials have been used in lubricants and detergents, on waterproof and bactericidal clothing, in scratch-resistant car and aircraft coatings and paints, and in microprocessors, semiconductors, power converters, self-cleaning windows, electron microscopes, and more. They may adsorb greater quantities of pollutants and facilitate more precise measurements (biosensors, environmental sensors, and metrology equipment). They have been used in the pharmaceutical industry for coating active ingredients, permitting their transport to specific areas (greater selectivity of action), preventing digestive absorption of intact proteins protected by resistant nanocoatings (oral insulin is under development), increasing the bioavailability of drugs administered transdermally, etc. (12).

## ■ Nanotechnology applications and implications

### Natural nanoparticles, anthropogenic nanoparticles, and nanomaterials / use of nanomaterials

Human beings have been breathing nanoparticles for millennia. Seventy percent to 80% of the airborne particles that people breathe today are in nanoscale. The origin of some of these particles is natural, while for some it is anthropogenic (13,14). A common question is: Since human beings have been living with such agents for so long, why would new nanoscale agents that are similar in size be harmful? Why worry about them? This approach, however, inherently assumes that everything about them is known, including how they factor into human disease. Actually, nothing could be further from the truth. Even natural nanoparticles can be risky, and the potential relationship between nanoparticles and the presence of disease is being demonstrated (15).

Several proposals have been put forward for harmonizing the international nomenclature for nanotechnology and related materials. However, much of the terminology is still being defined, and there are disagreements about definitions and differing uses of terms. The first option here is to adopt some of the explanations and definitions established by the ISO Committee (16,17,18).

The use of coal, stoves, ovens, frying pans, and grills is common today. These devices produce indoor anthropogenic nanoparticles, many of which can cause health impairments (19). In the past 100 years, their airborne presence has grown exponentially due to emissions from internal combustion engines, incinerators, and other devices. Such particles may bond with others, such as titanium dioxide, carbon black, iron oxides, and metallic fumes. Salicylic acid nanoparticles have been produced in large quantities since the 1940s, with widespread worldwide use (20). Thus, there are external and internal sources of anthropogenic nanoparticles, largely components of air pollution, which can be added to those of nonanthropogenic origin. The main new general nanoscale materials are:

- a. Liposomes: vesicles composed of double layers of phospholipids containing hydrophobic and hydrophilic environments. Liposomes are differently metabolized by the human body depending on the composition of their carriers and superficial functional groups (21). Drugs in liposomes may be protected from the enzymatic action of macrophages and can have controlled release and/or be sent to active sites (liposomes coated with monoclonal antibodies), facilitating dose and toxicity reduction for some products already on the market. Liposomes can be used in cosmetics such as sunscreens and in gene transfection, food, cleaning products, etc. (22).
- b. Quantum dots (QD): metal semiconductor nanoparticles or fluorescent semiconductor nanocrystals (quantum dots—II-VI and III-V) that exhibit properties dependent on their sizes and the effects of quantum confinement on electronic states. They spontaneously emit light, according to their different dimensions (18). QD can be used in photovoltaic cells, displays on various materials, to improve the resolution of computers, and in organic paint and glaze. The particles used in diagnostic dyes make them glint tissues many times more than traditional fluorescent dyes, allowing for better tissue identification, including for *in vivo* and *in vitro* tumor diagnosis (23).
- c. Carbon nanotubes (CNTs) can be understood as curved monomolecular layers forming graphene tubes, including those formed by single and multiwalled layers. They may have different components and shapes and be connected to a number of functional groups. CNTs are one of the new materials most used today. Very durable and flexible, with semiconductor properties dependent on the functional groups that they can engage, CNTs have numerous applications (24). CNTs can be the basis for biosensors with high specificity and sensitivity, can be linked to molecules (DNA, antibodies, enzymes, etc.) that can identify substances and cells, and may also be used in gas sensors, microorganisms, and so forth. They may carry drugs to specific locations and, in very thin films, can be used in paint, glass, and packaging; for protection, sensing, greater flexibility, and endurance; and for increasing the life and efficiency of lamps, displays, intense light emission sources, etc. (25).
- d. Fullerenes are carbon allotropes. Polycyclic systems form closed rings of carbon atoms in a spherical shape like a soccer ball, with 12 pentagonal rings and other rings made of hexagons. The first of these was given the name “buckminsterfullerene,” also known as a “Bucky ball,” with 60 carbon atoms (C<sub>60</sub>), giving rise to the name of the family: fullerenes. Other fullerenes have since been produced, with dif-

- ferent numbers of carbon atoms, linking functional groups to the structure and so forth. Fullerenes can be used in very strong, high-capacity packaging and shock-proof vests and can be functionalized as superconductors, insulators, and semiconductors in solar cell panels. Also used in polymer transistors, in health they can serve as carriers of drugs, as vaccines, and as good contrast agents for use in nuclear magnetic resonance (NMR); one of their derivatives may act as a protease inhibitor of HIV-1 (26).
- e. Dendrimer: the macromolecule's polymeric structure increases the possibility of functionalizations and the use of more specific probes in biosensors, as well as the ability to carry components such as medicine, paints, etc. Dendrimers can also be used as contrast in nuclear magnetic resonance (NMR), to promote gene transfection, and as the basis for biomimetic systems; they can also incorporate functional groups in their structure, which may alter their initial properties (27,28).
  - f. Fibrous silicates crystallize in fibrous form at limits ranging from 25 to 300 nm in diameter, reaching up to 500 nm to 20  $\mu\text{m}$  in length. Good insulators, their main industrial use is in real estate, from water tanks to tiled floors, with annual production volumes in the thousands of tons, even with restrictive legislation. Some of them with high tensile strength (silicon nitride, silicon carbide) have been used in the automotive industry. In addition, salicylic acid in nanoscale is produced commercially as a substitute for carbon black to reinforce tires. Its use has expanded, becoming commonplace in many cosmetics (20).
  - g. Carbon black is produced in volumes reaching hundreds of thousands of tons per year, especially through the incomplete burning of hydrocarbons. Used as ink for years, when added to rubber it can increase the resistance of tires (its main use) when most of the types of carbon black used are between 20 and 96 nm. It can also be used in plastics, printing inks, paints, toners, varnishes, dyes, and building materials (29).
  - h. Nanoclay nanoparticles are layered silicate minerals. An important example is the use of nanoclays in the reinforcement phase of polymer matrices for the preparation of polymeric silicates. Drugs can be distributed in the layers of materials for controlled release. Nanoclay nanoparticles can be used to coat food and in beverages, plastics, and car parts for reinforcement. Potable water can be created by treating industrial and municipal wastewater with organoclays in combination with other sorbents, and they have proven excellent for treating water contaminated with oil (30,31).
  - i. Nanoceramics are inorganic, nonmetal solid materials subjected to high temperatures and then cooled. Ductility increases with the use of ceramic nanoparticles. Nanocrystalline ceramics display excellent chemical resistance at high temperatures; they are used as components of high-temperature furnaces and can be pressed into complex net shapes and sintered at temperatures significantly lower than conventional ceramics (31). The main industries that use nanocomposites are the automotive, energy, packaging, coating, and filter industries (32).

There are several methods for synthesizing and growing nanomaterials. Usually, it can be done from larger materials, promoting their wear (top down), or in building materials from the manipulation of even smaller molecules and atoms (bottom up) (33). Many nanoscale materials have a tendency to come together (agglomerate), which depends on the conditions of the material itself and its surrounding environment. Chemical compounds may differ substantively in their properties at the nanoscale. Different physical structures of a chemical can have very different properties. The toxicities resulting from these properties should portray such phenomena. Agglomerates can keep nanometric dimensions, retaining their properties (or not) (34).

## Potential risks of nanoparticles and nanomaterials

Knowledge about the effects of nanoparticles and nanomaterials is rooted in different scientific disciplines. As shown by Oberdörster, Stone, and Donaldson (35), it is based on the evolution of virology, kinetic models of particles in the environment and the body, knowledge about the toxicology of fibers, etc.

### Toxicological metric

One of the fundamental issues associated with the impact of nanoparticles and nanomaterials is the metric used in studies on their toxicity. Traditionally, the relationship between a compound and its effects is related to its mass. This may not be true for nanomaterials or nanoscale particles, where the relationship can be better unders-

tood in terms of surface area, the number of particles/materials, surface functional groups, or several other characteristics of nanomaterials or nanoparticles.

In a study with  $\text{TiO}_2$ , Jiang *et al.* (36) show different effects on oxidative stress (OS) when testing different physical particles of  $\text{TiO}_2$ . The toxicities are presented in the following order: amorphous forms>anatase>mixed anatase/rutile>rutile. In this case, a significant difference was observed in the response between particles larger or smaller than 30 nm. When smaller, the effect appeared to be dependent on the number of particles. When larger, the response was similar for particle number and surface area. Different crystalline forms have different relative amounts of surface atoms, producing different reactivity depending on their structures. Using nine samples of anatase to study free radical generation, these authors showed that, in this case, the better metric was the surface area of the particle.

### Effects at the cellular level

Depending on their characteristics (surface area, size, charge, etc.), nanoparticles can cross cell membranes, causing lipid peroxidation, OS, and an increase in cytosolic calcium. Once inside the cell, nanoparticles can penetrate the nucleus through its pores, interact with DNA and the mitochondria, and act on the respiratory chain, generating reactive oxygen species (ROS). Nanoparticles can be actively incorporated through endocytosis via different mechanisms, generating OS, and through phagocytosis, with activation of NADPH oxidase as well as ROS production. An additional mechanism for increased ROS production is the activation of cellular receptors. Activated receptors, calcium, and increased ROS activate gene transcription of pro-inflammatory transcription factors, such as NF- $\kappa$ B. The lipid peroxidation products can form adducts with DNA and lead to genotoxicity, mutagenicity, apoptosis, and necrosis, in association with changes in the mitochondria (35,37,38).

The OS model helps us understand the evolution of the inflammatory process to apoptosis, with potential indicators of clinical and/or research endpoints of cell exposure to nanoparticles. When OS is low, NRF-2 activates antioxidant response elements, and antioxidant phase II enzymes are induced. With this, the rate of reduced glutathione (GSH)/oxidized glutathione (GSSH) remains high. Moderate oxidative stress causes activation of MAPK and NF- $\kappa$ B cascades, induction of AP-1 and NF- $\kappa$ B, and production of cytokines and chemokines. The result is an inflammatory response. Higher levels lead to changes in the mitochondrial PT pore and respiratory chain and generation of cytotoxicity and apoptosis. GSH/GSSH rates become low (39). Based on studies of respiratory, dermal, and endothelial cells, nanoparticles can activate macrophages and stimulate dendritic cells and lymphocytes to produce cytokines, interleukins, interferon, and tumor necrosis factor, leading to the generation of a pro-inflammatory process and inflammation (40).

In addition to their own structure, many nanoparticles/materials have the ability to carry contaminants from the environment, making this an important element in a compound's toxicity (41). Thus, it is important to assess the pathogenic potential of the nanostructures, making *in vivo* and *in vitro* studies essential. While much remains to be done in terms of adequate testing of nanoparticles/materials, several trials have been conducted to evaluate cytotoxicity and proliferative potential and to assess the genotoxicity of interference with gene expression (42).

### Effects on the respiratory system

There are two aspects of the respiratory system to consider: it is the main route of absorption to other organ systems, and it can incur serious damage from anthropogenic and nonanthropogenic nanoparticles and engineered nanomaterials.

### The system as airway passage

Breathing nanoparticles/materials can produce dynamics in the upper airway that differ from those of larger materials. For larger particles, it is generally known that the smaller particles among them penetrate the lung deeper and reach the alveoli. This may not be true for nanoparticles. Approximately around 90% of particles around 1 nm (e.g., some gold nanoparticles) are deposited in the nose and pharynx, and 10% in the tracheobronchial tree—essentially, none in the alveolar region. Ninety percent of all 5 nm nanoparticles (e.g., some silica, gold, silver, and iron oxide [II, III] nanoparticles) are retained and distributed relatively uniformly throughout the respiratory tree. Pulmonary absorption of 20-nm nanoparticles (e.g., some metal and even organic functionalized nanoparticles)

would reach 80%. More than 50% would be deposited in the alveoli (but 20% of them would be vented from the lung) and 15% in nasal and tracheobronchial regions (43).

Nanoparticles can agglomerate, settle in the surfactant, and then disagglomerate; bind to receptors and protein complexes; and be absorbed by macrophages and dendritic cells. Whether nanoparticles are insoluble or poorly soluble, when deposited in lung media, they are commonly removed by mucociliary tracheal epithelium. Macrophages then undergo phagocytosis and destroy the nanoparticles. However, phagocytosis is highly dependent on particle shape and size, even when the particles are not agglomerated (which strongly interferes with solubility). Nanoparticles can reach the interpleural space, where they are drained by the lymphatic vessels of the parietal pleura, reach the circulatory system, and are then distributed to various organs, causing considerable damage. Similarly, depending on their size, they can reach the blood through the alveolae and spread throughout the body. Others (CNTs) may be retained in the lungs (44).

An important route for nanoparticle absorption is the nose, where they cross the mucosa, penetrate the olfactory nerves, and can reach the central nervous system without entering the circulatory system. Various nanoparticles have demonstrated nose brain translocation. Oberdöster *et al.* (43) and Yu *et al.* (45) showed that after five days of nasal instillation of gold nanoparticles in rats, very high levels of nanoparticles appeared in the tongue, lungs, brain, olfactory bulb, septum, entorhinal cortex, striatum, and brain stem. After 15 days, although levels remained high, respiratory and neural distribution was observed in all bodily systems. This fact is of particular importance in the work environment and pharmaceutical use. In many cases, even one-third of the inspired dose reaches the brain, which makes it necessary to rethink many exposure indicators—for example, metals—since a considerable amount of smoke is in the form of metal nanoparticles.

### **Pulmonary toxicity**

CNTs have a length-to-diameter ratio that is almost always very high, which makes them mostly fibrillar. CNTs can cause inflammatory and asbestos-like toxic clinical conditions. Donaldson *et al.* (44) show how the dimensions and conformation of CNTs can determine such similarities, comparing them with asbestos and showing reactions *in vivo*. This supports the hypothesis that in nanoscale, size hinders phagocytosis (frustrated phagocytosis), which depends on the very elongated form of CNTs.

Without effective drainage, CNT penetration of the lung interstitium and even the interpleural space, with frustrated phagocytosis, would cause sustained pulmonary inflammation and, potentially, carcinogenic pleural diseases. Acute inflammatory reactions would exist, due to both the CNTs' own characteristics and the functional groups, structures, and other contaminants that could be attached to them.

The toxicity of CNTs, which can serve as an example for other nanomaterials/particles, can be increased by the presence of contaminants and decreased with their reduction (heated to high temperatures) (46). Many nanoparticles and other nanomaterials can cause inflammation and even allergies. Fever associated with metal fumes results from exposure to metallic nanoparticles. Asthma and asthma-like conditions can be triggered by nanoparticles, such as those in diesel exhaust. On the other hand, small controlled doses can be used to treat these same conditions. Nanocapsules of PGLA (polyglycolic lactic acid) with birch pollen were investigated and proved successful in desensitizing animals with asthma triggered by pollen exposure (40).

### **Cardiovascular effects**

Several studies have shown that higher levels of air pollution are associated with an increase in episodes of acute myocardial infarction, tachycardia, and arrhythmia. Engineered nanoparticles and nanomaterials can potentially lead to endovascular disorders. Chronic inflammation of the vascular intima is associated with frequent contact with nanoparticles, leading to the development of atherosclerosis and thrombosis (47).

The most important components of the nanoparticles in air pollution are metals, volatile organic compounds, and those derived from combustion, especially, vehicle exhaust such as diesel exhaust (48). Acutely, diesel exhaust could produce endothelial dysfunction and significant interference with thrombotic potential, with reduced fibrinolytic capacity, the release of tissue plasminogen activator (t-PA), and increased platelet activation, risk factors for thrombus formation, and acute myocardial infarction related to vehicular traffic peaks in major cities (47).

Barath *et al.* (49) showed the effects in healthy young men of diesel exhaust on vasoconstriction, vasodilator effects, and even the production of endogenous substances in response to vasodilators. They observed significantly lower arterial flow when men were exposed to air with diesel exhaust and polycyclic aromatic polycarbon, even in

response to any use of four vasodilators. The study showed that, in humans, nanoparticles may reduce endothelium-dependent or independent vasodilation, including drug-induced vasodilation. The explanation for this effect may lie in the basic dysfunction caused by nanoparticles at the cellular level. OS can lead to excess superoxide, which rapidly combines with NO in the vascular wall to form peroxynitrite, limiting the availability of NO and reducing smooth muscle relaxation.

Deb *et al.* (50) showed that nanostructures with gold, copper, iron, and cadmium sulfide (CdS) can bind to platelets via ADP receptors, and the likely target can be the low-affinity purinergic receptor P2Y<sub>12</sub>. Platelet aggregation seems to depend on the material and shape of particles and, with the exception of CdS, aggregation can be reversed with appropriate use of anticoagulants such as clopidogrel.

Lotti, Olivato, and Bergamo (51), however, believe that the chronic effects just described are not sufficient to explain the early onset of cardiovascular effects shortly after exposure to nanostructures. The action of particles directly on platelets or endothelial and metabolic mechanisms is a potential explanation for such acute events. Another possibility is related to the migration of nanoparticles through the nasal and tracheobronchial mucosa, producing catecholamines and tachykinins, which could lead to cardiac arrhythmias.

### **Skin absorption and effects**

Baroli (52) shows that the sophisticated structure of skin strongly influences the penetration of numerous nanoparticles/materials, stressing that penetration can occur in different ways and may depend on several parameters: shape, size of the nanoparticle, hydrodynamic diameter, etc. These parameters can affect the route and depth of penetration, the diffusion coefficient of dispersion in vehicles and on the skin, and the potential to interact with the components of the skin.

Generally, for transdermal lipid penetration without accelerators, very small particles (5-7 nm) are necessary. They must find their way through irregular columns of keratinocytes, some connected by desmosomes, and pass through layers of polar phospholipids. Fullerenes smaller than 3.5 nm, quantum dots, and other structures with these dimensions could pass that way (spherical > elliptical > needle shaped). Absorption can occur through aqueous pores with particles up to 36 nm, and even larger ones of up to a few micrometers can penetrate through the hair bulb (52,53). Specialized liposomes have been developed to cross the skin and introduce drugs and other products. Various parts of their membranes are replaced by proteins with controlled flexibility, so they can bend and avoid obstacles in their transcutaneous path (transferosomes) (52).

Some studies show that zinc and TiO<sub>2</sub> nanoparticles can penetrate only a few layers of the stratum corneum (three to five layers of corneocytes) (54), while others, such as the aforementioned liposomes, particularly when in the midst of lipids, can cross it.

In skin, keratinocytes (HKE) can function as transducers of environmental signals to the internal organic medium, converting external stimuli to proinflammatory cytokines. Particles interacting with HKE can, in theory, lead to changes, particularly with frequent contact, as in work situations. We must be aware that multiwalled CNTs can make HKE produce interleukin 8 and decrease cell viability in a dose and time dependency (53).

### **Digestion and absorption effects**

Nanoparticles/materials can readily be absorbed by the gastrointestinal (GI) tract. Translocation depends on the epithelial wall, the physiology of the GI tract, and the physicochemical characteristics of nanostructures. Hillyer and Albrecht (55) showed that diminished gastrointestinal uptake of gold nanoparticles administered orally to mice increased with the size of the particles, while Szentkuti (56), using different materials, showed that smaller particles are absorbed more readily and quickly than larger ones. Even coated materials, such as iron, can be absorbed passively, depending on the nature and size of the particles and the thickness of coatings (57), a property that could be used for the treatment of deficiency disorders or nutrient replacement for athletes. Reaching the capillaries, nanostructures could be carried to the liver by portal circulation or the lymphatic system. Larger particles (> 30 nm) tend to stay in the GI tract, but smaller ones are better distributed to organs such as the kidneys, liver, lungs, etc. Excretion/elimination depends on characteristics similar to those of absorption. Positive surface charges tend to increase elimination in urine and feces (58).

Some other potential effects merit reporting. The absorption of nanomaterials, especially metals, is not new to human history and can occur through the GI mucosa, reaching neurons and causing neurotransmitter release. Tachykinins are considered to be involved in some of the important aspects of nanoparticles associated with irritable

bowel syndrome, and a conducive genetic environment could explain the etiology to be clarified. The same may be true for Crohn's disease, ulcerative colitis, and even colon cancer. There have been descriptions of patients in which nanoparticles are near the cells (15).

### Neurological, endocrine, liver, and other organ effects

Inflammatory changes and OS in cortical regions were described, produced either by absorption via the olfactory nerve or nanoparticles crossing the blood-brain barrier (BBB). Several metal nanoparticles, fullerenes, and quantum dots can penetrate the barrier and have been associated with degenerative changes consistent with conditions such as Parkinson's and Alzheimer's diseases when there is exposure to high levels of environmental pollution, diesel exhaust, and nanoparticles. Changes at the neuromuscular junction associated with metal nanoparticles of 10 to 20 nm have also been described, making possible explanatory mechanisms for diseases of the motor plates (59).

Arriving at the circulatory system, several nanoparticles and nanomaterials can regularly reach organs of the hematopoietic system, depending on the volume of blood flow, binding with or even accumulating in them. This phenomenon can be used for the diagnosis or treatment of neoplastic liver conditions, for example. Similarly, exploring the little intercellular adhesion of the vascular neof ormation of cancers, there may be a tendency for nanoparticles to migrate to these regions and integrate into the tumors; this depends on the dimensions of spaces and pressures against nanomaterial drive but can occur even for particles without specific antibodies.

Dutta *et al.* (60) studied the 5th-generation poly (propylene imine) dendrimer (PPI), a hemolytic and cytotoxic amino terminal dendrimer, *in vitro*. PPI was compared with TPPI, the same dendrimer with the amino group "concealed" by t-Boc (tert-butyloxycarbonyl terminal), which is basically noncytotoxic and nonhemolytic; with MPPI, where mannitol did the same thing, with negligible hemolytic capacity and cytotoxicity to HepG2 and COS-7 cells; and with TuPPI, with tufsin, a tetrapeptide that activates macrophages, monocytes, and polymorphonuclear leukocytes by binding to these cells and promoting phagocytosis (to increase clearance of the product from circulation). The four dendrimers were studied *in vivo*, given to mice in three doses each, with blood samples analyzed and pathology studies performed at 24 hours and 15 days. A decrease in red blood cells and changes in hematologic parameters were the observed effects with PPI, but not with other dendrimers. The same held true for liver enzymes. The liver structure showed signs of degeneration in the first 24 hours, with recovery after 15 days of PPI use. The other dendrimers—TPPI, MPPI, and TuPPI—showed no changes after 24 hours. PPI toxicity was dependent on the terminal amino group and can be reduced with appropriate functionalizations. This is of great interest for the use of nanomaterials as drug carriers and for general assessment of biocompatible dendrimer production.

In a subchronic inhalation exposure study of silver nanoparticles, Sung *et al.* (61) showed ductal hyperplasia in male and female rats subjected to high concentrations. Besides these changes, nanoparticles have been found in known histopathological studies of liver diseases – for example, granulomas resulting from a treatment with colloidal gold, and carcinomas (15).

Gopalan *et al.* (62) demonstrated the sperm toxicity of ZnO and TiO<sub>2</sub> nanoparticles. They performed comet assay in germ cells with and without exposure to UV light and observed a reduction in DNA from particle action, with little additional effect from UV radiation. Ramdhan *et al.* (63) show the mechanisms whereby exposure of rats to low levels of diesel exhaust-rich nanoparticles (NR-DE) may increase plasma testosterone, while high levels do not. Medium or low exposure to NRDE for one to two months significantly increased steroidogenic acute regulatory protein (StAR) and side chain cleavage of the cytochrome P450 m-RNA (P450scc) and its protein expression in rat testes, where the elevation pattern was similar to that of plasma testosterone levels. The two exposures increased expression of the growth hormone (GH) receptor in the testes. Low exposure also increases m-RNA of testicular IGFI 1 and m-RNA of liver microsomal cytochrome P450 2C11 and its protein levels in rats. Increased expression of StAR and P450scc GH signaling pathways may regulate reproductive toxicity and interfere with the biosynthesis of testosterone from exposure to NR-DE.

In a review, Mcauliffe and Perry (64) found nanostructure effects in germ cells and/or other testicular cells. There were *in vivo* and *in vitro* studies with nanosilica, molybdenum, magnetic silicon oxide, latex, oral gavage with polymethylmethacrylate (PMMA), aluminum, and polyvinyl acetate with magnetite. In general, nanoparticles can cross the testicular barrier, bind with affinity to sperm mitochondria, and cause dose dependent cytotoxic effects; silver nanoparticles are the most toxic of those studied, and molybdenum nanoparticles the least toxic.

Nanoparticles of cadmium oxide, calcium phosphate, and gold infiltrate intracellular organelles involved in ovarian steroidogenesis and interfere with follicular development and maturation *in vivo* and *in vitro*, which may

cause apoptosis in human granulosa cells (65), leading to deregulation of estrogen and progesterone production. Hinthner *et al.* (66) found, in amphibians, that QD and silver nanoparticles in the presence or absence of T3 altered gene expression of thyroid hormone.

In an *ex vivo* human model, Wick *et al.* (67) studied whether polystyrene fluorescence beads of 50, 80, 240, and 500 nm could cross the placenta. They were able to demonstrate that plastic nanoparticles of up to 240 nm can do so. Over time, the marker tends to diffuse into tissues and be released. The placenta remained viable, which can be observed by glucose consumption, lactate production, human chorionic gonadotropin (HCG), and leptin in the fetus and placenta. A recent study by Keelan (68) with mice showed that nanoparticles/materials of up to 80 nm can cross the placenta and accumulate in the fetus. There may be changes in growth, but this can be reversed by modifications in surface particle charge. Nanoparticles/materials with surface amino or carboxyl groups were not absorbed by the placenta, which may be of great importance for future nanostructured drugs.

## ■ Nanotechnology in food: Important population exposure factor

Nanofoods are foods that have been grown, produced, processed, and/or packaged using nanotechnology techniques or tools, or to which manufactured nanomaterials have been added (69). Nanotechnology is already an integral part of the food production chain and can be used in: a) agriculture and livestock—where nanosensors can monitor soil conditions (pH, minerals, etc.) and crop growth; nanochips and nanosensors, which can detect animal and plant pathogens, preserve identity, and be used for tracking; nanodevices, which can deliver growth hormone, vaccines, DNA, fertilizers, and pesticides in a controlled fashion; and drugs, hormones, and vaccines for cattle; b) food processing—with nanoparticles being used as viscosifying agents or for removing selective pathogens and chemicals from food; nanoemulsion, used to add further dyes, stabilizers, flavonoids, and coenzyme Q10, and other compounds for better nutrient availability and dispersion, making it possible, for example, to produce foods with low lipid content that can retain their texture and taste; nanocapsules that improve the bioavailability of nutraceuticals and carry flavor enhancers; and the production of customized foods for patients with allergies and other illnesses and to satisfy aesthetic smell, taste, and color preferences; c) food packaging—with the use of nanofilms to prevent gas spoilage and absorption, or internal coating, producing lighter, stronger, or heavier packages; antibacterial and antifungal surface coatings with nanoparticles; and nanosensors for detecting chemicals and foodborne pathogens; d) food preparation and cooking: pots and pans—especially in the use of nanomaterials with antibacterial coating on pots and dishes; e) food preservation—besides packaging and production, with extensive use of nanosilver and other nanometals; and f) special supplements—such as nanosize powders to enhance nutrient absorption, and nanocapsules made of biological components such as vegetable proteins, to deliver important metals directly to humans without the need for their transport by intestinal enzymes, since they can cross cell membranes (5,57,70,71,12).

It is very important to recognize that many of the nanomaterials or nanoparticles used may not be soluble and may entail significant or unknown risk, and that the amounts already consumed can be quantified in the hundreds of tons. A potent antimicrobial, nanosilver is heavily present in many kinds of food-related equipment and devices and can, at least theoretically, be transported to food, as can other packaging components (nanocarbon materials, metals, nanoclay, etc.). All nanofoods must be carefully analyzed for safety and environmental impact (72).

Some of the most important food chains to monitor are those of dairy products, meat, and foods consumed by children and pregnant women (73). From the farm to the table, the risks to these groups are magnified. Major food companies are currently investing in nanofoods and may be introducing them into the market, even without the knowledge of regulators. Top food industries have conducted special research on flavor enhancers and modifiers, and cookies, ice cream, beverages, and many dairy products may already be in use or in the industry pipeline to the market. Devices that can instantly convert dirty water to potable water were developed using nanofilters, but knowledge about the transfer of nanoparticles from filters, packages, etc. to food is still in its infancy. Regulation is the way to halt the marketing of products with a dubious toxicology profile, as in the case of nanofoods, especially for children and pregnant women.

## ■ Difficulties in the workplace and general environment: Security, borders, end-points, measurement of nanoparticles and nanomaterials, and environmental impacts

Measurements must be taken both before and after manufacturing equipment is turned on; additional measurements after production begins could make it possible to differentiate exposure time. Though it would not prevent occupational exposure, at different times of the assessments it might facilitate the use of restrictions at each point. Problems still remain, however. In the case of nanomaterial production, a third general component enters the system: the very nanomaterial produced. The result is a series of unintentional internal and external nanoparticles and intentional nanomaterials generated in production. Ideally, the amount of particles to which an individual is exposed should be determined, but the question is, what should be measured? All nanoparticles and nanomaterials? There are devices that measure the curve number distribution of nanoparticles and nanomaterials, even the distribution curves of surface areas (74). It must be remembered, however, that, as far as it is known, an extensive number of parameters of each particle/material must be measured to determine the potential effects. Should every parameter be evaluated for all types of nanostructures found?

Maynard and Aitken (75) demonstrated some of the most important measures that must be taken in addition to particle number—namely, length, surface area, mass, solubility, fibrousness, etc. They understood that the parameters for each of these aspects must be evaluated to predict risks to human health. Despite the logic of the need for physical knowledge of compounds, which have several properties in terms of their physical structure, this poses a new and serious problem for occupational health. It must be known whether it is technically and economically feasible to measure these parameters throughout the evaluation. In a universe of thousands or millions of particles, with a mix of external and internal environments and intentionally produced particles/materials, it is unlikely that all the parameters can be established. As mass may be not enough in the case of nanoparticles and nanomaterials, and timing may pose questions about their air dynamic, it is essential to understand the work organization. Since workers' exposure is greater than the general population's, exposure scenarios are critical. Nanoparticles may persist in the environment, and the older the nanoparticles/materials, the farther they may have traveled, the greater the tendency to change, bond with contaminants, and disagglomerate, and the greater the possibility of bonding with background particles. Thus, classifying NOEL (No Observable Effect Level), LOEL (Low Observable Effect Level), OEL (Observable Effect Level), and other toxicological classes may be difficult.

With little international nanotechnology regulation in the workplace (apart from some general rules for worker protection), what is often found is self-regulation by several companies (*soft law*) and the general recommendations of the ISO Committee (ISO/TS 229) and Organisation for Economic Co-operation and Development (OECD) (76). Some companies have adopted these regulations, particularly in the production of carbon nanotubes, including the determination of internal exposure limits and actions on self- and general safety. The transatlantic debate and different levels of government regulation on workers' protection are intended to reduce the risk to workers, especially when the products are subject to the Regulation on Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH), the structural foundation of EU chemical regulation, in addition to those established by the German government, to take but one example. In the United States, the National Institute for Occupational Safety and Health (NIOSH) has a dedicated nanotechnology area and has issued recommendations on work limits (OELs) for some nanoparticles and materials (based on quantitative risk assessment using animal models—QRA) (77,78,79).

NIOSH is conducting a large number of studies on work space, measuring the risk and toxicity of nanostructures. This is of great importance worldwide, because many countries opt to use all or part of the U.S. threshold values in their own legislation (80). Among these studies, NIOSH has developed a technique for measuring nanoparticle emissions (NEAT) that uses a combination of techniques and measurement instruments to assess potential inhalation exposure in places where workers handle or produce engineered nanomaterials. Two aspects are critical for NEAT: a) portability: with direct reading instrumentation, and b) sampling-based filtering, which supplements the reading (specific filtering by source and personal breathing zone). The method is based on counting nanoparticles with nanocounters in many locations and at many times before, during, and after work, designating special locations and times for the count. When the principal locations of discharge are known, the use of filters to collect specimens is very important and has two purposes: to determine the specific mass of the material and to send the material for characterization by physical and chemical methods, including electron microscopy and X-ray diffraction. These methods, however, are focused on nanomaterials and do not reveal all the characteristics of unintended nanoparticles in the work environment (74).

This and other similar approaches are expensive and require sophisticated equipment. Control banding (CB) approaches are being promoted for countries and institutions as an alternative, with apparently good results. In general terms, CB involves plotting the potential risks of the nanoparticles involved (or the bulk chemicals with the same composition, plus a correction factor), based on the literature and other types of scientific knowledge, and the emission potential of the physical form of the material, yielding control classes that can be distinguished and indicate groups of safety measures to adopt (81). Measures range from personal protection to table hoods, fume hoods, and continuously closed systems to rethinking of the production process with experts. Very small materials with the potential to cross the skin barrier, such as fullerenes and quantum dots, for instance, may call for the use of skin protection and full-protection virus filters similar to those with a higher power to retain particles with values of  $< 100$  nm and  $> 500$  nm, and less for those  $> 100$  and  $< 500$  nm (82).

The advantages of the new properties offered by nanomaterials are so great that the consumer society is embracing them ever more rapidly. In addition to over a thousand everyday products that contain nanomaterials (The Project on Emerging Nanotechnologies, 2011), whose production involves the potential exposure of workers, in more traditional workplaces, where metal fumes, grinding, cutting, and the preparation of mixtures are common, risky nanoscale byproducts can be produced.

There are more challenges in studying workplaces. The outside environment may be polluted with nanoparticles that may enter the workplace. Even before the raw materials are received, workplace combustion machinery may generate nanoparticles when burning fuel. The work environment may have a mixture of foreign and occupational nanostructures before production even begins (74). It is very important in nanotechnology-related occupational and environmental health to distinguish between the health effects of intentional nanomaterials, nanoparticles derived from the work process (by-products), and external nanoparticles imported into the work environment. In the case of nanoscale structures, there are intra- and extra-occupational worker exposures, among them: a) those that occur prior to work, with unknown predetermined effects that facilitate a present or future effect; b) bioaccumulation, in many cases with no way of determining whether the exposure occurred at work or outside of it; c) multiple exposures. The obstacles can increase when health impact protocols are designed to mitigate only the impact of occupational nanomaterials (83).

In general, it is impossible to distinguish the clinical and laboratory end-points of anthropogenic and nonanthropogenic nanomaterials. OS, inflammatory and thrombogenic potentials, the risk of accumulation in neurological, liver, and testicular tissue, and the potential for respiratory effects do not appear to be exclusive to any of these types of structures. Some may present some specific toxic potential due to their chemical composition, physical structure, or even any of their particular characteristics; this seems to be the case for the dimensional characteristics of asbestos-like CNTs. Nevertheless, whether or not the exposure scenarios are unique, combining intra- and extra-work life, the end-points suggested are particularly those related to cardiovascular disease (CVD) and metabolic syndrome (MS). Furthermore, when exposure to respiratory hazards is recognized, specific pulmonary assessments, emerging only very recently, indicate something broader (84,85).

In any case, attempting to identify the agent that causes damage through a general assessment of risk factor profiles may be helpful, but without specificity, promising results won't have an impact on morbidity and mortality in the short term. In any case, proposals targeting workers do not generally deviate from the recommendations for the general population and/or workers in terms of CVD and MS.

Some relationships between the environment and nanotechnologies should be noted. Nanoparticles/materials have been used both to purify water and remediate environmentally impacted areas. Whether the impact is caused by metals, or even solvents, oils, etc., the large surface area and reactivity of nanomaterials may cause them to have greater reactivity with the impact material than the environment they are in and promote its removal. Water can be cleaned by magnetic, lipophilic, and hydrophilic properties and the destruction of contaminants from the high catalytic efficiency of some appropriate nanomaterial (86,87,88,89).

As seen below, some nanomaterials/particles can be toxic to biota and interfere in the entire ecosystem in ways as yet unknown. Ideally, considerable effort must focus on the life cycle of nanomaterials, from synthesis to their destruction or reuse. Therefore, it is not enough that a nanomaterial is used as the basis for food packaging and cannot reach the initial consumer of the food. That packaging may undergo further changes after use and be physically affected, transferring the materials to other humans and biota. What is troubling today is the apparent widespread use of silver nanoparticles in various types of clothing and the disposal of such products (90). Where are the nanoparticles going and how? What products are most at risk? A myriad of scenarios must be designed and influence production and consumption.

Some studies have assessed the toxicity of nanomaterials to biota. Nielsen *et al.* (91) showed the interesting effect of CNTs on brown alga (*Fucus serratus*). They found that the zygote is covered with CNT agglomerates, which can prevent the zygote from being fully crossed by light, which is critical for alignment of the polar body axis. In another survey of aquatic species, Moore *et al.* (92) showed the rupture of phagocytic blood cells (hemocytes) in marine clams when exposed to fullerene C<sub>60</sub> and CNTs. Lovorn *et al.* (93) showed the presence of gold nanoparticles in the gut of *Daphnia magna*, an interesting planktonic crustacean that can be analyzed because of the transparency of its structure. Particles were observed in the intestinal lumen and microvilli. However, analysis of toxicity in these environments entails some difficulties. Using *in vitro* dilutions of nanomaterials for toxicity assessment of cell cultures or aquatic biota, the hydrodynamics of the nanostructures can cause only part of them to be in contact with the cells or biota in the study. The concentration in solution is not the same as that to which animals, plants, cells, etc. are actually exposed. This can be controlled in cell cultures with permeable beds arranged on different cameras, but it would always be more difficult on free and mobile biota.

Controlling the hazards and risks posed by nanoscale merits international efforts and an agenda that recognizes the urgent need for greater knowledge and action for work settings, the general population, and the most varied environments. Monitoring using sentinel animals, or even nanosensors, helps, but only after the fact. Controlling nanoparticle emissions from industrial equipment and vehicles is important. The use of silver, for example, is probably very extensive, as is that of carbon nanotubes. The environment could be increasingly affected by the production of tennis racquets with CNT or special T-shirts with nanosilver particles instead of relevant uses for health and safety. The precautionary principle must be applied.

## ■ Governance and regulation in nanotechnologies

### Questions for political decision makers

“Governance” is what a government does—that is, the act of governing. It consists of isolated management processes, leadership, or parts thereof, including systems run by large companies or governments. When targeting a sector, an area of knowledge, or a specific public, policy must be consistent with the guidance provided for each area of responsibility. Corporate management, for example, may involve privacy policies on internal investment and the uses of information. On the other hand, in order to address the population’s wishes when setting rules and standards and to establish the ways in which such rules and standards are applied, governance is an area that must be administered by governments on behalf of States (94).

The arguments for decision markers stem from certain assumptions (95):

- a) Nanotechnologies do not represent a single productive sector but should be viewed as a whole, as a technology platform, representing a new technology revolution in industrial capitalism.
- b) The dynamics of nanomaterials bolster the platform concept. The same material can have multiple uses in dozens of industries and require interdisciplinary groups of experts for its design and development.
- c) A nanomaterial can have multiple modes of production. However, the modes of production, aim of production, and the materials themselves may lead to differences in the final product.
- d) A nanotechnology product may result from cognitive interaction among various disciplines, making it a genuinely transdisciplinary object, or represent far less sophisticated processes.
- e) Mass use of nanotechnology will probably be a reality by 2020.

In the governance of nanoparticles, nanomaterials, and nanotechnology products, there must be general control mechanisms dictated by society and expressed in public policies and regulations for governmental and nongovernmental organizations, including regulatory agencies.

What does the general public think about potential impacts? Scheufele *et al.* (96) show that several factors can interfere with this understanding. One such factor is apparently the greater familiarity of scientists with scientific issues. They found that scientists perceive more benefits and risks to health and the environment than the general public does. Cacciatore *et al.* (97) studied the American public and found that it made the following associations with nanotechnology, in descending order: medicine, equipment, the military, privacy, products, the environment, bioengineering, and sports.

And what is expected in nanotechnology in the decades to come? Would agencies handle major difficulties? As Renn and Roco (98) show, there is an evolutionary process in nanostructures, which move from first-generation passive products to second-generation active structures (they actively seek out specific locations, certain flows, target organs, etc.), molecular nanosystems (sized from atomic and molecular design), and systems of nanosystems.

To deal with these changes, researchers and society must tackle some important issues, such as the following.

### Questions for researchers and society to improve regulatory processes and decision-making

Even today, for most countries, the gap between investments in the development of nanomaterials and investments in environmental health and safety (EHS) and in studies of the ethical, legal, and societal issues (ELSI) related to nanomaterials is so wide that there is a tremendous lag between nanoprodukt development and knowledge about EHS, which may give rise to regulatory concerns (99). Whether or not such investment gaps remain, the lags are increasing, rendering any regulatory mechanisms obsolete. Market expansion and production trends aside, as thinking about governance evolves, EHS and ELSI should also be taken into account.

Bosso's (100) observation about health regulation is therefore relevant. He states that, given the inability of regulatory agencies to compel the necessary assessments of traditional chemicals, it is unlikely that regulators will be able to meet the regulatory demands of nanotechnology, but instead will adopt new approaches to governance related to the introduction of new substances in the market.

Bosso's (100) contention about the lack of evaluation appears to be defensible. Less than 10% of the regular non-nanotechnology compounds in the U.S. market underwent the extensive testing required to learn about a major portion of the potential chronic effects on the general population, the environment, and workers. If this figure is so low in the most scientifically and technologically developed country, many of whose established thresholds are directly embraced by several countries (80), the situation in other countries may be even worse. Despite the growing social commitment of the past 10 years, especially on the part of governments and international organizations made up of governments, much remains to be done. Complex molecular nanosystems (electric car systems, agricultural systems, sensors, etc.) with components based on bottom-up technology can multiply the potential benefits and concerns. Likewise, nanotechnology could help mitigate some global problems. However, there are concerns about the growing technology gap between economically developed and developing countries (101). Country interests should be respected, and it is therefore essential to change the traditional result of promoting needed smaller benefits while potentially furthering damage. Finding a solution may be difficult, but the effort must be made. In this sense, governance and social commitment call for:

- An explicit system to include ELSI in governance.
- Advances in toxicological evaluation, risk assessment, and mitigation (modeling?).
- Development of a multidisciplinary knowledge base to set up the innovation chain, from discovery to design, and, hence, its social use.
- Creation of an international naming and patent nomenclature.
- Strengthening of broader approaches aimed at developing tools, people, and organizations charged with the responsibility of taking advantage of new technologies.

In order to meet these challenges, four simultaneous characteristics of nanotechnology governance have been proposed (102). Governance should be:

- Transformative (including results-oriented projects focused on investment policies; science, technology, trade, education, and training policies; instruments for economic and technological integration).
- Responsible (including EHS and ELSI, participatory communication, methods for risk governance, regulation, and equitable access to benefits).
- Inclusive (participation by all interested sectors and organizations; partnership building).
- Visionary (including planning and a long-term vision; it should be adaptive, proactive, and support human development and sustainability). Governance must therefore be anticipatory.

However, it is a long way from proposal to achievement. Changes must take place. Although regulatory agencies traditionally need a large body of evidence for decision-making about chemical risks and it can take many years before they have a database on hazards and risks that they consider sufficiently reliable for decision-making, they

must change. The institutional competence to anticipate risks and gather enough information to make decisions about risks and defend against them should be questioned (103). The dilemma here is how to take anticipatory steps focused on risk, prevention, and institutional governance, especially when available data on the science of regulation are scarce.

The assumption is that the people who invent, design, synthesize, manufacture, incorporate into products, use, regulate, hold, or recycle chemicals and other materials, including nanoscale materials, often do not have enough information (including but not limited to information on the physical and chemical properties, life cycle, dangers, ultimate fate, exposure, inputs [energy, raw materials], and emissions) to make decisions that would enable these materials to be designed, produced, and maintained in an environmentally and socially sustainable manner (101). Nevertheless, such people are commonly found at the top tier of regulatory decision-making.

Anticipatory governance by itself has little possibility of evolving. However, major contributions, such as mathematical modeling of nanoparticles (104), emerging knowledge from evidence-based toxicology, alternative methods in toxicology studies, the search for a human toxoma (105), and the recent reform of the Toxic Chemical Substance Act (TSCA), together with the progress of REACH in Europe, are fostering innovative approaches to project evaluation aimed at “green” production of nanomaterials and products. All of this is part of a major transnational movement toward sustainability with interdisciplinary integration, including the humanities and humanistic work in nanosciences, with more training and participation by consumers and workers at decision points in a critical path toward change. Political and technical uncertainty are still a reality; thus, there must be no backtracking if progress is to be made toward an anticipatory, social, pluralistic, and participatory effort backed by strong scientific and technical fundamentals to protect human health and the environment.

## ■ Conclusions

Nanotechnologies offer great promise for transforming the 21st century and can serve as an inter/transdisciplinary matrix to foster scientific and technical reconfiguration of the materials with which products are manufactured every day. More than a group of techniques, they represent the typical environment for interaction among the different fields of knowledge, and it may be hard to group their products under the classic areas of knowledge and practice.

As noted, they may pose different risks and dangers depending on the structures and scenarios involved. Hazards and risks are dependent on the path taken and have a long history. And, while not absolute, this relativity entails the responsibility of being able to differentiate between hazards and risks at different stages of production processes when the object is workers' health; at different stages of consumption, when the object is population and consumer health; and in disposal, reuse, and new uses when the questions are multidimensional—work, consumption, and environmental impacts.

In addition to the care mentioned throughout the text, there are two major dangers that could easily translate into population risks if the vulnerabilities and differences between peoples, countries, and cultures are not reduced or eliminated: education and patents/intellectual property.

Nanotechnology appears to be irreversible. It is here to stay and must be understood as an advanced production platform. There is widespread consensus, therefore, that safety data are necessary before products are put on the market. However, what the necessary data consists of should be a political decision made by the competent authorities of States or groups of States after consulting the various stakeholders, workers, consumers, producers, researchers, regulators, legislators, and so forth. There are no pure techniques that can guarantee complete safety. When well-established, there holds—that is, critical points where the likelihood of a harmful incident increases—are only indicators of risk; in other words, probabilistic trends. Even for nonstochastic risks, which set limits with safety factors, some uncertainties are inherent to science, while others are due to measurable techniques and practices.

In light of this, more relevant participation by the population requires some understanding of invisible risks (which, in themselves, are nothing new to people who have always lived with them). The critical issue here is to provide basic tools for understanding to promote the free and informed participation of the population. This is fundamental to a better, more integrated North-South and South-South relationship and to broadening decision-making processes that can impact the lives of everyone. Inclusive decision-making processes will require increasingly better-educated populations if the public is actually to participate in decision-making. Guaranteeing the democratization of access to high-quality education is the first step toward better decision-sharing among nations.

Industrial property and patents can be a great economic stimulus or a factor in economic stagnation. Return for the guarantee of high investment for a time can ensure that investments continue to be made. However, the many patents in place in certain lines of business can reduce the potential for new developments, with the cost of each new step increased by patent costs, which stifles creativity and production. Also important in this context is the growing concentration of nanotechnology patents in the United States, where more of them are issued. From 2004 to 2010, there was a 14% to 19% increase in the patents issued to the top 10 patent-obtaining industries, and a 20% to 27% increase among the top 20, indicating a trend toward greater concentration that, if not halted by firm public policies, could reverse victories in the preservation of human and environmental health (77).

It is therefore time to seriously tackle two of the main problems we face: good education and the excessive centralization of political power. New thinking about nanotoxicology calls for the design of new milestones to move beyond the usual questions. And new questions elicit new responses that must point the way to protecting the health of workers, consumers, and the environment in general.

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## ■ Notes

- 1 **Agglomerate** - Set of weakly bound or freely joined particles, where the total specific surface area of the

agglomerate is similar to the sum of the particles separately.

**Aggregate** - Set of merged or tightly bound particles, in which there is a reduction of the total specific surface area compared to the sum of the particles' areas separately.

**Nanofiber** - A nano-object or nanomaterial, rigid or flexible, with two external dimensions at the nanoscale and a third, much greater dimension. The size difference between the two smaller dimensions must be less than three times and between them and the bigger, greater than three times. The larger size need not be in the nanometric scale.

**Nanomaterial** - Material with any external dimension on the nanoscale or having internal or external structure on the nanoscale. For some, the term "nanomaterial" has the same meaning as nano-object or even engineered nanomaterial, as distinguished from what is intentionally produced (nanomaterial) and what is unintentionally produced (nanoparticle).

**Nano-object** - A material with one, two, or three external dimensions at the nanoscale. For some, the same as nanomaterial, engineered nanomaterial, or nanostructured material.

**Nanoscale** - Considered in various international documents to be the scale from 0 to 100 nm and should be understood in relative terms. Some products that are important in cosmetology, for example, may have changing characteristics of the nanoscale, as around 300, 200nm. Others only reach values well below 100 nm.

**Nanotube** - A hollow cylindrical nanomaterial. Although the best-known materials produced are carbon nanotubes, others are produced from different materials.

**Ultraparticle** - Name given to nanoscale particles. For some, it should be smaller than 100 nm; others have accepted higher values, being the name associated with particle properties.



# Recreational water environments and health

Henry Salas

## ■ Introduction

There are enormous benefits to the mental and physical health and general well-being—rest, relaxation, and exercise—associated with the use of recreational water environments. The protection, proper management, and safe operation of natural coastal and freshwater recreational environments, as well as artificial recreational water environments (i.e., swimming pools, spas, and the like) are critical and imperative for minimizing the risk of potential adverse health impacts from the use of these environments. A negative health outcome attributed to sewage-contaminated recreational waters can also inflict a mortal blow on tourism, which is the economic mainstay of many countries, especially tropical island nations such as those in the Caribbean. The economic impact would not only affect employment but limit resources for basic services, including water and sewerage infrastructure, jeopardizing the overall health of the local population, which would also be deprived of safe recreational water environments.

## ■ Recreational water illness

As defined by the U.S. Centers for Disease Control and Prevention (CDC), recreational water illnesses (RWIs) are caused by germs spread by swallowing, breathing in mists or aerosols of, or having contact with contaminated water in swimming pools, hot tubs, water parks, water play areas, interactive fountains, lakes, rivers, or oceans. RWIs can be a wide variety of infections, including gastrointestinal, skin, ear, respiratory, eye, neurologic, and wound infections. Diarrhea is the most common RWI, often caused by germs like *Crypto* (short for *Cryptosporidium*), *Giardia*, norovirus, *Shigella*, and *E. coli* O157:H7. Children, pregnant women, and people with weakened immune systems are most at risk for RWIs.

The GESAMP/WHO study (1), based on global estimates of the number of tourists who use recreational waters and WHO estimates of the relative risks at various levels of contamination, estimates that bathing in polluted seas causes some 250 million cases of gastroenteritis and upper respiratory disease each year. Some of the people who contract these infections will be disabled over the longer term. The global impact can be measured by adding up the total years of healthy life lost through disease, disability, and death using the disability adjusted life years (DALY) measurement developed by WHO and the World Bank. This calculation reveals that the global burden of disease incurred by bathing in the sea is some 800,000 DALYs, comparable to the global impact of diphtheria and leprosy. Estimates put the cost to society, worldwide, at about \$2.4 billion per year, as presented in Table 29-1.

A study of gastrointestinal illness at 28 beaches spanning 160 km of coastline in Los Angeles and Orange Counties USA, in 2000 (2) concluded that each year, fecal contamination at Los Angeles and Orange County beaches caused between 627,800 and 1,479,200 excess gastrointestinal illnesses, with a public health cost of \$21 to \$51 million (in year 2000 dollars).

**Table 29-1.** Global human disease burden and associated economic cost from exposure to marine waters and shell fish contaminated with enteric microorganisms

<i>Cause</i>	<i>Disability-adjusted life years</i>	<i>Corresponding economic losses (rounded) in \$ millions</i>
Marine exposure		
Contaminated recreational waters	400,000 - 800,000	1,200 - 2,400
Contaminated shellfish	3,500,000 - 7,000,000	10,000 - 20,000

**Source:** Shuval, H.I. 1999. Scientific, economic and social aspects of the impact of pollution in the marine environment on human health - a preliminary quantitative estimate of the global disease burden. Unpublished report prepared for the Division on the Protection of the Human Environment, World Health Organization and GESAMP, 28 pp. (14 August 1999).

Ralston, *et al.* (3) suggest that health consequences in the United States from marine-borne pathogens have annual costs on the order of \$900 million, \$30 million of which is from direct exposure to the *Vibrio* species, and \$300 million, to gastrointestinal illness from beach recreation.

## ■ Recreational water environments

### Uses and risks: Coastal and fresh water

Recreational uses of inland and marine waters are increasing in many countries worldwide. These uses range from whole-body water contact sports, such as swimming, surfing, waterskiing, jet skiing, windsurfing, paddling, whitewater canoeing, sub-aqua diving, and therapeutic uses, to noncontact sports, such as fishing, boating, walking, bird watching, and picnicking. The U.S. Census Bureau (4) reports that in the United States, there were approximately 301 million swimming visits each year by persons over the age of 6 in 2009; 36% of children aged 7-17 and 15% of adults in the United States go swimming at least six times per year.

The risks associated with the use of recreational water environments entail various types of hazards, including drowning and injury, microbiological risks in water and sand resulting in RWIs, exposure to heat, cold, and sunlight, dangerous aquatic organisms, toxicity-producing algae in fresh and marine waters, and chemicals. Air can also be infected with pathogens from sewage-contaminated recreational waters.

The wastewater generated by coastal populations is usually discharged into the adjacent ocean. Common practice in many coastal cities in developing countries has been to discharge untreated wastewater into the nearest or most convenient body of water. Due to lack of economic resources, minimal consideration is given to the health and environmental implications of this practice. Raw sewage discharges have often occurred on or very near popular bathing beaches, causing gross beach contamination, with bacterial levels on the beaches sometimes approaching the levels of raw sewage. This can have aesthetic and ecological impacts in addition to potential health hazards, often resulting in severe economic consequences due to curtailed tourism. This health risk can be managed by the way in which sewage is discharged, as discussed later in this chapter.

### Uses and risks: Swimming pools and similar environments

Recreational use of swimming pools includes swimming, exercise, water sports, and overall diversion. The term "swimming pool" applies to pools supplied with fresh, marine, or thermal water, whether indoors or outdoors; public, semipublic, or domestic; supervised or unsupervised. Similar environments include hot tubs, Jacuzzis, whirlpools, natural spas (facilities using thermal and/or mineral waters), bathhouses (hammams), and so forth. for general relaxation, therapeutic uses, etc. "Hot tub" is the general term used for a variety of facilities designed for

sitting; they contain treated water, usually above 32°C, are often aerated, and are not drained, cleaned, and refilled for each user.

Except for the exposure to hazardous marine and freshwater organisms, the health risks associated with the recreational use of swimming pools are similar to those of natural water environments—more specifically, drowning and injury, microbial contamination, and exposure to chemicals. As a contained water body, a minor release of fecal matter or vomit from a child, for example, could have a significant negative health impact, especially under deficient chlorine doses and residuals. Head and spinal injuries are especially prevalent in swimming pools due to irresponsible diving in shallow depths and horseplay. Drownings of unattended children are also a major problem.

In the past two decades, the number of RWI outbreaks associated with swimming pools has increased substantially. Crypto, which can survive for days even in well-maintained pools, has become the leading cause of swimming pool-related outbreaks of diarrheal illness. In the United States, reported Crypto cases increased by over 200% in the period 2004–2008 (from 3,411 cases in 2004 to 10,500 cases in 2008) (5).

Although Crypto is chlorine-tolerant, most germs are not. Keeping chlorine at recommended levels is essential for maintaining a healthy pool. However, a 2010 study in the United States found that 1 in 8 public pool inspections resulted in the immediate closure of the pools due to serious code violations such as improper chlorine levels (6).

### Facts presented by the CDC for the United States

The following information on healthy swimming and recreational waters in the United States is taken directly from the CDC's Healthy Swimming Fast Facts:

#### Swimming in the U.S.

- In the United States during 2009, there were approximately 301 million swimming visits each year by persons over the age of 6 (4).
- Thirty-six percent of children aged 7-17 years, and 15% of adults in the United States, swim at least six times per year (4).
- Swimming is the fourth most popular recreational activity in the United States (4).
- Swimming is the most popular recreational activity for children and teens (ages 7-17) (4).

#### Swimming Pools and Hot Tubs/Spas

- There are 10.4 million residential and 309,000 public swimming pools in the United States (7).
- Almost 1 in 8 (12.1% or 13,532 of 111,487) routine pool inspections conducted during 2008 identified serious violations that threatened public health and safety and resulted in an immediate closure (6).
- More than 1 in 10 (10.7% or 12,917 of 120,975) routine pool inspections identified pool disinfectant level violations. Chlorine and other pool disinfectants are the primary barrier to the spread of germs (6).
- There are over 6.6 million hot tubs in operation in the United States (8).
- About half (56.8%) of spas are in violation of local environmental health ordinances, and about 1 in 9 spas require immediate closure (11%) (9).

#### Germs and Outbreaks

- A total of 134 recreational water-associated outbreaks affecting at least 13,966 persons were reported to CDC for 2007-2008, the largest number of outbreaks ever reported in a 2-year period (10).
- *Cryptosporidium* (or Crypto) is an extremely chlorine-tolerant parasite that can survive in a properly chlorinated pool for 3.5 to 10.6 days (11).
- Of 81 recreational water-associated outbreaks of gastroenteritis during 2007-2008, 74.1% were caused by Crypto (10).
- Of 70 gastroenteritis outbreaks associated with treated (for example, chlorinated) recreational water venues, 82.9% were caused by Crypto (10).
- In 2007, Crypto caused a statewide recreational water-associated outbreak that affected approximately 5,700 persons (12).

- More than 1 in 5 (21.6%) of American adults do not know swimming while ill with diarrhea can heavily contaminate water in which we swim with Crypto and make other swimmers sick (12).

### Injuries and Drowning

- In 2008, almost 4,600 persons visited an emergency department for pool chemical-associated injuries. The most common injury diagnoses were poisoning, which includes ingestion of pool chemicals as well as inhalation of vapor, fumes, or gases and dermatitis/conjunctivitis. More than half of the injuries occurred at a residence (10).
- Drowning is the leading cause of unintentional injury death among children aged 1 to 4 years. Drowning is the second leading cause of unintentional injury death among children 5 to 9 years (13).
- More than 60% of fatal drownings of 0- to 4-year-olds occur in swimming pools (14).
- In the United States in 2009, almost 24 million individuals participated in motor or power boat activities (4).
- In 2010, 3,153 persons were injured and 672 died in recreational boating accidents (15).
- Of those who drowned in a boating accident, 88% were reported to not be wearing a life jacket (16).

## ■ WHO Guidelines for Safe Recreational-water Environments (GSRWE)

In 1994, the World Health Organization (WHO) embarked on the development of guidelines concerning recreational use of the water environment. Guidelines of this type are primarily a consensus view among experts on the health risks posed by various media and activities and are based on a critical review of the available evidence. The *Guidelines for Safe Recreational-water Environments (GSRWE)* that resulted from this process were published in two volumes: Volume 1, *Coastal and Fresh Waters* in 2003 (17) and Volume 2, *Swimming Pools and Similar Environments* in 2006 (18).

### Overview of the WHO GSRWE Volume 1 and Volume 2

Volume 1 of the GSRWE describes the state of knowledge in 2003 about the impact of recreational use of coastal and freshwater environments on the health of users—specifically drowning and injury, exposure to cold, heat, and sunlight, water quality (especially exposure to water contaminated by sewage, but also to free-living pathogenic microorganisms in recreational waters), contamination of beach sand, exposure to algae and their products, and exposure to chemical and physical agents and dangerous aquatic organisms. Control and monitoring of the hazards associated with these environments are covered as well.

Volume 2 of the *Guidelines for Safe Recreational-Water Environments* describes the state of knowledge in 2003 about the impact of recreational use of swimming pools and similar environments on the health of users—specifically, drowning and injury, microbial contamination, and exposure to chemicals. Control and monitoring of the hazards associated with these environments are discussed.

The primary aim of the *Guidelines* is the protection of public health. The *Guidelines* are intended to be used as the basis for developing international and national approaches (including standards and regulations) to controlling the health risks from hazards that may be encountered in recreational water environments, as well as providing a framework for local decision-making.

A synopsis taken almost verbatim directly from the Executive Summaries of the WHO GSRWE Volume 1 (17) and Volume 2 (18) follows. The reader is directed to the publications for details and the references cited.

### Drowning and injury prevention

Drowning is a major cause of death worldwide, particularly for male children. Near drowning is also a serious problem, as it may have life-long effects. Drowning may be associated with swimming as well as with recreational water uses involving minimal water contact, such as recreational use of watercraft (yachts, boats, canoes) and fishing. Alcohol consumption is one of the most frequently reported contributory factors associated with drowning for adults, whereas lapses in parental supervision are most frequently cited for children. In cold weather, immersion cooling may be a significant contributory factor.

Most studies of accidental drowning have focused on children, and in some countries drowning is the leading cause of injury deaths among younger age groups. It has been suggested that in terms of swimming pools and similar environments, most drownings occur in domestic pools and hot tubs, many while the child's supervisor assumed the child was safely indoors. Also of concern in swimming pools is the danger of drowning and near-drowning due to inlets and outlets where the suction is strong enough to cause entrapment of body parts or hair, causing the victim's head to be held under water.

Of sports-related spinal cord injuries almost exclusively located in the cervical vertebrae, the majority appear to be associated with diving. Data suggest that body surfing and striking the bottom are also common causes of spinal injury. Alcohol consumption may contribute significantly to the frequency of injury. Other injuries associated with recreational water use activities include brain and head injuries, fractures, dislocations, and other minor impact injuries, and cuts, lesions, and punctures.

Data suggest that diving into the upslope of a pool bottom or into the shallow portion of the pool is the most common cause of spinal injuries in pools. Education and raising awareness appear to offer the most potential for diving injury prevention.

Prevention is the best way to reduce the incidence of injury and death related to the aquatic environment, and the majority of injuries can be prevented by appropriate measures at a local level with the removal of physical hazards to reduce human exposure. Additional measures include drowning prevention programs, public information and warnings, the provision of effective lifeguard supervision and rescue services, and the establishment of different recreation zones for different recreational activities.

Few preventive measures for drowning and near-drowning have been evaluated, although installation of isolation fencing around outdoor pools has been shown by some studies to decrease the number of pool immersion injuries by more than 50%. Recommendations are given for pool fences around domestic pool and for domestic or outdoor hot tubs.

Preventive measures for hair and body entrapment in pools and similar environments include the use of grilles on drain gates that prevent hair entrapment, dual drains, and accessible and/or pressure-activated emergency shut-off for the pump and the wearing of bathing caps. Warnings displayed in the form of clear and simple signs as well as water safety instruction and adult supervision all may have value as preventive actions.

Causes of other injuries in swimming pools include slippery decks, uncovered drains, reckless water entry, running on decks, tripping on swimming aids left on the poolside and stepping on glass from broken bottles. Maintenance of surfaces (including appropriate waste disposal), supervision of pool users, providing appropriate warnings, ensuring good underwater visibility, and pool safety education are among the actions that can reduce these incidents.

High temperatures in hot tubs, for example, can cause drowsiness, which may lead to loss of consciousness or to heat stroke and death, and it is recommended that water temperatures in hot tubs be kept below 40°C. Exposure to low temperatures in plunge pools, which are used in conjunction with saunas or steam baths, may result in slowed heartbeat, hypothermia, impaired coordination, loss of control of breathing, muscle cramps, and loss of consciousness. Temperature extremes should be avoided by users with medical problems, pregnant women, and young children. Educational displays and warning signs, warnings from pool staff, and regulations on time limits for use can reduce these adverse outcomes.

### **Sun, heat and cold:**

The recreational use of water environments sometimes leads to exposure of individuals to extreme solar radiation and to extreme conditions of heat or cold. Overexposure to ultraviolet radiation (UVR) may result in acute and chronic damage to the skin, the eyes, and the immune system. The most noticeable acute effect of excessive UV exposure is erythema, the familiar inflammation of the skin commonly termed sunburn. Photokeratitis and photo-conjunctivitis are other acute effects of UV exposure. Chronic effects include two major public health problems: skin cancers (both nonmelanoma skin cancers and malignant melanoma) and cataracts. Chronic exposure to UVR also causes a number of degenerative changes in the skin (e.g., freckles) and accelerates skin aging. There is also increasing evidence for an immunosuppressive effect of both acute high-dose and chronic low-dose UV exposure on the human immune system.

Not all effects of UV radiation are adverse. The best known beneficial effect is the stimulation of the production of vitamin D in the skin. UVR from artificial sources is also used to treat several diseases and dermatological conditions, including rickets, psoriasis, eczema, and jaundice.

Simple protective measures are available and should be adopted to avoid adverse health effects on the skin, eyes, and immune system. These include minimizing the amount of time spent in the sun, including complete avoidance of midday sun exposure; seeking shade; and wearing appropriate woven clothing, hats, and wrap-around sunglasses. Furthermore, a broad-spectrum sunscreen with sun protection factor of 15 or more should be applied liberally on all areas of the body not covered by clothing and should be reapplied often. Sun protection programs to raise awareness and achieve changes in lifestyle are urgently needed to slow down and eventually reverse the trend towards more skin cancers. The global solar UV index is an important vehicle to raise public awareness of UVR and the risks of excessive UV exposure and to alert people to the need to adopt protective measures.

Exposure to cold water may cause considerable problems for users of recreational waters. The immediate effect of sudden immersion in cold water can be a debilitating reflex response called cold shock, which includes life-threatening respiratory and cardiovascular effects and may lead to drowning. Sudden immersion in cold water often results in impaired swimming ability, which is believed to be responsible for the majority of sudden cold-water immersion deaths. Safety precautions include wearing suitable protective garments when swimming in cold water and using a lifejacket when boating to keep airways clear of water even when unconscious.

In a hot environment, people can suffer serious physical ailments, such as heat cramps, heat exhaustion, and heat stroke. The very young, the elderly, patients using drugs that interfere with temperature regulation, people suffering from preexisting chronic diseases, and frequent consumers of alcohol appear to be particularly susceptible. Avoidance measures include consumption of nonalcoholic, noncaffeinated beverages, replacement of salt lost through sweating, and retreat to shaded areas. Disorders due to heat occur most frequently when there are rapid changes in thermal conditions, such as during heat waves.

## Fecal pollution and water quality

The most frequent adverse health outcome associated with exposure to fecally contaminated recreational water is enteric illness. A cause-effect relationship between fecal- or bather-derived pollution and acute febrile respiratory illness (AFRI), which is a more severe health outcome than gastroenteritis, has also been shown. There is consistency in the overall body of evidence concerning health effects from fecally polluted recreational waters. After an extensive review (19) of 33 epidemiological investigations conducted in marine waters worldwide, the World Health Organization (WHO) concluded that intestinal enterococcus was the best indicator organism related to disease burden. The guidelines of Volume 1 are based primarily on the controlled randomized epidemiological trial studies conducted in the coastal marine waters of the United Kingdom.

The initial classification of a recreational water environment is based upon the combination of evidence for the degree of influence of (human) fecal material (by sanitary inspection of beach and water catchment) alongside counts of suitable fecal index bacteria (a microbial quality assessment). Where human inputs are minimal, investigation of animal fecal inputs should be explored. The outputs from the sanitary inspection and microbial water quality assessment can be combined to give a five-level classification for recreational water environments—very good, good, fair, poor, and very poor. Following the initial classification, it is proposed that all categories of recreational water environment would be subject to an annual sanitary inspection (to determine whether pollution sources have changed) and continued water quality monitoring. This novel and perhaps obvious approach to recreational water environment risk assessment and management has taken root in the United States, Canada, and the European Union, among other countries.

Population groups that may be at higher risk of disease include the young, the elderly, and the immunocompromised, as well as visiting populations susceptible to locally endemic disease. If such groups are significant water users, then this should be taken into account in risk assessment and management.

Management action in response to a recreational water environment classification indicating unacceptable fecal contamination can be both immediate, such as public health advisories, and long-term, such as pollution abatement.

The risk of illness or infection associated with swimming pools and similar recreational water environments is primarily associated with fecal contamination of the water. This may be due to feces released by the bathers or contaminated source water or, in the case of outdoor pools, may be the result of direct animal contamination (e.g., from birds and rodents). Many of the outbreaks related to pools and similar environments have occurred because disinfection was not applied or was inadequate. Nonfecal human shedding into the pool water or surrounding area is also a potential source of pathogenic organisms.

Swimming pool-related outbreaks of illness are not as frequent as in coastal and fresh waters but have been linked to viruses, bacteria, protozoa, and fungi. Viral outbreaks are most often attributed to adenovirus, although hepatitis A, norovirus, and echovirus have also been implicated in pool-related disease outbreaks. It should be borne in mind that the evidence linking viral outbreaks to a pool is generally circumstantial, and the causative viruses have rarely been isolated from the water.

*Shigella* and *Escherichia coli* O157 are two related bacteria that have been linked to outbreaks of illness associated with swimming in pools. Symptoms of *E. coli* O157 infection include bloody diarrhea (hemorrhagic colitis) and hemolytic uremic syndrome (HUS), as well as vomiting and fever in more severe cases. HUS, characterized by hemolytic anemia and acute renal failure, occurs most frequently in infants, young children, and elderly people. Symptoms associated with shigellosis include diarrhea, fever, and nausea.

The risk of illness in swimming pools associated with fecal-derived protozoa mainly involves two parasites: *Giardia* and *Cryptosporidium*. In the United States over the past two decades, Crypto has been identified as the leading cause of swimming pool-related outbreaks of diarrheal illness. These two organisms have a cyst or oocyst form that is highly resistant to both environmental stress and disinfectants. They also both have high infectivity and are shed in high densities by infected individuals. Giardiasis is characterized by diarrhea, cramps, foul-smelling stools, loss of appetite, fatigue, and vomiting, whereas symptoms of cryptosporidiosis include diarrhea, vomiting, fever, and abdominal cramps.

The control of viruses and bacteria in swimming pool water is usually accomplished by appropriate treatment, including filtration and the proper application of chlorine or other disinfectants. Episodes of gross contamination of pool water due to an accidental fecal release, however, cannot all be effectively controlled by normal treatment and disinfectant levels. Where pools or spas are not disinfected, accidental fecal releases pose an even greater problem. The only approach to maintaining public health protection under conditions of an accidental fecal release is to prohibit use of the pool until the potential contaminants are inactivated.

Pool operators can help prevent fecal contamination of pools by encouraging pre-swim showering and toilet use and, where possible, confining young children to pools small enough to drain in the event of an accidental fecal release. It is recommended that people with gastroenteritis not use public or semipublic facilities while ill or for at least a week after their illness.

As well as pathogenic enteric organisms, a number of infectious nonenteric organisms may be transferred through pool water and the surrounding environment via human shedding. Infected users can directly contaminate pool waters and the surfaces of objects or materials at a facility with primary pathogens (notably viruses or fungi) in sufficient numbers to lead to skin and other infections in users who subsequently come in contact with the contaminated water or surfaces. Opportunistic pathogens (notably bacteria) can also be shed from users and be transmitted via both surfaces and contaminated water. In addition, certain free-living aquatic bacteria and amoebae can grow in pool, hot tub, or natural spa waters, in pool or hot tub components or facilities (including heating, ventilation, and air-conditioning systems) or on other wet surfaces within the facility to the point where they may cause a variety of respiratory, dermal, or central nervous system infections or diseases.

Most of the legionellosis, an often serious infection caused by *Legionella* species, associated with recreational water use has been associated with public and semipublic hot tubs and natural spas. Natural spas (especially thermal water) and hot tub water and the associated equipment create an ideal habitat (warm, nutrient containing aerobic water) for the selection and proliferation of *Legionella*. *Pseudomonas aeruginosa* is also frequently present in hot tubs, as it is able to withstand high temperatures and disinfectants and to grow rapidly in waters supplied with nutrients from users. In hot tubs, the primary health effect associated with the presence of *P. aeruginosa* is folliculitis, an infection of the hair follicles that may result in a pustular rash.

It is less easy to control the growth of *Legionella* spp. and *P. aeruginosa* in hot tubs than in pools, as the design and operation of hot tubs can make it difficult to achieve adequate residual disinfection levels in these facilities. Thus, in public and semipublic facilities, frequent monitoring and adjustment of pH and disinfectant levels are essential, as are programmed “rest periods” to allow disinfectant levels to “recover.” In addition, facility operators should require users to shower before entering the water and control the number of users and the duration of their exposure. Thorough cleaning of the area surrounding the hot tub on a frequent basis (e.g., daily), complete draining and cleaning of the hot tub and pipe work on at least a weekly basis, frequent backwashing and filter inspection, and good ventilation are all recommended control measures.

Molluscipoxvirus (which causes molluscum contagiosum), papillomavirus (which causes benign cutaneous tumors—verrucae), *Epidermophyton floccosum*, and various species of fungi in the genus *Trichophyton* (which cause superficial fungal infections of the hair, fingernails, or skin) are spread by direct person-to-person contact or in-

directly, through physical contact with contaminated surfaces. As the primary source of these viruses and fungi in swimming pools and similar environments is infected bathers, the most important means of controlling the spread of the infections is educating the public about the diseases, including the importance of limiting contact between infected and uninfected people and medical treatment. Thorough frequent cleaning and disinfection of surfaces in facilities that are prone to contamination can also reduce the spread of the diseases.

### Free-living microorganisms:

In addition to microorganisms introduced into recreational waters through human or animal fecal contamination, a number of pathogenic microorganisms are free-living in certain areas or, once introduced, are capable of colonizing the environment.

*Vibrio* species are natural inhabitants of marine aquatic environments in both temperate and tropical regions. The occurrence of vibrios does not correlate with the occurrence of the traditionally used bacterial fecal index organisms, except perhaps in waters receiving human waste from disease outbreaks (mainly cholera). Due to the ubiquitous nature of *Vibrio* species in the aquatic environment, their presence in bathing waters cannot be controlled by water quality control measures such as waste water treatment and disinfection. Human carriers and shedding appear to be of only limited importance in the epidemiology of *Vibrio* infections associated with recreational water use. However, the risk of extra-intestinal infections associated with human pathogenic *Vibrio* species, especially wound and ear infections, during recreational activities in water is of health importance, although the infectious doses for such infections are unknown.

*Aeromonas* spp. are considered autochthonous inhabitants of aquatic environments and are ubiquitous in surface fresh and marine waters, with high numbers occurring during the warmer months of the year. Clinical isolation of these microbes presents the same seasonal distribution. Numbers may be high in both polluted and unpolluted habitats, with densities ranging from <1 to 1,000 cells per ml. Sewage can also contain elevated numbers (10<sup>6</sup> to 10<sup>8</sup> cells per ml) of aeromonads. *Aeromonas* has been found to have a role in a number of human illnesses, including gastroenteritis. Cases of wound infection in healthy people associated with recreational water have been described, as have cases of pneumonia following aspiration of contaminated recreational water.

Free-living amoebae are unicellular protozoa common to most soil and aquatic environments. Of the many hundreds of species of free-living amoebae, only members of the genus *Acanthamoeba*, *Naegleria fowleri*, and *Balamuthia mandrillaris* are known to infect humans, often with fatal consequences. *Acanthamoeba* have been isolated from natural and artificial waters. Certain species are pathogenic to humans and cause two clinically distinct diseases affecting the central nervous system: granulomatous amoebic encephalitis (GAE) and inflammation of the cornea (keratitis). *Naegleria fowleri*, which is found in thermal freshwater habitats worldwide, causes primary amoebic meningoencephalitis (PAM) in humans. PAM is usually fatal, with death occurring 3 to 10 days after exposure. Infection usually results from swimming in contaminated water, although the infectious dose for humans is not known. *B. mandrillaris* encephalitis is largely a disease of the immunocompromised host, and certain cases of GAE attributed to *Acanthamoeba* have in fact been shown to have been caused by *B. mandrillaris*.

Leptospire are excreted in the urine of infected animals, which can then contaminate soil, mud, groundwater, streams, and rivers. Humans become infected either directly through contact with infected urine or indirectly via contaminated fresh water or soil. Virulent leptospire gain entry to the body through cuts and abrasions of the skin and through the mucosal surfaces of the mouth, nose, and conjunctiva. In cases due to exposure to recreational water, the incubation period seems to vary between 2 and 30 days, but is generally between 7 and 14 days. The clinical manifestations of leptospirosis vary considerably in form and intensity, ranging from a mild flu-like illness to a severe and potentially fatal form of the disease, characterized by liver and kidney failure.

Evidence suggests that although infection with free-living microorganisms or pathogenic leptospire via recreational water use may be life-threatening, the incidence of such infection is very low and, in many cases, is limited to specific areas. As such, no specific guideline values were recommended by WHO, although authorities should be aware of the potential hazards posed by these organisms and act accordingly.

### Microbial aspects of beach sand quality

Bacteria, fungi, parasites, and viruses have all been isolated from beach sand. A number of them are potential pathogens. Factors promoting the survival and dispersion of pathogens include the nature of the beach, tidal phe-

nomena, the presence of sewage outlets, the season, the presence of animals, and the number of swimmers. Transmission may occur through direct person-to-person contact or by other means, although no route of transmission has been positively demonstrated.

Concern has been expressed that beach sand or similar materials may act as reservoirs or vectors of infection. However, the capacity of microorganisms that have been isolated from beach sand to infect bathers and beach users remains undemonstrated, and the real extent of their threat to public health is unknown. There is therefore no evidence to support establishment of a guideline value for index organisms or pathogenic microorganisms on beach sand.

The principal microbial risk to human health encountered in beaches and similar areas in some developing countries is that from contact with human feces resulting from defecating directly on the beaches due to the lack of sanitary facilities and/or cultural habits.

In developed countries, the major concern is animal excreta, particularly from dogs. Regulations that restrict access seasonally on frequently used beaches or place an obligation upon the owner to remove animal excreta, increased public awareness, and beach cleaning are preventive management actions.

### Algae and cyanobacteria in coastal and estuarine waters:

Several human diseases have been reported in association with many toxic species of dinoflagellates, diatoms, nanoflagellates, and cyanobacteria (blue-green algae) that occur in the marine environment. The toxicity of these algae to humans is due to the presence of algal toxins. Marine algal toxins become a problem primarily because they concentrate in shellfish and fish that are subsequently eaten by humans, causing shellfish poisoning that is not dealt with in Volume 1 of the WHO guidelines. Marine cyanobacterial dermatitis (“swimmers’itch” or “seaweed dermatitis”) is a severe contact dermatitis that may occur after swimming in seas containing blooms of certain species of marine cyanobacteria. The symptoms are itching and burning within a few minutes to a few hours after swimming in the sea where the cyanobacteria are suspended. Some toxic components, such as aplysiatoxin, debromoaplysiatoxin, and lyngbyatoxin A, have been isolated from marine cyanobacteria. These toxins are highly inflammatory and are potent skin tumor-promoting compounds.

*Nodularia spumigena* was the first cyanobacterium recognized to cause animal death. The toxin produced by *N. spumigena*, called nodularin, acts as a hepatotoxin in that it induces massive hemorrhage in the liver of mammals and causes disruption of the liver structure. To date, there have been no reports of human poisoning by *N. spumigena*, but humans may be as susceptible to the toxins as other mammals. Therefore, it is possible that small children may accidentally ingest toxic material in an amount that may have serious consequences. Inhalation of a sea spray aerosol containing fragments of marine dinoflagellate cells and/or toxins (brevetoxins) released into the surf by lysed algae can be harmful to humans. The signs and symptoms are severe irritation of conjunctivae and mucous membranes (particularly of the nose) followed by persistent coughing and sneezing and tingling of the lips. Available data indicate that the risk for human health associated with the occurrence of marine toxic algae or cyanobacteria during recreational activities is limited to a few species and geographical areas. As a result, WHO concluded that it was inappropriate to recommend specific guideline values. Within areas subject to the occurrence of marine toxic algae or cyanobacteria, it is important to carry out adequate monitoring activities and surveillance programs. In affected areas, it is appropriate to provide health information to general practitioners and the general public, in particular recreational water users. Precautionary measures include avoiding areas with visible algal concentrations and/or algal scum in the sea as well as on the shore, avoiding sitting downwind of any algal material drying on the shore, and showering to remove any algal material.

### Algae and cyanobacteria in fresh water:

Many species of freshwater algae may proliferate quite intensively in eutrophic (i.e., nutrient-rich) waters. However, they do not form dense surface scum or “blooms,” as do some cyanobacteria. Toxins they may contain, therefore, are not accumulated to potentially hazardous concentrations. For this reason, most adverse health impacts from recreational use of fresh waters have been associated with cyanobacteria rather than with freshwater algae.

Progress in analytical chemistry has enabled the isolation and structural identification from toxic cyanobacteria of three neurotoxins (anatoxin-a, anatoxin-a(s), and saxitoxins), one general cytotoxin, which inhibits protein synthesis (cylindrospermopsin), and a group of toxins termed microcystins (or nodularins, found in brackish wa-

ters), which inhibit protein phosphatases. Most of them have been found in a wide array of genera, and some species contain more than one toxin.

Allergic or irritative dermal reactions of varying severity have been reported from a number of freshwater cyanobacterial genera (*Anabaena*, *Aphanizomenon*, *Nodularia*, *Oscillatoria*, *Gloeotrichia*) after recreational exposure. Bathing suits, particularly wet suits, tend to aggravate such effects by accumulating cyanobacterial material and enhancing disruption of cells and liberation of cell content. It is probable that these symptoms are not due to recognized cyanotoxins but rather to currently largely unidentified substances. In contrast to dermal contact, uptake of cyanobacteria through ingestion or aspiration involves a risk of intoxication by cyanotoxins. Most documented cases of human injury through cyanotoxins involved exposure through drinking water, and they demonstrate that humans have become ill—in some cases seriously—through ingestion or aspiration of toxic cyanobacteria. Symptoms reported include abdominal pain, nausea, vomiting, diarrhea, sore throat, dry cough, headache, blistering of the mouth, atypical pneumonia, and elevated liver enzymes in the serum, as well as hay fever symptoms, dizziness, fatigue, and skin and eye irritations.

Health impairments from cyanobacteria in recreational waters must be differentiated between the chiefly irritative symptoms caused by unknown cyanobacterial substances and the potentially more severe hazard of exposure to high concentrations of known cyanotoxins, particularly microcystins. WHO has determined that a single guideline value therefore would not be appropriate. Rather, a series of guideline values associated with incremental severity and the probability of health effects is defined at three levels.

For protection from health outcomes not due to cyanotoxin toxicity, but rather to the irritative or allergenic effects of other cyanobacterial compounds, a guideline level of 20,000 cyanobacterial cells/ml (corresponding to 10 mg chlorophyll-a/l under conditions of cyanobacterial dominance) can be derived. A level of 100,000 cyanobacterial cells/ml (equivalent to approximately 50 mg chlorophyll-a/l if cyanobacteria dominate) represents a guideline value for a moderate health alert in recreational waters. The presence of cyanobacterial scum in swimming areas poses the highest risk of adverse health effects, due to abundant evidence for potentially severe health outcomes associated with these scum.

Because adequate surveillance is difficult and few immediate management options are available (other than precluding or discouraging use or cancelling water-sport activities such as competitions), provision of adequate public information is a key short-term measure. Medium- to long-term measures are identification of the sources of nutrient (in many ecosystems phosphorus, sometimes nitrogen) pollution and significant reduction of nutrient input in order to effectively reduce the proliferation not only of cyanobacteria, but of potentially harmful algae as well.

### **Aesthetic issues:**

The aesthetic value of recreational waters implies freedom from visible materials that will settle to form objectionable deposits, floating debris, oil, scum, and other matter, substances producing objectionable color, odor, taste, or turbidity, and substances and conditions that produce undesirable aquatic life. Clean beaches are one of the prime parameters desired by recreational users. Local economies may depend on the aesthetic quality of recreational water areas, and the environmental degradation of beaches is known to lead to loss of income from tourism. Water at swimming areas should ideally be clear enough for users to estimate depth, to see subsurface hazards easily, and to detect the submerged bodies of swimmers or divers who may be in difficulty. Aside from the safety factor, clear water fosters enjoyment of the aquatic environment. The principal factors affecting the depth of light penetration in natural waters include suspended microscopic plants and animals, suspended mineral particles, stains that impart a color, detergent foams, and dense mats of floating and suspended debris.

Visitor enjoyment of any beach is generally marred by litter, especially a problem in developing countries. The variety of litter found in recreational water or washed up on the beach is considerable and includes, for example, discarded food/wrapping, bottles/cans, cigarette butts, dead fish, discarded condoms, discarded sanitary towels, and syringes, needles, and other medical waste. Unlike most litter, medical waste and broken glass also represent hazards to health.

Objectionable smells associated with untreated sewage effluent, decaying organic matter such as vegetation, dead animals or fish, and discharged diesel oil or gasoline can deter recreational water and beach users. Odor thresholds and their association with the concentrations of different pollutants of the recreational water environment have not, however, been determined.

Marine debris monitoring can be used to provide information on the types, quantities, and distribution of marine debris, identify sources of marine debris, explore public health issues relating to marine debris, and increase public awareness of the condition of the coastline. Management options include manual or mechanical beach cleaning.

In addition to the environmental impact, severe aesthetic problems will result from the discharge of raw untreated sewage due to floating material (turds), grease and oil, and other disagreeable substances. WHO has considered that the minimum treatment would be preliminary treatment for sewage using milliscreens with openings of 1 to 1.5 mm and grease and oil removal systems, combined with an effective outfall discharging to the open ocean with an adequate current regime for mixing. More advanced treatment systems (primary, secondary, or tertiary) would be needed for the removal of organics and nutrients when discharging into rivers, lakes, estuaries, bays with limited circulation, etc.

### Chemical and physical agents:

Chemical contaminants can enter surface waters or be deposited on beaches from both natural and anthropogenic sources. Exposure is one of the key issues in determining the risk of toxic effects from chemicals in recreational waters. The form of recreational activity will therefore play a significant role. Routes of exposure will be direct surface contact, including skin, eyes, and mucous membranes, inhalation, and ingestion. In assessing the risk from a particular contaminant, the frequency, extent, and likelihood of exposure are crucial parts of the evaluation. pH has a direct impact on the recreational uses of water only at very low or very high pH values. Under these circumstances, it may contribute to irritation of the skin and eyes.

The potential risks from chemical contamination of coastal and freshwater recreational waters, apart from toxins produced by marine and freshwater cyanobacteria and algae, marine animals, or other exceptional circumstances, will be far lower than the potential risks from microbial contaminants. It is extremely unlikely that water users will come into contact with sufficiently high concentrations of most contaminants to cause ill effects following a single exposure. Even repeated (chronic) exposure is unlikely to result in ill effects at the concentrations of contaminants found in recreational water and with the exposure patterns of recreational users. However, it remains important to ensure that chemical hazards and any potential human health risks associated with them are controlled and that users can be reassured as to their personal safety.

In most cases, the concentration of chemical contaminants will be below drinking-water guidelines. As long as care is taken in their application, the WHO *Guidelines for Drinking-water Quality* can provide a starting point for deriving values that could be used to make a preliminary risk assessment under specific circumstances.

These guideline values relate, in most cases, to lifetime exposure following consumption of 2 liters of drinking-water per day. For recreational water contact, and intake of 200 ml per day—100 ml per recreational session with two sessions per day—may often be reasonably assumed.

An assessment of the chemical hazards in recreational water may involve inspecting the immediate area to determine if there are any immediate sources of chemical contamination, such as industrial outfalls; considering the pattern and type of recreational use of the water to determine whether there will be extensive contact with the water and/or a significant risk of ingestion; and chemically analyzing the water to support a quantitative risk assessment.

It is important that the basis of any guidelines or standards that are considered to be necessary for chemical constituents of recreational waters be made clear. Without this, there is a danger that even occasional, trivial exceedances of guidelines could unnecessarily undermine users' confidence. It is also important in evaluating chemical hazards that the risks are not overestimated. The risks should be related to risks from other hazards such as drowning or microbial contamination, which will almost invariably be much greater.

On the other hand, swimming pools and similar environments pose a more imminent health risk. Chemicals found in swimming pool water can be derived from a number of sources, namely the source water, deliberate additions such as disinfectants, and pool users themselves (these include sweat, urine, soap residues, cosmetics, and suntan oil).

There are three main routes of exposure to chemicals in swimming pools and similar environments: direct ingestion of the water, inhalation of volatile or aerosolized solutes, and dermal contact and absorption through the skin. The amount of water ingested by swimmers and bathers will depend upon a range of factors, including experience, age, skill, and type of activity. Experimental evidence suggests that water intake varies according to age and sex, with adult women ingesting the least and male children ingesting the most. Swimmers inhale from the atmosphere just above the water's surface, and the volume of air inhaled is a function of the intensity of effort and

time. Inhalation exposure will be largely associated with volatile substances that are lost from the water surface, but will also include some inhalation of aerosols, within a hot tub (for example) or where there is significant splashing. Dermal exposure depends upon the period of contact with the water, water temperature, and the concentration of the chemical.

The principal management-derived chemicals are disinfectants, added to minimize the risk to pool users from microbial contaminants. Coagulants may be added as part of the water treatment process to enhance the removal of dissolved, colloidal, or suspended material. Acids and alkalis may also be added to the water in order to maintain an appropriate pH for optimal water treatment and the comfort of bathers. The chemical disinfectants that are used most frequently include chlorine (as a gas, hypochlorite, or, generally for outdoor pools, chlorinated isocyanurates), chlorine dioxide, bromochlorodimethylhydantoin (BCDMH), ozone, and ultraviolet (UV) radiation (with ozone and UV usually being used in combination with a chlorine- or bromine-based disinfectant). Practice varies widely around the world, as do the levels of chemicals that are currently considered acceptable to achieve adequate disinfection while minimizing user discomfort. It is recommended that acceptable levels of free chlorine continue to be set at the local level, but in public and semipublic pools these should not exceed 3 mg/l and in public and semipublic hot tubs should not exceed 5 mg/l. It is recommended that total bromine not exceed 4 mg/l in public and semipublic pools and 5 mg/l in hot tubs. Where chlorinated isocyanurates are used, levels of cyanuric acid in pool water should not exceed 100 mg/l. Where ozone is used, an air quality guideline of 0.12 mg/m<sup>3</sup> is recommended to protect bathers and staff working in the pool building.

A number of disinfectants can react with other chemicals in the water to give rise to unwanted by-products, known as disinfection by-products. Most is known about the by-products that result from the reaction of chlorine with humic and fulvic acids, but there is evidence from model studies with amino acids that other organic substances will also give rise to a similar range of by-products. Although there is potentially a large number of by-products, the substances produced in the greatest quantities are trihalomethanes, of which chloroform is generally present in the greatest concentrations, and the haloacetic acids, of which di- and trichloroacetic acid are generally present in the greatest concentrations. Both chlorine and bromine will react with ammonia in the water (resulting from the presence of urine) to form chloramines (monochloramine, dichloramine, and nitrogen trichloride) and bromamines.

Trihalomethanes have been considered more than other chlorination by-products, reflecting the level of available information. Concentrations vary as a consequence of the concentration of precursor compounds, chlorine dose, temperature and pH. Trihalomethanes are volatile in nature and can be lost from the surface of the water, so they are also found in the air above the pool.

The guideline values in the WHO *Guidelines for Drinking-water Quality* can be used to screen for potential risks arising from swimming pools and similar environments, while making appropriate allowance for the much lower quantities of water ingested, shorter exposure periods, and noningestion exposure. Although there are data to indicate that the concentrations of chlorination by-products in swimming pools and similar environments may exceed the concentrations proposed by WHO for drinking-water, the evidence indicates that for reasonably well-managed pools, concentrations lower than the drinking-water guideline values can be consistently achieved. The risks from exposure to chlorination by-products in reasonably well-managed swimming pools would be considered to be small and must be set against the benefits of aerobic exercise and the risks of microbial disease in the absence of disinfection. Nevertheless, competitive swimmers and pool attendants can experience substantial exposure to volatile disinfection by-products via inhalation and dermal absorption. The chloramines and bromamines, particularly nitrogen trichloride and nitrogen tribromide, which are both volatile, can give rise to significant eye and respiratory irritation in swimmers and pool attendants. The provisional guideline value for chlorine species, expressed as nitrogen trichloride, in the atmosphere of swimming pools and similar environments is 0.5 mg/m<sup>3</sup>.

## Dangerous aquatic organisms

Dangerous aquatic organisms may be encountered during recreational use of freshwater and coastal recreational environments. Such organisms vary widely and are generally of local or regional importance. The likelihood and nature of human exposure often depend significantly on the type of recreational activity concerned.

Two types of risks can be distinguished in relation to dangerous aquatic species: injury or intoxication resulting from direct encounters with predators or venomous species, and infectious diseases transmitted by species that have life cycles linked to the aquatic environment.

Injuries from encounters with dangerous aquatic organisms are generally sustained by accidentally brushing past a venomous sessile or floating organism when bathing, inadvertently treading on a stingray, weeverfish, or sea urchin, unnecessary handling of venomous organisms during seashore exploration, invading the territory of large animals when swimming or at the waterside, swimming in waters used as hunting grounds by large predators, or intentionally interfering with, or provoking, dangerous aquatic organisms.

Disease vectors include mosquitoes, which transmit malaria parasites and the viruses responsible for dengue fever, yellow fever, and various types of encephalitis, and certain species of freshwater snails, which host the larval development of trematode parasites of the genus *Schistosoma*, which can cause a chronic, debilitating, and potentially fatal tropical disease known as bilharzia or schistosomiasis in humans. Preventive measures include asking local health authorities for guidance on the local vector-borne disease situation and risk prevention, wearing protective clothing, using repellents, and avoiding skin contact with water in schistosomiasis endemic areas. “In-water” hazardous organisms include piranhas, snakes, electric fish, sharks, barracudas, needlefish, groupers, and moray and conger eels. Many have been known to attack and wound humans. Preventive measures include avoiding swimming in areas where large sharks are endemic; avoiding wearing shiny jewelry in the water where large sharks and barracudas are common; avoiding attaching speared fish to the body where sharks, barracudas, or groupers live; avoiding wearing a headlight when fishing or diving at night in needlefish waters; and looking out for groupers and moray or conger eels before swimming into caves or putting hands into holes and cracks of rocks.

“Water’s-edge” hazardous organisms include hippopotami, crocodiles, and alligators. Preventive measures include keeping the animals at a distance whenever possible, avoiding swimming in areas inhabited by crocodiles or alligators, and embarking on safaris in hippopotamus- and crocodile-infested waters with a knowledgeable guide who can assess risks properly and judge the territorial behavior of hippopotami in water.

The effects of invertebrate venoms on humans range from mild irritation to sudden death. The invertebrates that possess some kind of venomous apparatus belong to one of five large phyla: *Porifera* (sponges), *Cnidaria* (sea anemones, hydroids, corals, and jellyfish), *Mollusca* (marine snails and octopi), *Annelida* (bristleworms), and *Echinodermata* (sea urchins and sea stars). Preventive measures include wearing suitable footwear when exploring the intertidal area or wading in shallow water, avoiding handling sponges, cnidarians, cone shells, blue-ringed octopi, bristle worms, or the flower sea urchin, avoiding brushing against hydroids, true corals, and anemones, and avoiding bathing in waters where Portuguese man-of-war are concentrated.

Venomous vertebrates deliver their venom either via spines, as with many fish species (e.g., catfish, stingray, scorpionfish, weeverfish, surgeonfish), or fangs, as in sea snakes. Injuries caused by venomous marine vertebrates are common, especially among people who frequently come into contact with these marine animals. Potent vertebrate toxins generally cause great pain to victims, who may also experience extensive tissue damage. Preventive measures include shuffling feet when walking along sandy lagoons or shallower waters where stingrays frequent, exercising caution when handling and sorting a fishing catch, wearing suitable footwear in shallow water and snake-infested areas, and carrying antivenin in snake-infested areas.

Volume 1 then cites *Monitoring Bathing Waters*, which provides guidance on the design and implementation of a monitoring program, including the design of a program that includes appropriate quality assurance, data collection, data handling, data interpretation, and reporting. In addition to this general guidance, guidance is provided in regard to specific hazards that may be encountered in areas of recreational water use. The application of guidelines and management options for healthy recreational water use are also discussed.

## Microbiological water quality guidelines/standards

Because of the importance of bacterial contamination, and to ensure that public health is protected at beaches and bathing waters, microbiological guidelines/standards are dealt with in some detail below.

To provide context and background for the many bacterial standards that have been adopted around the world, a review is presented of the history and application of microbiological water quality standards for primary contact recreation. This approach has been adopted here to focus on the fact that some developing countries still apply standards from developed countries that are currently outdated in those countries. For example, pre-1986 U.S. Environmental Protection Agency (USEPA) standards for fecal coliforms are still being used in some Latin American and Caribbean countries, even though the USEPA abandoned fecal coliforms for enterococcus in 1986.

Special note is taken of the first and most recent investigations conducted in the United States, which concluded that enterococcus, as an indicator organism, provided the best correlation with gastrointestinal symptoms attributable to swimming in contaminated waters. The relationship developed between mean enterococcus density

per 100 ml and the swimming-associated rate for gastrointestinal symptoms per 1,000 persons is presented along with the (USEPA) adaptation of enterococcus as the primary indicator organism in lieu of total and fecal coliforms in 1986. The use of enterococcus was confirmed in the USEPA's 2012 *Recreational Water Quality (20)* criteria.

After an extensive review of 33 epidemiological investigations conducted in marine waters worldwide, the World Health Organization (WHO) also concluded that intestinal enterococcus was the best indicator organism related to disease burden. The WHO *Guidelines for Safe recreational-Water Environments (GSRWE)* in Volume 1, *Coastal and Fresh Waters (17)*, are based primarily on the controlled, randomized epidemiological trials conducted in the temperate coastal waters of the United Kingdom.

The WHO and USEPA guidelines set the stage and provide the background for the rest of this chapter, along with subsequent publications focused primarily on microbiological guidelines for bathing beaches. The overwhelming evidence provided by most of the epidemiological studies conducted worldwide over the past 40 years and reviewed by the World Health Organization has shown that the indicator organism that correlates best with health outcome is enterococci for marine waters. Consequently, the use of total and fecal coliforms as an indicator organism has fallen into disfavor in recent years, since it was not shown to have a significant correlation with illness rates. Total and fecal coliforms are therefore considered inadequate indicators of disease burden and should be abandoned by all the countries in the Americas. The historical review presented below focuses on this issue and presents the evolution of microbiological water quality guidelines and standards to present-day recommendations.

However, simply adapting a particular set of standards is inappropriate without a thorough review of local circumstances and local/national economic factors. The guideline values should be interpreted or modified in light of regional and/or local factors that include the nature and seriousness of local endemic illness, population behavior, exposure patterns, and sociocultural, economic, environmental, and technical aspects, as well as competing health risks from other diseases that are not associated with recreational water. The recreational water quality guidelines recommended by the USEPA and WHO, which represent the present state of the art, are primarily based on epidemiological studies conducted in temperate waters. Application of these guidelines to the tropical waters of most of Latin America and the Caribbean may be a concern. WHO therefore recommended that countries, especially developing countries where priorities often must be set for projects of first necessity in the context of limited economic resources, conduct local epidemiological studies geared to establishing the relationship between health risk and indicator organisms. The cost of epidemiological studies is considered justifiable in the context of the large potential capital expenditures associated with control systems. Moreover, the adaptation of a particular risk level for human health should be based on the local socioeconomic situation if it is to be viable. Robinson and Salas (21) have proposed a methodological protocol for the epidemiological and environmental assessments of recreational water adapted to Latin America and the Caribbean.

Also, caution should be exercised in directly applying quantitative relationships between health risk and indicator organisms in other areas where the general health and immunity of the local population may be different.

## ■ Historical review of guidelines for coastal and freshwater environments

### United States of America

The first evaluations of water-contact recreation and disease incidence in the United States date back to the 1920s and 1930s: Simons *et al.* (22), Winslow and Moxon (23), and Coburn (24), where cautious suggestions were made for maximum permitted total coliform counts ranging from 100 to 10,000 per 100 ml. Ludwig (25) notes that the California coliform standard of 1,000 MPN/100 ml was developed during the 1940s, based entirely on aesthetic considerations in that when total coliform counts remained consistently below 1,000 MPN/100 ml the beaches remained aesthetically satisfactory with no visual evidence of sewage pollution.

Cabelli *et al.* (26) report that the U.S. total coliform limit of 1,000/100 ml “apparently developed from two sources: the predicted risk of salmonellosis as obtained from calculations made by Streeter (27) on the incidence of *Salmonella* species in bathing waters and attainability as determined by Scott (28) from microbiological surveys conducted at Connecticut bathing beaches.” This Connecticut standard was then adopted by many other U.S. state agencies.

As noted by the Committee on Bathing Beach Contamination of the Public Health Laboratory Service (29), Garber (30) reported on an inquest of different public health and control agencies in the USA concerning “how bacteriological standards were determined and why they were decided upon.” The most frequent reply was that there was no analytical background for the limits set other than the fact that epidemiological experience under the given standards had been satisfactory. This argument was used for standards ranging from a median coliform count of less than 2,400/100 ml down to a requirement that no coliform organisms should be present.

The first major epidemiological studies aimed directly at assessing the health risk of bathing in polluted waters were conducted during the period 1948-1950 by the U.S. Public Health Service. The findings (31) were that statistically significant epidemiologically detectable health effects at levels of 2,300 and 2,700 coliforms/100 ml were demonstrated by the studies on Lake Michigan in Chicago, Illinois, in 1948 and on the Ohio River in Dayton, Kentucky, in 1949, respectively. The third study, conducted in 1950 in the saline tidal waters of Long Island Sound at New Rochelle and Mamaroneck, New York, showed no relationship between total coliform levels and swimming-related diseases. Subsequent work in the same stretch of the Ohio River indicated that fecal coliforms represented 18% of total coliforms (26) and therefore would indicate that detectable health effects would occur at a fecal coliform level of about 400 MPN/100 ml. Applying a factor of safety, in that water quality should be better than that which would cause a health effect, in 1968 the National Technical Advisory Committee (NTAC) (32) to the USA Federal Water Pollution Control Administration developed a national fecal coliform guideline of 200 MPN/100 ml for fresh and marine waters that was based primarily on the two freshwater studies of Stevenson (31).

However, in 1972, in a USEPA-funded project, the Committee on Water Quality Criteria of the U.S. National Academy of Sciences (33), came to the following conclusion: “No specific recommendation is made concerning the presence or concentration of microorganisms in bathing water because of the paucity of valid epidemiological data.” Subsequently in 1976, the USEPA (34) presented fecal coliform guidelines that were essentially those presented in the NTAC (32) document. Notwithstanding, the primary rationale was based on the relationship of fecal coliform densities to the frequency of *Salmonella* isolations in surface waters, and the findings of the Stevenson (31) studies were essentially abandoned as a rationale. The final guideline proposed by the USEPA (34) was as follows: “based on a minimum of not less than five samples taken over not more than a 30-day period, the fecal coliform content of primary contact recreational waters shall not exceed a log mean of 200/100 ml, nor shall more than 10% of total samples during any 30-day period exceed 400/100 ml.” This bacteriological water quality standard continues to be used in many Latin American and Caribbean countries.

### USEPA 1986 water quality criteria

Based on a three-year (1973-1975) study conducted at New York City beaches, Cabelli *et al.* (26) concluded that enterococci (analytical procedures presented in USEPA) (35), as an indicator organism, provided the best correlation with gastrointestinal (vomiting, diarrhea, nausea, or stomachache) symptoms attributed to swimming in contaminated waters. Other indicators evaluated included total coliforms and their component genera (*Escherichia*, *Klebsiella*, *Citrobacter-Enterobacter*), fecal coliforms, *Escherichia coli* (*E. coli*), *Pseudomonas aeruginosa*, *Clostridium perfringens*, *Aeromonas hydrophila*, *Vibrio parahaemolyticus*, and *Salmonella*. Subsequent U.S. studies confirmed the superiority of enterococci as an indicator organism, and Cabelli *et al.* (26) developed a linear relationship between mean enterococcus density/100 ml and swimming-associated rate for gastrointestinal symptoms per 1,000 persons. Cabelli concluded that enterococci better mimicked the survival characteristics of the etiological agent, which Cabelli (36) concluded to be the human rotavirus with respect to gastroenteritis. Additional studies were conducted in the late 1970s and early 1980s (26,37) confirming the basic premise. A critique of this work is presented by Fleisher (38).

It must be recognized that the pathogen-to-indicator organism ratio is variable due to its dependence on the overall health of the discharging population. As noted by Cabelli *et al.* (26), the swimming-associated outbreak of shigellosis on the Mississippi River below Dubuque, Iowa, USA (39), appears to represent an instance where, although the 200/100 ml fecal coliform guideline was probably exceeded for some time, the outbreak did not occur until there was a large enough number of ill individuals and carriers in the discharging population. Also, comparisons made by Cabelli (40,43) of epidemiological studies conducted in Egypt with those conducted in the United States suggest the important role of population immunity, in that gastrointestinal illness rates in the U.S. studies were associated with bathing in waters with relatively much lower enterococci densities. These studies also demonstrated that swimming-associated gastrointestinal symptoms were much more prevalent among children (aged 10

and under) with lesser-developed immune systems than adults. This further suggests the importance of immunity in the epidemiology of the observed swimming-associated gastroenteritis. These factors imply that caution should be exercised in directly applying the relationships developed to other areas.

The USEPA (40) first presented the recommendation that enterococci be adapted by U.S. states as the primary indicator organism for primary contact recreations in lieu of the indicators applied at that time (primarily total and fecal coliforms). After a review and recalculation of the data, the USEPA (41) adopted the following criteria in 1986:

Fresh water:	<i>E. coli</i> : not to exceed 126/100 ml, or
Enterococci:	not to exceed 33/100 ml
Marine water:	Enterococci: not to exceed 35/100 ml

These guidelines were based on studies conducted by Dufour (37) and Cabelli (43) applying the empirical equations developed for highly credible gastrointestinal symptoms (HCGI) associated with swimming in fresh and marine waters, respectively. These guidelines were based on risk levels of 8 and 19 gastrointestinal illnesses per 1,000 swimmers at freshwater and marine beaches, respectively, which were estimated to be equivalent to the risk levels for 200/100 ml fecal coliform criteria. The USEPA (41) premise was that by using the existing criterion of 200 fecal coliform bacteria per 100 ml, the health risks mentioned above for freshwater and marine beaches have been unknowingly accepted.

These criteria are calculated as the geometric mean of a statistically sufficient number of samples, generally not less than five samples equally spaced over a 30-day period. Single-sample maximum allowable densities based on beach use were also promulgated and are presented in Table 29-2, taken from Dufour and Ballentine (44).

As per footnote 5 in Table 29-2, the Single Sample Maximum Allowable Density is based on the observed log standard deviations during the USEPA studies: 0.4 for freshwater *E. coli* and enterococci; and 0.7 for marine water enterococci. The USEPA also stated that each jurisdiction should establish its own standard deviation for its conditions, which would then vary the single sample limit.

Based on the above log normal distribution, different confidence levels (CL)—i.e., 75th, 82nd, 90th, and 95th percentiles—were assigned to different designated beach uses (see Table 29-2 and Figure 29-1). The geometric mean (CL=50th percentile) remains at 35 enterococci/100 ml, and all the CLs specified in Table 29-2 form part of the same log normal distribution with a standard deviation of 0.7, which would theoretically be equivalent to 19 gastrointestinal illnesses per 1,000 swimmers for marine waters.

For the category “Designated Beach Area” (75% CL) in Table 29-2, there would be a 75% probability that the specified value of 104 enterococci/100 ml would not be exceeded in a statistically sufficient number of data. Consequently, there would be a probability that 25% of the measurements would indeed exceed the specified value.

The Single Sample Maximum Allowable Density approach adopted in the USEPA guidelines in 1986 essentially applies a safety factor under the apparent premise that bathers should not be exposed to the higher indicator levels of the log normal distribution, which is applied based on beach use ranging from the 75th percentile for a designated beach area to the 95th percentile for an infrequently used full-body contact recreation beach area. This single

sample maximum criterion would inherently drive down the geometric mean substantially for most datasets and, consequently, the gastrointestinal illness rate would be lower. Compliance would also be more difficult to achieve.

**Table 29-2.** Indicator criteria for bacteriological densities (from Dufour and Ballentine) (28)

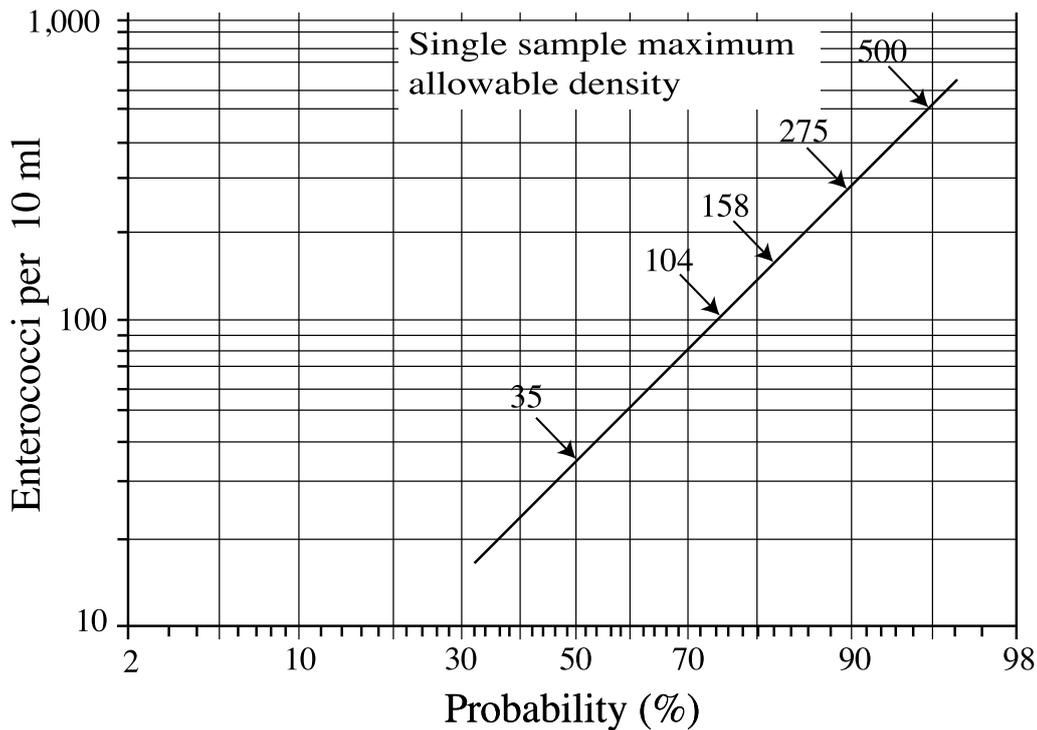
	Acceptable swimming associated gastro-enteritis rates per 1000 swimmers	Simple Sample Maximum Allowable Density <sup>4,5</sup>				
		Steady-state geometric mean indicator density	Designated beach area (Upper 75% CL)	Moderate full-body contact recreation (Upper 82% CL)	Lightly used full-body contact recreation (Upper 90% CL)	Infrequently used full-body contact recreation (Upper 95% CL)
Freshwater: Enterococci	8	33 <sup>1</sup>	61	89	108	151
<i>E. coli</i>	8	126 <sup>2</sup>	235	298	406	576
Marine waters: Enterococci	19	35 <sup>3</sup>	104	158	275	500

- (1) Calculated to nearest whole number using equation:  
(mean enterococci density) =  $\text{antilog}_{10} \frac{\text{illness rate}/1000 \text{ people} + 6.28}{9.40}$
  - (2) Calculated to nearest whole number using equation:  
(mean *E. Coli* density) =  $\text{antilog}_{10} \frac{\text{illness rate}/1000 \text{ people} + 11.74}{9.40}$
  - (3) Calculated to nearest whole number using equation:  
(mean enterococci density) =  $\text{antilog}_{10} \frac{\text{illness rate}/1000 \text{ people} + 0.20}{12.17}$
  - (4) Single sample limit =  $\text{antilog}_{10} \left\{ \left[ \log \text{indicator geometric mean density}/100\text{ml} \right] + \left[ \text{factor determined from areas under the normal probability curve for the assumed level of probability (see below)} \right] \times (\log_{10} \text{ standar deviation}) \right\}$
- The appropriate factors for the indicated one sided confidence level are:
- 75% C.L - .675
  - 82% C.L - .935
  - 90% C.L - 1.28
  - 95% C.L - 1.65
- (5) Based on the observed log standar deviations during the USEPA studies: 0.4 for freshwater *E. Coli* and enterococci; and 0.7 for marine water enterococci. Each jurisdiction should establish its own standar deviation for its conditions which would then vary the single sample limit.

C.L Confidence level

Dufour and Ballentine (1986)

Figure 29-1. USEPA ambient water quality criteria



### USEPA 2012 Water Quality Criteria

The Beaches Environmental Assessment and Coastal Health (BEACH) Act of 2000 directed the USEPA to conduct studies associated with pathogens and human health and to publish new or revised criteria recommendations for pathogens and pathogen indicators based on those studies. The epidemiological studies, referred to as the National Epidemiological and Environmental Assessment of Recreational Water (NEEAR), were conducted in the United States and Puerto Rico in the period 2003-2009, resulting in the release of the USEPA's 2012 recreational water quality criteria (RWQC) recommendations for protecting human health in all coastal and noncoastal waters designated for primary contact recreational use. Seven of the epidemiological studies were conducted at temperate beaches primarily impacted by wastewater treatment plants (WWTPs) that discharged effluent from treated municipal sewage. Three of those beaches were marine water and four were fresh water. Studies were also conducted at two additional beaches: a temperate beach in Surfside, South Carolina, impacted by urban runoff sources, and a tropical beach in Boquerón, Puerto Rico. A total of 54,250 participants were enrolled in the NEEAR studies (45,-47). The USEPA also considered epidemiological studies from other research efforts in developing these recreation criteria.

The 2012 RWQC are based on the use of two fecal indicator bacteria (FIB), enterococci and *Escherichia coli* (*E. coli*), as indicators of fecal contamination for fresh water and enterococci for marine water. The 1986 USEPA conclusion of the superiority of the relationship of these two indicator organisms with disease burden was confirmed. The new criteria are designed to protect primary contact recreation, where a high degree of bodily contact with the water, immersion, and ingestion are likely. The 2012 RWQC offer two sets of numeric concentration thresholds, either of which would protect the designated use of primary contact recreation and thus protect the public from exposure to harmful levels of pathogens, and are applicable to both coastal and noncoastal water bodies. Illness rates upon which these recommendations are based use the NEEAR definition of gastrointestinal illness—referred to as NEEAR-GI (NGI)—whose definition of GI illness is more comprehensive (i.e., NGI includes diarrhea without

the requirement of fever) than the highly credible gastrointestinal illnesses (HCGI) per 1,000 primary contact recreators used in developing the 1986 recommended microbiological water quality criteria. Because NGI is broader than HCGI, more cases of illness were reported and associated with aquatic recreation in the NEEAR study, using the NGI definition of illness, at the same level of water quality observed using the previous illness definition (i.e., HCGI).

The RWQC consist of three components: magnitude, duration, and frequency. The magnitude of the bacterial indicators is described by both a geometric mean (GM) and a statistical threshold value (STV) for the bacteria samples. The STV approximates the 90th percentile of the water quality distribution and is intended to be a value that should not be exceeded by more than 10 percent of the samples taken and used to calculate the GM. Table 29-3 summarizes the magnitude component of the recommendations as measured by culture-based methods. Two sets of recommended criteria are provided, each of which corresponds to two different illness rates.

Different approaches for statistical analyses of the data of both the NEEAR studies and the studies used for the 1986 criteria provided evidence to support the recommendation of a GM criterion value of 30 or 35 cfu per 100 ml. These approaches also provided evidence that the recommended RWQC are similarly protective of the designated use of primary contact recreation in both marine and fresh water. A similar analysis was conducted for *E. coli* in fresh water, resulting in the values in Table 29-3. The USEPA is presenting two sets of criteria (consisting of a GM and related STV) associated with two different illness rates. The criteria that correspond to an illness rate of 36 NGI per 1,000 primary contact recreators correlate to water quality levels associated with the 1986 criteria. Accordingly, this illness rate has a history of acceptance by the public. The criteria that correspond to an illness rate of 32 NGI per 1,000 primary contact recreators would encourage an incremental improvement in water quality. EPA recommends that states make a risk management decision to choose one or the other set.

As shown in Table 29-2, the 1986 bacteria criteria document included four single sample maximum (SSM) values appropriate for different levels of beach usage (use intensities). In the 2012 RWQC, USEPA withdrew those recommendations and instead provided states with optional precautionary Beach Action Values (BAVs) for use in monitoring and notification programs.

**Table 29-3.** Recommended 2012 RWQC

Criteria Elements	Recommendation 1 Estimated Illness Rate (NGI) 36/1,000 primary contact recreators		OR	Recommendation 2 Estimated Illness Rate (NGI) 32/1,000 primary contact recreators	
	GM (cfu/100 ml) <sup>a</sup>	STV (cfu/100 ml) <sup>a</sup>		GM (cfu/100 ml) <sup>a</sup>	STV (cfu/100 ml) <sup>a</sup>
Enterococci (marine & fresh)	35	130		30	110
<i>E. coli</i> (fresh)	126	410		100	320
<b>Duration and frequency</b> —The water body geometric mean (GM) should not be greater than the selected GM magnitude in any 30-day interval. There should not be greater than a 10% excursion frequency of the selected standard threshold value (STV) magnitude in the same 30-day interval.					

<sup>a</sup>USEPA recommends using USEPA Method 1600 to measure culturable enterococci, or another equivalent method that measures culturable enterococci, and using USEPA Method 1603 to measure culturable *E. coli*, or any other equivalent method that measures culturable *E. coli*.

There is a distinct need for a method to rapidly determine concentrations of fecal-indicator bacteria in recreational waters, because current methods require at least 18-24 to 48 hours from sample collection to availability of results. Bacteria concentrations in the water can change appreciably within hours, and recreational users may therefore be at risk of coming into contact with water that is not considered safe for recreation. The qPCR method can be performed in 2 to 6 hours and has been shown to be successful when implementing same-day beach management decisions (48). Alternatively, recreational use and revenue may be lost if the beach is erroneously posted as unsafe when the risk is low.

To address this need, the USEPA has also developed and validated a molecular testing method using quantitative polymerase chain reaction (qPCR) as a rapid analytical technique for the detection of *Enterococcus* spp. in recreational waters (USEPA Method 1611). This analytical technique vastly improves beach management by minimizing beach misclassification due to the up to 48-hour delay of the classical culture-based methods. The gPCR allows the local environmental and/or public control agencies to take rapid steps to alert the public and restrict the use of beaches that exceed the recommended water quality criteria on an almost real-time basis. However, qPCR-based approaches detect specific DNA sequences that have been extracted from a water sample; the results contain sequences from both viable and nonviable forms of the targeted indicator and are therefore not interchangeable with the results for enterococci determined using the culture-based methods that determine the culturable subset of the viable forms of the fecal indicator bacteria.

The equivalent qPCR values were computed from the combined NEEAR epidemiological regression model. The qPCR-based GM values rounded to 300 and 470 cce enterococci per 100 ml were found to correspond to approximately 32 and 36 cases of NGI per 1,000 primary contact recreators, respectively. Therefore, a comparable *Enterococcus* spp. measured by qPCR density to the enterococci measured by culture-based value was established.

In the NEEAR studies, children aged 10 years and younger exhibited a higher rate of illness than adults in fresh water, but did not for marine water exposures. The sample sizes in the epidemiological data were not large enough to evaluate potential differences for persons over 55 years of age, pregnant women, or other vulnerable individuals. USEPA's 2012 RWQC recommendations are based on the general population, which includes children. Because children may be more exposed and/or more sensitive to pathogens in recreational waters, the USEPA considered it important to have effective risk communication outreach to mitigate their exposure to contaminated recreational waters. The USEPA is also providing Beach Action Values (BAVs) that are the 75th percentile value of a water quality distribution based on the new criteria. The resulting values are presented in Table 29-4. The USEPA recommended that these values be used as a precautionary tool to provide an early alert to beachgoers, including families with children.

**Table 29-4.** Beach Action Values (BAVs)

Indicator	Estimated Illness Rate (NGI): 36 per 1,000 primary contact recreators	OR	Estimated Illness Rate (NGI): 32 per 1,000 primary contact recreators
	BAV (Units per 100 ml)		BAV (Units per 100 ml)
Enterococci – culturable (fresh and marine) <sup>a</sup>	70 cfu		60 cfu
<i>E. coli</i> – culturable (fresh) <sup>b</sup>	235 cfu		190 cfu
<i>Enterococcus</i> spp. – qPCR (fresh and marine) <sup>c</sup>	1,000 cce		640 cce

<sup>a</sup> Enterococci measured using EPA Method 1600, or another equivalent method that measures culturable enterococci.

<sup>b</sup> *E. coli* measured using EPA Method 1603, or any other equivalent method that measures culturable *E. coli*.

<sup>c</sup> EPA *Enterococcus* spp. Method 1611 for qPCR.

Based on the comparison of the tropical water epidemiological study conducted in Puerto Rico, as well as the beach study in Surfside, South Carolina, impacted only by urban runoff sources, with the other NEEAR beach studies conducted in temperate waters influenced by waste water treatment plants, the USEPA concluded that the criteria recommendations are scientifically defensible and protective of recreational use regardless of source or climate.

The USEPA NEEAR studies also indicated that there is no compelling distinction in the results between marine and fresh water. Recent literature is consistent with this finding and indicates that, of the factors influencing enterococci fate in the environment, there is evidence that sunlight, temperature, and predation are more important in controlling enterococci concentrations than salinity (49).

Zoonotic diseases are those that are communicable from animals to humans. Fecal contamination from non-human sources can transmit pathogens that can cause GI illnesses. However, the USEPA believes that the state of the science is not sufficiently developed to distinguish potential human health risks from nonhuman sources of FIB contamination and human sources of FIB on a national basis.

## International Organizations

In 1976, the European Economic Community (EEC) published *Quality Requirements (microbiological) for Bathing Waters* (50). The latest European Union (EU) guidelines for coastal and transitional waters, which were published on 15 February 2006 (51), are presented in Table 29-5 and have been adopted by some Caribbean countries.

**Table 29-5.** Coastal and transitional waters (EU 2006)

Parameter	Excellent quality	Good quality	Sufficient	Reference methods of analysis
Intestinal enterococci (I.E.) (cfu/100 ml)	100*	200*	185**	ISO 7899-1 or ISO 7899-2
<i>Escherichia coli</i> (E.C.) (cfu/100 ml)	250*	500*	500**	ISO 9308-3 or ISO 9308-1

\* Based upon a 95th-percentile evaluation.

\*\* Based upon a 90th-percentile evaluation.

The Caribbean Environment Programme (CEPPOL) held regional meetings in 1991 and 1993 on monitoring and control of sanitary quality bathing and shellfish-growing marine waters in the wider Caribbean. Due to the Caribbean's economic dependence on tourism, both the bacteriological and aesthetic water quality are very important. It was concluded at these meetings that Member Countries should adopt EEC, WHO, or (pre-1986) USEPA standards and guidelines for bacteriological quality of bathing waters until sufficient information is available, based on future epidemiological studies conducted in the Caribbean to modify the current standards (52).

As reported by Saliba and Helmer (53), prospective epidemiological cohort studies similar to the one conducted by Cabelli (generally referred to as "Cabelli-style studies") were conducted in a number of countries from 1982 to 1989. Saliba and Helmer (53) state that "...practically all studies showed higher morbidity among bathers as compared to non-bathers, but correlation between specific symptoms and bacterial indicator concentrations varied considerably." They furthermore concluded that although difficult to quantify "...the evidence clearly indicates that health risks do exist and are most pronounced in areas directly exposed to pollution by untreated sewage."

## ■ Standards for human health protection

### WHO guidelines

As already mentioned, in 1994, the World Health Organization embarked on the development of guidelines for recreational use of the water environment. The preliminary publication of the guidelines occurred in 1998 (54). As part of this process, Prüss (19) summarized the epidemiological studies conducted worldwide. Of the 37 studies evaluated, 22 qualified for inclusion in the evaluation; of these, 18 were prospective cohort studies; 2, retrospective cohort studies; and 2, randomized controlled trials. In 19 of the 22 epidemiological studies examined in the Prüss review, the rate of certain symptoms or symptom groups was significantly related to the count of fecal indicator bacteria in recreational water. Hence, there was consistency across the various studies, and gastrointestinal symptoms were the most frequent health outcome for which significant dose-related associations were reported. The overwhelming evidence provided by most of the epidemiological studies conducted worldwide over the past 40 years and reviewed by WHO (17) has shown that the indicator organisms that correlate best with health outcomes

were enterococci/fecal streptococci for marine waters. Other indicators exhibiting correlation were fecal coliforms and staphylococci.

In marine bathing waters, the United Kingdom's randomized controlled trials (55,56) probably contained the least amount of bias. These studies provided the most accurate measure of exposure, water quality, and illness compared with observational studies, where an artificially low threshold and flattened dose-response curve (due to misclassification bias) were likely to have been determined. The United Kingdom's randomized controlled trials were therefore the key studies used to derive the guideline values for recreational waters. However, it should be emphasized that they are primarily indicative for adult populations in marine waters in temperate climates. Studies that reported higher thresholds and case rate values (for adult populations or populations of countries with higher endemicities) may suggest increased immunity, which is a plausible hypothesis. Most studies reviewed by Prüss (19) suggested that symptom rates were higher in lower age groups, and the United Kingdom studies may therefore systematically underestimate risks to children.

WHO concluded that the controlled randomized trial studies were the most accurate, and the WHO Expert Committee based the new guidelines for marine waters on the only study of this type for enteric illness, reported by Kay and Fleisher *et al.* (55), in the United Kingdom. It was noted that these are temperate waters and may not be characteristic of tropical waters.

The guideline values for microbial water quality given in Table 29-6 are derived from the key studies described above. The values are expressed in terms of the 95th percentile of numbers of intestinal enterococci per 100 ml and represent readily understood levels of risk based on the exposure conditions of the key studies. WHO defined a 1% risk for illness occurrence due to bathing as "an excess illness of one incidence in every 100 exposures," compared to nonbathers. The values may need to be adapted to account for different local conditions.

**Table 29-6.** WHO guidelines for microbial water quality of recreational waters

<i>95th percentile intestinal enterococci per 100 ml</i>	<i>Basis of derivation</i>	<i>Estimated risk per exposure</i>
≤40 A	This range is below the NOAEL in most epidemiological studies.	<1% GI illness risk <0.3% AFRI risk  The upper 95th percentile value of 40/100 ml relates to an average probability of less than one case of gastroenteritis in every 100 exposures. The AFRI burden would be negligible.
41-200 B	The 200/100 ml value is above the threshold of illness transmission reported in most epidemiological studies that have attempted to define a NOAEL or LOAEL for GI illness and AFRI.	1-<5% GI illness risk 0.3-<1.9% AFRI risk  The upper 95th percentile value of 200/100 ml relates to an average probability of one case of gastroenteritis in 20 exposures. The AFRI illness rate at this upper value would be less than 19 per 1,000 exposures, or less than approximately 1 in 50 exposures.
201-500 C	This range represents a substantial elevation in the probability of all adverse health outcomes for which dose-response data are available.	5-10% GI illness risk 1.9-3.9% AFRI risk  This range of 95th percentiles represents a probability of 1 in 10 to 1 in 20 of gastroenteritis for a single exposure. Exposures in this category also suggest a risk of AFRI in the range of 19-39 per 1,000 exposures, or a range of approximately 1 in 50 to 1 in 25 exposures.

<p>&gt;500 D</p>	<p>Above this level, there may be a significant risk of high levels of minor illness transmission.</p>	<p>&gt;10% GI illness risk &gt;3.9% AFRI risk There is a greater than 10% chance of gastroenteritis per single exposure. The AFRI illness rate at the 95th percentile point of &gt;500/100 ml would be greater than 39 per 1,000 exposures, or greater than approximately 1 in 25 exposures.</p>
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## ■ Notes:

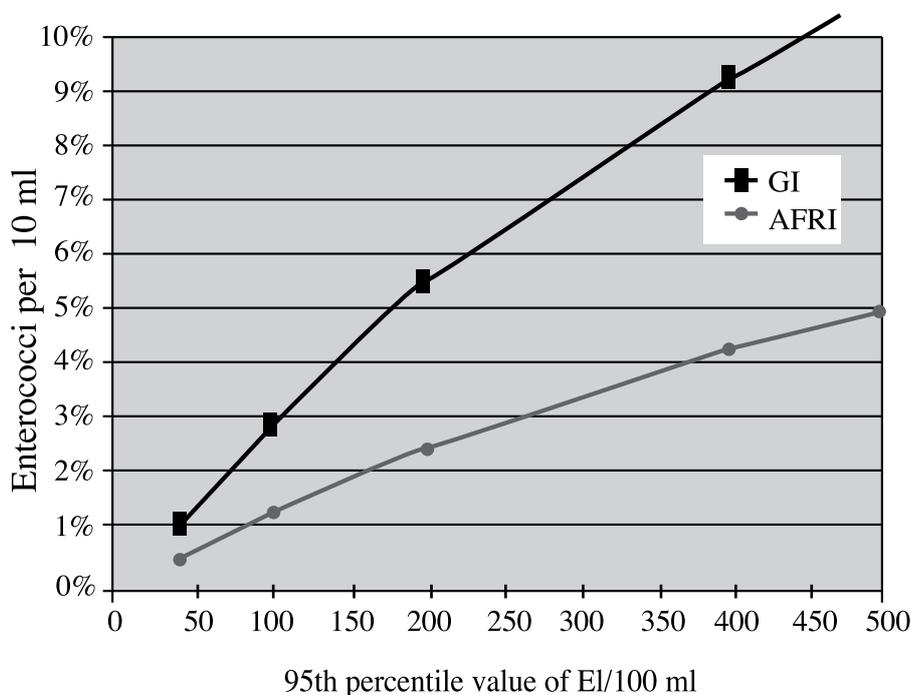
- 1 Abbreviations used: A–D are the corresponding microbial water quality assessment categories (see section 4.6 of WHO, 2003) (17) used as part of the classification procedure (Table 4.12 of WHO, 2003) (17); AFRI = acute febrile respiratory illness; GI = gastrointestinal; LOAEL = lowest-observed-adverse-effect level; NOAEL = no-observed-adverse-effect level.
- 2 The “exposure” in the key studies was a minimum of 10 min of swimming involving three head immersions. It is envisaged that this is equivalent to many immersion activities of similar duration, but it may underestimate risk for longer periods of water contact or for activities involving higher risks of water ingestion (see also note 7).
- 3 The “estimated risk” refers to the excess risk of illness (relative to a group of nonbathers) among a group of bathers who have been exposed to fecally contaminated recreational water under conditions similar to those in the key studies.
- 4 The functional form used in the dose-response curve assumes no further illness outside the range of the data (i.e., at concentrations above 158 intestinal enterococci/100 ml; see Box 4.3 of WHO, 2003). Thus, the estimates of illness rate reported above this value are likely to be underestimates of the actual disease incidence attributable to recreational water exposure.
- 5 The estimated risks were derived from sewage-impacted marine waters. Different sources of pollution and more or less aggressive environments may modify the risks.
- 6 This table relates to risk to “healthy adult bathers” exposed to marine waters in temperate north European waters.
- 7 This table may not relate to children, the elderly, or the immunocompromised, who could have lower immunity and might require a greater degree of protection. There are no adequate data with which to quantify this, and no correction factors are therefore applied.
- 8 Epidemiological data on fresh waters or exposures other than swimming (e.g., high-exposure activities such as surfing, dinghy boat sailing, or whitewater canoeing) are currently inadequate to present a parallel analysis for defined reference risks. Thus, a single series of microbial values is proposed for all recreational uses of water, because insufficient evidence exists at present to do otherwise. However, it is recommended that the length and frequency of exposure encountered by special interest groups (such as bodysurfers, board riders, windsurfers, sub-aqua divers, canoeists, and dinghy sailors) be taken into account (Chapter 1 of WHO, 2003).
- 9 Where disinfection is used to reduce the density of index organisms in effluents and discharges, the presumed relationship between intestinal enterococci (as an index of fecal contamination) and pathogen presence may be altered. This alteration is, at present, poorly understood. In water receiving such effluents and discharges, intestinal enterococci counts may not provide an accurate estimate of the risk of suffering from gastrointestinal symptoms or AFRI.
- 10 Risk attributable to exposure to recreational water is calculated after the method given by Wyer *et al.* (1999), in which a log<sub>10</sub> standard deviation of 0.8103 for fecal streptococci was assumed. If the

true standard deviation for a beach is less than 0.8103, then reliance on this approach would tend to overestimate the health risk for people exposed above the threshold level, and vice versa.

- 11 Note that the values presented in this table do not take account of health outcomes other than gastroenteritis and AFRI. Where other outcomes are of public health concern, then the risks should also be assessed and appropriate action taken.
- 12 Guideline values should be applied to water used recreationally and at the times of recreational use. This implies care in the design of monitoring programs to ensure that representative samples are obtained.

Figure 29-2, from which the WHO guideline values in Table 29-6 are derived, shows the dose-response relation between health risk and the 95th percentile value of the intestinal enterococci indicator for contracting gastroenteritis and acute febrile respiratory illness (AFRI) (56) by bathing in microbiologically contaminated water.

**Figure 29-2.** Risk for GI and AFRI due to EI exposure



## ■ The 95th percentile approach

WHO and many agencies have chosen to base criteria for recreational-water compliance upon either 95% compliance levels (i.e., 95% of the samples must lie below a specific value in order to meet the standard) or geometric mean values of water quality data collected in the bathing zone. Both have significant drawbacks. The geometric mean is statistically a more stable measure, but this is because the inherent variability in the distribution of the water quality data is not characterized in the geometric mean. However, it is this variability that produces the high values at the top end of the distribution that are of greatest public health concern.

It requires estimation of the population parameters known as the mean and standard deviation of the log normal distribution. One limitation of the method is that if the samples are not log-normally distributed, it will yield erroneous estimates of the 95th percentile. Also, if there are data below the limit of detection, these data must be assigned an arbitrary value based on the limit of detection.

The 95% compliance system, on the other hand, does reflect much of the top-end variability in the distribution of water quality data and has the merit of being more easily understood. However, it is affected by greater statistical uncertainty and, hence, is a less reliable measure of water quality, thus requiring careful application to regulation.

Other options include the percentile approach, in which a specified percentile, most commonly the 80th, 90th, or 95th, is calculated. A limit can then be set for making judgments about water quality, depending on whether the specified percentile value exceeds it or not. A simple ranking method by which a specified percentile may be calculated from the sample series being evaluated is given in Bartram and Rees (57). Other methods for calculating sample series percentiles are given by Ellis (58). Ninety-fifth percentile values calculated in this manner suffer from some of the same drawbacks described above for the 95% compliance system.

A more appropriate method of calculating the 95th percentile, which makes better use of all the data in the sample set, is to generate a probability density function (PDF) based on the distribution of indicator organisms over a defined bathing area and then to use the properties of this PDF to estimate the 95th percentile value of this distribution. In practice, the full procedure is rarely carried out, and 95th percentiles are calculated using the log-normal distribution method given in Bartram and Rees (57). This is called a parametric method, since it requires the estimation of the population parameters known as the mean and standard deviation of the lognormal distribution. One limitation of the method is that if the samples are not log-normally distributed, it will yield erroneous estimates of the 95th percentile. Also, if there are data below the limit of detection, these data must be assigned an arbitrary value based on the limit of detection.

### Guidelines for seawater

The guideline values for microbiological quality given in Table 29-6 are derived from the key studies described above. The cutoff or bounding guideline values (40, 200, 500) are expressed in terms of the 95th percentile of numbers of intestinal enterococci per 100 ml and represent readily understood levels of risk based on the exposure conditions of the key studies. The values may need to be adapted to account for different local conditions and are recommended for use in the recreational-water environment classification scheme discussed in the WHO *Guidelines* document. Also, by providing different risk levels, the decision to accept a given risk level is left to the discretion of the member states.

For the purposes of water quality monitoring, WHO established that the terms “fecal streptococci,” “intestinal enterococci,” and “enterococci” are considered to be synonymous (59). “Intestinal enterococci” is used in the WHO *Guidelines for Safe Recreational-Water Environments*. Exposure to recreational waters with these measured indicators refers to body contact that is likely to involve head immersion, such as swimming, surfing, white-water canoeing, scuba diving, and dinghy boat sailing.

Available evidence suggests that the guideline values presented in Table 29-6 provide a lesser degree of health protection than that considered tolerable in other areas of environmental quality regulation. However, the central “200” cut-off or upper bounding value represents a stricter standard than is encountered in many areas at present. Measures to discourage water use at times or in locations of greater risk may provide cost-effective means to improve health protection and water quality classification.

### Protocol for epidemiological investigations in Latin America and the Caribbean

WHO has recommended that countries, especially developing countries where priorities often must be set for projects of first necessity in the context of limited economic resources, conduct local epidemiological studies directed at establishing the relationship between health risk and indicator organisms. The WHO guidelines, as well as the USEPA 2012 RWQC, represent the state of the art. Notwithstanding, application of the WHO guidelines to the tropical waters of most of Latin America and the Caribbean may be a concern.

The cost of epidemiological studies is considered justifiable in the context of the large potential capital expenditures associated with control systems. Also, the adaptation of a particular risk level for human health should be based on the local socioeconomic situation if it is to be viable.

Furthermore, at the global launch of the WHO *Guidelines for Safe Recreational-Water Environments* during the XXVIII AIDIS Congress, held in Cancun, Mexico, on 30 October 2002, the following conclusions were reached:

“...Concerns were expressed about the broad applicability of the WHO Guidelines to Latin America and the Caribbean. Issues discussed included: tropical waters, local endemic illnesses, susceptibility of children and the elderly, tourists, and length of exposure.

*It was concluded that epidemiological studies should be conducted in the Region to evaluate the applicability of the WHO Guidelines to Latin American and the Caribbean temperate and tropical environments. It was also recom-*

*mended that pilot studies be conducted applying the Annapolis Protocol for beach management. Generally, there was recognition of the need for the guidelines and an appreciation was expressed for the efforts of WHO/PAHO.”*

### International expert consultation

An International Expert Consultation sponsored by PAHO, attended by world-renowned experts, was held in Mexico City from 28 to 30 November 2005 (60). The goal of the International Expert Consultation was to coordinate with national and international institutions in a collaborative effort in epidemiological research for tropical recreational bathing waters to ascertain the applicability of the WHO *Guidelines for Safe Recreational-Water Environments* to the tropical waters and conditions of Latin America and the Caribbean. The specific goal of the International Expert Consultation was to contribute to the development of a research protocol for epidemiological investigations. Among the participating international experts were Dr. David Kay (University of Wales, Great Britain), responsible for the epidemiological studies upon which the WHO guidelines are based, as well as Dr. Alfred Dufour (USEPA), a principle investigator in the development of the 1986 and 2012 USEPA guidelines.

A subsequent meeting financed by the Mexican Government was held in Acapulco, Mexico, immediately afterward on 1 to 2 December 2005 to present the results of the Expert Consultation to a larger audience to obtain insights and comments on the feasibility of implementing the proposed protocol in Mexico and other Latin American and Caribbean countries.

The object of this endeavor was to develop a protocol (61,62) for epidemiological studies tailored to Latin America and the Caribbean .

### Rationale for a study in Latin America and the Caribbean

While a number of previous epidemiologic investigations for bathing beaches have been conducted around the world, substantial methodological variation exists across these studies. For example, each individual investigation may apply a unique case definition, water quality measure, or procedure for case and control selection and exposure assessment, resulting in a lack of coordination and, hence, the inability to apply the results in WHO guideline development.

In the absence of a universal, specifically outlined peer-reviewed protocol, Latin America- and Caribbean based studies are subject to the aforementioned potential fallacies, as well as the design of a plethora of flawed investigations with opaque protocol or logistics design and inappropriate sample sizes. In addition, without a guiding protocol, the Region may produce a multiplicity of uncoordinated or incomparable investigations due to dissimilar exposed and bathing groups, poor or diverse exposure and outcome measures, or a heterogeneous confounder definition measurement. This lack of harmonization between studies will render data pooling impossible, and cross-study comparison from such unsystematic investigations may likely not be feasible. It is improbable that the results of these studies would relevantly contribute to the development of standardized WHO guidelines for tropical recreational waters. Advance awareness of these specific dangers is thus necessary to design the best possible protocol, which will lead to coordinated investigations that will contribute to future specific WHO guidelines for recreational waters in Latin America and the Caribbean.

To develop a suitable and sound regional protocol, the WHO guideline development process needs to be well understood. In addition, an embedded peer review of a draft protocol is needed before adopting a specific and finalized Latin America and Caribbean protocol. This final protocol should comprise specific logistics relevant to Latin America and the Caribbean and should ensure that all ethical considerations have been met, that the statistical analysis to be undertaken is well-defined, and that appropriate study populations are defined by power calculations in order to detect the effect between the exposure and the disease outcome being investigated.

The draft of the proposed protocol (61,62) is under final review by PAHO.

### Other standards

Many international, national, and local agencies have established guidelines and standards for water quality indicators to protect human health that can provide a reference point for planning. The standards of a few countries are summarized in Table 29-7. Standards worldwide vary widely, reflecting different philosophies, levels of risk, and/or levels of water use protection. The principal factor behind the range of standards is the origin of the supporting criteria, be they epidemiological, aesthetic, or ecological.

It is noted that many of the countries in Latin America that have issued national standards have adopted them directly, with minor modifications, from those employed in the United States, with perhaps minimal consideration

given to economic realities and development priorities. Developing nations, such as those in Latin America, differ from industrialized nations, where most of the research is conducted, in that the developing country must allocate limited financial resources to a greater number of basic public works and economic development projects. It is important that planners conduct a thorough review of the prevailing local water quality guidelines/standards (if any) to insure that local economic development priorities are reasonably accounted for. Control systems that protect recreational beaches and the environment, such as ocean outfalls, are among the most capital-intensive means of wastewater disposal, although life-time costs will be considerably lower in comparison with those of secondary wastewater treatment with onshore disposal. Consequently, the decision to design the system for other than minimum water quality standards should be supported by demonstrated need, or a stated local/national policy decision.

Microbiological standards are frequently expressed as a permissible mean concentration and a maximum value that should not be exceeded a given percent (90% is common) of the time. However, the relationship between these two criteria should be evaluated. For example, Kay *et al.* (63), show that the 1976 EEC mandatory criteria that 95% of samples have less than 2,000 fecal coliforms/100 ml is stricter than the geometric mean of 200/100 ml used by the USEPA prior to 1986. This analysis assumes a log-normal distribution with a standard deviation of 0.7 ( $\log_{10}$ ), which implies that for a mean of 200/100 ml, 95% of the samples would have to be less than 2,834/100 ml. However, it is noted that the pre-1986 USEPA guidelines also specified that 90% of the samples be less than 400/100 ml, which translates to a geometric mean of about 50 fecal coliforms/100 ml utilizing the same assumptions as Kay *et al.* (63). The USEPA guidelines and the implications of the Single Sample Maximum Allowable Density approach adopted in the 1986 guidelines and their subsequent abandonment in the 2012 RWQC have already been discussed.

The establishment of water quality objectives (standards) is dependent on existing or planned water uses in an area, and, as such, is site-specific.

**Table 29-7.** Microbiological water quality guidelines and standards for contact recreation

<b>Peru (64)</b>			
	<b>Units</b>	<b>Primary Contact</b>	<b>Secondary Contact</b>
Thermotolerant coliforms (44.5°C)	MPN/100 ml	200	1000
Total coliforms (35-37°C)	MPN/100 ml	1000	4000
Fecal enterococci	MPN/100 ml	200	**
<i>Escherichia coli</i>	MPN/100 ml	Absence	Absence
Parasitic forms	Organism/liter	0	
<i>Giardia duodenalis</i>	Organism/liter	Absence	Absence
<i>Salmonella</i>	Presence 100/ml	0	0
<i>Vibrio cholerae</i>	Presence 100/ml	Absence	Absence
<b>Columbia (65)</b>			
	<b>Units</b>	<b>Primary Contact</b>	<b>Secondary Contact</b>
Fecal coliforms	MPN/100 ml	200	--
Total coliforms	MPN/100 ml	1000	5000
<b>The Administrative Commission of the Uruguay River (66)</b>			
	<b>Units</b>	<b>Primary Contact</b>	<b>Secondary Contact</b>
Fecal coliforms	UFC/100 ml	2001; 80% < 500	
<i>Escherichia coli</i>	<i>E. coli</i> /100 ml	126 <sup>1</sup>	
Enterococci	Enterococci/100 ml	33 <sup>1</sup>	
<b>Paraguay (67)</b>			

Fecal coliforms			
Excellent	MPN/100 ml	none	
Very good	MPN/100 ml	80% < 250 <sup>2</sup>	
Satisfactory	MPN/100 ml	80% < 1000 <sup>2</sup>	
Not suitable	MPN/100 ml	>1000 <sup>2</sup>	
<b>Canada (68)</b>			
<i>Escherichia coli</i>	<i>E. coli</i> /100 ml	GM ≤200	
	<i>E. coli</i> /100 ml	SS ≤400	
Enterococci	Enterococci /100 ml	GM ≤35	
	Enterococci /100 ml	SS ≤70	
Cyanobacteria Cyanobacterial toxins	Total cyanobacteria Total microcystins	≤100,000 cells/ml ≤20 µg/l	
<b>Australia (69)</b>			
Intestinal enterococci	Enterococci /100 ml	95th percentile/100 ml A: ≤40 B: 41-200 C: 201-500 D: >500	
<b>Cuba (70)</b>			
Total coliforms	MPN/100 ml	1000 <sup>1</sup>	
Fecal coliforms	MPN/100 ml	GM 200 <sup>1</sup> 90% < 400 <sup>1</sup>	
<b>Argentina Microbiological Standards (71)</b>			
<i>Escherichia coli</i>	Colonies/100 ml	126 <sup>3,5</sup>	
<i>Enterococcus</i>	Colonies/100 ml	33 <sup>3,5</sup>	
	Colonies/100 ml	33 <sup>4,5</sup>	

\*\* For this subcategory, the parameter is not relevant, except for specific cases as determined by the competent authority

<sup>1</sup> Geometric mean of 5 samples in 30 days

<sup>2</sup> Samples taken during each of 5 weeks

<sup>3</sup> Fresh water

<sup>4</sup> Seawater

<sup>5</sup> Specified as the geometric mean limiting value. In addition for individual samples, limiting values are associated with the superior confidence limit (LCS) whose calculation is given in the Development Document (71)

## ■ Wastewater disposal options and human health risk

The issue of wastewater disposal options and human health risk was addressed in the WHO *Guidelines for Safe Recreational-water Environments*. The WHO findings are summarized in Table 29-8 for the major types of treatment and disposal practiced by coastal communities around the world. The least risk to human health is the alternative of an effective outfall even with only preliminary treatment.

**Table 29-8.** Risk to human health from exposure to sewage (including stormwater runoff and combined sewer overflows, WHO)

	Human health risk		
	Discharge directly on beach	Discharge from short outfall <sup>a</sup>	Discharge from effective outfall <sup>b</sup>
None <sup>c</sup>	Very high	High	NA <sup>d</sup>
Preliminary	Very high	High	Low
Primary (including septic tanks)	Very high	High	Low
Secondary	High	High	Low
Secondary plus disinfection <sup>e</sup>	-	-	-
Tertiary	Moderate	Moderate	Very low
Tertiary plus disinfection <sup>e</sup>	-	-	-
Lagoons	High	High	Low

<sup>a</sup> The relative risk is modified by population size. Relative risk is increased for discharges from large populations and decreased for discharges from small populations.

<sup>b</sup> Assumes the design capacity has not been exceeded and that extreme climatic and oceanic conditions are considered in the design objective (i.e., no sewage in the beach zone).

<sup>c</sup> Includes combined sewerage overflows if active during the bathing season (a positive history of total nondischarge during the bathing season can be treated as “low”).

<sup>d</sup> NA = not applicable

<sup>e</sup> Additional investigations recommended to account for the likely lack of prediction with fecal index organisms.

Coastal wastewater disposal is often posed as a choice between treatment or outfall, but Table 29-8 shows this to be a false choice. Even treated effluent must ultimately be disposed of through an ocean outlet or to rivers that eventually flow to the ocean. Table 29-8 clearly demonstrates that an effective outfall is superior to all nearshore discharges. Even with only preliminary treatment, the risk to human health is very low, and more advanced treatment does not significantly lower this risk. The underlying principle is that effective outfalls physically separate people from sewage. The reliability of an outfall, which is a civil engineering structure with minimal operation and maintenance requirements, is also much higher than treatment plants, which require high operation and maintenance and are subject to upsets, especially in developing countries.

The three principal types of discharge in Table 29-8 are:

- (i) Directly onto the beach;
- (ii) A “short” outfall, with likely contamination of recreational waters;
- (iii) An “effective” outfall, designed so that the sewage is efficiently diluted and dispersed and does not pollute recreational areas.

Although the terms “short” and “long” are often used, outfall length is generally less important than proper location and effective diffusion. An effective outfall has sufficient length and depth to ensure high initial dilution and to prevent sewage from reaching areas of human usage.

## ■ Routine beach monitoring

The purpose of beach monitoring is to ensure and demonstrate compliance with bathing water standards and the safety of bathing beaches. This is especially important for beaches frequented by tourists.

Routine national and/or local beach surveillance programs are conducted in most countries at specified locations and frequencies—for example, once a week or every two weeks, to comply with water quality standards and classify and manage bathing beaches.

As part of the WHO development of the *Guidelines of Safe Recreation-water Environments* (17), an Expert Consultation cosponsored by WHO and the USEPA was held in 1999 in Annapolis, Maryland, USA (72). The *Annapolis Protocol* that resulted from this meeting proposed an innovative approach to bathing beach classification based on risk evaluation, using long-term water quality data combined with sanitary inspections and the application of beach management practices. Aspects of the *Annapolis Protocol* have been adopted in the 2012 USEPA RWQC guidelines.

Present-day bathing beach classification systems are generally based on mandated periodic vigilance monitoring (5 samples per month is common) or single measurements of indicator organisms consistent with water quality standards. Such approaches may or may not capture transient events such as storms, and the single measurement systems have the inherent flaw of after-the-fact bathing beach classifications due to the 24- to 48-hour delay of microbiological indicator measurement results. As previously discussed, the ongoing development and evaluation of qPCR as a rapid analytical technique for the detection of *Enterococcus* spp and *E. coli* (73) address this issue. Furthermore, a monitoring program of fixed periodic measurements applied indiscriminately to all beaches would result in the same repeated values and beach classification for beaches that are either heavily contaminated or pristine and, as such, would be an inefficient use of monitoring resources.

The reader is referred to references 72 and 17 for details of the *Annapolis Protocol*. This protocol encompasses a combination of sanitary inspection, water quality measurements, and risk categories to monitor and classify beaches. The proposed monitoring frequency is presented in Table 29-9.

## ■ Beach certification programs

### Blue Flag program

The Blue Flag is a voluntary certification scheme for beaches and marinas operating in Europe that has proven an effective tool for environmental and safety management. In the Caribbean, as in Europe, the award criteria cover four aspects of beach and marina management: water quality, environmental education and information, environmental management, and safety and services. The program takes a holistic approach to sustainable tourism. Beaches are awarded the Blue Flag based on compliance with 32 criteria, including compliance with the EU enterococci guidelines.

### Blue Wave Program

The Blue Wave Program is a counterpart program for the environmental certification of beaches in the United States. Applicants for certification may include beach municipalities, local authorities, tourism boards, homeowners' associations, hotels, resorts, and others representing a beach or destination and must comply with seven Blue Wave Ethics. The program is recognized as a reliable benchmark for well-maintained beaches and ecofriendly tourism.

Table 29-9. Recommended monitoring schedule

Risk category identified by sanitary inspection	Microbial water quality assessment	Sanitary inspection
Very low	Minimum of 5 samples per year	Annual
Low	Minimum of 5 samples per year	Annual
Moderate	Annual low-level sampling 4 samples x 5 occasions during swimming season Annual verification of management effectiveness Additional sampling if abnormal results obtained	Annual
High	Annual low-level sampling 4 samples x 5 occasions during swimming season Annual verification of management effectiveness Additional sampling if abnormal results obtained	Annual
Very high	Minimum of 5 samples per year	Annual

## ■ Conclusions and recommendations

Although more than 90 years have passed since their first application, a range of three orders of magnitude continues to exist in microbiological indicator water quality standards around the world. The number of epidemiological studies that justify these total and fecal coliform standards is very limited, although the application of these standards can result in significant costs for control systems.

Extensive epidemiological studies conducted worldwide have shown that there is a quantitative relation between health risk and enterococci and *E. coli* levels, although factors such as the general health and immunity of the local population imply that caution should be exercised in directly applying the relationships found in other areas.

It is therefore recommended that developing countries in the Americas and elsewhere conduct local epidemiological studies aimed at establishing the relationship between health risk and indicator organisms. The cost of epidemiological studies is justifiable in the context of the large potential capital expenditures associated with control systems. Furthermore, adaptation of a particular risk level for human health should be based on the local socioeconomic situation if it is to be viable.

In the interim, it is recommended that the WHO *Guidelines for Safe Recreational-water Environments* or the USEPA's 2012 recreational water quality criteria (RWQC) recommendations be adopted in developing countries until further epidemiological investigations are conducted. Intestinal enterococci levels, which best relate to disease burden, should be adopted as the primary biological indicator for surveillance water quality monitoring of bathing beaches, and the transition from other indicator organisms should begin as soon as possible, based on the capabilities of the countries to do so.

The least risk to human health due to sewage disposal is the alternative of an effective outfall, even with only preliminary treatment.

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# Facilitating environment and early childhood care: Challenges for health and sustainable development in Brazil

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*“The fundamental emotion that makes possible the history of hominization is love.”(1)*

## ■ Introduction

A century and a half has passed since Charles Robert Darwin founded evolutionary biology. Since then, the cornerstone he laid has become the foundation of an impressive edifice that has confirmed the essence of the British naturalist’s theories while vertiginously expanding our knowledge about the origin, nature, and evolution of living things on our planet (2).

The understanding that life on Earth began approximately 3.5 billion years ago has led scientists to estimate that human beings branched off from our common ancestor, the chimpanzee—the only other living hominid—roughly 5 to 7 million years ago, and that archaic *Homo sapiens* evolved between 400,000 and 250,000 years ago. In November 2011, the human population was estimated by the United Nations at close to seven billion people (3), with humans being a dominant life form in terms of both spatial distribution and our effects on the biosphere.

The mental capacity and upright posture of humans made it possible to use the arms to manipulate objects, a factor that enabled humans to make and use tools, thus altering the environment more than any other living thing. Human beings are social by nature and particularly skillful at creating and using communication systems—mainly verbal, gestural, and written—to express themselves, share ideas, and organize themselves into complex social structures composed of cooperating or rival groups. The human capacity to interact with other living things and the environment produces tensions and conflicts that require mediation and the construction of ontological theories about the relationships between living things and their surroundings.

The discovery that evolution produced the human described above—through adaptations or aptitudes acquired through a combination of small, successive, random changes, resulting from natural selection over the course of generations, providing the skills required for humans to survive in their habitat—is both impressive and disconcerting: a mismatch between a description of humans deprived of and dissociated from the feelings and emotions that have certainly played an important role in bringing man to the “here and now,” where we more easily recognize ourselves. We will thus use the studies of Humberto Maturana, who provides an understanding of the *modus operandi* of the systemic organization of living things, guided by a particular notion of biology in which emotions play a key role in the development of the biotic system. Living things are understood as “*autonomous dynamic entities in continuous change based on their living conditions* (4).”

Thus, what determines the organization of living things is their own autopoiesis, understood as autonomy and triggered by the “living-environment-living” relationship. At the same time, this means the generation/regeneration of the relational and other spaces and the generation/regeneration of the relational system. This perspective goes beyond the adaptive explanation. It is in this creative “environment/system” that the social phenomenon emerges; to

Maturana, the “social phenomenon” is the domain of relational behaviors based on the original emotion of life: love. According to the author: “*To love is to accept the other as a legitimate other in the relationship* (5).” Love is a one-way street, where nothing is required or expected in return. According to Rios and Costa (6), *to love* is an intransitive verb that paves the way for a different relationship with the world. This attitude, however, requires one to forsake egocentrism and develop a systemic gaze or regard focused on the well-being of others and the environment. In other words, a perspective that gives the other a space where he or she can live fully, instead of telling the other what to do and how to do it.

This relational space of which the authors speak can be understood to approximate the concept of “facilitating environment,” found in the work of English pediatrician and psychoanalyst Donald W. Winnicott (7), who views the environmental context from the perspective of permanent creation, as he posits that nothing is there beforehand, whereas “ambience” is already present, created by cultural values and lifestyle. Although recognizing that creation is an ongoing process based on what is already in place, Winnicott works with the paradox that one must create what has already been created. He values the permanent link between one’s personal concept of the world, which is created gradually, and sharing the reality of the environment with one’s peers. This relational concept entails an ethic of care with regard to oneself and, simultaneously, the environment. Safra (8) provides a good translation of Winnicottian thought on this matter:

*“Every human birth occurs paradoxically. The birth of a child promotes a rupture from that which is placed in the environment, while, at the same time, transmission of the family’s particular cultural traditions to the infant is taking place. The emergence of a singularity demands definition of all that is part of the world by dint of the child’s birth. Paradoxically, it is at once a rupture and an encounter with what is already in place. The creation of the world by the child by means of its gestures and the welcome it receives by its parents enable [the child] to happen in its family history.”*

The following reflection by Elias is particularly appropriate in this context (9):

*“The individual person is not a beginning and his relations to other people have no beginnings. (...) each gesture and act of the infant is neither the product of his ‘inside’ nor of his ‘environment’, nor of an interaction between an ‘inside’ and an ‘outside’ which were originally separate, but a function and precipitate of relations, and can be understood—like the figure of a thread in a net (emphasis ours)—only from the totality of the network. Likewise the speech of others develops in the growing child something which is entirely his own, entirely his language, and at the same time a product of his relations to others, an expression of the human network within which he lives.”*

Elias continues to provide an understanding of the growing human from a sociological standpoint, adding what we previously discussed through neurobiology, psychology, and psychoanalysis:

*“In the same way, ideas, convictions, affections, needs and character traits are produced in the individual through intercourse with others, things which make up his most personal ‘self’ and in which is expressed, for this very reason, the network of relations from which he has emerged and into which he passes. (...) It is the order of this incessant interweaving without a beginning that determines the nature and form of the individual human being. Even the nature and form of his solitude, even what he feels to be his ‘inner life’, is stamped by the history of his relationships—by the structure of the human network in which, as one of its nodal points, he develops and lives as an individual.”*

Different theoretical contexts produce different meanings for the term “environment,” presenting it as that which surrounds bodies on all sides, a set of substances, circumstances, or conditions in which a given object exists or a given action occurs. The Brazilian National Environmental Policy (PNMA) (10), established by Law 6938 of 1981, defines the environment as “the set of conditions, laws, influences, and interactions of a physical, chemical, or biological nature that permit, protect, and govern all forms of life.” The natural environment can be contrasted with the environment constructed and influenced by humans.

With this introduction, we invite the reader to walk down a path other than the one that discusses the influence of the environment (or of countless environments) on the life of humans. All the more so, because by associating

environment and health (understood broadly), we present our understanding of what involves human beings and is involved in our behaviors within society.

In our proposition, we highlight the role of what we call a facilitating emotional environment for the healthy development of human beings, approximating it to the concept of the social determinants of health, which encompass countless factors associated with the generation of health, the intensity of life experiences, and expressions of creativity that enable individuals to overcome the factors that create malaise and suffering and thus limit and undermine the quality of life. We therefore view the sustainable development of Brazil as the result of profound transformations in Brazilian society and dare to include in the constitution of its greatest good —Brazilian citizens— a dimension that includes the facilitating environment for early emotional development as an undeniable factor in the generation of health and well-being.

On this road toward healthy development, together with these scholars of primary emotional development, we state our conviction that individual ability to take on life's issues with greater autonomy is bound up with the relational experiences of the initial moments of life, when personal patterns of living and coexisting are defined. This road involves such different dimensions as the economic, ecological, social, and political domains in the constitution of man, his culture, his vulnerabilities, and his autonomy (11).

From this standpoint, in 2007, the Oswaldo Cruz Foundation, in partnership with the Ministry of Health of Brazil, proposed the development of a strategy articulated around a wide range of interventions focused on how we understand and tend to this most special moment of childhood and on the need to develop public policies in this field. These interventions, which can be undertaken by several actors, can be simple or complex and not always integrated with one another, with several objectives and different degrees of priority. They share an impact on child development in the stage up to the age of 6 years, the period considered early childhood in Brazil. Thus was born the *Brasileirinhas e Brasileirinhos Saudáveis [Healthy Little Brazilians] Strategy (EBBS): First Steps for National Development*.

## ■ Theoretical framework

### The social determinants of health

Over the course of the 20th century, permanent tension permeated the various approaches involved in the initial development of public health as a scientific discipline —namely, the predominance of the medical-biological approach over sociopolitical and environmental approaches. However, the definition of health as a state of complete physical, mental, and social well-being, as defined in the Constitution of the World Health Organization (WHO) in 1948, is a clear expression of a rather broad concept of health:

*“The most important single long-term principle for the future work of WHO in the fostering of mental health—as opposed to the treatment of psychiatric disorders—is the encouragement of the incorporation into public-health work of the responsibility for promoting the mental as well as the physical health of the community” (12).*

The Alma-Ata Conference of 1978 and the activities inspired by the slogan *Health for All by the Year 2000* placed the spotlight back on the subject of the social determinants of health. In Brazil, they provided major elements in support of Brazilian Health Sector Reform during the recent dictatorship, at a time in which different important actors discussed what the role of health should be and how to exercise it. The issue of “*democracy and health*” became a matter of debate, and discussions continued and expanded into the current understanding that “*democracy is health*.”

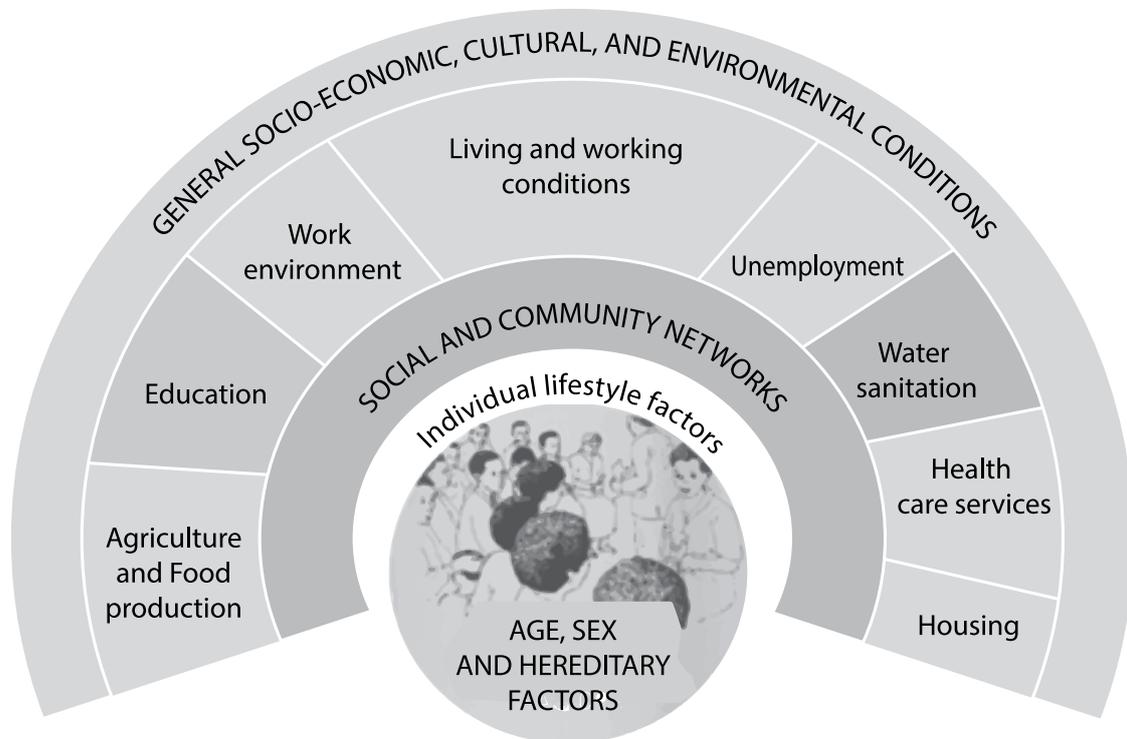
In the 1980s, the prevailing understanding was centered on individual medical care, focusing on health as a private good. In the 1990s, the debate on the Millennium Development Goals began shifting this emphasis to social determinants, leading to the creation of the WHO Commission on Social Determinants of Health in 2005.

In 2006, the National Commission on Social Determinants of Health (*Comissão Nacional sobre Determinantes Sociais da Saúde*, CNDSS) (13) was established in Brazil, composed of representatives from the social, cultural, scientific, and business fields. The CNDSS also had an Intersectoral Working Group, composed of representatives from various ministries and the National Councils of State and Municipal Health Secretaries (CONASS and CO-NASEMS, respectively) (14).

The CNDSS defines the social determinants of health (SDHs) as the economic, cultural, psychological, behavioral, and other factors that influence the appearance and distribution of health problems and their risk factors among the population. It understands that inequities in health are not exclusively the result of a lack of access to health services, but also the impact of inequality on other sectors, such as the housing, employment, education, and fiscal sectors (15).

The Commission emphasized discussion and proposals on the issue of inequities in health, in the understanding that health inequalities are “avoidable, unfair, and unnecessary” and valid targets for intervention (16).

**Figure 30-1.** Dahlgren and Whitehead (1991) model of the social determinants of health (17).



The factors and mechanisms related to the social determinants of health can be addressed from various perspectives tied to “physical and material” aspects associated with the health and disease process, such as lack of public investment in infrastructure as a consequence of economic and political decisions; “psychosocial factors,” which address the relationships between perceptions of social inequalities; “psychobiological” mechanisms and health conditions; and “ecosocial” interactions, which attempt to integrate the “multilevel” individual and collective relations into a single dynamic and historical perspective (16).

The CNDSS chose the Dahlgren and Whitehead model as the framework from which to conduct SDH-targeted interventions and foster equity in health, covering the various levels that these interventions should affect: *proximal* determinants (related to individual behavior), *intermediary* determinants (related to living and working conditions), and *distal* determinants (related to the economic, social, and cultural macrostructure) (17).

The rationale for choosing this model was its simplicity and ease of understanding by several audiences and the clear graphic depiction of the various SDHs, enabling it to guide the organization of CNDSS activities and the contents of its final report.

With a distinct outlook on the social determinants of health, the *Brasileirinhos* Strategy proposes a reflection on the psychic factors underlying the generation of health and citizenship: specifically, primitive emotional development. For this purpose, the strategy places the dialogue between frames of reference for health inequities and

the concept of a “facilitating environment” in early childhood for human growth, development, and maturation, as posited by D.W. Winnicott (18).

## ■ The facilitating environment and primitive emotional development

In the mid-20th century, working in the fields of pediatrics, psychoanalysis, and ethology, John Bowlby<sup>1</sup> and D.W. Winnicott (19) noted the importance of the formation of adaptive patterns to life and their impact on the freedom of every human being to enjoy his own life experience.

As reported by Temporão and Penello (20), Bowlby had been invited to advise WHO on the mental health of homeless children in 1950, and Winnicott had worked as a volunteer, treating children who had been separated from their parents and families during World War II. These critical experiences were incorporated into their work and used to support theories in the field of child psychoanalysis, converging toward the adoption of an expanded concept of health that also included psychological aspects.

In this chapter, we will discuss frames of reference for the field of social determinants of health, primitive emotional development, and early childhood care and their relation to public health policies.

Winnicott coined the term “good-enough parent” to facilitate understanding of what constitutes good and sustainable environmental provision. Namely, it is one that, at the start of a new being’s life, corresponds to the body-mind of the mother: it necessarily includes her own existence, support networks, fantasies, and desires and her imaginary or real constructs, and serves as a supportive and welcoming environment for the child. This support is represented by the mother’s arms, which hold the newborn tenderly and firmly. Thus, a “good-enough mother” (21) is one capable of intuitively giving her child what it needs to grow and mature, including the means of dealing with possible bumps along the way. The environmental provision usually offered by the biological mother can be created by a substitute figure (including the father) through loving, creative, and non-bureaucratic ties. This concept leads us to believe that, during this phase of infant development, love can be effectively expressed only in terms of the care provided in this trust-building environment. Emphasis is placed on the bond created, a process essential for raising children who are healthy, happy, and better able to interact with and contribute to the production of good environmental conditions. We believe it is worth working toward an ecological approach to life, providing the infant and its caregiver with an environment that meets the adequate standard of quality.

According to Winnicott, life can be viewed as an ongoing process of creation and can be understood as one in which the tendencies that nature instills in man foster the spontaneous movement of life: autopoiesis, subjective self-creation, and creation, as already noted in this text. Thus, a facilitating environment is one that facilitates the gradual integration of early life experiences and acquisition of the awareness that we exist psychically distinct from our environment and are in permanent interaction with the reality that surrounds us, since we are part of it physically, socially, politically, personally, and spiritually.

In this regard, it bears stressing the close relationship between care and sustainable development, as noted by Leonardo Boff (22) in an article published at the time of the United Nations Conference on Sustainable Development, also known as Rio+20: “It is imperative that public policies consider another reality to add to sustainability: care.”

The author adds, “Care is the experience of the relationship between the need to be cared for and the will and predisposition to give care.” Thus, care is a precondition for existence, as the lodestar for the actions of human beings in their mission as caretakers of one another, the planet, and life itself, thus ensuring sustainability.

According to Penello (23):

*“Public policies in this field should consider that the healthy development of Brazilians and the country’s sustainable development start at the beginning of life: (...) the determinants of health, vulnerability, and risks have an impact not only on the caregiver but on those who are (or are not) receiving care.”*

Therefore, healthy public policies should be guided by care, an essential element for forging ties among all those involved in the generation of health and citizenship. This tie between all human beings is what supports the facilitating environment, a principle we will address below.

Thus, maturation is a never-ending, ever-adaptive process from an evolutionary standpoint—one that has been considered an important indicator of health and a decisive contributor to social development: “*The basis for a society is the whole human personality (...) It is not possible for persons to get further in society-building than they can get in their own personal development* (24).”

It is in this regard that Winnicott proposes a rather singular understanding of the development of the whole human personality, its constitution always in contrast to “the other” with whom it establishes bonds, suggesting a circular configuration that broadens and expands, from the desire and body of the mother up to a broader social participation, presented as the Theory of Social Circles (25). It is interesting to note how the author approaches democratic values, highlighting them as capable of creating a facilitating environment for the creation of citizenship:

*“A democracy is an achievement, at a point of time, of a limited society... [of which] one can say: In this society at this time there is sufficient maturity in the emotional development of a sufficient proportion of the individuals that comprise it for there to exist an innate tendency towards the creation and re-creation and maintenance of the democratic machinery.”*(26)

Some basic elements of the democratic machinery are the free and secret ballot, not only so that the people can choose both logically and illogically, but also so they vote out and rid themselves of leaders. This choice will allow more or less rapid progress of the civilizing project/process of a given culture. This ability of each individual to influence the whole, and of the whole to influence each and every individual, is an important characteristic of the development of a society, associated with the potential of the individual personality to mature throughout life and dependent on all the machinery that society places at the disposal of its citizens for this purpose.

## ■ Why focus on early childhood?

The importance of primitive emotional development in defining and shaping health patterns for life is also being considered by neuroscience research, a field through which biology has experienced resurgence in the 21st century, searching for paths to understanding brain/mind phenomena, supported especially by the concept of neuroplasticity. Terra comments on this topic, invoking the work of James Fraser Mustard and Richard Tremblay:

*“It is also very important to understand that, in addition to mental aspects, and even as their material basis, an extraordinary cerebral plasticity occurs in the first years of life, with the extremely rapid formation of trillions of new connections among the 100 billion neurons of the human brain. All this occurs in a short time, in a manner programmed to respond to environmental incentives, and in different areas, triggered at certain periods. These are the ‘windows of opportunity’, critical moments at which the functions and competencies important for our performance and survival in better conditions are organized. At no other time of the life cycle will such a dynamic situation occur. The process of incredibly rapid development that occurs from gestation until the end of the first 3 years of life is genetically marked and powerfully influenced by the environment. To each new incentive corresponds a newly established network of connections”* (27).

The concept of a “facilitating environment” seems even clearer when one considers that these processes occur in such early stages of development, when the baby still does not exist as an isolated being, but is instead utterly dependent on others for the continuity of its existence:

*“(...) by this continuity of environmental provision, and only by this, the new baby in dependence may have a continuity in the line of his or her life”* (28).

Winnicott refers here to the work of Bowlby, who highlights the importance of continuity of care at the beginning of the baby’s personal life, even before he or she is able to objectively perceive the whole mother as the person she is, by observing the baby’s reaction to the mother’s absence (even temporary) if beyond the baby’s capacity to keep her image alive (29).

The capacities of the human brain and their relation to the development of the species, as viewed from the standpoint of brain/mind relations, have also been supporting research on the neurobiology of feelings and the ex-

pression of emotions. These aspects buttress the findings of authors who address primitive emotional development using psychology and psychoanalysis as foundations, and reiterate the importance of including the promotion of mental health in public health. Damasio questions the practical value of considering public health from this perspective:

*“(...) the success or failure of humanity depends in large measure on how the public and the institutions charged with the governance of public life incorporate that revised view of human beings in principles and policies [...] capable of reducing human distress and enhancing human flourishing.”(30)*

The issue at hand is to mobilize the technical staff and managers of health services, as well as all professionals who operate within the spectrum of the intersectoral approach to care, as the individuation process implies that a subject is yet to come, and even when there is apparently no subject—as in the child who does not yet speak, in cases of autism, in the intimidated child—one should presume that subjectivity exists, merely waiting to be questioned.

Thus, listening to the young child and his caretakers is an ethical issue that supports the child’s right to constitute himself as a subject, especially if constitutive process is facing challenges. And this observation can only be made if parents, attentive caregivers, and experts are present and engaged, even captivated by a special interest in the child, always opposing the notion that the body of the child be viewed as a merely biological entity, as there is no human being without mental life.

This constant, experienced presence with the infant supports the construction of its psychic apparatus, enabling the brain to offer its neuroplasticity for the registration of symbolic processes. It is thus said that parents are the first and indispensable masters of the brain (31).

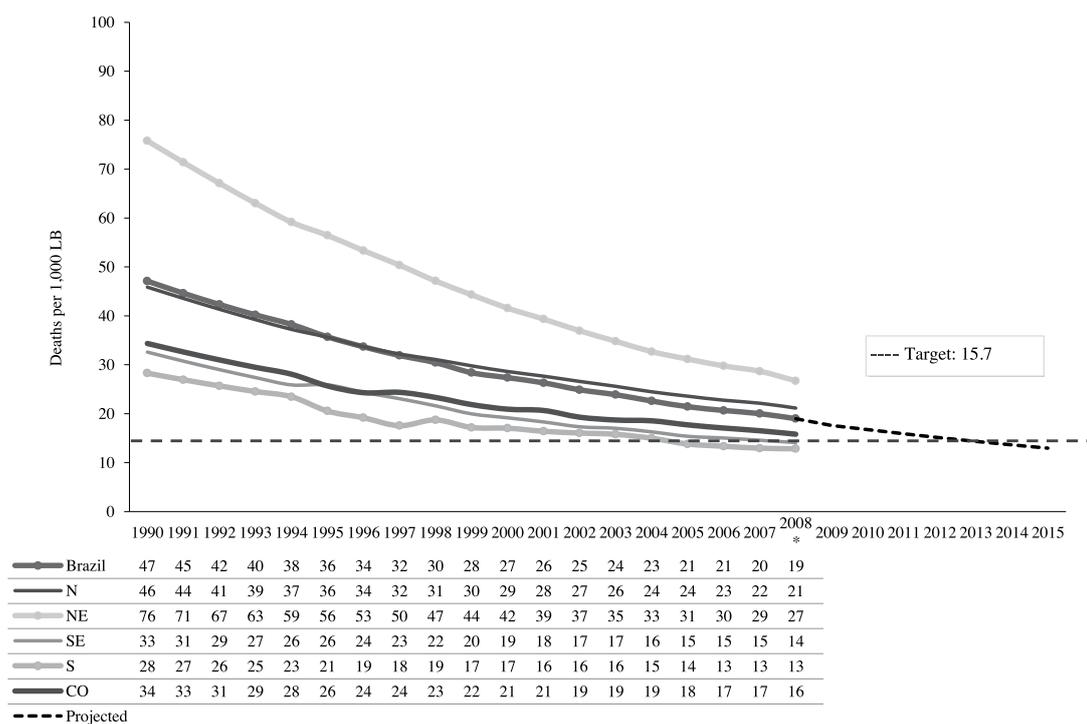
## ■ The Brasileirinhas e Brasileirinhos Saudáveis (“Healthy Little Brazilians”) Strategy: Inputs for a public policy geared to early childhood

### Brief history

According to the National Children and Women’s Demographic and Health Survey (32), as of 2006, Brazil had 14,210,000 children in the 0 to 4 year age group, corresponding to 7.59% of the country’s total population.

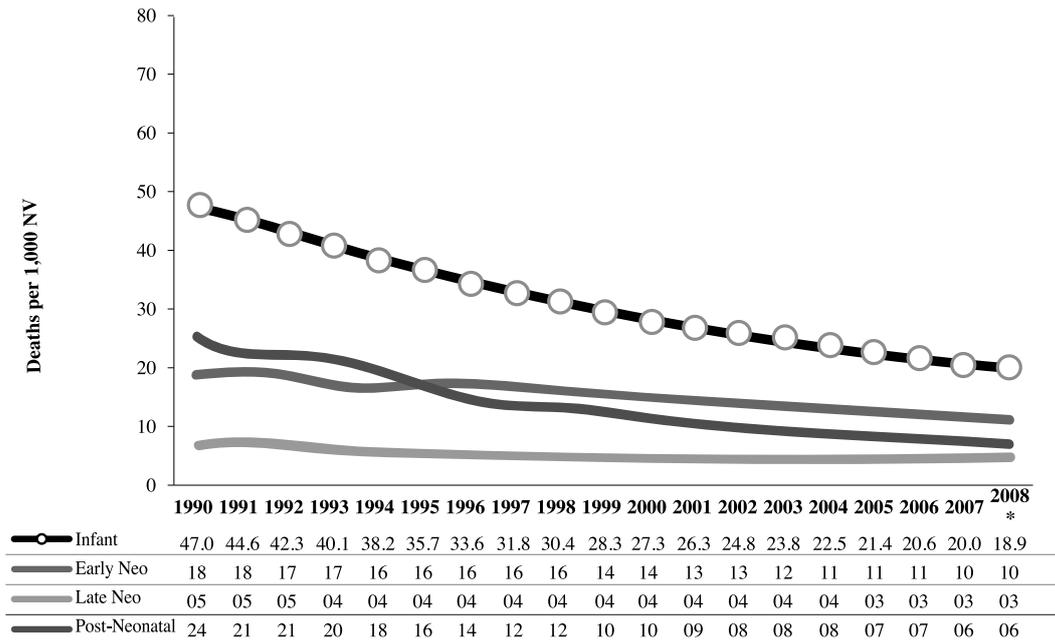
The results of Brazilian efforts to reduce infant mortality between 1990 and 2008 are clearly visible, as shown in the graph below, with projected figures up to the achievement of the Millennium Development Goals target by 2015.

**Figure 30-2.** Trend in infant mortality rate (per 1,000 live births). Brazil and its regions, 1990–2008\* and up to 2015 (projected) (33).



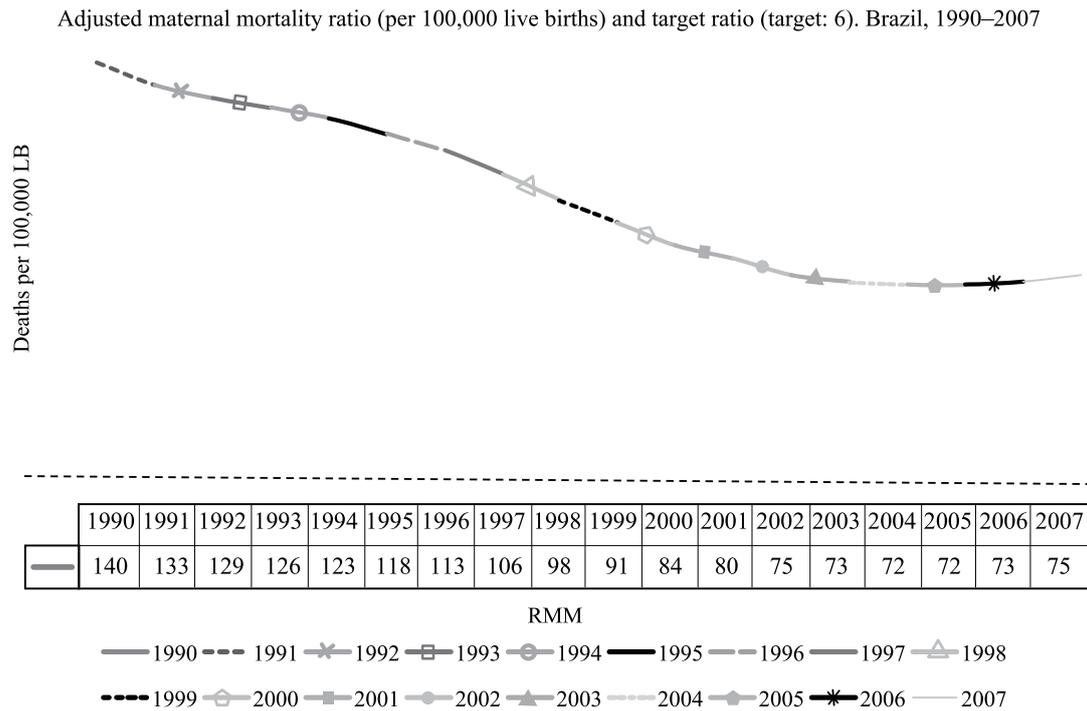
**Source:** Coordenação Geral de Informações e Análise Epidemiológica / Departamento de Análise da Situação de Saúde / Secretaria de Vigilância em Saúde / Ministério da Saúde. 2011.

Despite successful reduction of the infant mortality rate from 47 per 1,000 live births to 19 per 1,000 (with a projected further reduction to 15 per 1,000 by 2015), the challenge of reducing neonatal mortality (Figure 30-3) persists. The neonatal period accounts for 52% of all deaths in children <1 year, and particular attention is required to early neonatal deaths —i.e., those occurring in the first week of life. The leading causes of death in this period are complications associated with the infant's condition at birth, the quality of care in pregnancy and childbirth, and the quality of neonatal care.

**Figure 30-3.** Trend in infant, early neonatal, late neonatal, and post-neonatal mortality rates in Brazil, 1990 to 2008 (34).

**Source:** Coordenação Geral de Informações e Análise Epidemiológica / Departamento de Análise da Situação de Saúde / Secretaria de Vigilância em Saúde / Ministério da Saúde. 2011.

The target established for Millennium Development Goal 5 is a 75% reduction in maternal mortality between 1990 and 2015. In Brazil, the corrected maternal mortality ratio was 140 per 100,000 live births in 1990, declining to 75 per 100,000 live births in 2007 (Figure 30-4). Thus, to reach the established goal, the country would have to reach a maternal mortality ratio of fewer than 35 deaths per 100,000 live births by 2015 (35).

**Figure 30-4.** Trend in maternal mortality ratio in Brazil, 1990 to 2007 (36).

**Source:** Coordenação Geral de Informações e Análise Epidemiológica / Departamento de Análise da Situação de Saúde / Secretaria de Vigilância em Saúde / Ministério da Saúde. 2011.

According to the UNICEF *State of the World's Children 2009* report, the majority of maternal and neonatal deaths can be prevented by such interventions as antenatal care, births attended by skilled health workers, emergency obstetric and neonatal care, and post-partum visits for both mothers and newborns, through a “continuum of care linking households and communities to health systems.”(37)

Therefore, in order to meet the targets established for Millennium Development Goals 4 and 5, greater interaction and expansion of health actions are essential. In this regard, public policies should intervene in the inequalities faced by different groups and individuals, combining all actions in a manner consistent with the recommendations of the final report of the Brazilian National Commission on Social Determinants of Health (CNDSS).

CNDSS suggests interventions that adopt as a reference the principles and strategies of health promotion set forth in a series of six WHO International Conferences (Ottawa, Adelaide, Sundsvall, Jakarta, Mexico City, and Bangkok) held between 1986 and 2005. The first of these merits special attention, as it led to the Ottawa Charter, aimed at fighting the problems that generate inequities in health and moving toward the coordinated expansion of efforts to promote healthy development of the population. The Charter recognizes that peace, education, housing, food, income, a stable ecosystem, social justice, and equity are key to the health of populations. Adopting healthy public policies, creating supportive environments, strengthening community action, developing personal skills, and reorienting the health services are identified as key conditions for health promotion.

Thus arose, in 2007, the *Mais Saúde* (“More Health”) Target Plan of the Brazilian Ministry of Health (38), based on seven broad lines of action, including health promotion. This occasion revived expectations of working, through the field of health, toward a civilizing project that would produce health, citizenship, and democracy. To this end, it was considered essential to reassess the care provided to Brazilian citizens from the earliest stages of life to combat inequalities and promote sustainable development in the country. Within this context, the Pacts for the Reduction of Maternal and Child Mortality and the *Estratégia Brasileirinhas e Brasileirinhos Saudáveis* (EBBS) were formulated as first steps for national development — projects committed to growth, well-being, and equitable access to health, demonstrating the importance of comprehensive child care on Brazil’s political agenda.

The EBBS was regulated by Ministry of Health Decree No. 2395 of 7 October 2009, which established an administrative structure that created the following entities through an approach that stressed collective action and respect for differences:

- I. National Coordinating Unit—represented by Instituto Fernandes Figueira, a unit of the Oswaldo Cruz Foundation. The structure of the Coordinating Unit has two dimensions: (i) political/institutional—represented by the deputy technical coordinator and executives; and (ii) technical/advisory—represented by local supporters, facilitators, consultants, collaborators, and administrative personnel.
- II. National Technical Advisory Committee—a more inclusive space, in which government entities and organized civil society participate.
- III. National Executive Group—a working group for monitoring the National Plan of the EBBS.
- IV. Local Executive Group—executive group for planning and operationalizing the EBBS at the municipal level. Technical coordination of this group is the responsibility of local supporters, in a co-management arrangement with a representative of the local health department (*Secretaria Municipal de Saúde*, SMS), by means of Terms of Agreement formalizing the inclusion of the municipality in the Strategy.

## ■ Considerations on Primary Health Care (PHC) in Brazil

One of the cornerstones of health sector restructuring in Brazil, promoted by the Federal Constitution of 1988, was the establishment of the Unified Health System (UHS), created in the 1990s and grounded in the following basic principles: (i) universal access for all Brazilian citizens to all services at all levels of care; (ii) equity; (iii) emphasis on the public's involvement in health policy-making and the monitoring of policy implementation; and (iv) structuring of the health services network in a decentralized, regionalized, and hierarchical manner.

The UHS was regulated by Organic Law No. 8080 of 19 September 1990; Law No. 8142 of 28 December 1990; and, subsequently, by a series of Basic Operating Standards (*Normas Operacionais Básicas*, NOB), Operating Standards for Health Care (*Normas Operacionais de Assistência à Saúde*, NOAS), decrees, and regulations. In 2006, the Ministry of Health launched the Health Pact for Consolidation of the UHS (*Pacto pela Saúde—consolidação do SUS*), composed of the Pact in Defense of the UHS (*Pacto em defesa do SUS*), the Pact for Life (*Pacto pela Vida*), and the Management Pact (*Pacto de Gestão*).

The UHS implementation process progressed to the adoption of a series of measures geared to strengthening primary health care, understood as follows by the Brazilian Ministry of Health:

*“(...) an array of health actions, in the individual and collective spheres, that encompasses health promotion and protection, disease prevention, diagnosis, treatment, rehabilitation, harm reduction, and health maintenance, with the object of delivering comprehensive care that has an impact on the health situation and autonomy of the people and on the determinants and conditioning factors of health in communities. It is provided through the exercise of care and management practices that are democratic and participatory, under the form of teamwork targeted to populations of specific territories, for which it assumes health-related responsibilities, taking the dynamic nature of the territory in which these populations live into account. It employs complex and varied care technologies, which should help manage the most prevalent and important health-related demands and needs, considering the criteria of risk, vulnerability, and resiliency, as well as the ethical imperative that every health demand, need, or suffering should be attended to. It is conducted with the highest degree of decentralization and capillarity, close to the lives of the people. It should be the preferred point of contact of every user, the main gateway into the system, and the communications center of the Health Care Network.”(39)*

This concept shows that the Brazilian health system is developing primary health care that is comprehensive, broad, and inclusive.

According to Starfield (40), four characteristics of PHC should be assessed: (i) access (“first contact”: the major point of entry into the system); (ii) continuity of care or longitudinal care (a characteristic that strongly modulates the possibilities of clinical practice); (iii) comprehensiveness (responsibility for all health problems of the assigned

population); and (iv) coordination (the capacity to take responsibility for the user even when sharing care with other specialized services within the system).

PHC represented a conceptual and technological innovation in the way health systems are viewed worldwide, as well as a major challenge for health administrators and health care providers steeped in a model of curative, individualistic care. An important characteristic of primary care is that it presupposes the provision of support to the person rather than merely the treatment of disease, promoting family and community interventions when necessary.

The Family Health Strategy (*Estratégia Saúde da Família*, ESF) is the model adopted by the Ministry of Health as the priority for structuring PHC in Brazil. Based on the notion of health surveillance and the strengthening of ties between health care professionals and the population, it provides for the delivery of ongoing comprehensive health care to individuals and families, their follow-up over time, and the monitoring of their referrals and cross-referrals to other levels of the health system.

The core unit of the ESF is a multidisciplinary team —composed of a physician, a nurse, a nurse technician or nurse's aide, and four to six community health workers (CHWs)— responsible for delivering care to approximately 1,000 families (3,000 to 4,000 people). In the year 2000, the ESF began introducing Oral Health Teams. As of 2007, Family Health Support Centers (*Núcleos de Apoio à Saúde da Família*, NASF) began to be established to coordinate ESF support activities, providing social workers, psychologists, dietitians, and physical therapists, among personnel from other professions and specialties (41). ESF teams are required to receive the public and provide comprehensive care on an ongoing basis. Educational and intersectoral action to combat the health problems identified are also among these teams' assigned roles.

Primary care is one of the main strategies of a health system. When strengthened, it makes it possible to reduce inequalities and improve individual and community health.

## ■ The EBBS: Research-intervention in six municipalities

As one of its main lines of action, the EBBS carried out a research-intervention project during the biennium 2010-2011 for the purpose of generating knowledge on ways to develop new approaches in the implementation of intersectoral public policies in the early childhood domain, thereby reducing inequities and promoting citizenship.

Based on the understanding that all epistemology is contextual (42), it was decided to use the mapping method and, in partnership with managers and civil society at large, construct paths for providing integrated care for children and their families in different Brazilian regions.

Considering that the EBBS was born of an initiative and partnership between FIOCRUZ and the Ministry of Health and is part of the trajectory of the Brazilian Health Sector and Psychiatric Reforms, the concepts of mainstreaming and intersectional action are the cornerstones of its guidelines (43).

The mainstreaming approach permeates different actions and entities and increases the possibility of communication and group actions that lead to changes in health practices. The intersectoral approach, in turn, is a joint process that entails the forging of ties among the stakeholders involved so that, through dialogue, co-accountability and co-management activities will be undertaken (44).

These concepts of cross-cutting and intersectoral action, present in the National Policies for Health Promotion and Humanization, are frames of reference for the EBBS that are aligned with the Alma-Ata (1978) and Ottawa (1986) conferences, which considered the social determinants key factors in individual and public health. Reducing inequity and promoting health required a guarantee of human rights, equity in power relationships —involving the issues of age, gender, and race/ethnicity— and public spaces for democratic practice for effective implementation of public policies.

### The mapping method

The selection of the mapping method as the methodology for this project reflects the concept of what constitutes research, the involvement of the researcher in the field or realm of experience, the researcher's investigatory relationship with the topic studied, and knowledge-building. There is no knowledge without practice or subjects, just as there are only practices and subjects when there are social, cultural, and political relations (45).

Within this context, a key player in the EBBS research/intervention project is the *local researcher-supporter*. To perform this role, health professionals were sought who were working in municipal management and had the capacity to coordinate with the field of experimentation, where the dynamic is essentially interactive: monitor processes,

encourage discussion, facilitate and coordinate instruments, and —together with the team— develop alternatives for action.

As to the ways of conceiving research, building knowledge, and managing public policies, the local researcher-supporter should implement actions with a commitment to ethics and to effecting change in the quality of life of children and their families, establishing sustainable modes of articulation.

Through its management structure, the EBBS offers space, time, and support for interlocution and knowledge-building in a dialectic relationship by means of face-to-face and virtual structures (virtual forums, text sharing, in-person visits and supervision, thematic workshops, and meetings of local researchers/supporters).

A valuable instrument for implementing these devices is the Balint-Paideia methodology, a way of operationalizing group processes in both the relationship between supporters and their teams and between these and the working groups in their communities, improving the skills of the professionals working in PHC. This concept was developed by Cunha with the goal of creating a tool capable of applying the precepts of the National Humanization Policy. It addresses the challenges of cross-sectional and intersectoral action and the “expanded clinic”<sup>2</sup> as a means of improving the quality of clinics and management in primary care, making it an innovative tool for facilitating what the EBBS intends to achieve. According to Cunha and Dantas (46):

*“The ‘Balint-Paidéia group’ is at once a management instrument and a tool for workers to cope with the complexity of their work and the relations intrinsic to it. It is a group for managerial discussion of clinical cases, made up of physicians and nurses from primary healthcare teams. The purpose of these encounters is to enable professionals to present their cases, deal with the subjectivities involved, exchange ideas in an environment mediated by the manager/supporter, and ponder theories, always seeking solidarity among the group and increasing the capacity for analysis and intervention.”*

An example of this method’s applicability and good acceptance by health workers can be seen in a cancer care project developed with staff of federal public hospitals in Rio de Janeiro. In this project (47), the method was used for the discussion of clinical cases to offer a welcoming environment to professionals who must communicate bad news as part of their daily activities, thus fostering emotional preparedness beyond matters of a technical nature and promoting sensitization in clinical listening to honor the humanitarian values espoused by the UHS.

### Definition of pilot territories

The main criterion for the selection of pilot territories, or *core municipalities*, for the study was regional diversity. Six municipalities in the five macroregions of Brazil were selected by consensus with CONASS and CONASEMS (Table 30-1). Four of the chosen municipalities are state capitals (Rio Branco, Acre; Campo Grande, Mato Grosso do Sul; Rio de Janeiro, Rio de Janeiro; and Florianópolis, Santa Catarina) and two are located in the State of Pernambuco (Araripina and Santa Filomena) in the area known as the Sertão do Araripe Citizenship Territory (*Território da Cidadania Sertão do Araripe*), which covers an area of 12,020.30 km<sup>2</sup> and is composed of 10 municipalities, half of whose population lives in rural areas.

In Rio de Janeiro, three communities were selected because of their demographic characteristics: Babilônia, Chapéu Mangueira, and Santa Marta, located in the same municipal health management program area.

The *per capita* gross domestic product (GDP) in 2008 demonstrates the diversity of the selected core municipalities: Rio Branco, 11,776 Reales; Campo Grande, 14,002; Araripina, 3,968; Santa Filomena, 2,778; Rio de Janeiro, 25,122 and Florianópolis, 20,184 (48).

**Table 30-1.** Demographic characteristics and health indicators of the core municipalities (49).

Municipality/State	Population	Infant Mortality Rate	ESF Coverage
Rio Branco, AC	305,951	17.69	28.6%
Campo Grande, MS	755,104	13.26	77.94%
Araripina, PE	79,876	26.78	39.25%
Santa Filomena, PE	14,692	25.00	100%
Rio de Janeiro, RJ	6,186,713	13.75	9.2%
Florianópolis, SC	408,163	9.93	82%

## ■ The plane of experience: mapping inequities and building paths

The “map guide” is developed during the research process, considering the effects on the object of research (field/plane of experience), the researcher, and the results (50). Acknowledging that forging ties and bonds depends on how people and teams take responsibility for the individuals under their care, local researcher-supporters were instructed to “follow clues,” in the sense of reflecting on what was going on in their municipality, their partners and sectoral and institutional linkages (government and civil society), and the approaches that were being used for early childhood care.

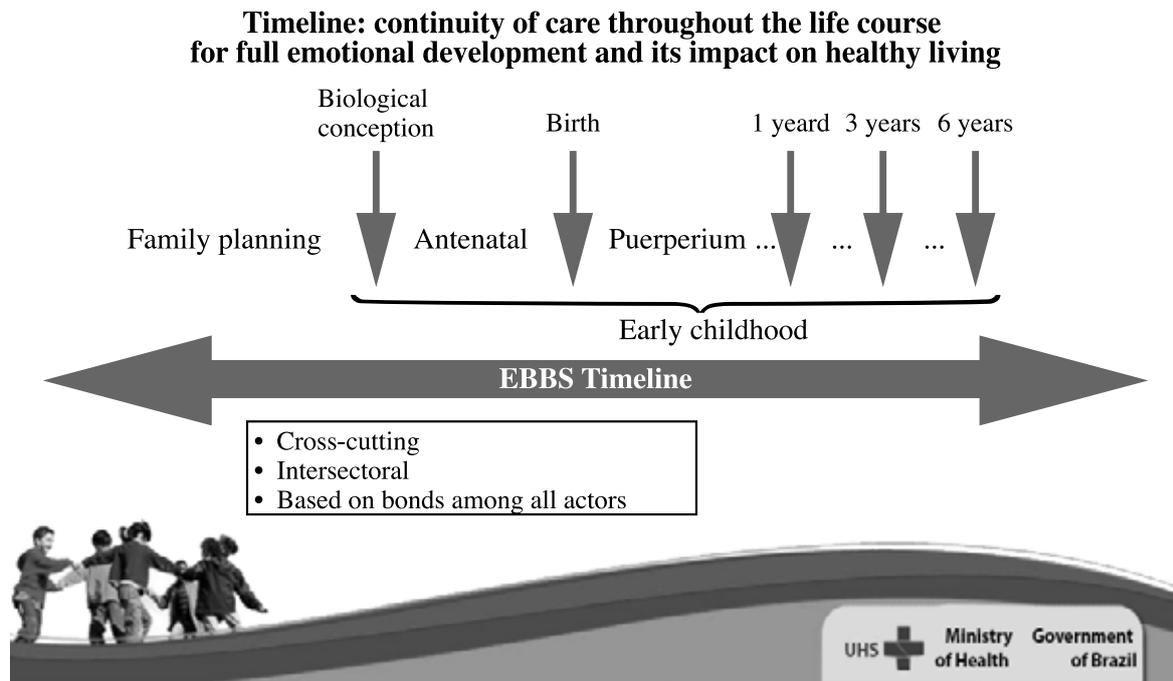
Development of the EBBS began with the mapping method, by which we sought to understand the legal frameworks relevant to health production and citizenship, including: the Constitution of Brazil, the Child and Adolescent Statute, the Pact for Life and the Pacts for the Reduction of Maternal and Child Mortality, and related health-sector policies in the Ministry of Health. In addition, efforts were made to learn about successful experiences and bold public policies implemented at the municipal and state levels throughout Brazil, among them the Sobral experience (51) and programs such as *Primeira Infância Melhor* (52), *Mãe Coruja Pernambucana* (53), and *Mãe Curitibana* (54). Also considered were university services, trade associations, professional boards, and diverse networks such as the National Early Childhood Network (*Rede Nacional Primeira Infância*). An international experience is the *Chile crece contigo*, a strategy developed in Chile and now implemented as a countrywide policy (55).

Exchanges with these initiatives provided greater support for the construction of what we call a “sensitive mapping” of municipalities, whereby local challenges and potential were mapped out and studied. For this purpose, each local researcher-supporter was given a copy of “Timeline: continuity of care throughout the life course” (Figure 30-5), an instrument to guide the mapping process and support the drafting of local agendas and plans. This conceptual and methodological tool assists with the visualization of activities that warrant expansion and facilitates the identification and recognition of new relational technologies and the development of ties and bonds, in line with the precepts of the EBBS.

The Timeline is a line of movement designed to elicit analysis of care coverage, seeking continuity and the integration of processes and taking context, local diversity, and its relation to Brazilian public policies into account, based on the engagement of local researcher-supporters and the impact of the research-intervention in the pilot municipality.

Using this timeline, individual and collective projects for each segment of early childhood care (family planning, antenatal care, childbirth and puerperium, and care until the 6th year of life) can be expanded through health promotion activities and by heightening health awareness among society at large to reduce the vulnerabilities of the population.

Figure 30-5. Timeline: continuity of care throughout the life course (56).



*Source:* EBBS. First steps for national development.

With an eye to evaluation and a view to integrating the potential of the three spheres of UHS management to fully develop comprehensive early childhood care, in November 2010, a workshop was held with representatives of the state and municipal health departments of every core municipality and representatives of the technical agencies of the Ministry of Health. This workshop marked the beginning of efforts to develop the Plan of Action and Shared Work Agenda, with linkage among the three spheres of management and the EBBS National Coordinating Unit.

The logical matrix proposed for the construction of the Plan of Action provided for the consolidation of challenges and potential (Table 30-2).

**Table 30-2—** Summary of core municipality challenges and potential.

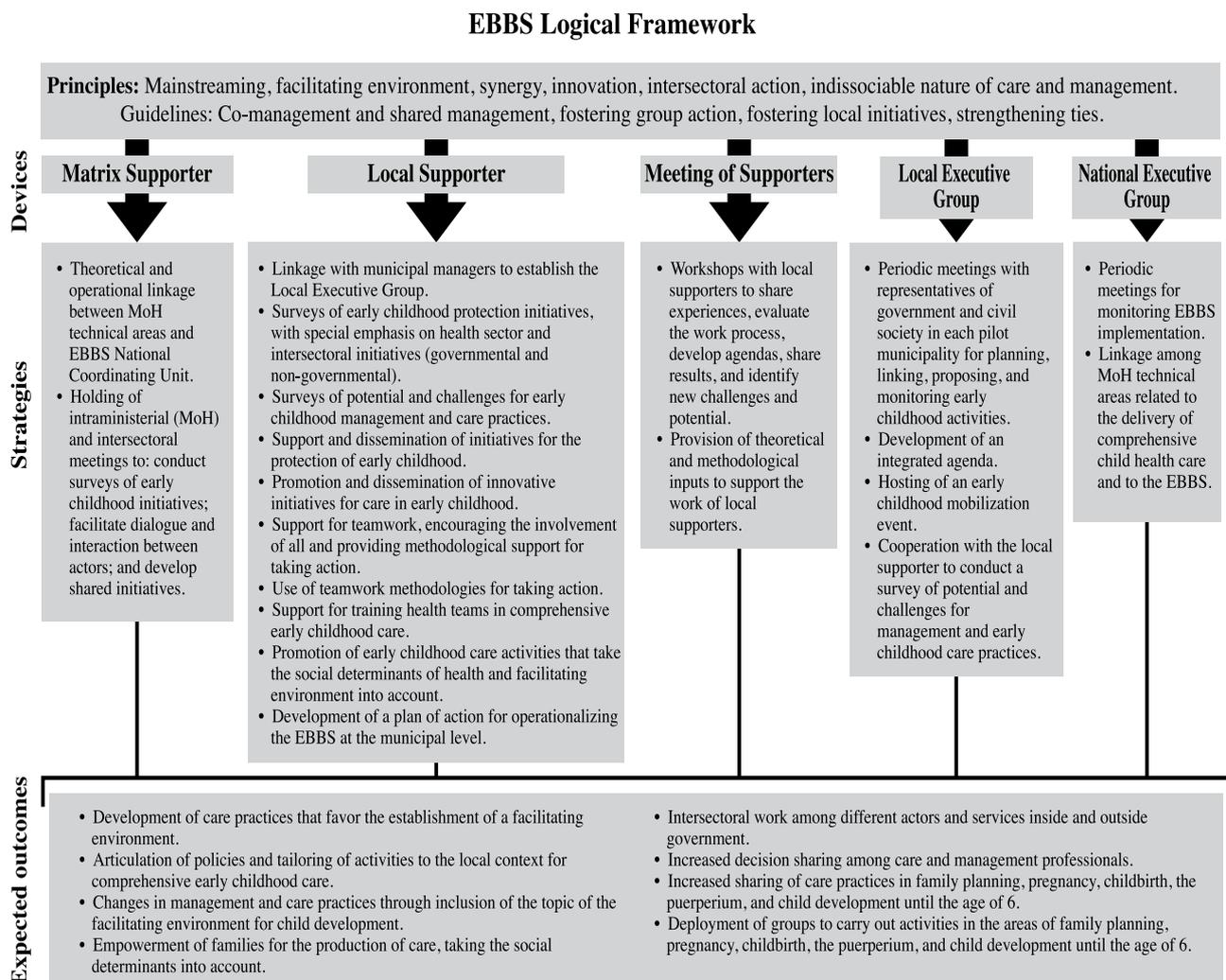
<b>Campo Grande</b>	
<b>Challenges</b>	<ol style="list-style-type: none"> <li>1. Guaranteed antenatal care and compassionate childbirth by training professionals to serve as facilitators in forging the bond between mother and baby.</li> <li>2. Raising awareness among professionals to serve as facilitators in forging the bond between mother and baby.</li> </ol>
<b>Potential</b>	<ol style="list-style-type: none"> <li>1. Use of the <i>Rede Amamenta Brasil</i> methodology in other initiatives.</li> </ol>
<b>Florianópolis</b>	
<b>Challenges</b>	<ol style="list-style-type: none"> <li>2. Expansion of the <i>Rede Amamenta Brasil</i> Network.</li> <li>3. Structuring of the <i>Caderneta da Mulher</i> (“Woman’s Passbook”).</li> <li>4. Unification of intersectoral databases (social services, health, and education) so that all have access to a single record for each child and adolescent.</li> <li>5. Expansion of the network of Social Welfare Referral Centers (<i>Centros de Referência de Assistência Social</i>, CRAS) and coordination with PHC.</li> </ol>
<b>Potential</b>	<ol style="list-style-type: none"> <li>6. <i>Capital Child</i> Program.</li> <li>7. <i>Creche Amiga da Amamentação</i> (Breast-feeding-friendly Day Nursery) Program.</li> <li>8. School Care Program.</li> <li>9. <i>Floripa 40</i> Program.</li> </ol>
<b>Rio Branco</b>	
<b>Challenges</b>	<ol style="list-style-type: none"> <li>1. High turnover of PHC professionals.</li> <li>2. Integration of the care network.</li> </ol>
<b>Potential</b>	<ol style="list-style-type: none"> <li>1. Qualitative improvement of maternity facilities within an integrated process.</li> <li>2. Adaptation of hospital networks for easier access to family members.</li> <li>3. Compassionate childbirth.</li> </ol>
<b>Rio de Janeiro</b>	
<b>Challenges</b>	<ol style="list-style-type: none"> <li>1. Multiplicity of policies and fragmentation of maternal and child care activities.</li> </ol>
<b>Potential</b>	<ol style="list-style-type: none"> <li>1. Greater family health coverage.</li> <li>2. Complete Early Childhood education program.</li> <li>3. Linkage among child-oriented lines of care.</li> <li>4. Promotion of child empowerment.</li> <li>5. Promotion of responsible fatherhood.</li> </ol>
<b>Sertão do Araripe (Araripina and Santa Filomena)</b>	
<b>Challenges</b>	<ol style="list-style-type: none"> <li>1. Lack of information systems.</li> <li>2. Low coverage of care (Araripina)</li> <li>3. Poor quality of primary care.</li> <li>4. High rates of violence against women and children.</li> <li>5. Deficient referral to high-risk antenatal care services.</li> <li>6. Deficient incentives for breastfeeding.</li> <li>7. Lack of daycare facilities.</li> </ol>
<b>Potential</b>	<ol style="list-style-type: none"> <li>1. Increased antenatal care coverage in Araripina.</li> <li>2. Women’s Health Center.</li> <li>3. Social welfare network.</li> <li>4. Implementation of the <i>Mãe Coruja</i> program in the state of Pernambuco.</li> </ol>

## ■ The EBBS today

Based on the Plans of Action and the Shared Work Agenda, which were built on the foundations of cross-cutting intersectoral action, the *research-intervention* stage was implemented in Stage 1 of the EBBS, which is already at another stage. The conclusion of this stage coincided with the results provided by a fourth-generation assessment conducted by researchers from the National Institute for Women's, Children's, and Adolescents' Health (Instituto Fernandes Figueira)/FIOCRUZ. The purpose of this investigation was to analyze the EBBS process and its implementation in the different intervention sites – i.e., the six pilot municipalities, to identify the favorable or unfavorable contextual factors influencing the intervention and contribute to the development of the National Policy for Comprehensive Child Health Care and other early childhood care initiatives (57).

The evaluative survey, conducted through the use of participatory and consensus methodologies that involved participants of the EBBS implementation process, built, agreed upon, and validated the theoretical model of the Strategy, which guided development of the evaluation criteria to be applied to the pilot municipalities. The EBBS theoretical model, represented in the logical framework diagram below, illustrates the operationalization of the strategy intervention, clearly showing the linkages among its components: principles, guidelines, devices, strategies, and expected effects (Figure 30-6).

Figure 30-6. EBBS logical framework



At the end of the evaluative research stage, a series of recommendations targeting the EBBS Local Executive Group, EBBS local supporters, and the EBBS guidelines were agreed upon: *promotion of local initiatives, strengthening of ties and bonds, promotion of group activities, and co-management and shared management.*

Beyond the realm of research, particular attention should be given to the training efforts that have been carried out in partnership with the Technical Area for Child Health and Breastfeeding (*Área Técnica de Saúde da Criança e Aleitamento Materno, ATSCAM*) of the Department of Programmatic and Strategic Action (*Departamento de Ações Programáticas e Estratégicas, DAPES*) of the Health Care Secretariat of Brazil's Ministry of Health.<sup>3</sup> In continuation of the first phase of the project, the EBBS —with the aid of the UniverSUS Distance Education platform, duly adapted for this objective— has been working toward in-person and long-distance education for Ministry of Health consultants in all 27 states of Brazil. The primary focus has been on coordinators of the technical areas involved in child health and breastfeeding in all states and their capitals, as well as other government agencies and representatives of civil society, with the aim of establishing an interfederative pact to strengthen development and implementation of the National Policy for Comprehensive Child Health Care (*Política Nacional de Atenção Integral à Saúde da Criança, PNAISC*) in Brazil.<sup>4</sup>

## ■ Conclusions

The development of a political project in the field of health that sustainably and permanently ensures universal access to goods and services and guarantees citizens' rights can be guaranteed only by adequate allocation of the resources required for its funding. In order to achieve this, health must be viewed and prioritized as a strategic component of development plans and not merely as a secondary component. This stance repositions the foundations on which health determinants should be evaluated. Social inequality, when manifested in the field of health, is therefore the most perverse expression of a development model and cannot be fully addressed until other variables are. Here should be mentioned the efforts of the Brazilian Government in this regard, especially the combining of its expanded income redistribution policy with the *Bolsa Família* program (58), the *Brasil sem Miséria* plan (59), and the *Brasil Carinhoso* activities (60), which have been contributing to the rapid reduction of inequality.

In the field of health, the *Rede Cegonha* initiative, which redesigned care in pregnancy, compassionate childbirth, and the first two years of a child's life, also warrants a special mention (61).

Based on the material presented in this chapter, the development of a Comprehensive Care Track for Early Childhood is essential. The design of health strategies and policies targeting women and children should be permeated by and facilitate the construction of a "facilitating environment" at the earliest stages of life to foster comprehensive child development.

To take action in defense of this facilitating environment, we are called on to offer new approaches for enriching existing public policies, focusing primarily on women and children but also including policies for men and for mental health, with contributions from the National Policies for Humanization and Health Promotion, the construction of networks, and, mainly, the strengthening of PHC through the Family Health Strategy.

The innovative "Healthy Little Brazilians Strategy —First Steps for National Development" was presented in this chapter from two standpoints: one theoretical-conceptual and one of "how to" in the plane of experience. We hope that dialogue between the frames of reference for primitive emotional development and the facilitating environment for life will enrich the discussion of the social determinants of the health and the essential care (62) that predates human life and lead to the formulation of public policies that reduce inequities and promote sustainable development in Brazil.

## ■ Recommendations

- Promote the creation of intersectoral bodies directly linked to the Presidency of the Republic for the development of cross-cutting social policies, with a focus on the relationship between healthy child development and national development.
- Promote social and community participation in the formulation of health policies and construction of networks of care in this field.

- Promote the implementation of integrated policies for women's, children's, and adolescents' health as national priorities.
- Promote intersectoral initiatives in the areas of women's, children's, and adolescents' rights to reduce inequities.
- Promote the development and strengthening of public policies on early childhood that consider the emotional development of the child.
- Promote the establishment of local commissions on social determinants of health, linked to care provided by expanded clinics as a means of better combating inequities.
- Promote the production and dissemination of knowledge based on the local experiences of Brazilian municipalities and geared to the provision of comprehensive care in early childhood.
- Promote the upgrading of professionals from social networks for early childhood care.
- Promote the dissemination of innovative care technologies to PHC teams through the use of co-management and participatory management contracts.
- Promote training for PHC teams in the care of pregnant women, newborns, children, and families through an integrated and coordinated approach to forging ties through group-based mechanisms.
- Promote care for men by Family Health Strategy professionals to promote family planning and reflection on fatherhood through a facilitating environment.
- Promote the development and establishment of municipal early childhood plans.
- Promote the regular provision of integrated training in child development for professionals in the territories, particularly those in the health, education, and social welfare sectors, through a facilitating environment approach.
- Promote the implementation of intersectoral activities that give families a leading role in the forging the bonds, child development, and the protection of children.
- Promote intersectoral coordination in the development of agendas and the planning of local activities for the implementation of early childhood initiatives, especially in the education, social welfare, labor, justice, sports and leisure, human rights, and women's policies sectors.

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## ■ Notes

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- 3 This technical area was renamed General Coordination Unit for Child Health and Breastfeeding (*Coordenação Geral de Saúde da Criança e Aleitamento Materno*) in 2013.
- 4 The PNAISC was approved by the National Health Council in October 2014. As of December 2014, it was under evaluation by the Tripartite Interagency Commission for integration with the Unified Health System (UHS).



# Addressing the social determinants of noncommunicable diseases in the Americas<sup>1</sup>

Douglas Webb

## ■ Introduction

Noncommunicable diseases (NCDs)—mainly cardiovascular disease, diabetes, cancer, and chronic respiratory disease—are a significant global health and development challenge. They are the single greatest cause of preventable illness, disability, and mortality worldwide, responsible for more deaths than all other causes combined. The social and economic impacts of NCDs are significant. NCDs reduce global and national economic output, strain health systems, burden vulnerable households, put human rights at risk, and hinder progress on every Millennium Development Goal.

NCDs are unevenly distributed among and within countries. Lower-income countries face large burdens, especially disproportionately high rates of NCD-related premature mortality. These countries have lower capacities to respond and simultaneously contend with ongoing communicable disease burdens. Within countries, various forms of disadvantage tend to be associated with NCDs, owing partly to greater exposure to the four main behavioral risk factors for NCDs: tobacco use, harmful use of alcohol, physical inactivity, and unhealthy diet.

These behavioral causes have root causes. Differential exposures to NCD risk behaviors and preventive care can be traced to inequities in the conditions of daily life and further traced to underlying social, economic, political, environmental, and cultural factors (and policy choices), broadly known as social determinants. Effectively and sustainably addressing the health and developmental burden of NCDs requires careful attention to these root causes. Responding to NCDs, like responding to HIV and other health issues, is *not* simply a matter of changing individual behavior in isolation; broader changes in social, economic, environmental, and cultural contexts are also needed.

Leadership and action from the health sector is the anchor for NCD responses. However, 30 years of lessons from the AIDS response are a powerful reminder that the health sector cannot address complex health challenges on its own. Significant, complementary assistance from other sectors and stakeholders is crucial, especially to address social determinants. Multisectoral action as a cornerstone of NCD responses has been endorsed at the highest political levels, such as in the 2011 UN Political Declaration on the Prevention and Control of Noncommunicable Diseases.

A number of global and regional frameworks already exist to guide multisectoral action on NCDs and their social determinants, most recently the *WHO Global Action Plan for the Prevention and Control of Non-communicable Diseases 2013-2020*. These frameworks identify enablers for successful multisectoral action on NCDs and health more broadly: hyphen-level political commitment, governance mechanisms to facilitate and coordinate multisectoral responses, and robust structures for monitoring, evaluation, and accountability. These enablers have also been

illustrated extensively in practice, not just with respect to NCDs but to other health challenges, such as HIV. This chapter builds on these foundations.

This chapter offers an analysis of the health and developmental burden of noncommunicable diseases, explaining that NCDs and their risk factors are rooted in social determinants, and documents the high-level political momentum for taking multisectoral<sup>2</sup> action in the NCD response. This chapter makes two key contributions. First, it presents a typology of multisectoral action on NCDs that highlights three general categories of possible action outside the health sector: expanding delivery platforms; NCD-specific actions on social determinants; and NCD-sensitive actions on social determinants. **Expanding delivery platforms** involves using settings outside the health system—schools, workplaces, public-sector institutions—to deliver conventional biomedical and behavioral interventions to individuals and/or groups. Actors outside the health sector often have unique positions within communities, which can help extend the reach of services and information to remote and otherwise marginalized populations. The strength of actors outside the health sector, however, lies in addressing underlying social determinants directly through population-based policy and programmatic action.

These actions may be either NCD-specific or NCD-sensitive. **NCD-specific actions on social determinants** are laws, policies, and programs whose primary purpose is action on the social determinants of NCDs. These actions attempt to change conditions of daily life to promote physical activity and limit the production, advertising, and consumption of tobacco, alcohol, and unhealthy foods. Examples include taxes on tobacco and alcohol products, restricted “junk food” advertising to children, the provision of smoke-free areas, and limits on trans fats. **NCD-sensitive actions on social determinants** touch on the core business of actors outside the health sector, such as regulating employment and labor conditions, increasing access to education, challenging harmful gender norms, promoting a rights-enhancing legal environment, setting urban development policy, or developing social protection programs. Addressing NCDs is not the *raison d'être* of these broader activities. These actions matter in their own right, but since they also tend to shape the nature, extent, distribution, and potential impact of social disparities and marginalization and, therefore, NCD distribution; the goal is to make the core business of actors outside the health sector even more sensitive to NCDs, to maximize positive impacts that reduce the risk of NCDs while minimizing negative impacts.

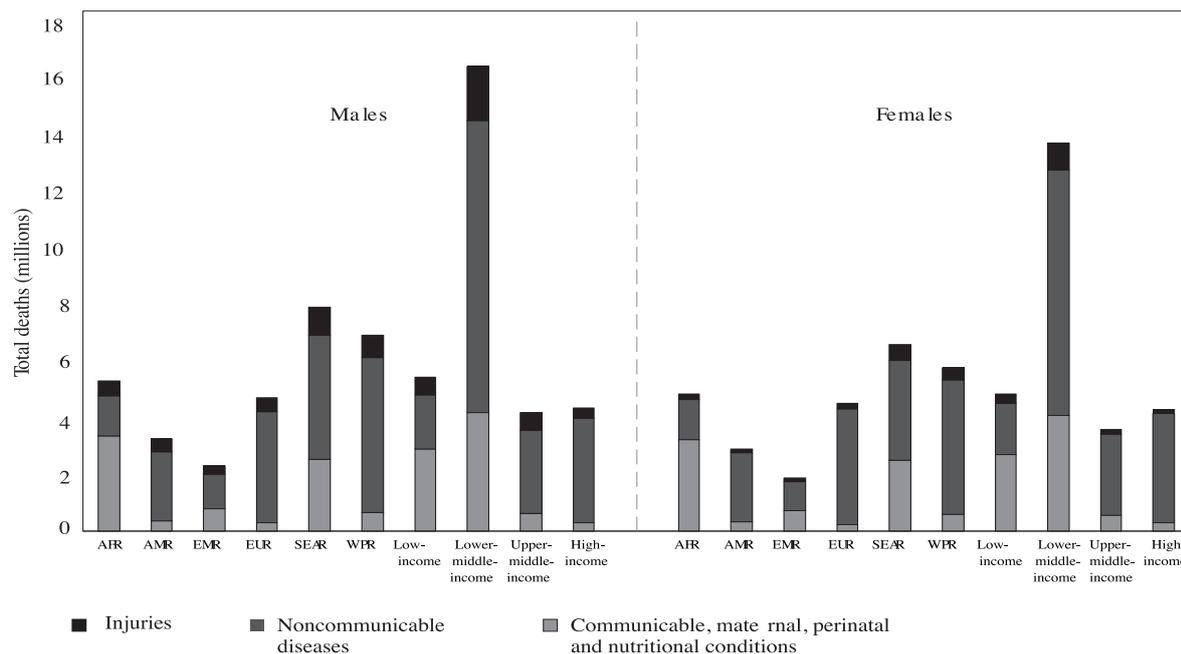
Second, the chapter provides a framework that outlines more specific areas and opportunities for actors outside the health sector to take action on the social determinants of NCDs. The framework has two parts. The first describes opportunities for NCD-specific and NCD-sensitive actions across the policy and program lifecycle. The second part describes opportunities to create an enabling environment that promotes multisectoral action. Actors outside the health sector are uniquely positioned to help build political will, enabling legal frameworks, enforcement mechanisms and effective governance structures that are multisectoral and participatory—all anchored in a human rights-based approach.

## ■ Noncommunicable diseases: A global health and development challenge

### NCDs: Status and trends

NCDs—principally cardiovascular disease (CVD),<sup>3</sup> diabetes (1),<sup>4</sup> cancer, and chronic respiratory disease—are the world's leading forms of preventable illness, disability, and mortality<sup>5</sup> (2,3,4,5,6,7,8). In 2010, all NCDs accounted for nearly 35 million (two-thirds) of the 53 million global deaths, killing more people than all other causes combined. Five of the top six specific causes of death worldwide were NCDs (9). NCDs were responsible for 54% of disability-adjusted life years (DALYs)<sup>6</sup> globally in 2010. By comparison, the next highest contributors—communicable diseases and maternal, neonatal, and nutritional disorders—were responsible for 35% of DALYs. The contribution of NCDs to disease burden has grown since 1990, when communicable diseases were the number one cause of DALYs at 47% and NCDs accounted for 43% (10).

NCD epidemics are a global challenge. While they are often misconstrued as a problem of high-income countries, NCDs place an equal—or even greater—burden on low- and middle-income countries (LMICs). LMICs account for approximately 80% of all NCD deaths and 90% of NCD deaths before the age of 60 (2,11). These countries have a lower capacity to respond and tend to face a double burden of increasing NCD prevalence on top of high rates of infectious diseases, mainly HIV, tuberculosis (TB), and malaria. Figure 31-1 demonstrates that, for both men and women, mortality from NCDs surpasses mortality from all other causes in the Region of the Americas.

**Figure 31-1.** Global distribution of deaths by cause, by region and sex, 2010

Source: (2)

Cardiovascular diseases, chronic obstructive pulmonary diseases, cancer, and diabetes mellitus are the chronic noncommunicable diseases of greatest interest for public health in Latin America and the Caribbean (12,13). In both subregions, noncommunicable chronic diseases are responsible for two out of three deaths in the general population (12) and nearly one-half of deaths among people under 70 years of age (14). This group of disorders is the leading cause of mortality in men and women, and continues to increase at an extremely fast pace worldwide and in Latin America and the Caribbean (12). Of the 3,537,000 deaths registered in Latin America and the Caribbean in 2000, 67% were caused by these chronic diseases. Ischemic heart disease and cancer accounted for the majority of deaths in individuals 20 to 50 years of age. Noncommunicable diseases contributed 76% of the DALYs to the overall disease burden. In addition to early mortality, chronic noncommunicable diseases lead to complications, sequelae, and disability that limit functionality and productivity. Furthermore, these diseases require onerous treatment at enormous financial and social costs that sap resources in both the health systems and social security. For example, the cost of diabetes in Latin America and the Caribbean in 2000 was estimated at \$65.2 billion, \$10.7 billion of which was direct costs and \$54.5 billion, indirect costs (15). Direct and indirect diabetes costs in the United States were estimated at \$132 billion in 2002, and medical care for chronic diseases represents 75% of the total health care cost in the country (16). In Mexico it was estimated that the cost of hospitalization services for hypertension and diabetes mellitus alone in 2006 was higher than the cost of hospital and outpatient services for most infectious diseases (17). A 2002 study in Jamaica estimated the costs associated with diabetes and hypertension at US\$33.1 million and \$25.6 million, respectively (18). Primary prevention of chronic diseases could reverse their cost to the health care systems and to individuals. It is estimated that if only 10% of adults in the United States increased their physical activity by walking regularly, for example, \$5.6 billion could be saved in heart disease-related costs (19).

These diseases (which include ischemic heart disease, cerebrovascular disease, hypertensive disease, and heart failure) accounted for 31% of the mortality burden and 10% of the total disease burden in the world in 2000 (12). The age- and sex-adjusted mortality rate for cardiovascular diseases was highest in Nicaragua, the Dominican Republic, and Trinidad and Tobago, exceeding 200 per 100,000 population. The rate in Barbados, Canada, Chile, Costa Rica, Ecuador, El Salvador, Mexico, Peru, and Puerto Rico was below 150 per 100,000 population. The latest available data (2000-2004) show that mortality from diseases of the circulatory system was higher in men (223.9 per 100,000 population) than in women (179.3 per 100,000). There also are vast differences among the subregions, from 35 to 50 per 100,000 population in Mexico and Central America, respectively, to 170 per 100,000 in North

America (20). A study that compared mortality trends for cardiovascular diseases in 10 Latin American countries between 1970 and 2000 found a strong and steady decline in mortality from coronary and cerebrovascular diseases in Canada and the United States. In Latin American countries in the same period, however, a decline in mortality from ischemic heart disease was reported only in Argentina, and a decline in mortality from cerebrovascular diseases only in Argentina, Chile, Colombia, Costa Rica, and Puerto Rico. The same study found less pronounced drops in mortality from ischemic heart disease in Brazil, Chile, Cuba, and Puerto Rico, and mortality from that cause increased in Costa Rica, Ecuador, Mexico, and Venezuela. That increase could be the consequence of unfavorable changes occurring in most Latin American countries with respect to the risk factors for this disease, such as improper diet, obesity, lack of physical activity, and smoking, in addition to somewhat ineffective hypertension control and disease management (21). A study on the risk for acute myocardial infarction conducted in four Latin American countries found that high serum cholesterol, smoking, hypertension, high body mass index, and a family history of coronary heart disease were, as a whole, responsible for 81% of all cases of acute myocardial infarction in Cuba, 79% in Argentina, 76% in Venezuela, and 70% in Mexico (22). Stroke claimed 271,865 lives in 27 countries in the Region in 2002. The burden of stroke ranged from 5 to 14 potential years of life lost due to disability per 1,000 population. This figure was higher in the countries of the Americas than in most countries of the developed world. Stroke was the leading cause of death in Brazil in 2003; Mexico and Central America had the lowest mortality rates from that condition. In nearly all the subregions of the Americas, mortality from cerebrovascular disease was higher in women than in men. Mortality due to stroke fell by 10% to 49% between 1970 and 2000 in most Latin American and Caribbean countries, with the exception of Mexico and Venezuela, whose mortality from stroke remained unchanged. In Canada and the United States, on the other hand, there was a more pronounced drop, around 60% in the same period. Mortality from cerebrovascular diseases in 2000 was two to four times greater in Latin America and the Caribbean than in the United States (21). The reasons for these differences are not well known, although it is suspected that there are significant differences in the incidence of cerebrovascular events, access to services, quality of medical care for stroke, and risk-factor control.

Future projections suggest an even greater NCD burden. WHO estimates that by 2020 NCD-attributable deaths will have increased by 15% globally, with an increase of over 20% anticipated in the WHO regions of Africa, South-East Asia, and the Eastern Mediterranean (2). By 2030, NCDs are expected to be the major cause of death in all regions, including Africa, and kill 52 million people per year, nearly five times more than communicable diseases (2). Also by 2030, the proportion of DALYs attributed to NCDs in LMICs is projected to reach 45%, up from 33% in 2002 (23).

## NCDs and development

NCDs impose several interrelated social and economic costs. Lost productivity due to illness, disability, or death from NCDs can place a drag on macroeconomic growth and shift public budgets from other important health and development objectives. Likewise, NCDs place an enormous and growing burden on health systems. Households face onerous social and economic costs. NCDs—and poor health generally—can exacerbate poverty and insecurity, with the burden of care often falling on women and girls. Taken together, these costs affect progress toward each of the Millennium Development Goals (MDGs).

NCDs also have human rights dimensions. The right to health is enshrined in numerous international legal instruments and in some national constitutions (24).<sup>7</sup> Avoidable NCD morbidity and mortality jeopardizes this right. NCDs and poor health generally may also interfere with other human rights, such as access to education and freedom from discrimination. Human rights violations, in turn, can put people at greater risk for NCDs. Underlying social exclusion, marginalization, and discrimination can create conditions that increase vulnerability to risk behaviors for NCDs. High NCD rates in various indigenous communities that have been dispossessed of their land and suffered various forms of exclusion are a case in point (25).

## Macroeconomic costs

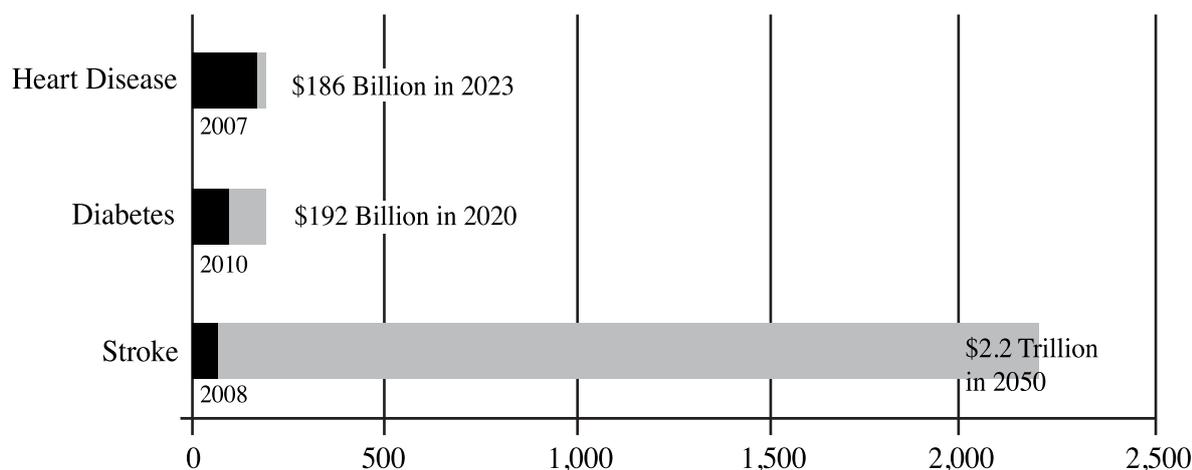
NCDs entail significant macroeconomic costs. They are projected to cost the global economy more than \$47 trillion over the next 20 years, a sum equivalent to eradicating two-dollar-a-day poverty in 2.5 billion people for the next 50 years (28). For LMICs, economic costs from the four major NCDs are estimated to exceed \$7 trillion from 2011 to 2025. This is roughly equivalent to \$500 billion per year, or 4% of GDP for LMICs in 2010 (26). Tobacco use alone costs the world 1% to 2% of its GDP each year (27).

NCDs constitute a larger share of lost output in higher-income countries, not because the epidemiological burden is necessarily worse but because labor and health care costs are higher. NCD mortality and disability have the potential for even greater negative impacts on development in LMICs, where they kill at younger ages relative to richer nations. Consequently, health costs begin earlier, and productivity losses are felt during the more economically productive, higher-earning years (2). By 2020, two-thirds of the expected 7.5 million global deaths from tobacco will occur in LMICs and half will be among people in their economically productive middle years (35-69) (28,29). Early mortality and morbidity from NCDs can prevent LMICs from fully reaping the social and economic benefits of the demographic dividend, wherein a country experiences a large and healthy working-age population and a low dependency ratio (ratio of dependents aged 0-14 and over 65 to the working population aged 15-64) (30). Early NCD mortality and disability also negatively impact long-term labor supplies in sectors that require more experienced, skilled personnel, ultimately negatively impacting GDP (25).

### Health system costs

NCDs place an enormous burden on health systems, *accounting for approximately 75% of global health care spending*, a figure that is only expected to rise (31). In 2011, diabetes alone cost health systems at least \$465 billion, or 11% of global health care costs. By 2030, this number is projected to exceed \$595 billion (32). The NCD epidemic in the United States is a striking example of the expense associated with full coverage of NCD care, raising questions of sustainability without concomitant changes in treatment technology and greater investments in prevention (33) (see Figure 31-2).

**Figure 31-2.** Projected costs of chronic diseases in the U.S.



*Source:* (34)

Data on health system costs in LMICs are relatively sparse, largely due to limited NCD surveillance systems. In India, the four main NCDs together with mental and neurological disorders accounted for nearly 39% of total health expenditures in 2004, with CVD by itself accounting for 15.6% (34,35). In 2007, the public sector in Thailand spent 21% of inpatient curative health expenditures on the four main NCDs and mental health (36). Mexico spent 6.7% of total health expenditures on CVD, diabetes, and obesity alone in 2006 (39,40). Costs in lower-income settings are expected to rise rapidly, in some instances exceeding costs in higher-income countries (25).

## Household-level social and economic impacts

Estimating the macroeconomic impacts of poor health is not always possible or reliable. Household-level analyses are useful in picking up microeconomic and distributional impacts, especially in the context of low-level epidemics, as illustrated by household impact studies in countries with low HIV prevalence (38). The social and economic costs felt at the household level are especially severe among people already marginalized and vulnerable to shocks. Medical expenditures, which are often out-of-pocket in LMICs, shift income from other important goals like asset accumulation, education, and food security. In the absence of effective, affordable health care and social protection, households can accumulate debt and/or liquidate income-generating assets to pay fees (2). Globally, direct payments for health care impoverish up to 100 million people per year (39). Evidence indicates that medical costs for NCDs can be particularly devastating. In India, the odds of incurring catastrophic hospitalization expenditures are 160% higher for cancer than for a communicable disease (40). Meanwhile, productivity losses from a sick, disabled, or deceased family member impair the ability of a household to generate income, increasing the risk or severity of poverty. Children may drop out of school to care for a sick family member or to find work. Caregivers, often women and girls, may suffer from stress, further compounding family difficulties and increasing vulnerabilities (2,41). In sum, NCDs, like poor health generally, can expand and deepen poverty, perpetuating intergenerational deprivation and reinforcing gender inequities among already vulnerable households.

## NCDs and the MDGs

The impacts of NCDs on development are more than just economic or financial, as evidenced by the impacts of NCDs on each of the MDGs. Some of the links between NCDs and the MDGs are highlighted in Table 31-1.

**Table 31-1.** NCDs and the MDGs

MDGs	Links to NCDs
1: Eradicate Extreme Poverty and Hunger	<ul style="list-style-type: none"> <li>• Out-of-pocket medical expenditures and inability to work due to NCDs exacerbates poverty and often limits expenditures on other necessities, such as food (2,29).</li> <li>• Household spending on NCD risk behaviors, such as tobacco and alcohol, also reduces money for food or shelter (2).</li> </ul>
2: Achieve Universal Primary Education	<ul style="list-style-type: none"> <li>• Sacrificing children's education is one possible consequence as families become burdened with NCDs (2).</li> </ul>
3: Promote Gender Equality and Empower Women	<ul style="list-style-type: none"> <li>• Women are more likely to sacrifice work or education to care for a sick family member (41).</li> <li>• Women bear the brunt of second-hand smoke and have difficulty negotiating smoke-free spaces for themselves and their children (42).</li> <li>• Women are predisposed to certain NCDs, such as breast, ovarian, and cervical cancers.</li> </ul>
4 and 5: Child Mortality and Maternal Health	<ul style="list-style-type: none"> <li>• Of annual tobacco-related deaths from second-hand smoke, one half are among women and one-quarter are among children under 5 years of age (3). Pregnant women and their unborn children are at risk for second-hand smoke.</li> <li>• Overweight and obesity among women increases the risk of gestational diabetes (high blood sugar in pregnant women with no previous diagnosis of diabetes), which is a risk to the health of both mother and child during pregnancy and birth (42,43). The child may be at greater risk for Type 2 diabetes and CVD in adult life (43).</li> </ul>

MDGs	Links to NCDs
6: Combat HIV/AIDS, Malaria, and Other Diseases	<ul style="list-style-type: none"> <li>• Diabetes increases the risk of TB because it affects the body's ability to fight infection (45,46).</li> <li>• Antiretroviral therapy for HIV can increase the risk of CVD by changing cholesterol levels, metabolism, and deposition of body fat (46).</li> <li>• One out of five TB deaths is related to smoking (3) and smoking also causes further illness in people living with HIV, including bacterial pneumonia and AIDS-related dementia (32).</li> </ul>
7: Ensure Environmental Sustainability	<ul style="list-style-type: none"> <li>• Pesticide use and deforestation caused by tobacco farming and curing are detrimental to the environment (31).</li> </ul>
8: Global Partnership for Development	<ul style="list-style-type: none"> <li>• The global political agenda recognizes the scope and magnitude of the NCD challenge, as well as the need for a multisectoral response (see the section on political context).</li> <li>• Multiple actors from governments, civil society, the private sector, and philanthropic foundations are already taking action on NCDs. To promote coordination, WHO has developed an updated Global Action Plan 2013-2020 (46).</li> <li>• Combating the NCD epidemic requires access to affordable and essential medicines, especially in developing countries.</li> </ul>

### NCD risk factors and the need for multisectoral action

NCDs have many risk factors. Four modifiable risk behaviors are key: tobacco use, harmful use of alcohol, physical inactivity, and unhealthy diet (see Table 31-2). These risk behaviors are prevalent worldwide and increasingly common in LMICs. Tobacco use alone kills more than 6 million people each year, accounting for one in six NCD deaths (47). Biological risk factors, such as high blood pressure<sup>8</sup> and overweight and obesity (48,49),<sup>9</sup> arise in part from the four major risk behaviors and also contribute to the global NCD epidemic.

**Table 31-2.** The four main NCDs and their shared risk behaviors

NCDs	Common modifiable risk behaviors for NCDs			
	Tobacco use	Harmful use of alcohol	Physical inactivity	Unhealthy diet
Cardiovascular disease	√	√	√	√
Diabetes	√	√	√	√
Cancer	√	√	√	√
Chronic respiratory disease	√			

Source: (2)

NCDs, like many health issues, are unevenly distributed among and within countries, often patterned along various forms of disadvantage. That NCDs disproportionately impact some LMICs and groups is due in part to greater exposure to the four main risk behaviors. Differential exposures to NCD risk behaviors and access to health services, in turn, can be traced to inequities in the conditions of daily life and further traced to underlying social, economic, political, environmental, and cultural factors (and policy choices)—broadly known as social determinants (50). NCDs, like HIV and other health issues, are *not* simply a matter of personal responsibility (51).<sup>11</sup>

Multisectoral action is critical for effective, sustainable NCD responses globally, nationally, and locally. The root factors that influence disease outcomes are neither inevitable nor immutable. They are social, political, and economic *choices* made by decisionmakers who are sometimes unaware of their ultimate impacts on health and NCDs.<sup>12</sup> Effectively and sustainably addressing NCD burdens and inequities requires different social, political, and economic choices. Within these spheres, actors outside the health sector are uniquely positioned to take action.

## Political context for addressing the social determinants of NCDs

Addressing NCDs and their social determinants through multisectoral action is now recognized at the highest political levels. In September 2011, the United Nations General Assembly held a High-level Meeting on the Prevention and Control of Noncommunicable Diseases—only the second time in its history that the General Assembly convened on a health issue (the first being AIDS in 2001). The resulting Political Declaration recognized NCDs as a global health concern and threat to social and economic development, including attainment of the MDGs (52). The Political Declaration committed the UN to five areas of action:

1. Reduce risk factors and create health-promoting environments;
2. Strengthen national policies and systems;
3. International cooperation, including collaborative partnerships;
4. Research and development; and
5. Monitoring and evaluation.

The Political Declaration called on countries to develop multisectoral national policies and plans on NCDs by the end of 2013 (Article 45). It also stressed the need to adopt whole-of-government and whole-of-society approaches in the NCD response (Articles 33-42).<sup>13</sup>

In October 2011, WHO convened the World Conference on Social Determinants of Health, uniting partners to discuss action on the developmental drivers of health and health inequities, including NCDs. The resulting Rio Political Declaration expressed “determination to achieve social and health equity through action on social determinants of health and well-being by a comprehensive intersectoral approach.” The meeting drew explicit attention to the role of non-health-sector actors in improving health and reducing health inequities (53).

Subsequently, in May 2012, the World Health Assembly adopted a global target of a 25% reduction in NCD-associated premature mortality by 2025 (54).

In June 2012, the Rio+20 Conference on Sustainable Development was unequivocal in its recognition of the need for concerted action on NCDs and stressed the importance of developing national policies and plans:

We acknowledge that the global burden and threat of non-communicable diseases constitutes one of the major challenges for sustainable development in the twenty-first century. We commit to strengthen health systems towards the provision of equitable, universal coverage and promote affordable access to prevention, treatment, care and support related to non-communicable diseases, especially cancer, cardiovascular diseases, chronic respiratory diseases and diabetes. We also commit to establish or strengthen multi-sectoral national policies for the prevention and control of non-communicable diseases. We recognize that reducing, inter alia, air, water and chemical pollution leads to positive effects on health (Article 141) (55).

In May 2013, the World Health Assembly endorsed the *WHO Global Action Plan for the Prevention and Control of NCDs 2013-2020*, adopted the Global Monitoring Framework on NCDs, and requested the development of a global coordination mechanism (56).

These recent high-level political commitments reinforce the principles underlying the 2003 Framework Convention on Tobacco Control (FCTC), a groundbreaking, legally binding international treaty negotiated under the auspices of WHO. The FCTC, which has 177 States Parties,<sup>14</sup> calls for a comprehensive, multisectoral approach to tobacco control that goes beyond health to include such areas as trade, taxation, education, justice and law enforcement, environment, and agriculture (57).

Interference by various vested interests, lack of financial and technical resources, and other barriers have contributed to under-implementation of the FCTC among Parties (58). In light of this, accelerated implementation of the FCTC has been called for in the Political Declaration,<sup>15</sup> the Rio Declaration on Social Determinants of Health,<sup>16</sup> and the *Future We Want*, the outcome document of the Rio+20 UN Conference on Sustainable Development.<sup>17</sup>

In response, a July 2012 UN Economic and Social Council (ECOSOC) resolution emphasized the need for the UN to work across sectors to facilitate FCTC implementation, specifically encouraging:

...integration of the World Health Organization Framework Convention on Tobacco Control implementation efforts within the United Nations Development Assistance Frameworks, where appropriate,

in order to promote coordinated and complementary work among funds, programs and specialized agencies (Article 1) (59).

Finally, NCDs and their social determinants feature in key intergovernmental processes on the post-2015 development agenda, especially with regard to how health is framed within the agenda. The UN Development Group has begun a series of global, regional, and national consultations on the post-2015 agenda (60). The initial results have highlighted the prominence of NCDs in health and development more broadly. A high-level meeting of the global thematic consultation on health has listed “reducing NCDs and their risk factors” as a health priority in the post-2015 era (61). Preventing “priority” NCDs is a proposed target within an illustrative health goal in the report of the Secretary General’s High-Level Panel of Eminent Persons on the Post-2015 Development Agenda, issued in May 2013 (62). Targets for NCDs also appear in a subsequent report by the Sustainable Development Solutions Network, another advisory body to the Secretary General on the post-2015 development agenda (63). How NCDs are ultimately framed in the post-2015 framework, including its links with other development goals outside the health sector, will have significant implications for the global response to NCDs and the governance of that response.

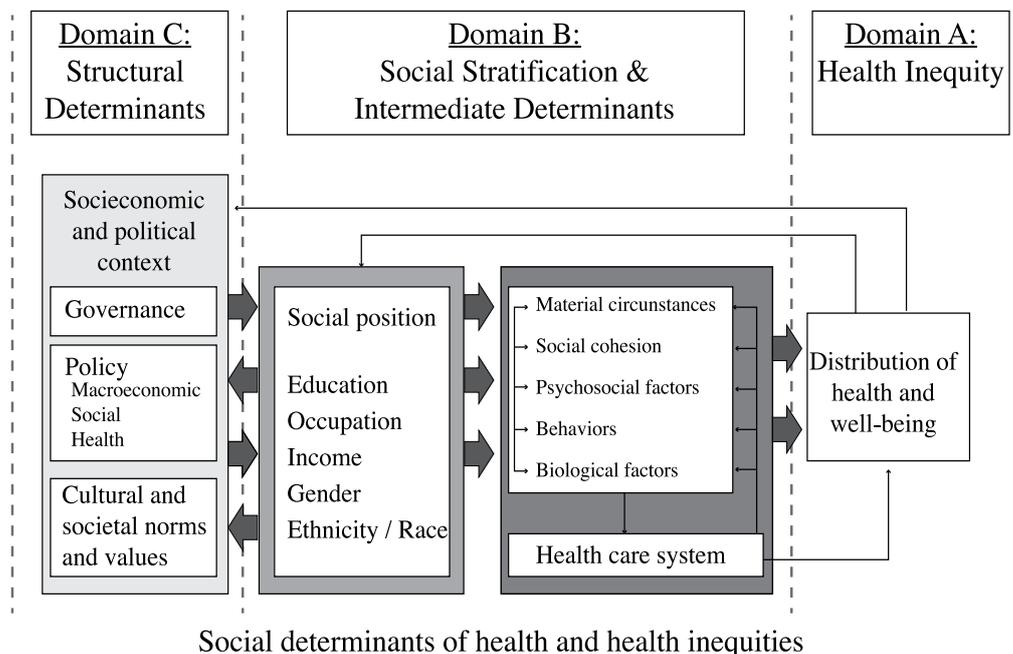
## ■ The Social Determinants of NCDs

This section highlights root causes of the level and distribution of NCDs. It presents a version of the framework on social determinants of health developed by the Commission on Social Determinants of Health (CSDH) and applies the CSDH framework and its three interacting domains to NCD outcomes and risk factors.

### A social determinants of health framework

In 2008, the CSDH formalized a social determinants of health framework to describe the relationships between macro-level socioeconomic and political factors, social stratification, and the resulting patterns, or inequities,<sup>18</sup> of disease risk factors and ultimately disease (50). Figure 31-3 is one version of the framework.

Figure 31-3. Version of the CSDH Framework



Source: adapted from (50)

The CSDH framework has three main interacting domains. Because the framework flows from epidemiological observations of inequitable health outcomes, it is best explained from the far right (outcomes) to the far left (“causes of causes”).

- **Domain A** represents the patterns or inequities observed in health outcomes and the social and economic impacts due to poor health. Differences among groups, within and across countries, are partly mediated by the health care system but primarily determined by intermediate factors. These intermediate factors are expressed in Domain B.
- **Domain B.** Exposures to intermediate factors, including material circumstances and behavioral, biological, and psychosocial factors that determine health, are shaped by social stratification. Social stratification across intersecting dimensions of socioeconomic status, gender, and ethnicity or race creates a differential experience of, and vulnerability to, these intermediate factors, and is based on social position. Social position, in turn, is shaped by structural determinants, as represented in Domain C.
- **Domain C.** Structural determinants include systems of governance, economic policies, and other government policies that shape and are shaped by society. National and local contexts influence and are influenced by global factors, including global and regional governance arrangements, trade regimes, and treaties.

It is implicit in the model that socioeconomic and political contexts and policy choices exert the strongest influence on social position and stratification and therefore impact intermediate determinants and disease outcomes.

The CSDH emphasized that health inequities follow social gradients. Systematic differences in health are observed along axes of socioeconomic position, gender, race/ethnicity, and geography, *even when health care is universally available and free*. People experience different exposures and vulnerabilities to health-damaging conditions depending on these dimensions of social stratification. Underpinning the social determinants of health approach is the concept of empowerment, understood across three intersecting dimensions: material (having the material conditions necessary for health), psychosocial (having control over one’s life), and political (having a political voice and participating in decision making) (50). A social determinant of health approach builds resilience through empowerment at the individual, community, and national levels.

Social determinants of health are not necessarily synonymous with social determinants of health inequities. Rather, social determinants of health become social determinants of health inequities if they are experienced differently, based on dimensions of social stratification. This distinction has significant policy implications. For example, a health related behavioral policy that uses health messages to encourage fruit and vegetable consumption might impact groups differently, depending on their ability to access or afford fruits and vegetables. Social and cultural norms may affect tastes and preferences or other characteristics. Policies that reduce poor health in the aggregate may do little to reduce relative inequities among groups.

Finally, the three domains in Figure 31-3 impact health throughout the life course. A life-course perspective to health acknowledges that health risks tend to accumulate over time, beginning in the earliest years of life, even before birth, and continuing during childhood, adolescence, and later stages of life. A life-course perspective complements a social determinants of health approach, not only for understanding how social determinants shape disease risk factors, access to care, and, ultimately, disease, but also for identifying potential entry points for action.<sup>19</sup>

## Applying a social determinants of health framework to NCD outcomes and risk factors

The CSDH Framework and its three domains – health inequity, intermediate determinants, and structural determinants – help illuminate root causes in the level and distribution of NCDs. CVD and diabetes are used as illustrative examples, given the wide scope of the NCD epidemic (and the reality of multiple overlapping NCD epidemics).

### Domain A: Health inequity

Health outcomes display significant social gradients or differences by socioeconomic variable, primarily occupation, income, and education. Higher socioeconomic status is generally associated with better overall health. Intersecting with socioeconomic gradients are health inequities between men and women, those due to race/ethni-

city, and those between geographical regions of residence, such as urban/rural. There is variability in the prevalence and patterning of NCD outcomes and risk factors in and among countries.

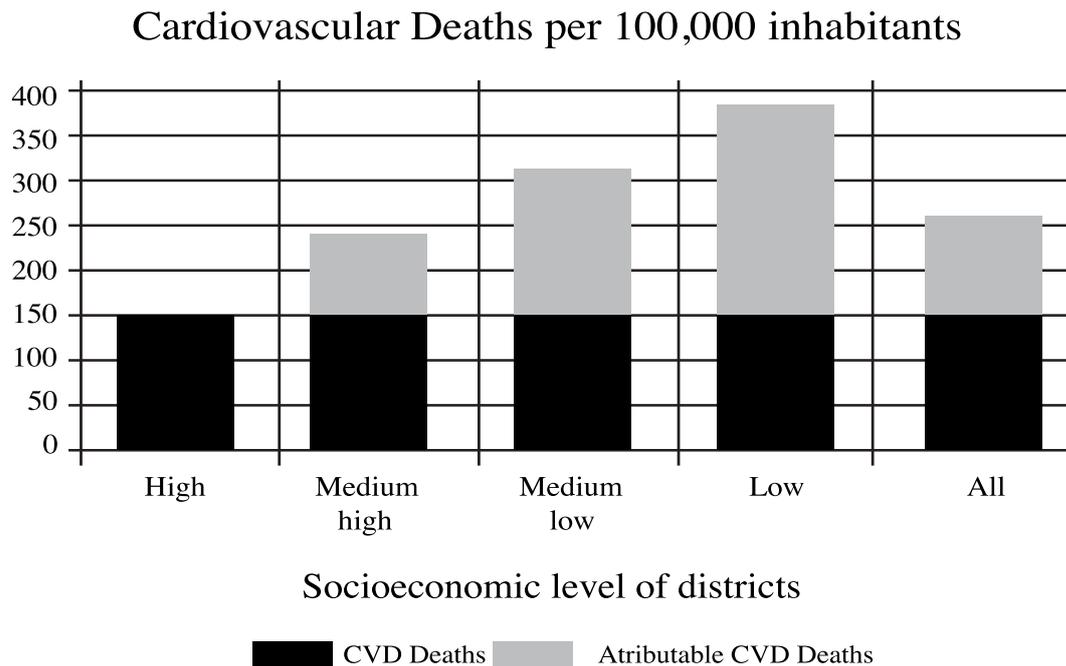
### Distribution of cardiovascular disease and diabetes by sex

CVD is the leading cause of death globally among men *and* women. In all but the oldest age groups, men tend to have higher prevalence, incidence, and mortality rates, a finding that has remained consistent historically and across countries and regions (64). Women tend to lose fewer years of life due to CVD because they develop the disease about 7-10 years later than men do (65,66). Globally, diabetes prevalence shows little sex difference (143 million women versus 142 million men in 2010), though the gap is expected to widen by 2030 (222 million women versus 216 million men) (67). Sex differences are evident, however, at the country and regional levels. In China, 50.2 million of all diabetics are men; 42.2 million are women (68). The reverse is true in the WHO African and Eastern Mediterranean Regions, where diabetes is more prevalent among women (2).

### Distribution of CVD and diabetes by socioeconomic status

In high-income countries, CVD and diabetes disproportionately affect lower socioeconomic groups (69,70). In lower-income countries, the evidence is more limited. A 2008 study in Porto Alegre, Brazil, measured the relationship between CVD and district socioeconomic level, finding that the premature death rate for CVD was 2.6 times higher in poorer districts of the city (see Figure 31-4) (71).

Figure 31-4. Cardiovascular deaths of people aged 45-64 and social inequities: Porto Alegre, Brazil



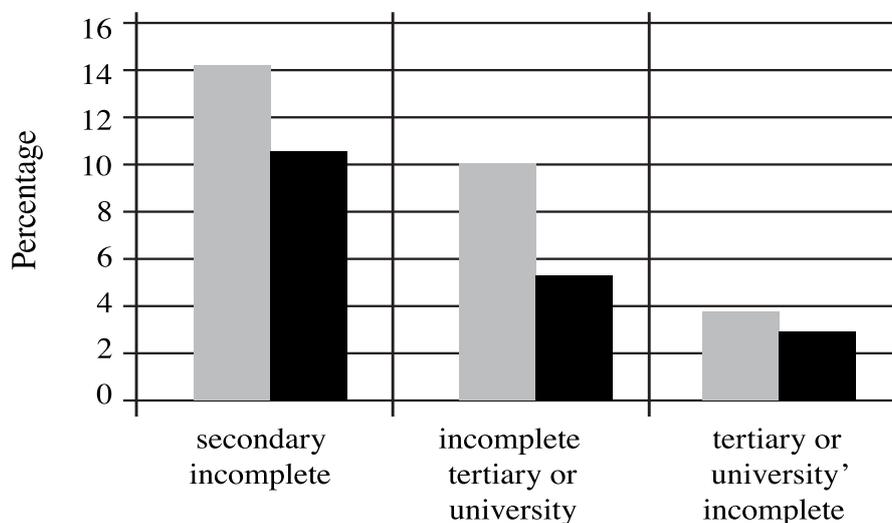
Source: (71)

### Distribution of CVD and diabetes by educational attainment

In high-income countries, low education is associated with a higher risk of CVD, but the evidence is less clear in lower-income settings (72,73). The 2009 INTERHEART study across 52 high-middle, and low-income countries found that low education was consistently associated with increased risk of heart attack in all regions, but most markedly in high income countries (72). Another study across 44 countries suggests that more education may have no protective effect on CVD in LMICs, particularly for women (73). Evidence from rural Vietnam suggests that the risk of dying from CVD among people with no formal education is 4.5 times higher than for those with primary and higher education (74).

Globally, diabetes prevalence is inversely associated with education (73). Evidence from Buenos Aires, Argentina, for example, shows that diabetes is associated with lower levels of education (75) (see Figure 31-5).

Figure 31-5. Social patterning of diabetes by education, Buenos Aires, Argentina



\**P-trend men = 0.0032 P-trend women = 0 .0095*

■ men ■ women

Source: (75)

### Domain B: Social stratification and intermediate social determinants of health

A strong evidence base causally links biological and behavioral risk factors to NCDs. Most, if not all, are preventable or modifiable in varying degrees. Within the CSDH Framework, these biological and behavioral risk factors are considered intermediate social determinants. They are influenced by social position and directly impact disease incidence and outcomes.

The role of the health system is important, especially in helping to control biological risk factors, such as high cholesterol, high fasting plasma glucose, high blood pressure, and overweight and obesity. Antihypertensive drugs can help control blood pressure, while statins are highly effective in controlling cholesterol. Yet, even in contexts with universal health coverage, patients can face social and economic barriers to access (50,76,77). For example, inequities in access to diabetes care within countries are driven by several factors, such as the educational level of those who need care and the distances that people must travel to access health services (43).

Many biological risk factors for NCDs are driven, in turn, by behavioral risk factors: tobacco use, harmful use of alcohol, physical inactivity, and unhealthy diet. While the health system can play a role, the effectiveness of most biomedical approaches will be enhanced when combined with multisectoral action on the social determinants that influence risk behaviors in the first place. A social-determinants approach to health should not be understood as

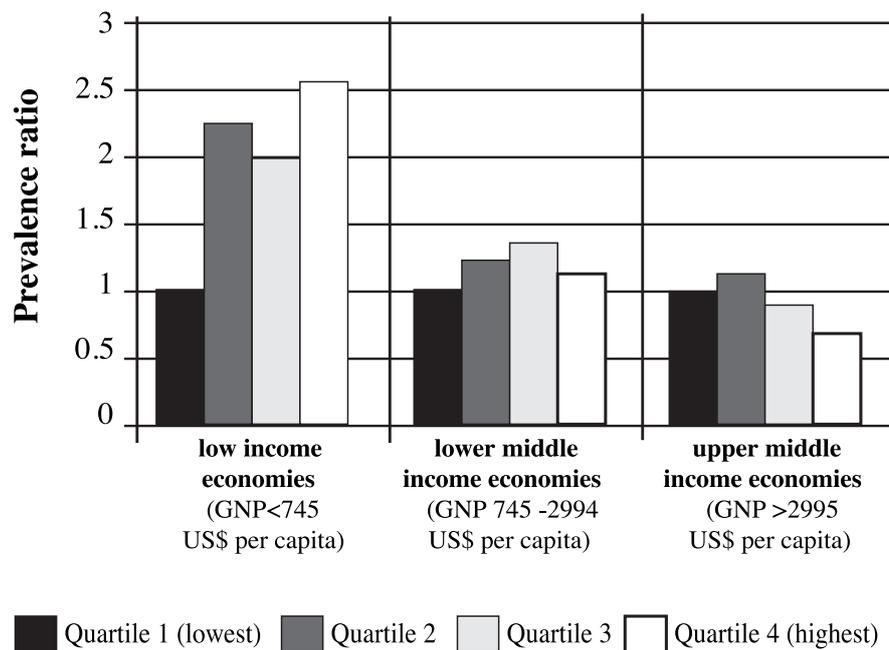
separate from medical approaches, but rather, it is integrative and complementary, influencing service utilization and risk behaviors.

### Social stratifications: Obesity

Obesity is an intermediate social determinant of NCDs. It is a major biological risk factor for CVD and diabetes, and its global prevalence is rising (43,78). The obesity epidemic began in high-income countries in the 1970s and 1980s and has subsequently increased in LMICs as well (79). One explanation for this trend is the nutrition transition, which posits that as countries develop economically, there is a shift to unhealthy dietary habits and low levels of physical activity, beginning with the groups that are better off. Over time, as countries further develop economically and undergo urbanization, unhealthy diets and physical inactivity become increasingly prevalent among lower socioeconomic groups and less prevalent among higher socioeconomic groups (80,81).

In lower-income countries, obesity tends to affect people with higher incomes or education. The opposite is true in higher-income countries: obesity affects those with lower incomes or education. A 2004 study among women from 37 countries is a case in point. Obesity prevalence was higher among more educated women in low-income countries but lower among more educated women in upper-middle-income countries (see Figure 31-6) (82). Another major study among 54 LMICs showed a positive association between income and overweight/obesity among women (83).

Figure 31-6. Obesity prevalence in women, by educational status in countries at different levels of economic development



Source: (82)

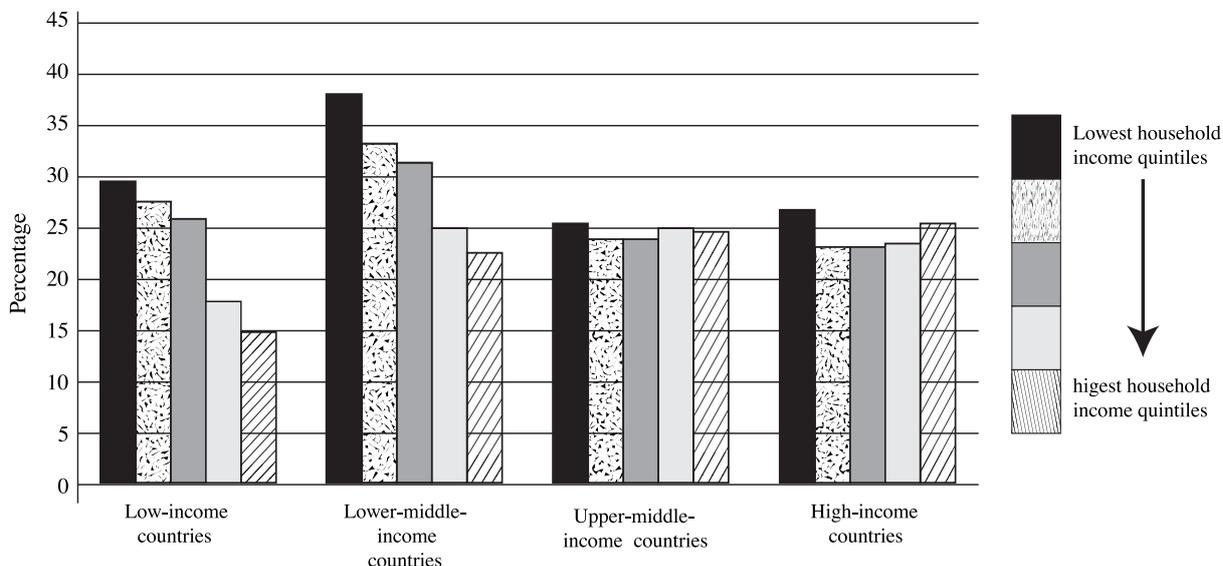
### Social stratifications: Behavioral risk factors for NCDs

The four main behavioral risk factors for NCDs—tobacco use, harmful use of alcohol, physical inactivity, and unhealthy diet – are shaped by social position. Like obesity, they are intermediate social determinants of NCDs within the CSDH Framework. In high-income countries, behavioral risk factors tend to be more prevalent among disadvantaged groups.

## Tobacco use

Tobacco use is the only modifiable risk factor common to all four main NCDs (29). Tobacco use and related mortality are increasingly concentrated in LMICs. By 2030, 70% of tobacco-related deaths will be in LMICs (84). In every region of the world, lower-income groups are more likely to use tobacco (5,65). Generally, men are more likely to use tobacco and, as a result, tobacco is a larger contributor to disease burden for men than for women (47). However, women are taking up smoking at alarming rates,<sup>20</sup> especially in LMICs, driven by aggressive tobacco industry marketing to new consumers. Increased efforts are needed to help women as well as men avoid smoking (27).

**Figure 31-7.** Smoking prevalence by income quintiles



**Source:** Global atlas on cardiovascular disease prevention and control. WHO, World Heart Federation, and World Stroke Organization, 2011

## Harmful use of alcohol

Regular consumption of excessive amounts of alcohol (binge drinking) is not only associated with CVD but also other health risks, including HIV and other sexually transmitted infections, domestic violence, TB, and road traffic accidents (2,47,85-87). Evidence on the distribution of harmful use of alcohol in low-income countries is limited. What evidence does exist suggests that it is more prevalent among lower socioeconomic groups and more prevalent among men than among women (88). In 2010, alcohol use was the third-leading risk factor for overall disease burden among men (7.4%) versus the eighth-leading risk factor among women (3%) (47).

## Physical inactivity

Regular physical activity has been shown to lower the risk of coronary heart disease and stroke, diabetes, hypertension, certain cancers, and depression (89). An imbalance between too much energy input from dietary intake and insufficient energy expenditure through physical activity is associated with increased risk of overweight and obesity. Sufficient moderate physical activity (the equivalent of 150 minutes per week) improves cardiovascular fitness. Individuals in higher-income countries tend to have lower overall levels of physical activity (2). *Within* higher-income countries, however, people with higher incomes tend to be more physically active (90-95). There are also differences in physical inactivity by sex, as women are less likely than men to be physically active across all regions and in nearly every country (2,96). Women may perceive certain neighborhoods as unsafe for a walk. Gender norms or concerns about safety may also discourage girls and women from playing outside, walking to and from school, and engaging in sports (97,98).

## Unhealthy diet

Consumption of high levels of trans fats, saturated fats, processed and refined foods, sugar, salt, and sugary drinks is associated with increased risk of CVD and diabetes, while adequate consumption of fruits and vegetables is associated with reduced risk of coronary heart disease and stroke (2,99,100). Unhealthy diet tends to follow a socioeconomic gradient. Higher-quality diets are associated with persons of greater affluence, while energy-dense diets that are nutrient-poor are associated with persons of more limited economic means (101). Unhealthy diets are also associated with lower levels of education (102). Differences are seen among men and women. Low fruit intake represented a 50% greater share of disease burden among men than among women in 2010 (47).

## Material circumstance as an intermediate social determinant for NCDs

Within the CSDH Framework, material circumstance is another intermediate social determinant of health. For NCDs, community or neighborhood environments largely define the conditions in which people live and have a significant influence on the risk of obesity and diabetes (103). A randomized control study in which mothers and families were given the opportunity to move from a neighborhood with a high level of poverty to a neighborhood with a lower level of poverty found that moving to a better-off neighborhood was associated with reductions in obesity and diabetes (103). Multiple mechanisms have been proposed whereby neighborhood environment affects the risk of obesity, including interrelated material mechanisms. These material mechanisms include the nature of the built environment, such as proximity to food outlets selling processed foods, as well as psychosocial mechanisms, such as conforming to social norms of behavior. For example, one study found that U.S. children living in unfavorable social conditions – unsafe surroundings, poor housing, and no access to sidewalks, parks, and recreation centers – were 20-60% more likely to be overweight or obese compared with children not facing such conditions (101).

## Domain C: Structural determinants of health

Structural determinants of health refer to macro-level socioeconomic, political, and cultural factors and contexts. These factors, which shape and are shaped by society, include government and economic policies, urbanization, cultural norms and others. National and local contexts influence and are influenced by global factors, including global and regional governance arrangements, trade regimens, and treaties.

Structural factors matter in their own right, above and beyond health. They generate social stratifications of individuals and groups, including by income, education, and occupation. As expressed in the CSDH Framework, social stratifications (Domain B) ultimately result in health inequities (Domain A). Thus, structural determinants also matter greatly for NCD prevention and development.

Because structural determinants of NCDs are macro-level root causes, their precise impacts on NCD outcomes are sometimes hard to determine. Nevertheless, a wealth of evidence shows that policies (and policy changes) *do* have certain or probable impacts on NCD dynamics and risk factors. Tobacco use provides a comprehensive example.



### BOX 31-1. TOBACCO USE AND THE STRUCTURAL DETERMINANTS OF HEALTH

The shifting global patterns of tobacco consumption and mortality provide a snapshot of how various structural determinants impact NCD risk factors, disease, and ultimately death. Tobacco consumption is declining in high-income countries because people in those countries increasingly understand the dangers of smoking, while governments continue to implement tobacco control laws and policies in line with the FCTC, such as legislating for smoke-free public places or work environments. Canada and Australia have made efforts to de-glamorize tobacco use by posting graphic health warnings on cigarette boxes and/or requiring that cigarettes be sold in plain, olive-colored

packages (28,104). Tobacco-related mortality is declining in high-income countries due to lower consumption patterns but also to the success of population-wide primary prevention and individual health-care interventions in reducing NCD-mortality in general (2). *The situation is different in LMICs*, where globalization of trade, targeted marketing, population growth, greater social acceptability of smoking, and continued economic development have all contributed to the rise in tobacco consumption. One particular concern is the fact that tobacco companies have begun marketing directly to women, often using campaigns centered on creating an association between smoking and gender equality (28).

## Case studies on the structural determinants of health and NCD dynamics

Trends in regional tobacco consumption and mortality tell the broad story. The case studies that follow provide further insight into how specific structural determinants can impact NCD dynamics.

### Trade liberalization and foreign direct investment in Mexico

In Mexico, the availability of unhealthy food and beverages has increased significantly. Globalization, trade liberalization (105,106),<sup>21</sup> and foreign direct investment<sup>22</sup> have been contributors. The 1994 North American Free Trade Agreement (NAFTA) among the United States, Canada, and Mexico has contributed to the nutrition transition in Mexico. By opening trade, NAFTA paved the way for rapid increases in foreign direct investment, which drove the expansion of the food processing industry and with it, the distribution, marketing, and retailing of processed foods in Mexico (107). Other factors influencing the availability and affordability of unhealthy foods in Mexico include urbanization and food and agricultural subsidies affecting global commodity prices (107,108).

Data on total energy intake among Mexicans before and after NAFTA demonstrate the impact. Between 1988 and 1999, the percentage of total energy intake from fat among Mexicans increased from 23.5% to 30.3%. Purchases of refined carbohydrates increased by 37.2% over the same period. Absolute increases in energy intake from fat were higher in the wealthier north and Mexico City (30%-32%) than in the poorer southern region (22%). Increases were significant, however, throughout the country (107). Today, over 8% of Mexicans have diabetes, which costs the country \$15 billion each year according to WHO estimates (109). The situation in Mexico demonstrates the long causal chain linking structural determinants to NCDs and development—from trade liberalization and foreign direct investment to unhealthy diets to disease outcomes to developmental impacts.

### Food policy in the United States

In 2007-2008, the adult age-adjusted prevalence of obesity in the U.S. was 33.8% (110). Childhood obesity in America is growing three times faster than adult obesity. These health trends are accompanied by tremendous economic costs. In 2008, the U.S. spent \$147 billion on obesity-related illness (111).

America's obesity epidemic is connected to agricultural policies dating back to the 1960s, when the U.S. government promoted cheaply grown commodity crops (e.g., corn, wheat, rice, and milk) to provide Americans with inexpensive, calorie-dense meals. Today, this same "cheap food policy" is believed to contribute to the supply of nutrient-poor snacks, sugary beverages, and foods high in saturated fats (111). Notwithstanding the high obesity rates, America's farmers continue to receive support from the government for the production of certain commodities. In 2001, when falling crop prices threatened farmers' business, farmers received government payouts totaling \$20 billion (111). Many of these subsidies are permissible under WTO rules, illustrating again the ways in which trade agreements can ultimately influence health, including NCDs.

U.S. social policy may also contribute to the country's obesity rates. The United States spends billions of dollars a year on food assistance through its Supplemental Nutrition Assistance Program (formerly food stamps). The program, run by the U.S. Department of Agriculture, provides meals and subsidizes food purchases for participants (112). However, some studies show that participants are more likely to be obese than income-eligible nonparticipants (113). This relationship holds across all age groups and is more consistent among long-term users of the program (113,114). Even where studies do not show such a link, experts agree that the program is missing an opportunity to improve diets among low-income Americans. State and local efforts to restrict what beneficiaries can buy (e.g., limiting the purchase of soda) have thus far been thwarted by the federal government. Social policies that inadvertently promote the consumption of energy-dense, nutrient-poor foods and drinks may serve to maintain and worsen inequities in NCD risk factors and outcomes. Social protection instruments thus have the potential to either alleviate or worsen NCD epidemics.

## ■ Action on the social determinants of NCDs

This third part of the chapter demonstrates that successful multisectoral action on the social determinants of NCDs is possible. The first section presents some existing frameworks for action on NCDs and their social determinants. The second section outlines key enablers required for successful multisectoral action on NCDs, drawing on lessons from the field, including lessons from the AIDS response. The third section introduces a typology of multisectoral action on NCDs, with three general categories of possible action outside the health sector. These are supported by country examples.

## Existing frameworks for multisectoral action on NCDs

Several global frameworks already exist to guide multisectoral action on NCDs (see Table 31-3). These are often supported by regional frameworks.

**Table 31-3.** Key global frameworks for action on NCDs

Year	Framework	Significance for action on the social determinants of NCDs
2003	WHO Framework Convention on Tobacco Control <a href="http://www.who.int/fctc/en/">http://www.who.int/fctc/en/</a>	First legally binding global health treaty negotiated under the auspices of WHO. First treaty aimed at the control of a key NCD risk factor. First treaty with demand-reduction measures. Most FCTC provisions outline multisectoral action on the social determinants of tobacco use.
2004	Global Strategy on Diet, Physical Activity and Health <a href="http://www.who.int/dietphysicalactivity/strategy/eb11344/strategy_english_web.pdf">http://www.who.int/dietphysicalactivity/strategy/eb11344/strategy_english_web.pdf</a>	Recommends action at multiple levels on two key modifiable risk factors for NCDs: unhealthy diet and physical inactivity.
2008	Action Plan for the Global Strategy for the Prevention and Control of NCDs <a href="http://whqlibdoc.who.int/publications/2009/9789241597418_eng.pdf">http://whqlibdoc.who.int/publications/2009/9789241597418_eng.pdf</a>	Consolidates comprehensive, multisectoral action on the four main NCDs into one plan with performance indicators. Most recommendations involve multisectoral action on social determinants of NCDs. Endorsed by Member States of the World Health Assembly.
2010	Set of Recommendations on the Marketing of Foods and Non-Alcoholic Beverages to Children <a href="http://whqlibdoc.who.int/publications/2010/9789241500210_eng.pdf">http://whqlibdoc.who.int/publications/2010/9789241500210_eng.pdf</a>	Policy-level recommendations aimed at changing the food environment. Explicit recognition of a life-course approach to NCDs by highlighting unique vulnerabilities of children to both marketing and to NCDs. Endorsed by the Member States of the World Health Assembly.
2010	Global Strategy to Reduce Harmful Use of Alcohol <a href="http://www.who.int/substance_abuse/msbalcstrategy.pdf">http://www.who.int/substance_abuse/msbalcstrategy.pdf</a>	Focuses on 10 areas of national action that include: leadership; health services; community action; drunkdriving; alcohol availability, marketing, pricing, and informal production; impact mitigation; and monitoring.
2011	WHO “Best Buys” <a href="http://www.who.int/nmh/publications/best_buys_summary.pdf">http://www.who.int/nmh/publications/best_buys_summary.pdf</a>	Identifies low-cost, high-return interventions to prevent and control NCDs. Highlights multisectoral action on social determinants.
2013	NCD Global Monitoring Framework (GMF) <a href="http://www.who.int/nmh/global_monitoring_framework/en/">http://www.who.int/nmh/global_monitoring_framework/en/</a> The Revised Global Action Plan for the Prevention and Control of Noncommunicable Diseases <a href="http://apps.who.int/gb/ebwha/pdf_files/WHA66/A66_R10-en.pdf">http://apps.who.int/gb/ebwha/pdf_files/WHA66/A66_R10-en.pdf</a>	GMF: comprises nine voluntary global targets and 25 indicators aimed at preventing, controlling, and tracking the four main NCDs and their key risk factors. Revised Global Action Plan 2013-2020: includes a comprehensive set of actions to accelerate the reduction of the NCD burden so that sufficient progress is made by 2020 on the global targets set for 2025. Provides a minimum set of NCD actions, many on social determinants, that countries with resource constraints may prioritize.

The WHO FCTC is noteworthy among global frameworks for action on NCDs for several reasons. First, it is the only legally binding treaty directly linked to NCDs and the first global health treaty negotiated under the auspices of WHO. It has been broadly ratified, with 177 Parties.<sup>23</sup> Second, the scope of the FCTC is broad. It takes a multisectoral approach to addressing the supply- and demand-side measures of tobacco use and emphasizes several overlapping social determinants. Third, the FCTC incorporates a life-course perspective through provisions

related to the sale of tobacco products to minors, recognizing the unique vulnerabilities of young people to nicotine addiction, marketing, and advertising. Finally, the FCTC underscores the gender dimensions in the supply and consumption of tobacco and calls for women to participate fully in policy-making and implementation. Governance issues are formally addressed in Article 5 of the FCTC, which calls for multisectoral national plans, coordination structures, and policy-making independent of tobacco industry interests. In mitigating power differentials in decision-making, governance issues are critical to a social-determinants approach.

The FCTC and the other global frameworks in Table 31-3 are highlighted because of their attention to concrete, multisectoral action to prevent and control NCDs. Many other global frameworks on social determinants do not explicitly mention NCDs. These frameworks are important for two key reasons: social determinants often matter in their own right for reasons beyond NCDs or health, and even if a global framework is not specifically designed to prevent or control NCDs, it may nonetheless do so by addressing social determinants or human rights more broadly. The 1979 Convention on the Elimination of All Forms of Discrimination against Women (CEDAW) and the 2004 United Nations Convention against Corruption, both important conventions, were not drafted or ratified with NCDs in mind. Nevertheless, some of their provisions are directly relevant to action on the social determinants of NCDs, especially where the provisions address ingrained structural inequities that drive inequities in the distribution of NCDs. These and other conventions, declarations, and frameworks provide additional political support, intellectual depth, and innovative ideas for addressing the social determinants of NCDs.

### Key enablers of action on the social determinants of NCDs

Although multisectoral action can take many forms and often depends on context, some key enablers or principles are clear: high-level political commitment, governance mechanisms to facilitate and coordinate multisectoral responses, and robust structures for monitoring, evaluation, and accountability. While these key enablers are insufficient on their own for successful multisectoral action, they are often necessary prerequisites. They are reflected in many of the global frameworks for action on NCDs and have been illustrated extensively in practice with respect to NCDs and other health challenges, such as HIV.

#### Political will

Countries that have succeeded in developing coherent action on the social determinants of health have done so with political will at the highest levels of government. Building support for coherent action requires evidence and arguments that improving social conditions can improve population health, reduce health inequities, and support other national development objectives. Building such support can be challenging, especially when navigating the interests of powerful lobbies, such as those of the tobacco, pharmaceutical, food, and beverage industries. Analysis of the social costs of health inequities, such as the study conducted by the Marmot Review in England (115), provides persuasive arguments that *inaction* on social determinants of health is less cost-effective than action.

#### Governance mechanisms

All areas of public policy affect health and health equity to varying degrees. Three key elements of health-promoting public policies are:

- A coherent approach across government to ensure that policies in one arm of government do not counteract policies in another;
- Joint action across distinct departments to achieve specific objectives; and
- Engagement with stakeholders outside of government (50).

Experience has shown that health-promoting public policies can be achieved with strong management, towards a clearly identified and accepted objective, with mechanisms for accountability and transparency, and with participation from stakeholders in decision-making (116). More specific guidelines have been developed through collaborative research. For example, the Adelaide Statement that resulted from a joint initiative between WHO and the government of South Australia proposed tools and instruments to support governments in building “health in all policies” with a focus on equity (see Box 31-2). In addition, the Secretariat to the WHO Commission on Social Determinants of Health and the Public Health Agency of Canada (PHAC) compiled 18 case studies from countries of all income levels on how action in different sectors can positively influence health and health equity.



### BOX 31-2. HIGHLIGHTS FROM THE ADELAIDE STATEMENT

- *Inter-ministerial and inter-departmental committees* are fundamental to ensure cross-fertilization of diverse stakeholder interest.
- *Cross-sectoral action teams* ensure a multidisciplinary approach to reduce the potential disruption caused by entrenched positions.
- *Integrated budgets and accounting* incentivize teams and stakeholders to work towards unified objectives.
- *Cross-cutting information and evaluation systems* provide a coercive availability of information and accepted evaluation methodology for cross-sectional action teams, which, in the absence of such information, could seek to act on a non-unified basis.
- *Joined-up workforce development* provides an accepted basis for the development of stakeholders and ideas.
- *Community consultations and Citizens' Juries* widen the base of information from diverse actors or stakeholders and strengthen ownership and transparency of the policy process.
- *Partnership platforms* create a forum in which stakeholders can propose and debate divergent views on a non-confrontational basis.
- *Health Lens Analysis* is a formalized five-step process to ensure that different agencies achieve mutually beneficial outcomes. Leadership from the cabinet or premier level initiates the process by inviting the lead agency to undertake the analysis. Step one involves establishing good working relationships between agencies in diverse sectors and agreeing to the joint policy focus. Step two is an evidence gathering exercise, during which mutually beneficial impacts between policy areas and health are identified and evidence-based policy options are reviewed. Step three asks partner agencies to jointly produce a report that sets out policy recommendations. Step four involves partners steering the recommendations through the decision-making process. The fifth and final step is for partners to evaluate the effectiveness of the process.
- *Impact assessments* are tools that can be used to assess the health or health equity impacts of policies and projects in diverse sectors. They may use a mixture of quantitative, qualitative, and participatory techniques. Impact assessments are used by policymakers and planners across government departments at national and local levels. At the national level, for example, they may be used to assess the impact of trade policy on health and health equity. At local level, for example, they may be used to assess the impact of new roads or the location of fast food outlets on health and health equity.
- *Legislative frameworks* are a means of establishing prioritized policies or reforms for health and other desirable social outcomes within a set of enforceable, agreed upon regulations (116).



### BOX 31-3. GOVERNANCE OF THE AIDS RESPONSES

In the earlier years of the AIDS epidemic, many structures responsible for national AIDS responses were housed within ministries of health. The corresponding entity at the global level was WHO. At the time, many health sector-based structures were not equipped to respond on their own to the multidimensional AIDS epidemic, contributing to the creation of UNAIDS at the global level. At national levels, especially in countries with generalized epidemics, national AIDS commissions (NACs) or programs (NAPs) became common. Many NACs have been housed outside ministries of health, in some cases within offices of presidents and prime ministers, affording them a high degree of political cachet. Building structures for multisectoral coordination in the AIDS response has not been without challenges. Some evidence suggests that some countries with NACs have not necessarily succeeded in achieving multisectoral coordination any better than countries in which AIDS responses remain housed in

ministries of health. Many explanations could be put forward. One is that effective coordination across sectors may have less to do with organizational structures than with effective leadership, whether that leadership is from an official multisectoral coordination structure or from a particular line ministry, like a health ministry. Other lessons from AIDS responses are pertinent. NACs can be expensive and largely donor-financed, raising questions of sustainability. Moreover, the effectiveness of NACs can be hampered by the creation of partially parallel structures, such as Country Coordinating Mechanisms as required for Global Fund grants. Global and national AIDS governance continues to adapt as lessons are learned and context changes. Increasingly, countries are moving their NACs back into ministries of health. It remains to be seen whether ministries of health are now better equipped to implement strategic multisectoral AIDS responses than they were 15-20 years ago.

The governance of the AIDS responses offers opportunities as well as relevant lessons for NCDs. It may be beneficial for governance models for both AIDS and NCDs to evolve in synergy. Biomedical responses to AIDS could remain squarely under the remit of ministries of health, but NACs could shift their focus to social determinants, not just in relation to AIDS but also to health outcomes more broadly, including other communicable and noncommunicable diseases. NACs would then become structures focused on the social determinants of health, rather than on any disease in isolation, and coordinate multisectoral action accordingly. Rather than repeat steps of the past, it may be that multisectoral responses to AIDS and NCDs—and the governance mechanisms that support both – should join forces.

### Monitoring progress and achieving accountability

A monitoring and accountability framework for NCD responses is critical, especially for ensuring effective multisectoral action on the social determinants of NCDs. WHO has developed a global monitoring framework for the prevention and control of NCDs, which was adopted by the World Health Assembly in May 2013. The Global Monitoring Framework (GMF) contains nine voluntary global targets with 25 indicators—all aligned with the global target of a 25% reduction in NCD-associated premature mortality by 2025<sup>24</sup> (see also Table 31-3). The GMF is intended to enable worldwide tracking of the four main NCDs and their key risk factors, as well as to promote action (117). A separate set of process-oriented “action plan indicators” will also be agreed on to help monitor countries’ progress in implementing the *WHO Global Action Plan for the Prevention and Control of Non-communicable Diseases 2013-2020* (118).

The GMF offers a foundation on which countries can build an NCD monitoring system tailored to their contexts. One key opportunity for governments is to build on the GMF by establishing national NCD targets and indicators related to the social determinants of health and health inequities. Often, information systems are geared to tracking disease outcomes and trends rather than social determinants, even where information systems are strong. Tools and processes must be developed that gather information on the underlying factors that contribute to poor health.

Other examples and tools may help governments build their NCD monitoring systems. The Marmot Review in England, for example, proposed a set of NCD-related indicators to support monitoring of strategies to reduce health inequities across the life course<sup>25</sup> (115). The London Health Observatory and the Institute of Health Equity published baseline data for these indicators in 2011 using data available from authorities at the local level, and updated the initial data in 2012 as part of an ongoing monitoring process in England (119). Mechanisms for monitoring inequities at the municipal level have been developed and might be leveraged for improving monitoring systems at the national level. The Urban Health Equity Assessment and Response Tool, developed by WHO in collaboration with partners, is a tool to aid decision-making in urban areas and includes indicators of health outcomes and social determinants (120). Data can be gathered from surveys in cities. The social determinant indicators are in the domains of the physical environment and infrastructure, social and human development, economics, and governance.

Accountability for meeting the targets and other goals within the GMF and Global Action Plan may be promoted through two additional measures. These measures might help address challenges in reporting systems based on mutual accountability, which risks each party less rigorously evaluating the other in order to alleviate its own commitments. The first measure is the establishment of an independent, third-party accountability mechanism. Such a mechanism could gather accurate, transparent measurements of progress, reporting results, and recommendations to the highest possible multilateral authority (121). The second measure is to open the stream of data collection and interpretation to civil society—for example, by accepting shadow reports. UNAIDS has employed such a strategy in monitoring the AIDS response. Such reporting can be particularly useful in providing additional insights on progress in marginalized groups.

### Typology of multisectoral action

Most documented examples of multisectoral action on the social determinants of NCDs are from high- and middle-income countries. Even so, action is possible and necessary within countries of all income levels. Countries across the income spectrum have partnered with the CSDH and are implementing the social determinants of health approach in ways tailored to national and local contexts (122).

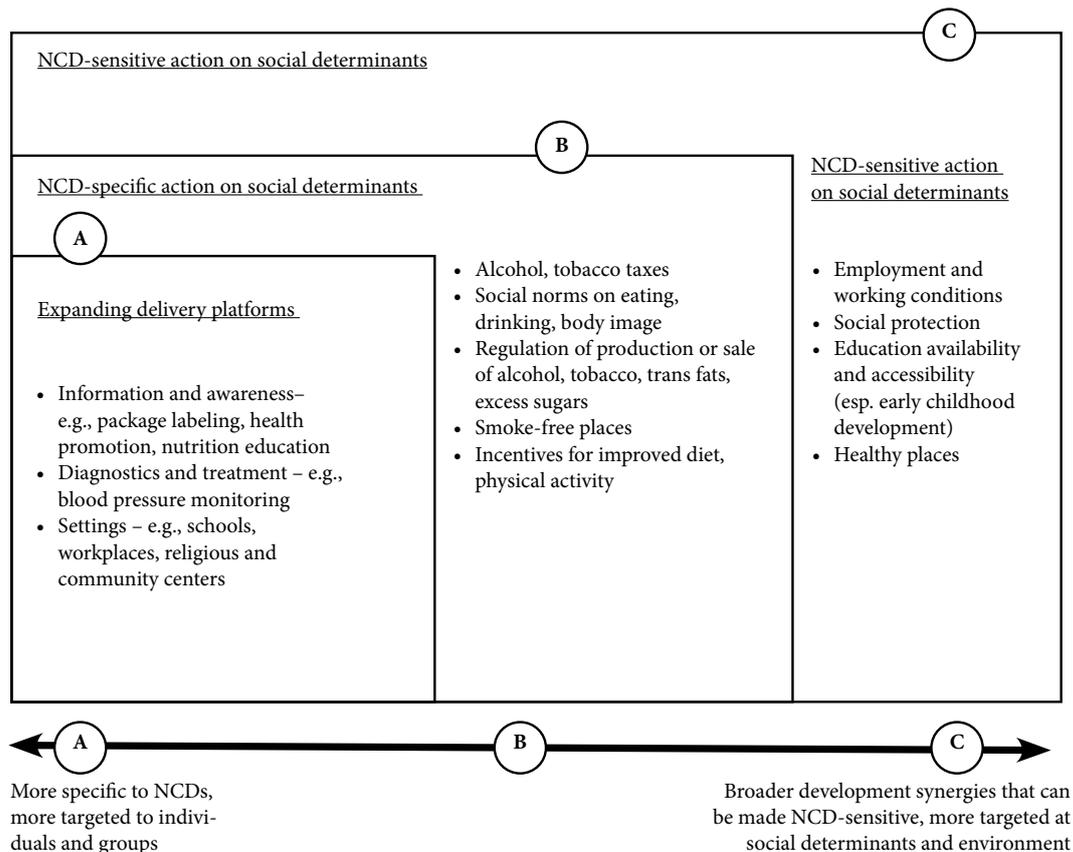
The examples below further demonstrate that multisectoral action on social determinants of NCDs is possible and can be effective in multiple contexts. They illustrate a typology of action outside the health sector that falls within three general categories:

- A) Expanding delivery platforms;
- B) NCD-specific actions on social determinants; and
- C) NCD-sensitive actions on social determinants (see Figure 31-8).

*Expanding delivery platforms* involves using settings outside the health system—schools, workplaces, public sector institutions—to deliver conventional biomedical and behavioral interventions to individuals and/or groups. A common example is the promotion of healthy diets and physical activity in schools and workplaces. While such approaches may extend the reach of health-related information and services to vulnerable and marginalized groups, they tend not to address social determinants *per se*. They focus more on individual decision-making and less on the contexts in which decisions are made. The second and third categories *are* about addressing social determinants, or the larger environment. Some actions are *NCD-specific*, such as laws and policy changes on tobacco use. Others are *NCD-sensitive*. These actions are not typically implemented for NCD prevention or control. Instead, they are the core business of other sectors outside health. Since their core business can ultimately impact NCDs, it can be made NCD-sensitive such that positive impacts on NCDs are maximized and negative impacts minimized.

The typology and examples are intended to catalyze discussion and innovation in other contexts and across other sectors. For each example, key considerations for actors outside the health sector are provided. The examples are only illustrative. Examples include outcome evaluations on diseases or risk factors, while others are descriptions of interventions.<sup>26</sup> NCD-sensitive actions, in particular, often do not track NCD outcomes, as they are not carried out with NCDs explicitly in mind. Finally, effective action may involve combination approaches that cut across different levels of this typology, as illustrated by some examples below.

**Figure 31-8.** Typology of multisectoral action on NCDs. Many real-world examples use combination approaches of one or more categories, including action within the health sector.



## A

Expanding delivery platforms

Expanding delivery platforms involves using settings outside the health system—for example in schools, workplaces, and religious and community centers—to deliver conventional biomedical and behavioral interventions to individuals and/or groups. These interventions include various diagnostics and treatments, as well as information intended to raise awareness and change behavior. Delivering biomedical and behavioral interventions outside the health system can expand the reach of these interventions, especially for remote and otherwise marginalized populations.

Specific examples of expanding delivery platforms include the monitoring of blood pressure, glucose, and insulin in schools and workplaces, food package labeling for nutritional content (e.g., calories and fats), and caloric postings at restaurants. Religious and community leaders are well-positioned to deliver compelling messages. School-based approaches, such as health promotion and nutrition education to support the adoption of healthy diets and physical activity, have been widely introduced. Effective school-based interventions include lessons on diet and/or physical activity delivered by trained teachers, supportive school policies, physical activity programs, a parent/family component, and healthy food options through school services. School gardens to provide healthy food for school meals are part of a wider strategy to improve nutrition in many countries (123).

The example below (Box 31-4) illustrates an example of how actors outside the health sector can expand delivery platforms for NCD prevention and control.



#### **BOX 31-4. A MULTI-LEVEL, COMMUNITY-WIDE PROGRAM TO INCREASE PHYSICAL ACTIVITY IN SÃO PAULO, BRAZIL**

*Agita São Paulo* was introduced in 1996 to increase knowledge about the importance of physical activity and levels of physical activity among the population in the state of São Paulo, Brazil. The program involved community-level deployments targeted at school students, local municipalities, workers, and the elderly. It encouraged activity in three settings: home, transport, and leisure time.

*Agita São Paulo* was launched by the state health ministry and coordinated by the Center for Studies of Physical Fitness Research Laboratory of São Caetano do Sol. The program design was grounded in social theory, and development and implementation of the program involved multiple partnerships across governmental and nongovernmental organizations and different sectors, such as education, sports, health, industry, and commerce. The program featured annual “mega events” for each target group, free coverage by mass media, special promotional material and giveaways, improvements in physical

environments, and prescriptions of “doses” of physical activity by medical professionals. Cross-sectional surveys among the population revealed that knowledge about the program and its main messages increased from 37% to 60% between 2002 and 2008. The proportion of the population reporting no physical activity fell from nearly 10% to less than 3% between 2002 and 2008. The proportion of residents reporting less than 150 minutes of activity per week (the recommended level) fell from 43.7% to 11.6%. Limited data available in Brazil more broadly uses the same instrument and indicates opposite trends, rendering it likely that the observed positive outcomes are attributable to *Agita São Paulo* (124-126). **Considerations for development actors:** *Agita São Paulo* involved the coordination of multiple sectors to access its target population in a suite of non-health settings. Medical professionals worked alongside development actors to instill awareness and knowledge, and to elicit behavior change.

## B

NCD-specific actions on social determinants

NCD-specific actions on social determinants are laws, policies, and programs whose primary purpose is action on the social determinants of NCDs. Tobacco taxes, for example, make tobacco products more costly for everyone<sup>27</sup> but disproportionately deter youth, minorities, and smokers of lower socioeconomic status (a tax represents a greater proportion of income for these persons) (27). Because minority status and low SES are positively asso-

ciated with tobacco consumption (127), tobacco taxes might reduce aggregate levels of, and inequities in, tobacco use. Higher taxes on tobacco and other unhealthy products might also mitigate the sometimes harmful impact of trade liberalization on NCDs, particularly when combined with lower taxes on healthier items. Examples of NCD-specific actions on social determinants are zoning laws that restrict the density of fast-food restaurants in a particular geographical area (128) or policies that incentivize street vendors to sell fruit rather than less-healthy foods, particularly in lower-income urban areas (129). Some actions can have multiple mechanisms of impact. For instance, graphic health warnings on cigarette boxes not only raise awareness of health harms but also shape social and cultural norms (130).

Boxes 31-5 and 31-6 illustrate NCD-specific actions on social determinants: graphic warning labels on cigarettes in Canada and bicycle programs that encourage physical activity in Colombia.



### BOX 31-5. GRAPHIC WARNING LABELS ON CIGARETTES IN CANADA.

The tobacco industry routinely attempts to glorify smoking through marketing and advertisements. In ads targeting men, smoking is associated with masculinity and virility. In the growing proportion targeting women, smoking is associated with glamor, independence, and gender equality (30). Countries have responded. In 2001, Canada introduced strong graphic health warnings on the outside of cigarette boxes. One evaluation found that Canadian smokers who had read, thought about, and discussed the new labels at baseline (91% of those surveyed) were more

likely to have quit, made an attempt to quit, or reduced their smoking three months later, after adjusting for intentions to quit and smoking status at baseline (131). Similar pictorial warnings have been adopted by about one-quarter of countries worldwide. Article 11 of the FCTC compels Parties, within three years of acceding, to require tobacco product health warnings that cover at least 30%, and preferably 50%, of the visible area on a cigarette pack (28).



### BOX 31-6. URBAN INTERVENTIONS AND PHYSICAL ACTIVITY PROMOTION; THE CICLOVÍA AND CICLORUTA PROGRAMS IN BOGOTÁ, COLOMBIA.

As elsewhere, NCDs account for a growing burden of disease in Colombia, with chronic and degenerative diseases accounting for eight of the country's 10 leading causes of mortality in 2010 (130). Urbanization has contributed to the NCD epidemic in part by leading to reduced physical activity. In recent years, interventions encouraging physical activity, such as building bicycle paths, have gained momentum and proved to be promising globally (131). Such policies have the capacity to change the physical environment to increase access to recreational activities and promote active commuting (132).

Two programs in Bogotá are illustrative. The *CicloVía* program is a community-based program in which streets are temporarily closed to motorized vehicles to allow exclusive access for pedestrians, cyclists, skaters, and others for active recreation. *CicloVía* currently involves a circuit of 121 km of main avenues that are closed every Sunday and holiday (72 events per year, from 7 a.m. to 2 p.m.) (132). It has been replicated in numerous other countries since its inception in 1976. The *CicloRuta* program, meanwhile, is one of the most extensive bicycle paths in the world, built over the course of seven years beginning in 1996. It covers over 340 km and connects Bogotá's residents to major bus routes,

and community centers (133). One study compared participants from *CicloVía* (streets closed) with those from *CicloRuta* (bike path) to assess associations of program participation with physical activity, safety, social capital, and equity. Most *CicloVía* participants met the physical activity recommendation in leisure time (59.5%), and most *CicloRuta* participants met it by cycling for transportation (70.5%). *CicloVía* participants reported a higher sense of safety and social capital than did *CicloRuta* users. Most *CicloRuta* users reported living in low socioeconomic status categories (53.1%), had lower educational attainment (27%), and did not own cars (82.9%). Most *CicloVía* participants reported living in middle socioeconomic status categories (64%), had low-to-middle educational attainment (51.1%), and did not own cars (66.1%) (132).

**Considerations for actors outside the health sector:** Developed to improve quality of life and overcome inequities, bicycle programs are an effective way to increase physical activity by addressing its social determinants. They require health sectors to work in concert with ministries of transportation, among other sectors, to arrive at a mutually beneficial result.

## C NCD-sensitive actions on social determinants

Some of the most powerful determinants of NCDs and their distribution lie at the macro level, where overarching laws, policies, and social structures reflect and shape the distribution of power and other resources throughout society. These determinants include employment and working conditions, social protection, education (especially early childhood development), and healthy, safe living conditions. Some of the earliest, groundbreaking work on the social determinants of health was centered on employment and working conditions. The Whitehall studies in the UK demonstrated that despite universal free health coverage through a national health service, gradients in cardiovascular mortality persisted along gradients in employment. Those in lower rungs of the hierarchy with less autonomy over their work had higher levels of mortality than those at higher rungs. Similarly, shift work is associated with higher rates of NCD morbidity and mortality (134).

Action in these areas generally matters in its own right and for a suite of other health, human rights, and development objectives. Early childhood development is a case in point. Gestational diabetes may lead to perinatal complications. Medical interventions that target gestational diabetes, such as dietary advice and blood glucose monitoring, reduce the risk of serious perinatal complications (135). Investing in early childhood development, however, matters beyond diabetes or NCDs. Recent research in LMICs provides strong evidence that effective programs, policies, and other interventions in the early years “can protect children from the negative consequences of poverty.” Such programs include preschool services for young children and parental support to improve the home learning environment. Early child development services can be integrated with services to support parental needs, such as education, vocational training, and improved employment opportunities and conditions. Investments in early child development are cost-effective; models of long-term economic benefits of investing in early child development show a cost/benefit ratio of 6.4 to 17.6 (136).

Because broader social and economic policies and programs matter for reasons beyond NCDs—and because they are often the core business of actors outside the health sector—the challenge is to make these policies and programs NCD-sensitive. Making policies and programs NCD-sensitive involves understanding the ways in which broader efforts impact positively and negatively on NCD prevention and control and, once understood, working across sectors to maximize the positive impacts and minimize unintended negative ones.

Shifting the use of payments from various social protection programs, including cash transfers and public works schemes, away from harmful items such as alcohol, tobacco, and processed foods toward healthier items such as fruits and vegetables is an attractive opportunity for making social protection NCD-sensitive. One recent example is in New York City, where the municipal government tried to limit the use of food stamps for purchasing junk food (137).

The following examples from the United States, Chile, and Brazil (Boxes 31-7 to 31-9) demonstrate overarching social and economic policies and programs that address root causes of NCDs. They indicate how policies and programs can be NCD-sensitive and suggest opportunities for making them more so. The United States example is a social experiment linked to a national housing program. The intervention explicitly tracked biological outcomes and provides strong evidence for the hypothesis that neighborhood characteristics are important determinants of health. The final example, from Brazil, is an illustration of a comprehensive combination approach. It involves health care, NCD-specific measures such as tobacco control, and NCD-sensitive measures such as conditional cash transfers to reduce inequities.



### BOX 31-7. MOVING TO OPPORTUNITY FOR FAIR HOUSING DEMONSTRATION PROGRAM AMONG LOW-INCOME URBAN POPULATIONS IN THE UNITED STATES.

The social determinants approach to improving the health of low-income urban populations in poor neighborhoods involves creating employment opportunities and increasing employability through skills training, as well as improving conditions in the neighborhood by reducing poverty; bettering the physical environment; improving the quality of schooling (especially for early child development); improving housing; developing amenities and safe green spaces; improving access to health services; and building social cohesion through community projects (51). In 2000, 3.5 million poor people across the United States lived in neighborhoods with poverty concentrations in excess of 40%. A growing evidence base suggests that such concentration has a variety of detrimental effects on the current well-being and future opportunities of residents in these areas. The harmful effects of high-poverty areas are thought to be especially severe for children, whose behavior and prospects may be particularly susceptible to a number of neighborhood characteristics, such as peer group influences, school quality, and the availability of supervised after-school activities (138,139).

To reduce the vulnerabilities of disadvantaged groups, a national initiative from the U.S. Department of Housing and Urban Development (HUD) provided tenant-based conditional housing vouchers with location restrictions and housing counseling. Between 1994 and 1998, housing authorities in five demonstration sites—Baltimore, Boston, Chicago, Los Angeles, and New York—worked in partnership with local nonprofit counseling organizations to recruit about 4,600 very-low-income families for the Moving to Opportunity (MTO) Program. The families, all of which lived in public housing or private-assisted housing projects in the poorest parts of these cities, responded to outreach that offered them a chance to move from their current homes and neighborhoods through housing vouchers (138,139).

The demonstration sites shared some characteristics, including the presence of large, distressed public housing developments in concentrated poverty neighborhoods (where more than 40% of the population lived below the poverty line). The cities differed in other ways: in the racial and ethnic composition of their eligible populations and in the nature of their housing markets. Despite these differences, the demonstration was implemented with considerable uniformity, particularly with respect to recruitment, informed consent of participants, issuance of vouchers, and the rules governing their use. Through joint training, central oversight, and regular monitoring and data collection, HUD ensured that the procedures developed for the MTO Program were carefully followed (138,139).

At 4-7 years, improvements in multiple health and social economic indicators were observed, including a significant decrease in obesity prevalence among adults in experimental versus control groups (138). At 10-15 years, there was no longer a statistically significant program impact on obesity, but MTO participants remained 5 percentage points less likely to be *extremely* obese (BMI  $\geq$  35 kg/m<sup>2</sup>) compared with control groups. The MTO Program also generated declines in diabetes prevalence of up to 6 percentage points for the experimental group and reduced the likelihood of having high-risk levels (>4 mg/l) of high-sensitivity C-reactive protein (a measure of inflammation), which have been shown to be predictive of cardiovascular disease risk. There were positive impacts on mental health in virtually all indicators for both adults and youth (139).

#### Considerations for actors outside the health sector:

MTO is a rare example that directly links action on root social determinants of health such as poverty with ultimate NCD health outcomes. Other actions to address poverty and inequality should also consider impacts on NCDs and, if possible, monitor outcomes.



### BOX 31-8. CHILE CRECE CONTIGO (CHILE GROWS ALONG WITH YOU) PROGRAM

In Chile, children born in poor neighborhoods are more likely to have developmental delays and fewer years of education, as well as perform poorly in school. Subsequently, when these children reach adulthood, they are more likely to have lower incomes, high fertility rates at earlier ages, and provide poor health care and nutrition to their own children, thereby contributing to the intergenerational transmission of disadvantage. At the aggregate level, these impacts can impede national social and economic development. To reduce social and economic inequities (and thus invest in development), the *Chile Crece Contigo* Program is a form of social protection that aims to provide equal opportunities for all Chilean children in their first eight years of life, independent of social status, gender, geographic origin, family structure, or any other factors that might cause inequity. The program involves a comprehensive network of services across sectors, such as education, labor, and

health. Specific components include education programs for all citizens, legislation that creates stronger maternity and paternity rights (e.g., extension of prenatal leave to one year when a child is born with a disability), improved care for children (e.g., friendly hospital pediatric services), and skills development programs (e.g., parental skills workshops) (140).

#### Considerations for actors outside the health sector:

*Chile Crece Contigo* takes a multisectoral approach to creating equal opportunities for children. Investing in early childhood development is critical for social and economic development in its own right. It also has implications for NCDs—social and economic inequities lead to inequities in NCDs. Programs that are broad in scope, such as the Chile program, should evaluate impacts on NCDs, if possible, and be tailored to achieve maximum positive benefit.



### BOX 31-9. TAKING A SOCIAL DETERMINANTS APPROACH TO CVD AND DIABETES IN BRAZIL

In Brazil, there has been a 20% decline in age-standardized mortality from NCDs (mainly CVD and respiratory diseases) since 1996. This decline has been attributed to health policies, such as tobacco control policies, that have contributed to a decrease in smoking while increasing access to primary health care. Even so, CVD, diabetes and other NCDs remain a major public health concern in Brazil, responsible for 72% of annual deaths. Three facts in Brazil are particularly worrisome: 1) there are unfavorable trends in a number of risk factors; 2) the prevalence of overweight and obesity and diabetes is rising; and 3) morbidity and mortality from CVD, diabetes, and other NCDs are greatest among the poor. The persistent upward trends in obesity are occurring despite recent interventions, including free professionally supervised physical activity classes in several cities, national legislation to ensure that a minimum of 30% of the national school lunch budget is spent on locally grown fresh foods, and national regulation of the marketing of foods with a high sugar, salt, or unhealthy fat content. Brazil's successful legislative and regulatory measures for tobacco control, including its fiscal ones, could

be used to guide measures that promote healthy diet and physical activity (141).

A major part of the problem in Brazil, as in many countries, addresses social inequity, which patterns the distribution of health-related behaviors. A key program to address social inequity in Brazil is *Bolsa Família*, Brazil's conditional cash transfer system. *Bolsa Família* covers roughly 52 million people (about 25% of the Brazilian population) and targets poor families with children. Almost 25% of the fall in the Gini coefficient measure of income inequality in Brazil since 2001 is attributable to *Bolsa Família*. Other program impacts include increased food security, improved nutritional outcomes among children aged 12 to 59 months, and reduced school absence and child labor among older children (142).

#### Considerations for actors outside the health sector:

Cash transfer programs such as *Bolsa Família* have the potential to positively impact NCD outcomes on multiple levels, specifically by reducing inequities such as poverty and inequality that ultimately lead to disease. In the future, disease outcomes should be tracked, if possible.

## ■ Roles for actors outside the health sector

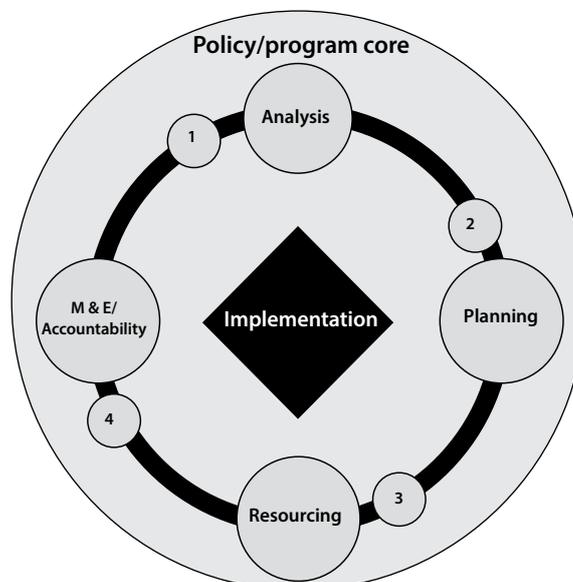
NCD responses require a multisectoral, coordinated approach wherein actors outside the health sector work alongside specialist health partners. This section looks more closely at opportunities for NCD-specific and NCD-sensitive action on social determinants, as outlined in the typology. It presents a framework of suggested action outside the health sector with illustrative examples.

The framework has two parts. The first relates to building/implementing NCD-specific and NCD-sensitive actions across the policy and program lifecycle—from analysis and planning to resourcing, to monitoring, evaluation, and accountability. The second part involves the enabling environment in which actors outside the health sector tend to have unique competencies and wherein multisectoral policy and programs can be realized. Specific opportunities are described for building political will and enabling legal frameworks, enforcement mechanisms, and effective governance structures that are multisectoral and participatory—all anchored in a human rights-based approach.

The framework is meant to describe opportunities for a wide variety of actors, including ministries of finance and planning; other line ministries; local governments; international financing institutions; UN agencies, funds, and programs; civil society; academia; and the private sector. Not all options or roles are meant to apply to all actors equally. Some actors will be suited for some of the elements, and within each element, may have very specific contributions to make, tailored to their interests, mandates, capacities, and available resources. Opportunities will be highly context-specific.

Many of the opportunities for action are not necessarily unique to NCDs. In many cases, it will be more useful and practical for actors outside of the health sector to examine the ways in which their core business impacts on a broader variety of health outcomes and health inequities. Ministries of transportation are an example. They will play varying roles not just related to NCDs but also to HIV, maternal health, and other conditions. For NCDs, the ministry may focus on safe, affordable, and effective forms of transportation infrastructure and services that encourage physical activity (Box 31-6). Ministries of transportation may also focus on cleaner forms of public transportation that reduce air pollution and respiratory-related NCDs. For HIV, the ministry may focus on how new transportation networks may facilitate the spread of HIV and what measures can be taken to reduce this spread (e.g., distribution of condoms at truck stops). For maternal health, the ministry will be concerned about designing transportation infrastructure and services that provide speedy access for women to health facilities, especially in the case of emergency obstetric complications. While further detailing of specific opportunities sector-by-sector or actor-by-actor is beyond the scope of this chapter, it would be a useful exercise during in-country planning.

**Figure 31-9.** Recommendations and framework of suggested action



<i>Enabling environment</i>			
A) Political leadership	B) Legal frameworks	C) Governance	D) Human rights

## Policy/Program Core

### 1. Analysis

- Identify various social determinants and how they impact the level and distribution of NCD outcomes and risk factors. Various entry points could include:
  - the direct impacts of social stratification on health (e.g., psychosocial stress and coping mechanisms, such as smoking and alcohol),
  - the specific exposures and vulnerabilities that marginalized groups experience uniquely or disproportionately (e.g., environmental pollution and respiratory ailments), and
  - the ways in which social determinants create inequities in access to health care, even in situations where health care is universal and affordable (143).
- Investigate the social and economic impacts of NCDs at the macro and micro level, *inter alia* through the analysis of existing data (e.g., demographic and health surveys, household income and expenditure surveys, etc.). Identify in particular impacts that impede the social and economic objectives of potential partners outside the health sector.
- Identify inequities in the NCD burden, especially in terms of sex, gender, race, ethnicity, and socioeconomic status, and economic lines. Identify the underlying processes giving rise to these inequities.
- Examine the impact of specific policy measures (e.g., impact of tobacco taxes on tobacco use).
- Examine the impact of various development interventions (e.g., social protection) in terms of reducing the overall burden and distribution of NCDs and associated risk factors. A critical first step is examining how existing policies and programs outside the health sector can be made NCD-sensitive.
- Develop rapid assessment tools and approaches to assist policymakers and planners. These include tools for situation analysis, national strategic planning, and costing.
- Utilize health impact assessments and other tools to prospectively understand how developmental projects and policies might impact NCDs, both positively and negatively (144).

### 2. Planning

- Ensure appropriate attention to social determinants and multisectoral action in national plans for NCD prevention and control.
- Integrate NCDs into poverty-reduction strategies and national and local development plans, highlighting the developmental dimensions of NCDs.
- Integrate NCDs into relevant sector plans and sector-wide approaches.
- Include NCDs in the negotiation of UN Development Assistance Frameworks and Country Program Documents.
- Identify opportunities for whole-of-society responses that include civil society, the private sector, and academia.

### 3. Resourcing

- Develop sustainable, multisectoral financing mechanisms for international assistance (e.g., multi-partner trust funds for technical support and grants, rapid financing facility for loans and investment support).
- Establish multisectoral budget lines for action on NCDs.
- Consider dedicating personnel or departmental units to policy or program implementation related to NCDs and health more broadly.

### 4. Monitoring, evaluation, and accountability

- Establish indicators across planning and implementation to measure progress toward multisectoral engagement and impacts on NCDs and their risk factors.

- Develop a multisectoral monitoring framework that is aligned with the recently approved Global Monitoring Framework, perhaps adapting instruments used for the UN General Assembly Special Session on AIDS.
- Develop indicators for policy, law, governance, human rights, and political leadership on NCDs, perhaps building on the UNAIDS National Commitment and Policy Instrument.
- Report on social determinants of health indicators, including those for NCDs, in various global development reports.
- Develop capacity to monitor progress in equity in terms of NCD outcomes, risk factors, health service access, and in key social determinants, such as levels of education and income.
- Ensure that progress among most affected groups is tracked.
- Leverage existing data and surveys to capture and understand progress on NCDs, risk factors, and social determinants.
- Consider creating an independent mechanism or group that assesses progress on commitments and reports findings and recommendations to the highest possible multilateral authority (121).
- Consider leveraging civil society assessments as part of monitoring and reporting systems at national and global levels.
- Develop spending assessment techniques, perhaps building on existing tools (e.g., National AIDS Spending Assessment).

## Enabling environment

### A. Political leadership

- Mobilize attention to social determinants of health and NCDs, especially in achieving the MDGs and in developing the post-2015 development agenda.
- Build capacity among civil society organizations to advocate for action on the social determinants of NCDs and promote accountability.
- Ensure sufficiently high political representation and leadership in multisectoral coordination bodies for NCDs.

### B. Legal frameworks

- Review and refine laws that act as direct or indirect access barriers to health care, especially NCD-related care.
- Maximize use of flexibilities within multilateral and bilateral trade agreements to access essential medicines for NCD care and to implement policies that reduce risk behaviors, particularly among youth and adolescents.
- Pass laws and policies that safeguard the rights of people living with NCDs. These could be nondiscrimination laws that include reference to specific NCDs or to real or perceived health status more generally.
- Use the law to maximize safe and healthy environments, such as improving the food environment and safe recreation spaces.
- Consider laws and policies that promote consumer awareness, such as those on nutrition labelling.
- Fully implement the provisions of the Framework Convention on Tobacco Control, as well as the legal aspects of other recommended approaches (e.g., MPOWER, Global NCD Action Plan 2013-2020, etc.).

### C. Governance

- Develop effective multisectoral coordination structures for NCDs (and possibly other diseases, such as HIV).
- Ensure meaningful community participation, especially by networks of affected and vulnerable groups.
- Safeguard the independence of regulatory authorities and reduce corruption in the development of public health programs and the protection of public health interests (145). Article 5 of the FCTC provides a useful example, particularly in terms of limiting interference by the tobacco industry.

- Thoroughly examine the potential public health impacts of free trade negotiations to ensure that the sovereign right of the State to adopt public health measures such as tobacco control and access to affordable medicines is not compromised.
- Assess policy gaps and institutional capacities. These may include elements of the legal framework that: limit the scope of action and tools of national public health agencies; permit undue influence by industry and special interest groups on the independence of regulatory authorities; or unduly increase the price of essential diagnostics and medicines.

#### D. Human rights

- Emphasize NCD prevention and control as important to making the right to health a reality.
- Promote universal health coverage, so that all groups have guaranteed equal access to a defined basic set of health promotion, prevention, curative, and rehabilitative services.
- Address the multiple social impacts of NCD-related illness—impacts that can hinder the achievement of a number of other human rights, such as education.
- Highlight persistent inequities in NCD-related outcomes, risk factors, and access to care, especially where these are linked to infringements of human rights and exclusion.
- Consider using NCDs as an entry point for action on human rights-related issues.

## ■ Conclusions and recommendations

NCDs are a health, development, and human rights issue. They have been recognized as such at the highest global political levels and are already reflected in various intergovernmental processes related to the post-2015 development agenda. NCDs are an enormous and growing strain on health systems worldwide and exact social and economic costs at the national and household level. LMICs facing daunting NCD burdens, a situation that is likely to worsen without concerted, whole-of-society prevention efforts. Inequities are apparent within countries, where NCD outcomes and risk factors are patterned along various socioeconomic gradients.

Addressing the global NCD epidemic will require leadership from the health sector. The health sector, however, cannot meet the challenge alone. Multisectoral responses that tackle the underlying, overlapping, and interacting social determinants of NCDs will be required. The WHO *Global Action Plan for the Prevention and Control of NCDs 2013-2020*, the Global Monitoring Framework, and various other strategies already point the way forward for a whole-of-government and whole-of-society response. Future work can and should explore in greater depth many of this chapter's key themes. These may include sector-specific case examples of and guidance for action on NCDs. They may also include topics like effective governance structures for multisectoral coordination and participation, transparency and accountability mechanisms, human rights-based approaches to NCDs, municipal and decentralized responses, and the role of the law. Tools will also be needed to facilitate critical functions, such as planning, costing, financing, monitoring, and evaluation. A suite of cutting-edge knowledge should help ensure that the world is able to respond to one of the most significant threats to human development in the 21st century.

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## ■ Notes

- 1 This chapter is an adaptation of a UNDP Discussion Paper: *Addressing the Social Determinants of Non-communicable Diseases* <http://www.undp.org/content/undp/en/home/librarypage/hiv-aids/discussion-paper--addressing-the-social-determinants-of-noncommu.html>
- 2 The terms ‘multisectoral’ and ‘intersectoral’ are used interchangeably in various fora. Some have suggested that they mean different things, with multisectoral referring to whole-of-government approaches and intersectoral referring to whole-of-society. An equally viable distinction could be that intersectoral action is a subset of multisectoral action, referring to not just action across sectors that may or may not be coordinated but to action that is specifically joint and coordinated, taking advantage of potential synergies. This document tries to consistently use multisectoral as a more general term. Where intersectoral is used, it is generally with respect to official use in a particular forum or publication.
- 3 CVD includes atherosclerosis, stroke, and rheumatic heart disease, but the largest contributor to global CVD burden is coronary heart disease and cerebrovascular disease (1).
- 4 The majority of diabetes cases are classified as Type 1 or Type 2 diabetes. The difference is the mechanism leading to insulin deficiency; Type 1 is characterized by autoimmune destruction of insulin producing cells in the pancreas, whereas Type 2 occurs when cells develop resistance to insulin (2). Type 1 diabetes accounts for 5-10% of cases whereas Type 2 accounts for 80-95%, depending on the population (3). This report refers mainly to Type 2.
- 5 NCDs are a large cluster of conditions and thus may be more accurately described as ‘interlinked epidemics’. The WHO names CVD, diabetes, cancer, and chronic respiratory disease as the “four main NCDs” (4); other NCDs include mental and neurological disorders such as dementia and Alzheimer’s disease; autoimmune disorders such as psoriasis; bone and joint conditions such as osteoporosis and arthritis; and renal, oral, eye, and ear diseases (5). Mental health and physical health can impact each other (6,7). Poor mental health is a risk factor for heart disease (8,9). It also increases the risk of mortality for people already with coronary heart disease (10).
- 6 DALYs are the sum of years of life lost (YLLs) and years lived with disability (YLDs).
- 7 See Universal Declaration of Human Rights: <http://www.un.org/en/documents/udhr/>. Article 25 provides that, “everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services”. See also the International Covenant on Economic, Social and Cultural Rights, Article 12. For a detailed interpretation, see the right to the highest attainable standard of health (Article 12 of the International Covenant on Economic, Social and Cultural Rights). General Comment No. 14, E/C12/2000/4. Geneva, UN Committee on Economic, Social and Cultural Rights, 2000. <http://www2.ohchr.org/english/bodies/cescr/comments.htm>.
- 8 High blood pressure is defined as systolic blood pressure of  $\geq 140$  mmHg and/or diastolic blood pressure of  $\geq 90$  mmHg, or using medication to lower blood pressure (4).
- 9 WHO defines overweight and obesity as abnormal or excessive fat accumulation that may impair health. Using body mass index (BMI), which is a person’s weight in kilograms divided by the square of his or her height in meters, the WHO definition is: a BMI greater than or equal to 25 is overweight; a BMI greater than or equal to 30 is obesity (50). In June 2013, the American Medical Association classified obesity as “a disease” (51).
- 10 Social determinants of health, broadly understood, are the conditions in which people are born, grow, live, work, and age, and the systems put in place to prevent disease and treat illness when it occurs. The social determinants of health include the structural drivers of the conditions of daily life: the distribution of power, money, and resources shaped by social, economic and political forces. The conditions of daily living include both material and psychosocial conditions – having control over one’s life and participating in decisions that affect one’s life (52)0. The social determinants of NCDs are outlined in Section 2.
- 11 Transnational food, beverage, and tobacco companies often prey on various disadvantages, invoking corporate tactics to deceive, control, and addict vulnerable consumers (53).

- 12 See Section 2 for examples.
- 13 A whole-of-government approach to health is one in which all sectors of government – agriculture, trade, finance, communications, transportation, etc. – develop policies that achieve their respective departments’ objectives while also benefiting health. A whole-of-society approach to health extends beyond government to also recognize the important affect that families, communities, civil society, the private sector and other stakeholders have on factors influencing health. Civil society plays key roles in implementation, bringing forward information and concerns of different constituencies, helping promote accountability, and delivering needed services to hard-to-reach groups. Different elements of the private sector can play major roles, especially in how they produce, distribute, and market different products. Communities themselves are crucial in communicating needs, contextualizing effective responses, holding people accountable for commitments, and shaping norms.
- 14 As of August 2013.
- 15 The 2011 Political Declaration called for accelerated FCTC implementation and for WHO, in coordination with other agencies of the United Nations system, to support national efforts toward FCTC implementation.
- 16 Recognizing that “substantially reducing tobacco consumption is an important contribution to addressing social determinants of health and vice versa,” paragraph 14 (iv) of the Rio Political Declaration on Social Determinants of Health calls for accelerated implementation of the FCTC among Parties and encourages nonmember countries to consider acceding.
- 17 As noted, the Rio+20 Outcomes Declaration paragraph 141 states: “We also commit to establish or strengthen multisectoral national policies for the prevention and control of noncommunicable diseases”.
- 18 The CSDH emphasized that where systematic inequalities related to health are avoidable, yet not avoidable, such inequalities are inequitable. Taking action then becomes a matter of social justice. Because the systematic inequalities detailed in this report are in fact avoidable, the term ‘inequities’ is used throughout.
- 19 NCDs in particular tend to accumulate over time. For further discussion on a life-course approach to NCDs, especially during the critical early years [INSERT: see xxxxx].
- 20 The proportion of females who smoke is expected to rise from 12% in 2010 to 20% by 2025 (34).
- 21 Trade liberalization is the reduction and elimination of tariff and nontariff barriers to trade such that products can be more easily imported and exported among countries. Trade liberalization has been posed as a means to reduce poverty and improve food security and health equity in developing countries, namely by facilitating greater transfer of capital, technology, knowledge, and people (105,106).
- 22 Foreign direct investment is the investment by a company or entity in one country into an entity or company based in another country.
- 23 As of August 2013.
- 24 This target, adopted at the 65th session of the World Health Assembly in 2012, is central to the WHO Global Action Plan for the Prevention and Control of NCDs 2013-2020.
- 25 For example, one policy recommendation was to improve programs to address the causes of obesity across the social gradient. One process indicator for this recommendation was the percentage of children identifying their usual mode of travel to school as being by bicycle or walking.
- 26 This is because intervention research on social determinants is often more difficult than research on biomedical factors, for example. Randomized control trials, the gold standard of medical intervention research, can be more costly and time-consuming (and sometimes unethical or otherwise impossible) when examining social and economic interventions as opposed to biological ones. Different, methodologically diverse approaches to evidence for social interventions are needed.
- 27 A 10% increase in cigarette prices reduces demand by 2-6% in HICs and by 2-8% in LMICs.