

Environmental Gradients and Health Inequalities in the Americas




*Access to Water and Sanitation
as Determinants of Health*

This report shows that, while the Region of the Americas as a whole was on track to meet the targets of MDG 7 in water and sanitation, large, pervasive, and growing inequalities between and within countries remain hidden behind the regional averages.

Tackling these environmentally determined health inequities should be the highest priority in the post-2015 development agenda: inequality is a growing threat to both global health governance and sustainability.

The first step is to document, measure, and monitor these inequalities.

This report could serve as a benchmark for assessing the impact of actions taken toward health equity under new and existing policies and comparing the results over time.



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Foreword

United Nations Millennium Development Goal 7 (MDG 7), Target C, aims to “reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation” by the year 2015.¹ Latin America and the Caribbean already reached the MDG 7 target for safe drinking water in 2012 and, since then, the Joint Monitoring Programme² stated that the Region as a whole was also on track to meet the MDG 7 target for sanitation. However, this progress masks deep social and environmental inequalities within the Region, which in turn undermines health equity. They stand in the way of progress toward the achievement of inclusive societies in which people live in healthy and safe environments with the opportunity to fulfill their potential and lead long, healthy, dignified, and productive lives. The fact is, these inequalities are unnecessary, avoidable, unfair, and unjust: they are inequities in the truest sense.³



This report explores, at the ecological level, the presence, magnitude, and depth of the gradients and inequalities of several health outcomes in the Americas. It shows how the context is defined by a social hierarchy created by lack of access to improved sources of water and sanitation. The report also examines at the relationship between this lack of access and outcomes such as infant mortality, maternal mortality, and life expectancy. It confirms that environmental exposure and the burden of disease tend to follow a parallel gradient and that these trends are also often disproportionately associated with lack of access to water and sanitation. Water and sanitation are fundamental components of development and, as such, they should be recognized and defended as global public goods. Above all, water and sanitation are core elements in the realization of human dignity, and they are therefore fundamental human rights, which in fact were recognized by the United Nations General Assembly in 2010.⁴

The existence of these inequities and social gradients in the Americas is not acceptable for a region that is on track to meet MDG 7. The evidence presented in this report is just the tip of the iceberg, but it clearly shows the need for policies and actions that focus on equity in the quest for universal access to water and sanitation. Future policies must consider the many populations that lack or have limited access to water, sanitation, and hygiene (WASH) and seek to eliminate their unfair impoverishment due to the cost of access, as well as their increased risk for disease and its related toll. Innovative actions are needed to effectively address this neglected condition in the Region. As discussions on the post-2015 development agenda proceed, it is imperative to tackle these health inequities through actions on the environmental and social determinants of health.

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- 1 United Nations Development Programme (UNDP). Available at: <http://www.undp.org/content/undp/en/home/mdgoverview.html>.
- 2 UNICEF-WHO Joint Monitoring Program (JMP). Progress on drinking water and sanitation 2012 update. New York, 2012.
- 3 Whitehead M. The concepts and principles of equity and health. WHO Regional Office for Europe; Copenhagen: 1990.
- 4 United Nations General Assembly. The human right to water and sanitation. Resolution A/RES/64/292; New York: July 2010.



Photo: PAHO

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Acronyms

AMRO	WHO Regional Office for the Americas
CSDH	WHO Commission on Social Determinants of Health
EDA	Exploratory Data Analysis
GBD	Global Burden of Disease
GLASS	UN Global Analysis and Assessment of Sanitation and Drinking Water
HCI	Health Concentration Index
IE	Index of Effect
ISO	International Organization for Standardization
JMP	WHO/UNICEF Joint Monitoring Program
LAC	Latin America and the Caribbean
MDG	Millennium Development Goal
PAHO	Pan American Health Organization
rREA	regional Rapid Epidemiological Assessment
SDG	Sustainable Development Goal
SII	Slope Index of Inequality
UN	United Nations
UNDP	UN Development Programme
UNICEF	UN Children's Fund
WASH	water, sanitation and hygiene
WHO	World Health Organization

ISO-alpha3 acronyms for PAHO Countries and territories:

ABW (Aruba); AIA (Anguilla); ANT (Netherlands Antilles); ARG (Argentina); ATG (Antigua and Barbuda); BHS (Bahamas); BLZ (Belize); BMU (Bermuda); BOL (Bolivia); BRA (Brazil); BRB (Barbados); CAN (Canada); CHL (Chile); COL (Colombia); CRI (Costa Rica); CUB (Cuba); CYM (Cayman Islands); DMA (Dominica); DOM (Dominican Republic); ECU (Ecuador); GLP (Guadeloupe); GRD (Grenada); GTM (Guatemala); GUF (French Guiana); GUY (Guyana); HND (Honduras); HTI (Haiti); JAM (Jamaica); KNA (Saint Kitts and Nevis); LCA (Saint Lucia); MEX (Mexico); MSR (Montserrat); MTQ (Martinique); NIC (Nicaragua); PAN (Panama); PER (Peru); PRI (Puerto Rico); PRY (Paraguay); SLV (El Salvador); SUR (Suriname); TCA (Turks and Caicos Islands); TTO (Trinidad and Tobago); URY (Uruguay); USA (United States of America); VCT (Saint Vincent and the Grenadines); VEN (Venezuela); VGB (Virgin Islands, UK); VIR (Virgin Islands, USA).



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Executive summary

In June 2012, the Joint Monitoring Programme (JMP) released its report on the current situation and trends of water, sanitation, and hygiene (WASH). It declared that the Region of the Americas has reached MDG Target 7c for water, and that it is on track to meet MDG Target 7d for sanitation by 2015. Almost simultaneously, the United Nations Global Analysis and Assessment of Sanitation and Drinking Water (GLASS) 2012 Report pointed out the presence of wide disparities in access to WASH as the main challenge to extending and sustaining services in the Region, particularly in Latin America and the Caribbean (LAC). According to the Global Burden of Disease (GBD) 2010 Study, an average of 4,000 premature deaths (4.5 per million) and 323.4 disability-adjusted life years lost (DALYs) per million were attributable to lack of access to improved WASH sources in LAC in 2010, down from 26,400 premature deaths in 1990 (38.6 deaths and 3,051.7 DALYs per million).

The Social Determinants of Health—that is, the general conditions and circumstances in which people are born, grow, live, work, and age, including quality access to water and sanitation—play a central role in the production of population health and the generation of human development. Social inequalities in health are “the causes of the causes” of poor health outcomes. As a matter of fact, quality access to water and sanitation is the very epitome of an environmental determinant of health. It plays a prominent role in establishing social position and shaping the social hierarchy, thus determining the distribution of health and well-being.

This report, by enlisting the techniques of exploratory data analysis, has been able to produce a regional rapid epidemiological assessment (rREA) of access to water and sanitation as social stratifiers that generate a highly unequal distribution of health in the Region. It provides systematic and original evidence on the presence, magnitude, depth and trends of inequalities in the distribution of key health outcomes across social gradients defined by a set of WASH variables assessed ecologically at the country level.

The main findings of this report are:

1. The sex and age distribution of access to water and sanitation in the countries of the Americas correlates with the stages of demographic transition and population development.
2. Urban areas have higher rates of access to water and sanitation, while both urban and rural areas in some countries still have very low rates of access to both. The correlation between access to water and access to sanitation is high both in urban and rural areas. There are marked inequalities between countries, especially in access to improved sanitation facilities in rural areas.
3. Access to water and sanitation varies depending on the relative social position as defined by fertility rate, human development, income, mean years of schooling, and CO₂ emissions. Water and sanitation can be considered proxies of social position, acting as determinants of health both in themselves and as determinants of other social determinants of health. Quality access to water and sanitation is the very epitome of an environmental determinant of health. It plays a prominent role in establishing social position and shaping the social hierarchy, thus determining the distribution of health and well-being.
4. Access to water and sanitation strongly correlate with life expectancy at birth, healthy life expectancy, infant mortality, under-5 mortality, and maternal mortality. Over the period from 1990 to 2010, a gradient is seen in all of these variables. As access to both water and sanitation increase, life expectancy and healthy life expectancy increase and infant mortality, under-5 mortality, and maternal mortality decline. While both absolute and relative inequalities are decreasing for total life expectancy at birth, inequality for disability-free life expectancy is on the rise.

5. Access to water and sanitation correlate strongly with social position as defined by income and the burden of disease. Trends between 1990 and 2010 show that, although tremendous progress has been made, both mortality and DALY rates due to unimproved WASH are still concentrated in the poorest population and that the social gap between the better-off and the worst-off is widening.
6. Case studies from Brazil and Peru illustrate that WASH-related health inequalities exist not only between but also within countries and that the correlations at the subnational level are even stronger. Environmentally determined inequalities in population health outcomes defined by access to WASH can be seen between regions and subregions, since they are reflections of the social determination of health at different levels of social organization.

While this report shows that the Region of the Americas as a whole is on track to meet the targets of MDG 7 in water and sanitation, it is also true that large, pervasive, and growing inequalities between and within countries remain hidden behind the regional averages. Tackling these environmentally determined health inequities should be the highest priority in the post-2015 development agenda: inequality is a growing threat to both global health governance and sustainability. The first step is to document, measure, and monitor these inequalities. This report could serve as a benchmark for assessing the impact of actions taken toward health equity under new and existing policies and comparing the results over time.

Introduction: the Region is on track, but...

*We must not remain gradient-blind.**

Carissa F. Etienne

Director, PAHO

The global and regional paths toward Millennium Development Goal 7

In June 2012, the Joint Monitoring Programme (JMP) released its report on the current situation and trends in water, sanitation and hygiene (WASH). Importantly, it declared that the Region of the Americas (AMRO) has already reached Millennium Development Goal (MDG) target 7c in water, and that it is on track to meet MDG target 7d for sanitation in 2015 (1). Relative to the rest of the world, especially the developing world, AMRO stands high in its accomplishments and progress under MDG 7.

As the countries of the Region of the Americas continue their paths toward attainment of the MDGs in 2015 and beyond, there is an ongoing need for updated assessments of progress and any obstacles that may emerge. This is particularly true for the regional status of water and sanitation—the core issue addressed in MDG target 7, which is to reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation.

The need to look through the equity lens

Almost simultaneously with the release of the JMP 2012 update, the UN-Water GLASS 2012 Report pointed out the wide disparities in access to WASH within AMRO, particularly in Latin America and the Caribbean (LAC), as the main challenge to extending and sustaining services (2). In fact, the region is known by its huge social disparities and health inequalities (3-6).

Thanks largely to the work of the WHO Commission on Social Determinants of Health (CSDH), there is a growing recognition of the central role played by the general conditions and circumstances in which people are born, grow, live, work, and age—i.e. the social determinants of health, including quality access to water and sanitation—in the production of population health and the generation of human development. At the core of this construct for understanding and acting upon the “causes-of-the-causes” of health is the realization of the detrimental effects of social inequalities in health, which are shaped by the unequal distribution of wealth, power, and resources at global, national, and local levels, which in turn are influenced by policy choices (7).

Rationale of the Report

The concept of social stratification of health is at the core of the theoretical framework of the CSDH. This report relies on the techniques of exploratory data analysis (Tukey's EDA) (8) to convey a regional rapid epidemiological assessment (rREA) of access to water and sanitation as social stratifiers that reproduce unequal distributions of health and are therefore regarded as determinants of health in the Region. Hence, the aim of the rREA was to provide systematic and original evidence on the presence, magnitude, depth, and trends of inequalities in the distribution of key health outcomes across social gradients defined by a set of WASH variables assessed ecologically at the country level.

* World Health Assembly WHA66, GER Panel Side Event on Health Equity; Geneva: May 22, 2013.



Photo: PAHO

Background: context and concepts

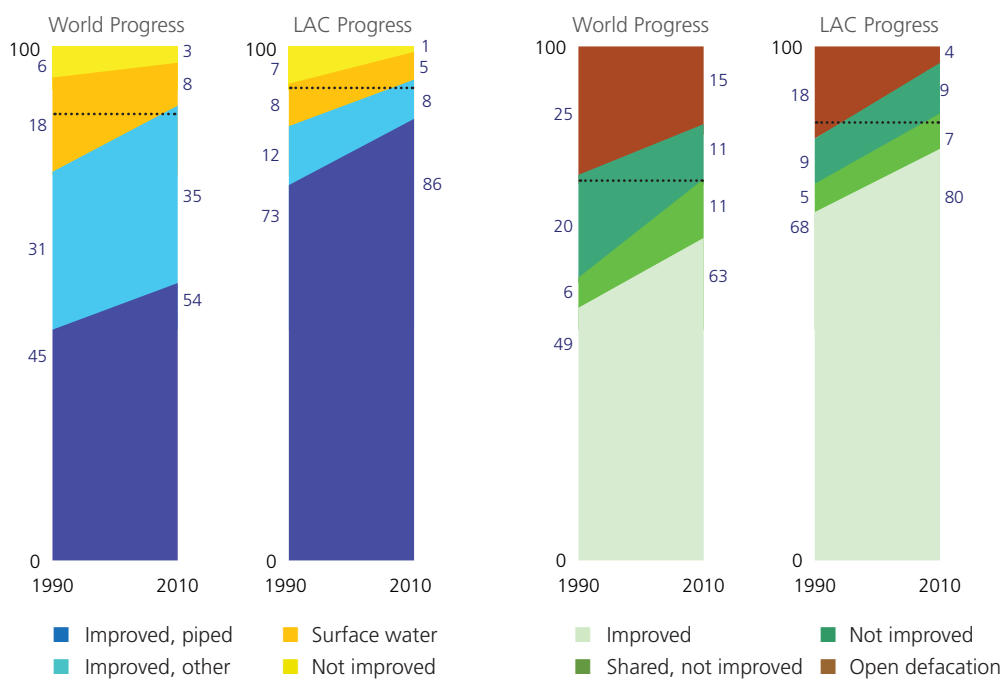
Situation and trends in access to water and sanitation in the Region

In 1990, 73% of the population in LAC had access to piped water in their homes while 7% were using unimproved sources of drinking water. Improved sanitation facilities were available for 68% of the population, but 18% practiced open defecation. At the global level, only 45% of the population had access to piped water; 49% were using improved sanitation facilities; and 25% were practicing open defecation. By 2010, 86% of the population in LAC had access to piped water in the household and only 1% were using unimproved sources of drinking water. Eighty percent of the population had access to improved sanitation facilities, but 4% still practiced open defecation. At the global level, 54% had access to piped water; 68% were using improved sanitation facilities; and 15% of the people in the world were practicing open defecation in 2010.

Twenty years after the 1990 MDG baseline, both the world and LAC have made significant strides in the average number of people who have gained access to improved sources of water and sanitation. These results are a measure of the level of effort, commitment, and investment made by governments, the private sector, communities, and individuals to reach these goals. Both the world and the Americas have met the MDG target for drinking water, which is to reduce by half the proportion of population without sustainable access to safe drinking water by 2015. Furthermore, the Region of the Americas as a whole is about to meet the sanitation target, which is to reduce by half the proportion of the population without sustainable access to basic sanitation by 2015 (Figure 1). In 2010, these regional averages represented 564 million people in LAC with access to improved sources of water (versus 36 million without it) and 480 million with access to improved sources of sanitation (versus 120 million still without it).

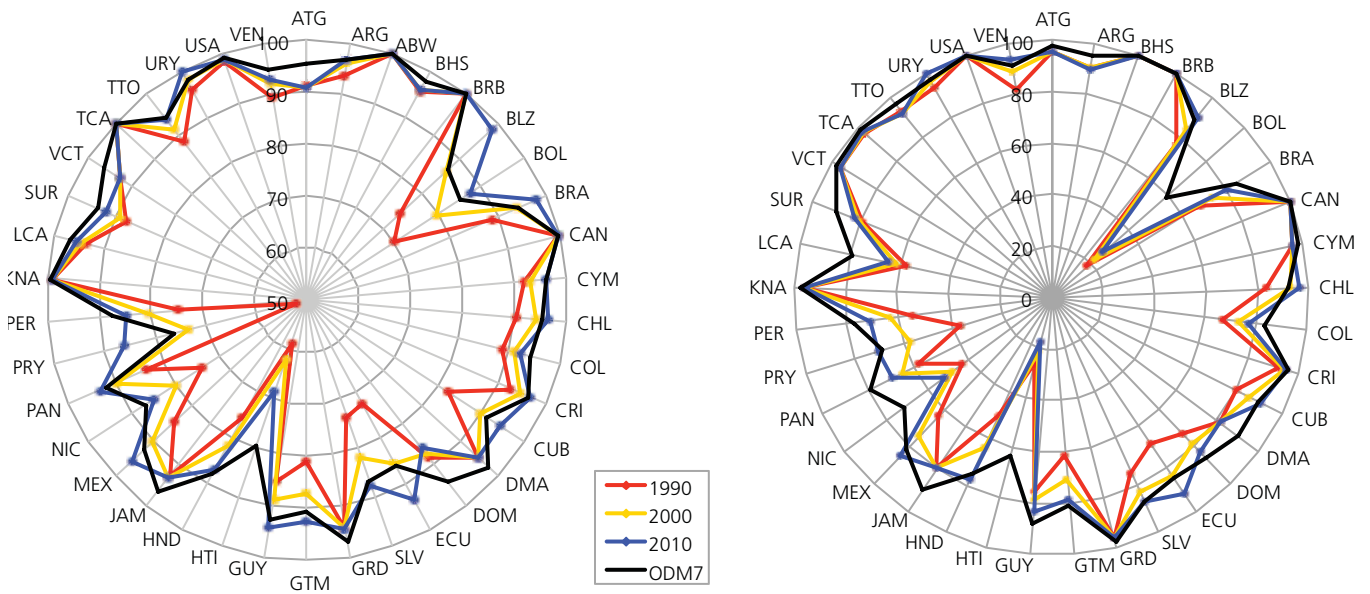
A closer look at this welcome picture reveals, however, that not all the countries are progressing in the same way or at the same pace. Figure 2 gives an overview of country progress in the Americas with respect to water and sanitation coverage in 1990, 2000, and 2010 vis-à-vis the 2015 MDG target. On the one hand, it shows uneven progress toward MDG 7 and, on the other hand, the noticeable gap remaining to achieve universal access (i.e. 100% coverage) to these basic services.

Figure 1 Twenty-year progress in access to water (left) and sanitation (right). The World and Latin America and the Caribbean; 1990, 2000, and 2010



Source: (1)

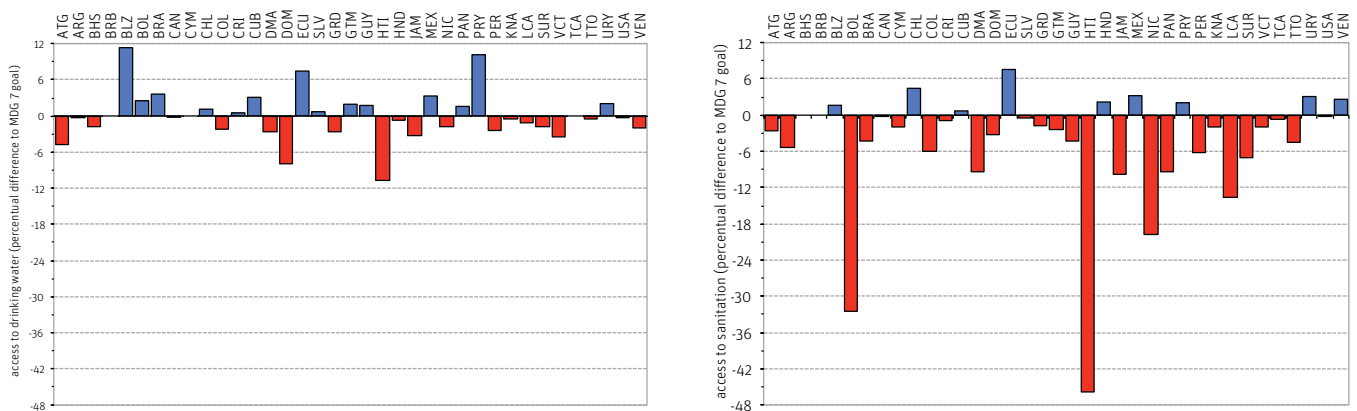
Figure 2 National coverage of access to improved sources of drinking water (left) and sanitation (right). Countries of the Americas; 1990, 2000, and 2010



Data source: (1).

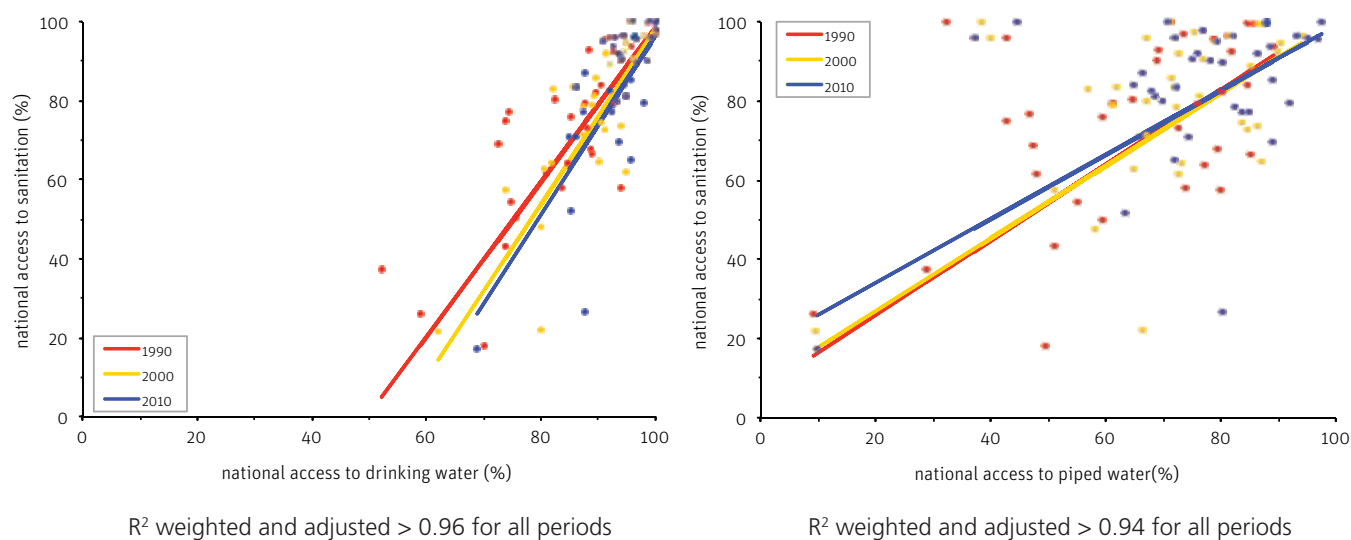
In fact, as of 2010 nearly half the countries in the Americas had failed to reach the MDG 7 target for drinking water and as many as three out of every four countries had failed to reach the target for sanitation (Figure 3). Moreover, the rate of progress in access to these two basic services has not been the same. Figure 4 shows that at each point in time the countries below the weighted regression lines had greater access to water, especially piped water, than to sanitation, —a lag that jeopardizes water quality and safety. Thus it can be seen that significant inequalities between countries are hidden by the regional averages.

Figure 3 National progress toward MDG 7 in drinking water (left) and sanitation (right). Countries of the Americas; 1990-2010



Data source: (1).

Figure 4 Weighted correlation of access to drinking (left) and piped (right) water on access to sanitation. Countries of the Americas; 1990, 2000, and 2010



Data source: (1).

According to the results of the Global Burden of Disease (GBD) 2010 Study, on average, 4,000 premature deaths were attributable to lack of access to improved WASH sources in LAC in 2010 (4.5 deaths and 323.4 DALYs lost per million), down from 26,400 in 1990 (38.6 deaths and 3,051.7 DALYs lost per million) (9-10). Yet diarrhea still figures prominently within the five leading causes of burden of disease among children aged 1 to 4 in LAC (10).

To reiterate, it is according to national and regional averages and to the indicators of access to WASH services as they are currently defined and applied operationally that the countries of the Americas are expected to meet the MDG 7 targets by 2015. In addition to the considerable social gap remaining to be addressed under the post-2015 development agenda, failures in water quality, continuity of service, affordability, and reliability are paramount concerns both for the Region and globally. These pressing issues have taken on even greater importance since the United Nations General Assembly, in its Resolution 64/292 of July 2010, explicitly recognized the right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment of life and all human rights (11).

Access to water and sanitation as environmental determinants of health

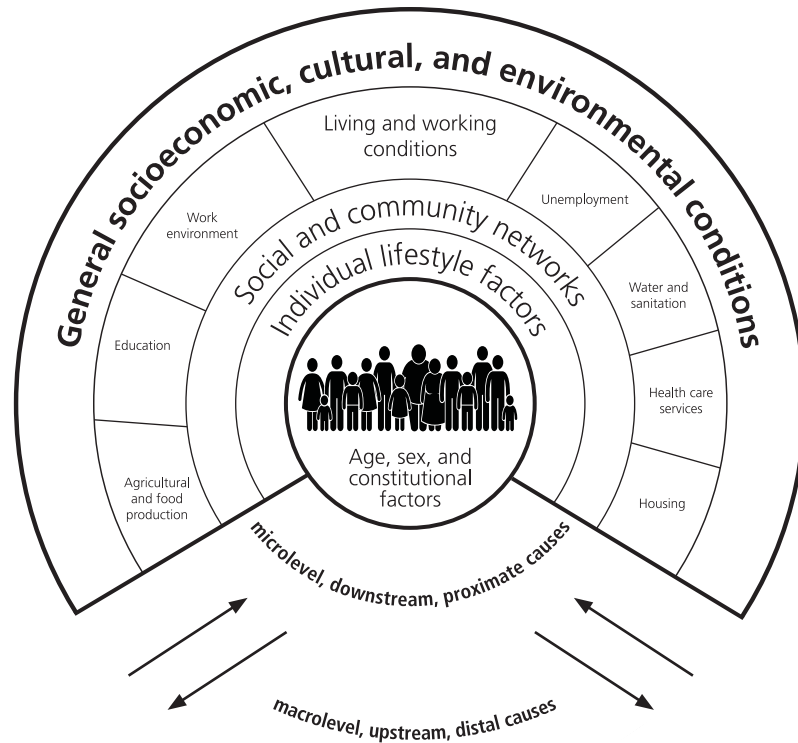
The determinants of health model is a hypothetical construct for understanding population health and the multiplicity of factors that determine its level and distribution. In a broad sense, the determinants of health model is the most recent and comprehensive attempt to account for causality in epidemiology and its translation into policy intervention from both the population and societal perspectives (12). Thus, the model is particularly relevant to public health research and practice in order to understand the social production of health equity and inequity (13).

The current determinants of health model, advanced by Dahlgren and Whitehead (14), is firmly rooted in the eco-epidemiology paradigm, as it recognizes causes of health and “causes-of-causes” of health (i.e. their determinants) at multiple levels of organization and within the historical context of both societies and individuals (15). These levels of organization range from the proximate (biological and behavioral) to the distal (social and environmental) determinants of population health. The model’s signal feature is its focus on interactions between causes at different levels (Figure 5).

The determinants of health model has guided the WHO strategy to promote health equity in Europe (16), the Independent Inquiry into Inequalities in Health in the United Kingdom (17), and the Committee on Assuring the Health of the Public in the 21st Century of the Institute of Medicine of the National Academies in the United States (18). More recently, it was adopted and adapted by the WHO Commission on Social Determinants of Health (Figure 6), which defined social determinants as

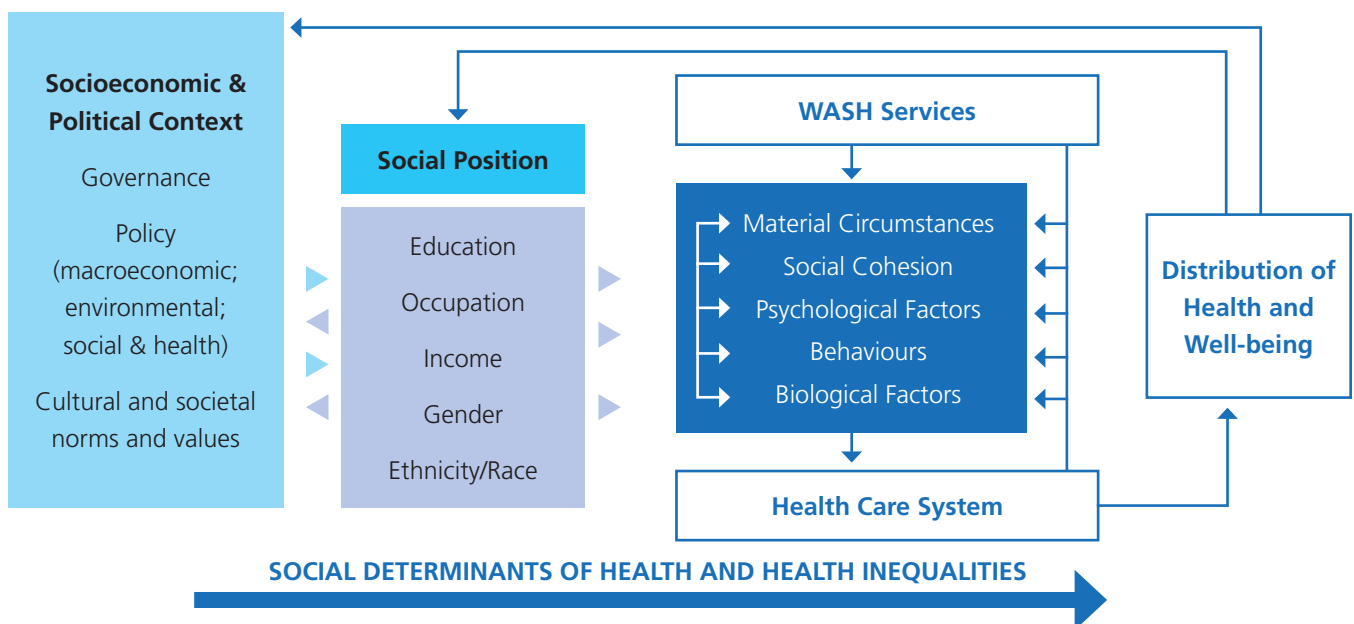
the general conditions and circumstances in which people are born, grow, live, work, and age. Quality access to water and sanitation is the very epitome of an environmental determinant of health. It plays a prominent role in establishing social position and shaping the social hierarchy, thus determining the distribution of health and well-being (7).

Figure 5 The Dahlgren and Whitehead model of health determinants



Source: (13); used with permission from the Institute for Futures Studies, Stockholm, Sweden.

Figure 6 Schematic representation of the social determinants of health conceptual model (modified)



Source: (7); modified by PAHO.

Methods: data, metrics, and analyses

Definitions and data acquisition

The data on water and sanitation in this report come from the WHO-UNICEF JMP 2012 updated country-level estimates (1). These estimates are in the public domain and have been generated by the JMP methodology, which is designed to make the estimates comparable between countries and over time.

Exploratory data analysis (EDA) was applied to the environmental and social inequalities in health in the Americas using PAHO Regional Core Health Indicators (19) and WHO-UNICEF JMP databases (1) with units of analysis aggregated at the country level. The indicator definitions in this report are taken from the JMP.

The five dimensions of social and environmental determinants selected for exploratory analysis in this report were fertility, human development, income per capita, schooling, and levels of CO₂ emissions, while the five health dimensions assessed were life expectancy at birth, disability-free life expectancy at birth, infant mortality, under-5 mortality, and maternal mortality. These dimensions have been taken mainly from the PAHO Core Health Indicators Regional Initiative, which in turn relies on various publicly accessible and internationally comparable data series, such as the United Nations Population Division, the World Bank, the United Nations Development Fund, the United Nations interagency estimation groups, the Institute for Health Metrics and Evaluation, and the PAHO Regional Mortality Database, among others (see References).

In the Brazil case study, the drinking water parameter was called “general water supply network coverage”; access to sanitation was called “sewage coverage”, and the health indicator was defined as the percentage of live births in a given year that had received no prior prenatal care. The data come from tabnet.datasus.gov.br and are from both census and the National Household Sample Survey (PNAD) data for the years 2001 and 2009. The PNAD data are provided by state and cover the entire country.

In the Peru case study, the 2000 drinking water parameter was called “potable water” and the 2010 drinking water parameter was called “safe water.” Access to sanitation was called “sewage coverage”. Infant mortality was defined as the “number of deaths in children under age 1 per 1,000 live births” and the under-5 mortality rate was “deaths in children under age 5 per 1,000 live births”. The data come from the Basic Health Indicators for Peru for the years 2000, 2003, 2005, and 2010 (available at: www.dge.gob.pe/portal/), and the percentage of access to potable water for Callao used in the calculations for 2000 is for the year 2003. The data are shown by department and cover the entire country.

Summary measures of environmental health inequalities

The exploratory analyses of health inequalities were conducted using both the abridged and the unabridged distribution of the five health outcome variables. The former was used to explore gap inequality, summarized by range-based measures. The latter was used to generate more robust summary measures of gradient inequality, such as those based on regression (slope index of inequality, relative index of inequality) and disproportionality (health concentration index, Theil index), which are standard use in the social epidemiology literature on social inequalities in health (20-21). Population weighted averages, weighted least square regression, and logarithmic transformation were applied, as appropriate, to account for heteroskedasticity and nonlinearity. These summary measures were generated for at least two relevant points in time in order to capture any pattern of change. The Minujin and Delamonica (22) analytical framework was used to assess both the mean population trend (improving or worsening) and changes in the social gap/gradient (narrowing or widening).

More specifically, the first step in the exploratory data analysis was to compute the unbiased (population-weighted) estimators of health outcome rates by country quantiles of WASH as equity stratifiers. Next, the absolute and relative gaps were computed as metrics of inequality (i.e., Kuznets-type indexes) by subtracting and dividing, respectively, the health outcome rates of the top (most advantaged) from the bottom (most disadvantaged) WASH quantiles. Then the Slope Index of Inequality (SII) was

computed as the metric of absolute gradient inequality by regressing country-level health outcome rates on a relative scale of WASH social position as defined by the cumulative class interval mid-point of the equity stratifier. A weighted least squares regression model was used to address the inherent heteroskedasticity in the aggregated data by applying Maddala's method, described elsewhere (23). Finally, the Health Concentration Index (HCI) was computed as the metric of relative gradient inequality using nonlinear optimization to fit a Lorenz concentration curve equation (24) to the observed cumulative relative distribution of populations ranked by equity stratifiers and health outcomes across the countries studied and numerically integrating the area under the curve. The same analytical procedure was followed for the subnational units in the country case studies.

Methodological restrictions

The generation of evidence on WASH inequality gaps and gradients in health was based on Tukey's principle of exploratory data analysis, i.e., it was aimed at *pattern extraction* rather than confirmatory causal interpretation (8). Thus, bivariate rather than multivariable contrast was favored, as well as a redundancy approach. The analysis does not draw any inferences, and no explicit claims on causality are made. This is an ecological study; to avoid the risk of ecological fallacy, it is important to refrain from making individual-level inferences.

Findings: inequalities in health by access to water and sanitation

Descriptive findings

- Demographic transition and access to water and sanitation

- Geospatial distribution of access to water and sanitation

Analytical findings

- Access to water and sanitation and their gradients as proxies of social position

- Inequalities in health by access to water and sanitation

 - Inequalities in life expectancy

 - Inequalities in healthy life expectancy

 - Inequalities in infant mortality

 - Inequalities in under-5 mortality

 - Inequalities in maternal mortality

- Inequalities in the burden of disease attributable to unimproved water and sanitation

 - Income-related inequalities in WASH-attributable mortality

 - Income-related inequalities in WASH-attributable DALYs

- Country case-studies

 - Brazil

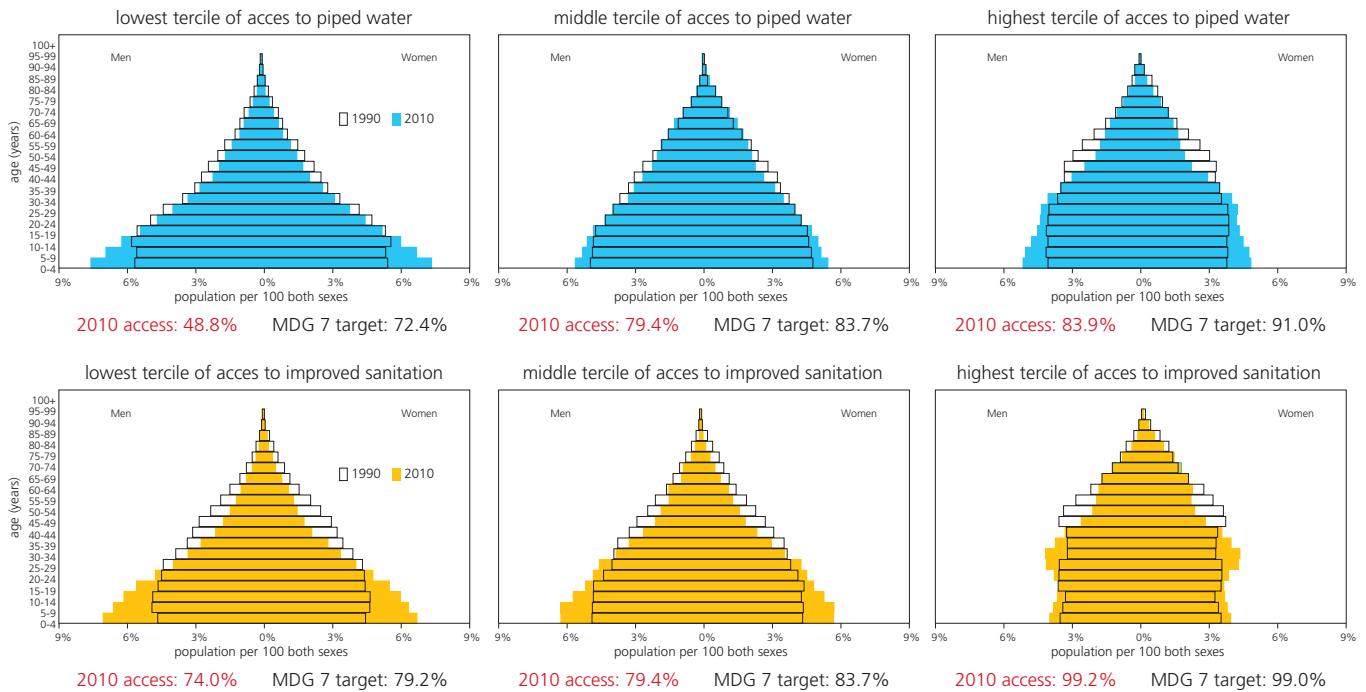
 - Peru

Descriptive findings

Demographic transition and access to water and sanitation

In the AMRO countries, the sex and age distribution of access to WASH correlates with the stages of demographic transition. These stages in demographic transition reflect the shift from high birth and death rates to low birth and death rates as a country develops from a pre-industrial to an industrialized economic system. Figure 7 shows this transition for country terciles with the least to the most access to improved water and sanitation.

Figure 7 Demographic distribution by age and sex according to country tertiles of access to piped water (upper panel) and sanitation (lower panel). Region of the Americas; 1990 and 2010



Geospatial distribution of access to water and sanitation

Rural areas in the AMRO countries have seen a significant overall increase in their percentage of population with access to drinking water, but urban areas continue to have higher rates. The same is true for improved access to sanitation; although in some countries both urban and rural areas still have very low rates (Figure 8 and Figure 9).

The correlation between access to water and access to sanitation is high in both urban and rural areas. There are marked inequalities between countries, especially in access to improved sanitation facilities in rural areas (Figure 10).

Figure 8 National coverage of access to improved sources of drinking water in urban (left) and rural (right) scenarios. Countries of the Americas; 1990, 2000, and 2010

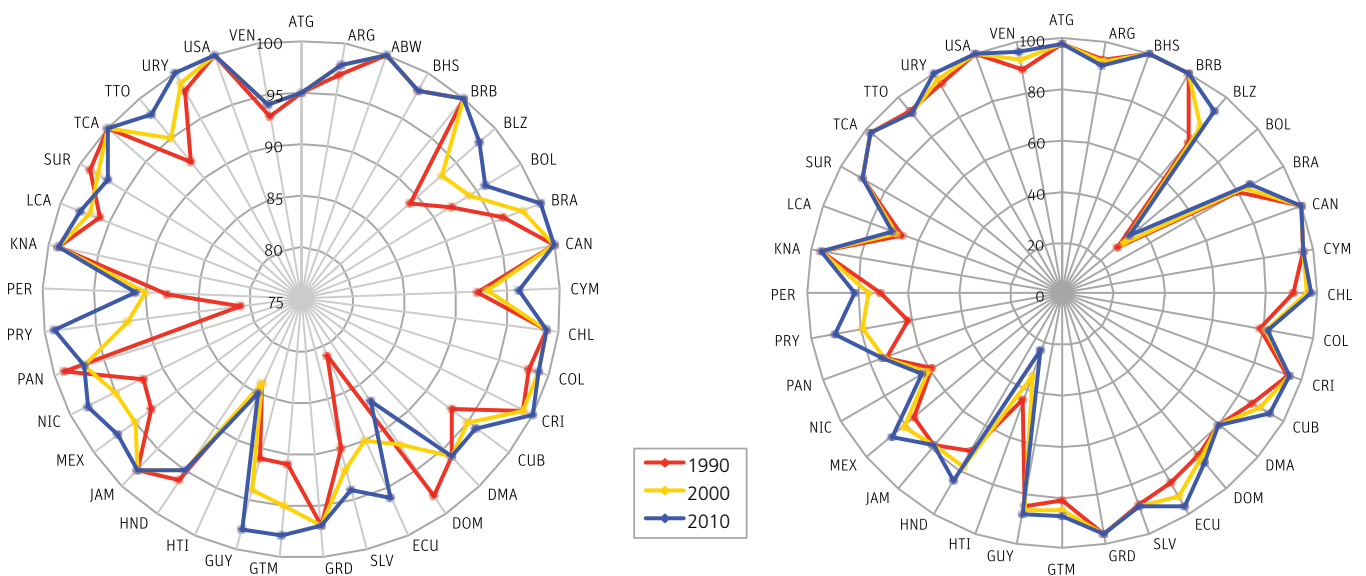


Figure 9 National coverage of access to improved sanitation facilities in urban (left) and rural (right) scenarios. Countries of the Americas; 1990, 2000, and 2010

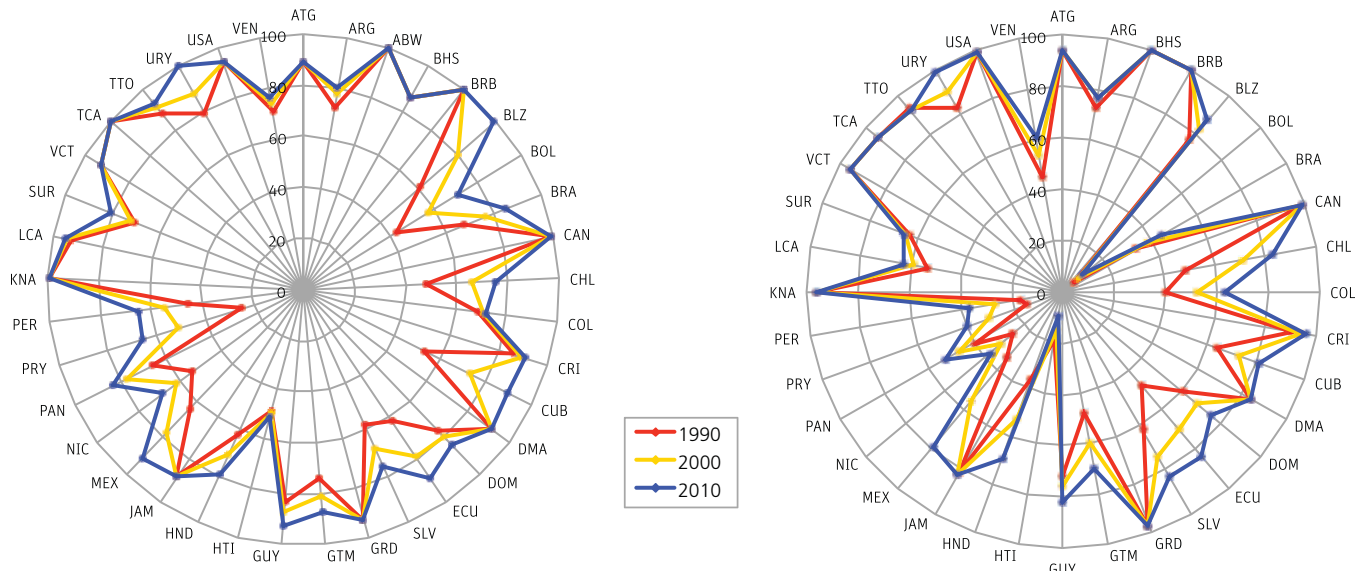
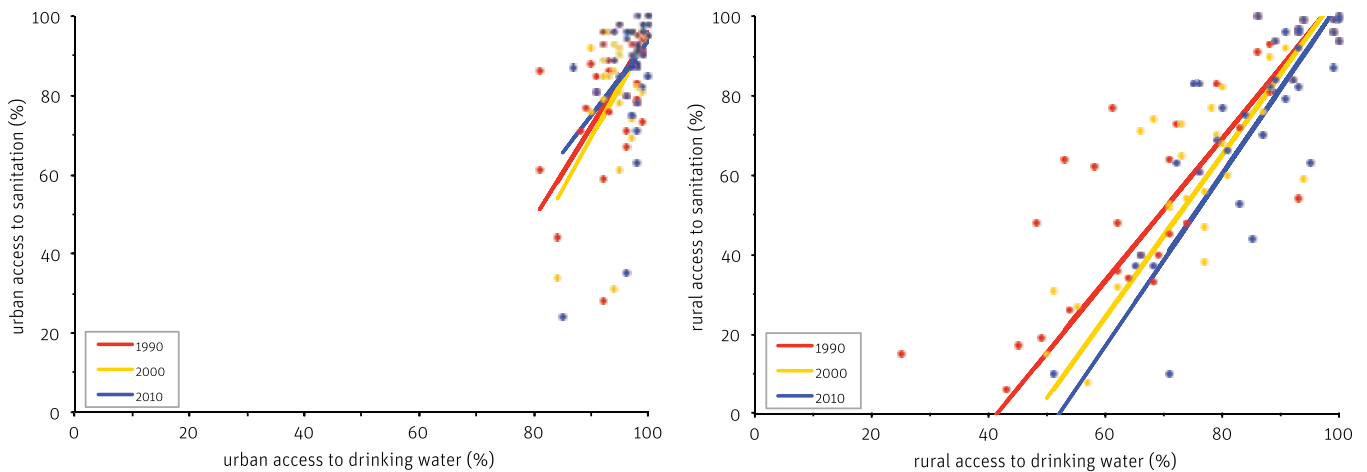


Figure 10 Weighted correlation of access to drinking water on access to sanitation in urban (left) and rural (right) scenarios. Countries of the Americas; 1990, 2000, and 2010



R^2 weighted and adjusted > 0.95 for all periods

R^2 weighted and adjusted > 0.93 for all periods

Analytical findings

Access to water and sanitation and their gradients as proxies of social position

Since the social determinants of health are the general conditions and circumstances in which people are born, grow, live, work, and age, they could include many factors. The following graphs show the relationship between several of these determinant factors and access to WASH. Specifically, they analyze how access to drinking water and improved sanitation change depending on the relative social position defined by fertility rate, human development, income, mean years of schooling, and level of CO₂ emissions. The results are presented in three panels: gradients of access to improved water by country terciles, gradients of access to improved sanitation by country terciles, and indices of the effect of access to WASH on each of the indicators of social position.

From these graphs it can easily be seen that increasing access to water and sanitation correlates with improved conditions in terms of the criteria viewed as necessary for social development. Through both decades, from 1990 to 2010, a gradient is seen for all these variables. For example, as the number of children per woman decreases, the percentage access to both water and sanitation increases (Figures 11-13). Similarly, when the AMRO countries are stratified according to the Human Development Index (HDI) and aggregated into terciles, higher HDI levels correlate with increased access to water and sanitation (Figures 14-16). The same is true for income (with a nonlinear effect, since above a certain income level there are no changes in access to WASH) (Figures 17-19), mean years of schooling (Figures 20-22), or levels of CO₂ emissions (with a nonlinear effect as well) (Figures 23-25). It should be pointed out that the absolute values for each tercile differ from one year to the next; it is quite likely that the gradient would have been more marked if the distribution had been kept constant.

Since these social determinants influence health outcomes, it may be assumed that an improvement in any one determinant will result in an improvement in the health of the population. Given the correlation between improved living conditions due to social determinants and increased access to water and sanitation, it can be assumed that access to water and sanitation will also influence health outcomes in the same way. When population groups are ranked by their percentage of access to water or sanitation, gradients in health outcomes will be seen (as presented in the next section). Therefore, access to water and sanitation can be considered a proxy of social position. In this case, access to WASH becomes not only a determinant of health itself but also a determinant of other social determinants of health.

Figure 11 Gradients of access to improved water sources by country terciles of fertility. Region of the Americas; 1990, 2000, and 2010

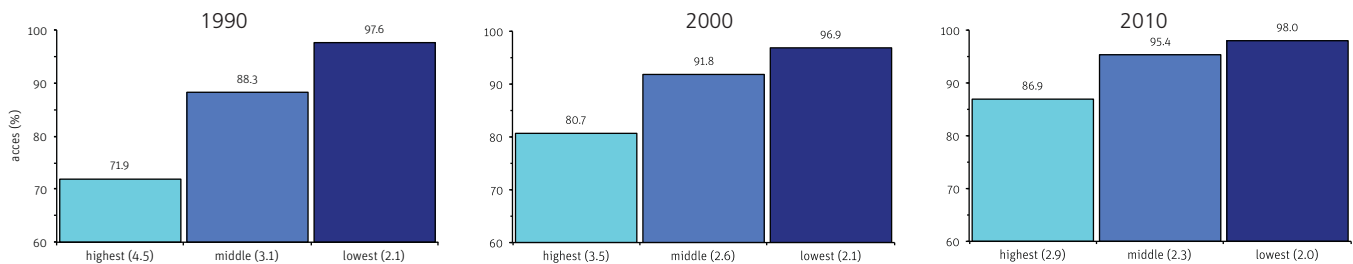


Figure 12 Gradients of access to improved sanitation facilities by country terciles of fertility. Region of the Americas; 1990, 2000, and 2010

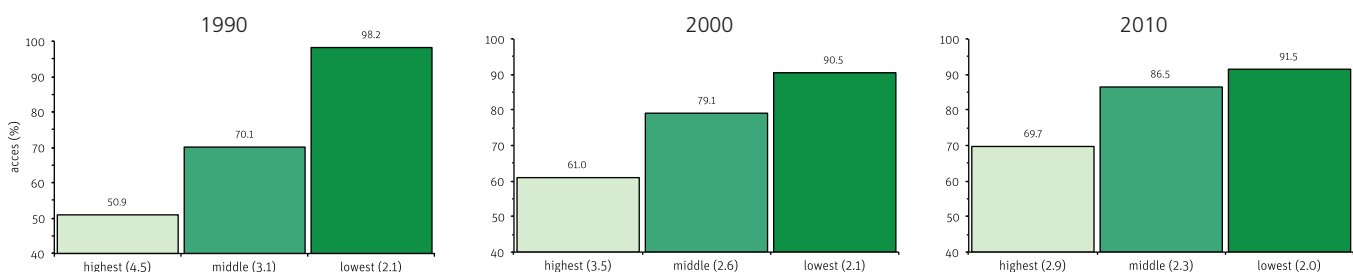


Figure 13 Weighted correlation of access to water (left) and sanitation (right) on fertility, and indexes of effect. Countries of the Americas; 1990, 2000, and 2010

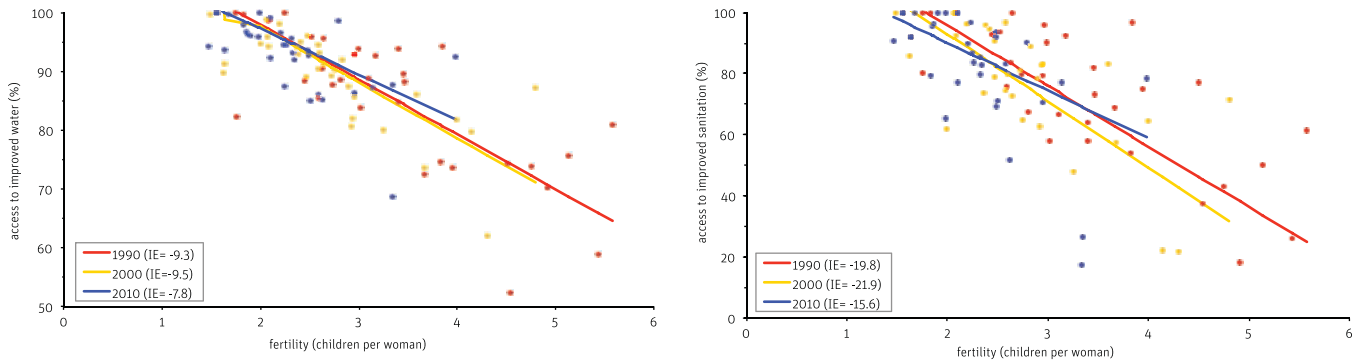


Figure 14 Gradients of access to water by country tertiles of human development. Region of the Americas; 1990, 2000, and 2010

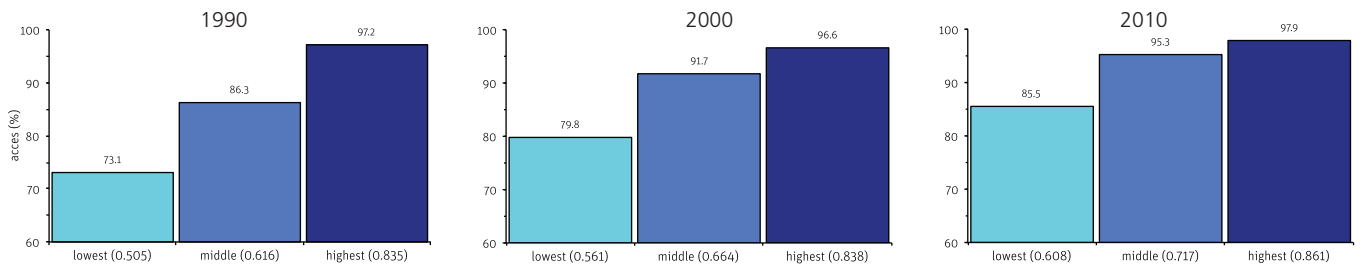


Figure 15 Gradients of access to sanitation by country tertiles of human development. Region of the Americas; 1990, 2000, and 2010

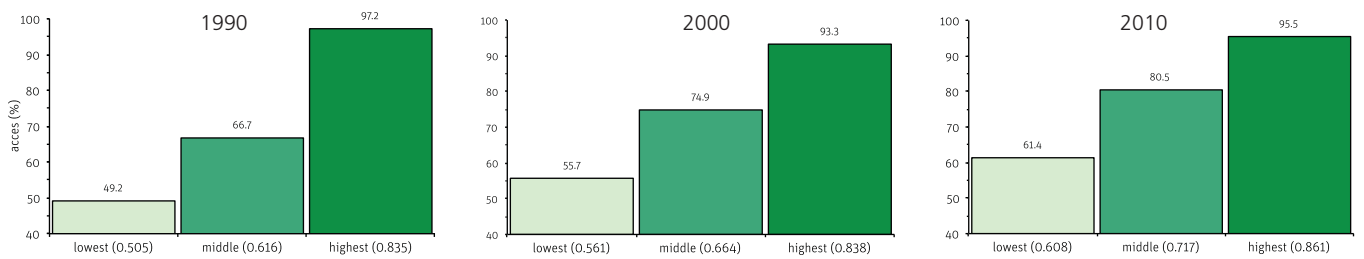


Figure 16 Weighted correlation of access to water (left) and sanitation (right) on human development, and indexes of effect. Countries of the Americas; 1990, 2000, and 2010

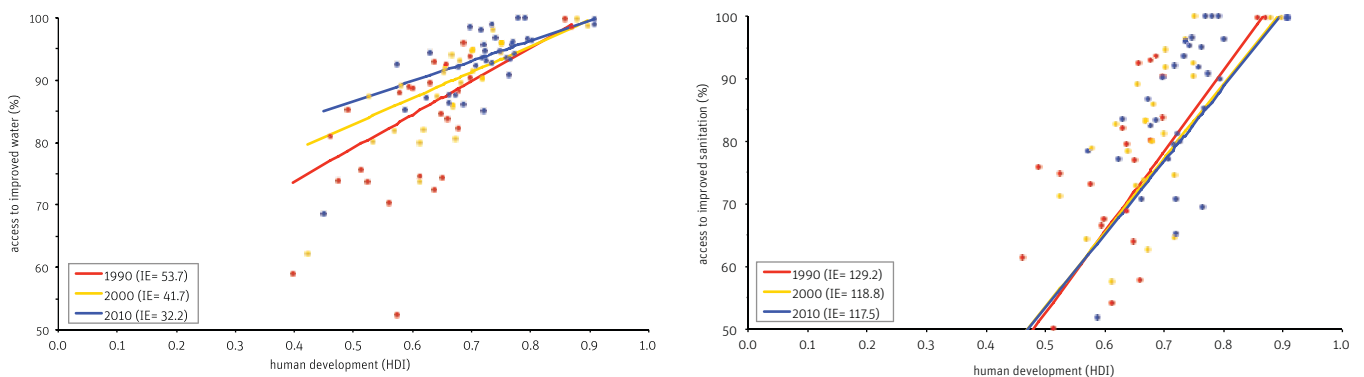


Figure 17 Gradients of access to water by country terciles of income. Region of the Americas; 1990, 2000, and 2010

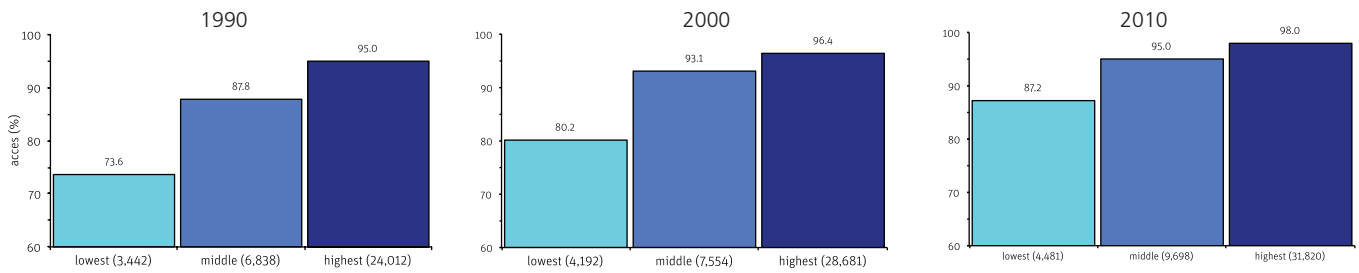


Figure 18 Gradients of access to sanitation by country terciles of income. Region of the Americas; 1990, 2000, and 2010

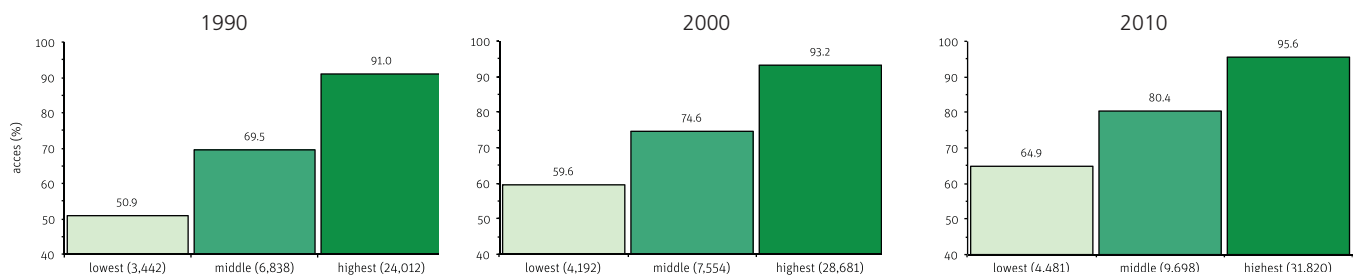


Figure 19 Weighted correlation of access to water (left) and sanitation (right) on income, and indexes of effect. Countries of the Americas; 1990, 2000, and 2010

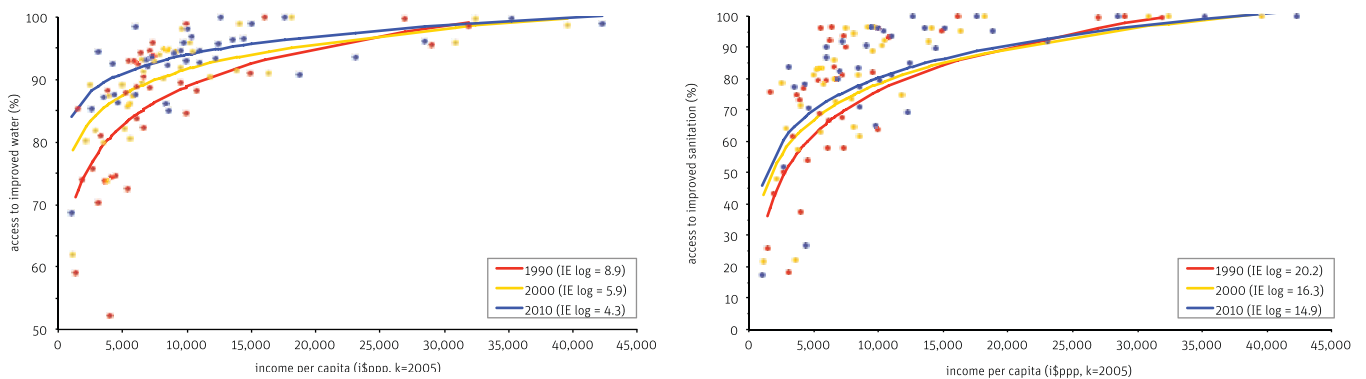


Figure 20 Gradients of access to water by country terciles of mean years of schooling. Region of the Americas; 1990, 2000, and 2010

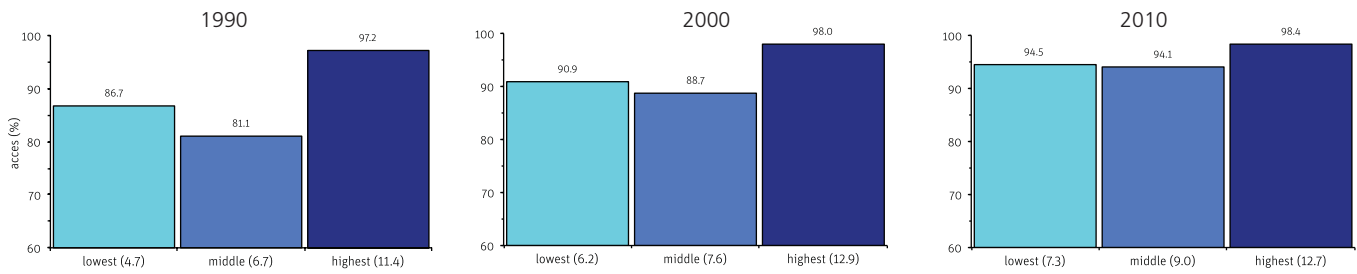


Figure 21 Gradients of access to sanitation by country terciles of mean years of schooling. Region of the Americas; 1990, 2000, and 2010

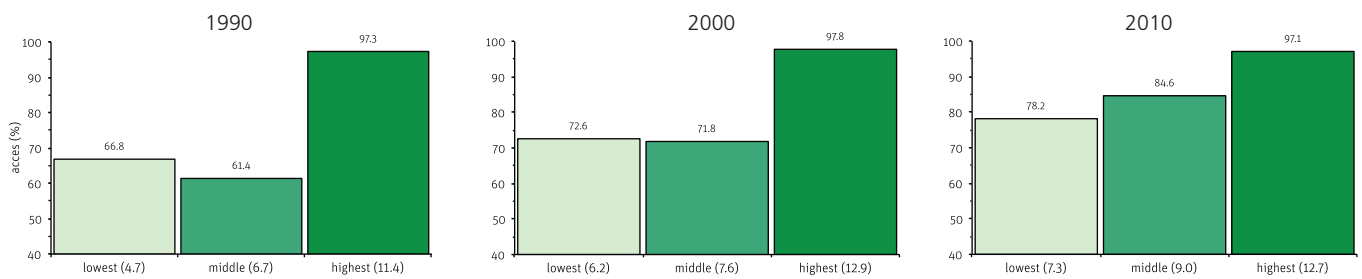


Figure 22 Weighted correlation of access to water (left) and sanitation (right) on mean years of schooling, and indexes of effect. Countries of the Americas; 1990, 2000, and 2010

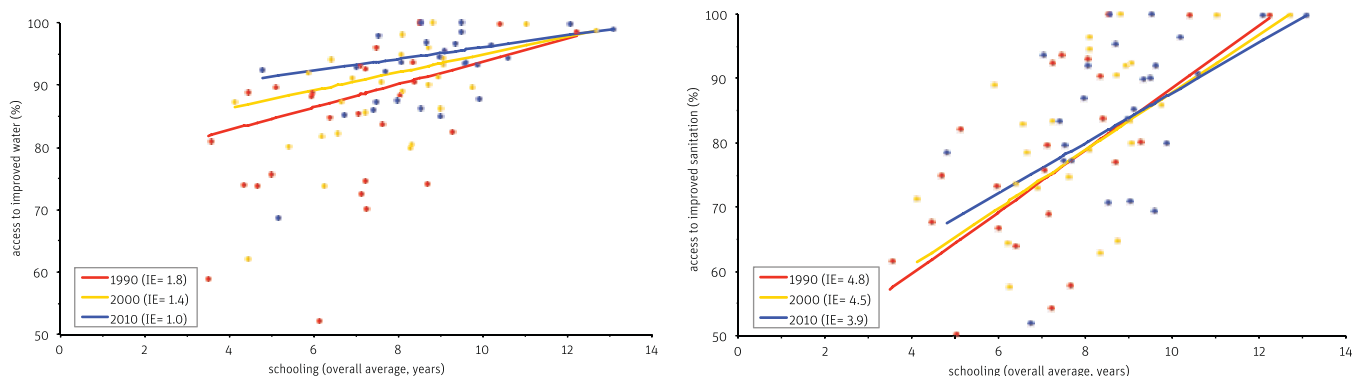


Figure 23 Gradients of access to water by country tertiles of CO₂ emissions. Region of the Americas; 1990, 2000, and 2010

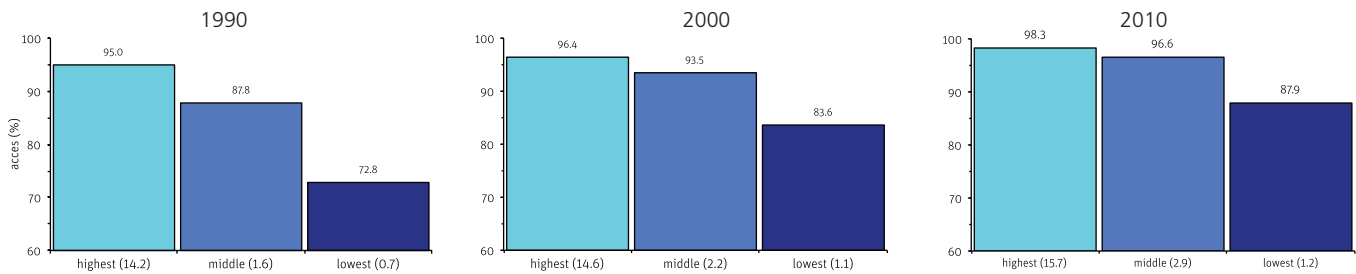


Figure 24 Gradients of access to sanitation by country tertiles of CO₂ emissions. Region of the Americas; 1990, 2000, and 2010

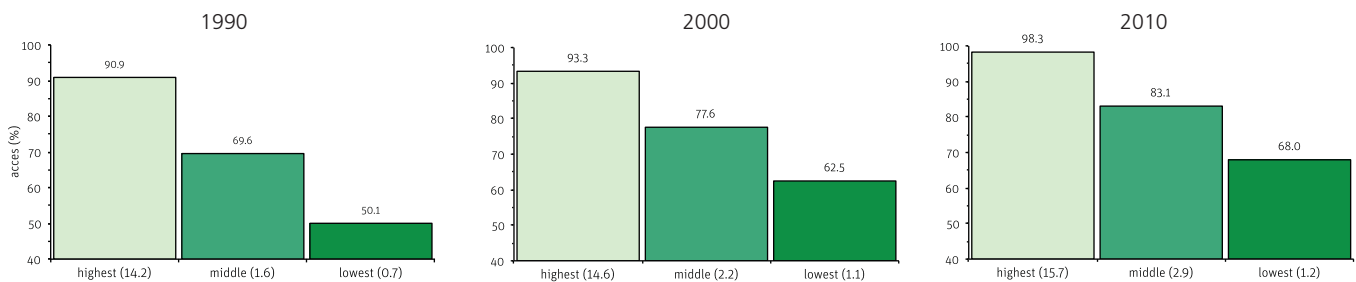
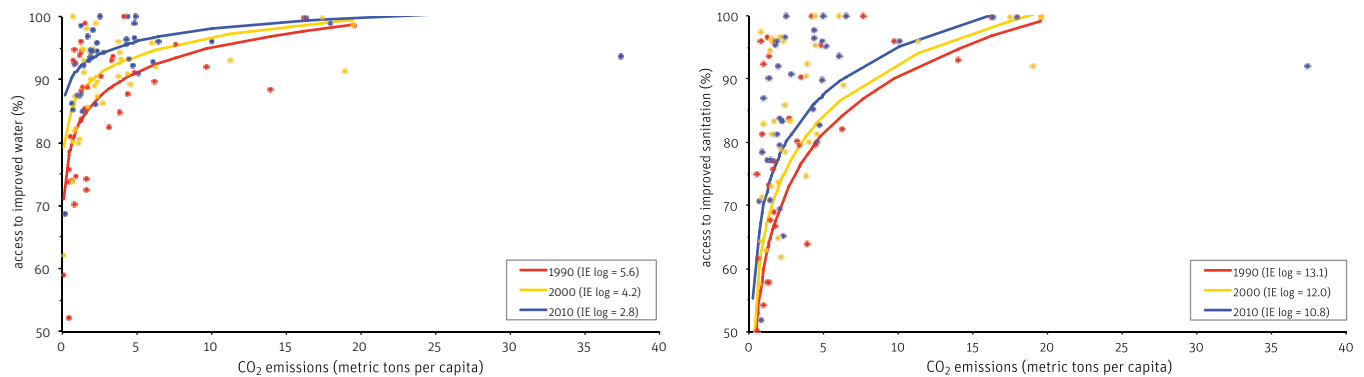


Figure 25 Weighted correlation of access to water (left) and sanitation (right) on CO₂ emissions, and indexes of effect. Countries of the Americas; 1990, 2000, and 2010



Inequalities in health by access to water and sanitation

Because access to water and sanitation are environmental determinants of health, distributional impacts on health outcomes could be seen when grouping the population by percentage of access to these services. Based on the rREA of social groupings ranked by increasing access to water and sanitation, it would be expected that key health outcomes should improve as well.

The following graphs depict the relationship between several of these health outcomes and levels of access to WASH. Specifically, they show how life expectancy, healthy or disability-free life expectancy, infant mortality, under-5 mortality, and maternal mortality change according to relative social position as defined by access to drinking water and improved

sanitation. The results are presented in four panels: gradients of health outcomes by country terciles for access to improved water, regression lines and concentration curves for inequality in the health outcome according to access to improved water, gradients of health outcomes by country terciles for access to improved sanitation, and regression lines and concentration curves for inequality in the health outcome according to access to improved sanitation.

Inequalities in life expectancy

In AMRO, life expectancy has been increasing, having risen from 71.2 years in 1990 to 74.1 years in 2000 and 76.2 years in 2010, and it correlates directly with social position as defined by access to improved WASH (Figures 26 and 28). Both absolute and relative inequality between the worst-off and the better-off were decreasing across the social gradient. The trend is particularly marked for access to water, where the Slope Index of Inequality (SII) was 7.4 years in 1990, 6.6 in 2000, and 5.8 in 2010 and the Health Concentration Index (HCI) was -0.31 in 1990, -0.29 in 2000, and -0.25 in 2010. It is less marked for sanitation, where the SII hovered between 7.9 years in 1990, 8,0 in 2000, and 7,0 in 2010, while the HCI had a similar pattern of -0.37 in 1990, -0.40 in 2000, and -0.37 in 2010, signaling a wide social gap. As the inequality concentration curve shows, 50% of all expected years of life lost due to premature mortality in 2010 concentrated in the lowest 32 percentiles of the population by access to water, and the lowest 24 percentiles by access to improved sanitation (Figures 27 and 29).

Figure 26 Gradients of life expectancy at birth by country terciles of access to water. Region of the Americas; 1990, 2000, and 2010

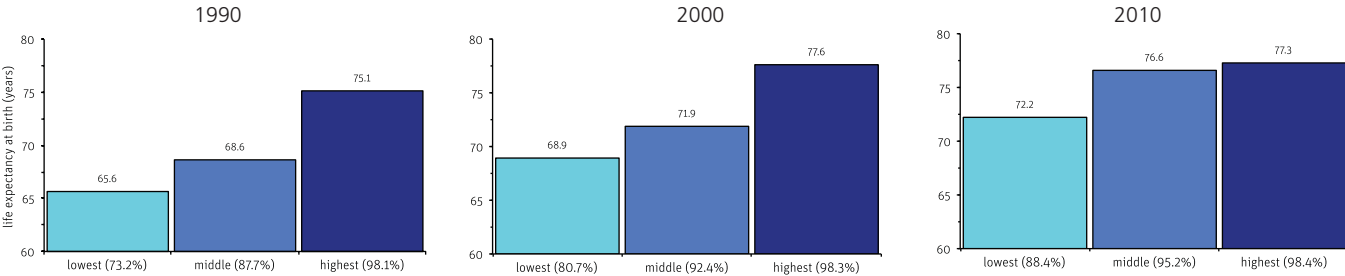


Figure 27 Weighted regression lines and concentration curves of inequality in life expectancy at birth by access to water. Countries of the Americas; 1990, 2000, and 2010

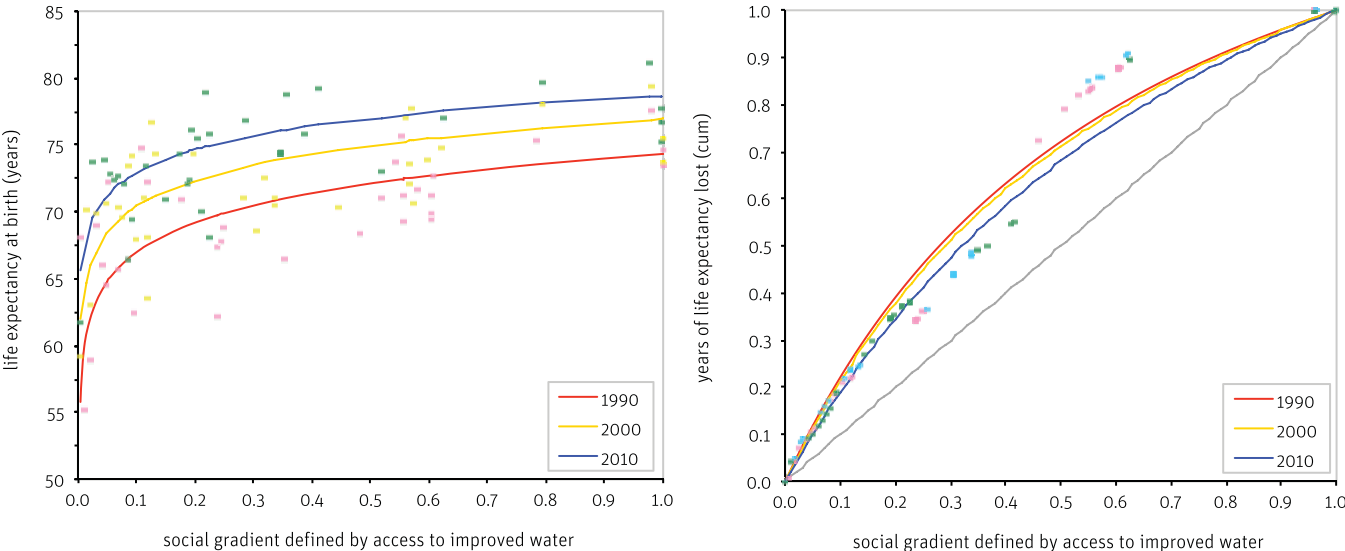


Figure 28 Gradients of life expectancy at birth by country terciles of access to sanitation. Region of the Americas; 1990, 2000, and 2010

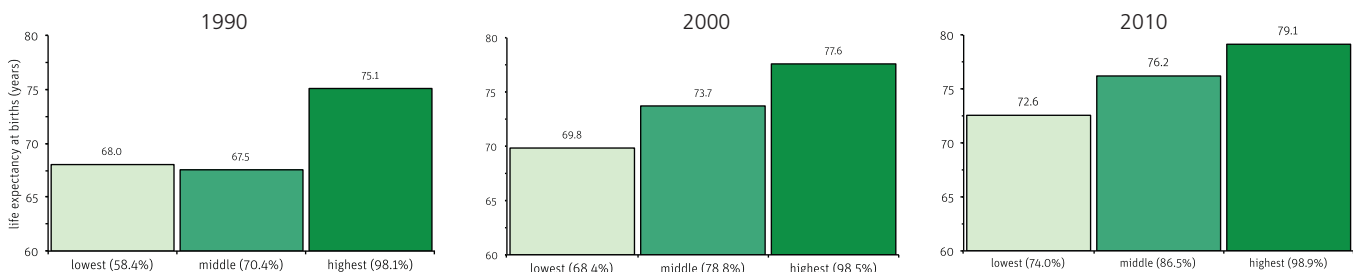
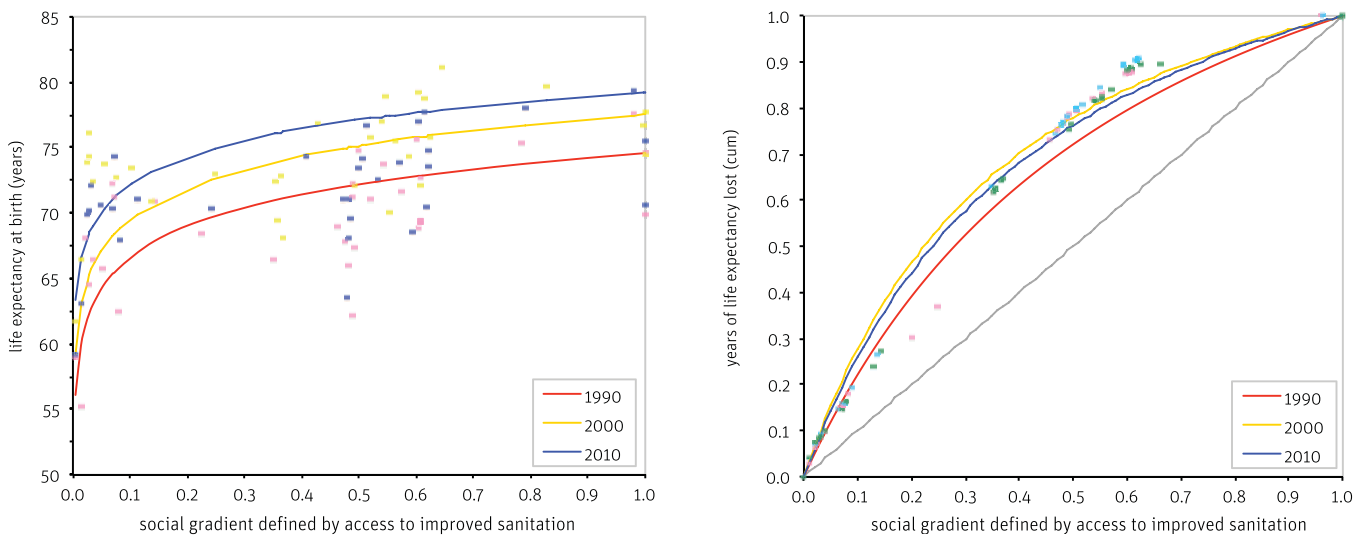


Figure 29 Weighted regression lines and concentration curves of inequality in life expectancy at birth by access to sanitation. Countries of the Americas; 1990, 2000, and 2010



Inequalities in healthy life expectancy

Healthy or disability-free life expectancy has also been increasing, from 61.6 years in 1990 to 64.2 years in 2010, and the trend correlates directly with social position as defined by access to improved WASH (Figures 30 and 32). However, unlike total life expectancy, absolute inequality in healthy life expectancy is increasing across the social gradient, and relative inequality shows little change. The trend is more marked for sanitation, where the SII went from 5.6 years in 1990 to 6.4 years in 2010, while the HCI stalled at -0.38 in 1990 and 2010. The trend for water is not as pronounced: the SII went from 5.2 years in 1990 to 5.6 years in 2010 and the HCI went from -0.33 in 1990 to -0.29 in 2010. The inequality concentration curve shows that 50% of all expected years of healthy life lost in 2010 concentrated in the lowest 29 percentiles of the population by access to water and the lowest 23 percentiles by access to improved sanitation (Figures 31 and 33).

Figure 30 Gradients of healthy life expectancy at birth by country terciles of access to water. Region of the Americas; 1990 and 2010

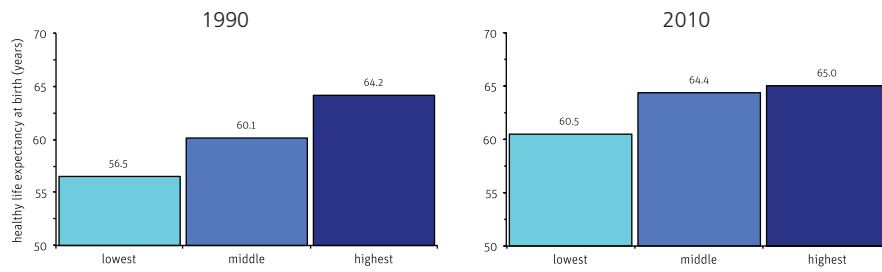


Figure 31 Weighted regression lines and concentration curves of inequality in healthy life expectancy at birth by access to water. Countries of the Americas; 1990 and 2010

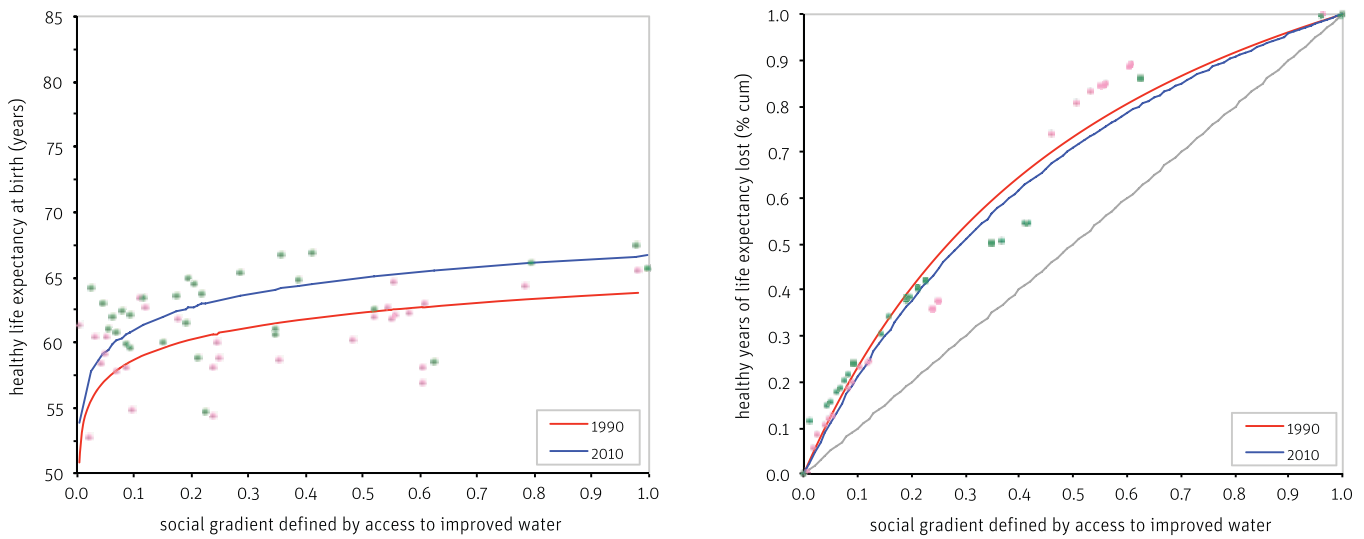


Figure 32 Gradients of healthy life expectancy at birth by country terciles of access to sanitation. Region of the Americas; 1990 and 2010

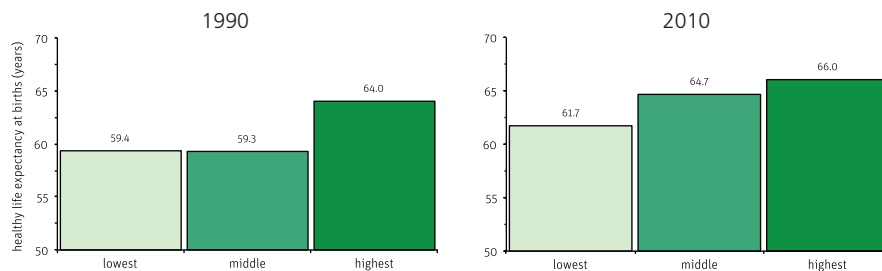
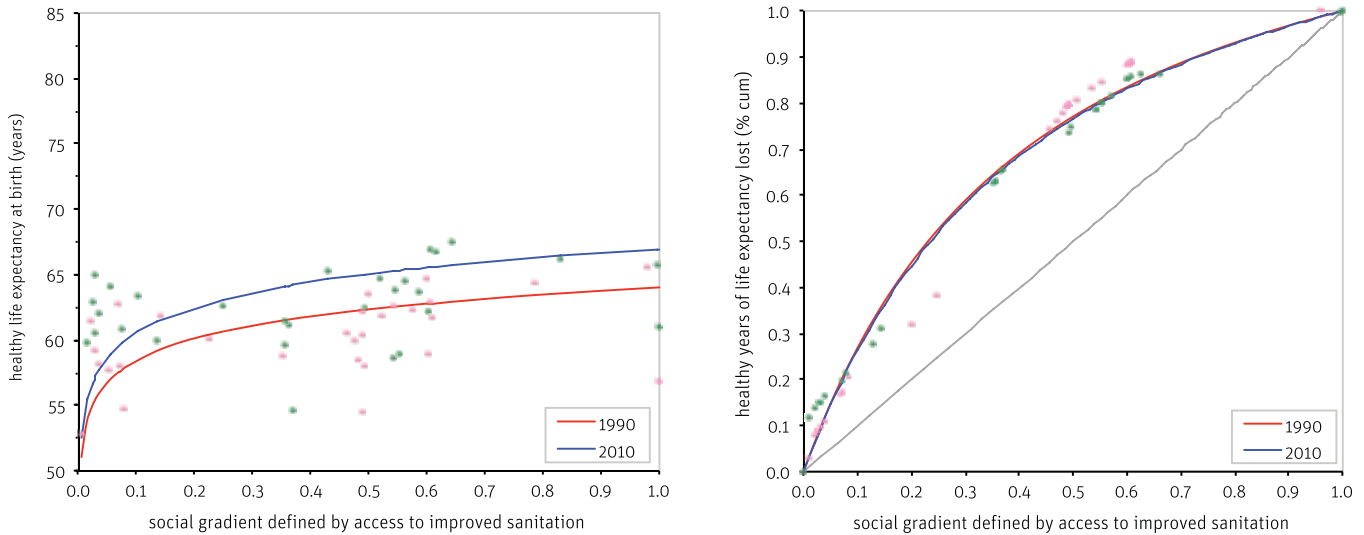


Figure 33 Weighted regression lines and concentration curves of inequality in healthy life expectancy at birth by access to sanitation. Countries of the Americas; 1990 and 2010



Inequalities in infant mortality

In AMRO, the infant mortality rate has been declining, from 29.0 per 1,000 live births in 1990 to 19.7 per 1,000 in 2000 and 13.2 per 1,000 in 2010. At the same time, there is an inverse correlation between infant mortality rate and the relative social position as defined by access to improved WASH (Figures 34 and 36). While there is still a wide social gap, both absolute and relative inequality between the worst-off and the better-off are decreasing across the social gradient, albeit at a slower rate when defined by access to water. Specifically, the SII in infant mortality across the gradient defined by access to water narrowed from -34.5 per 1,000 live births in 1990 to -23.0 in 2000, and to -14.7 in 2010, while the HCI was -0.32 , -0.27 , and -0.22 , respectively. By contrast, the SII for sanitation was -36.7 per 1,000 live births in 1990, -26.0 in 2000, and -17.1 in 2010, while the HCI was -0.38 , -0.36 , and -0.28 , respectively. The inequality concentration curve shows that, as of 2010, 50% of all infant deaths concentrated in the lowest 33 and the lowest 29 percentiles of the population by access to water and sanitation, respectively (Figures 35 and 37).

Figure 34 Gradients of infant mortality by country terciles of access to water. Region of the Americas; 1990, 2000, and 2010

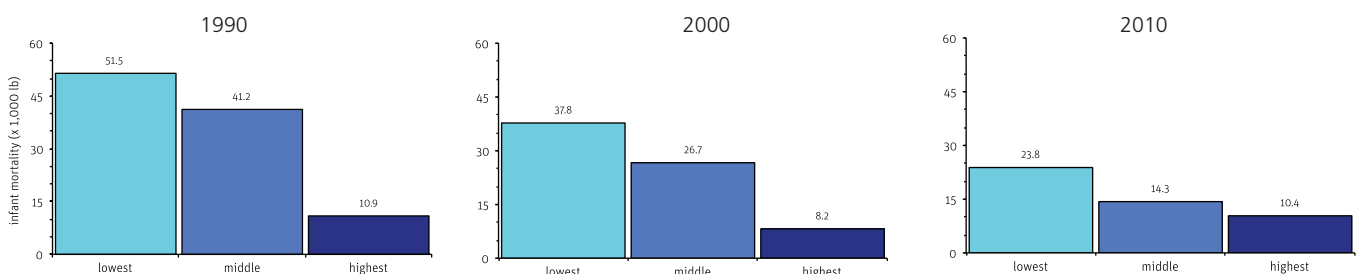


Figure 35 Weighted regression lines and concentration curves of inequality in infant mortality by access to water. Countries of the Americas; 1990, 2000, and 2010

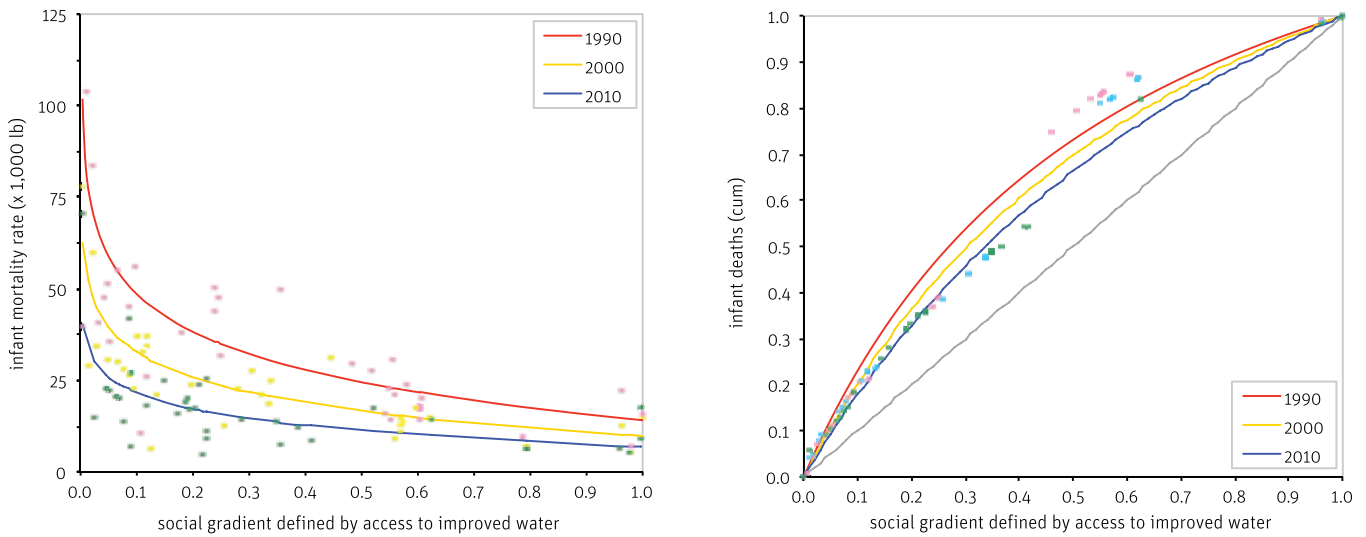


Figure 36 Gradients of infant mortality by country terciles of access to sanitation. Region of the Americas; 1990, 2000, and 2010

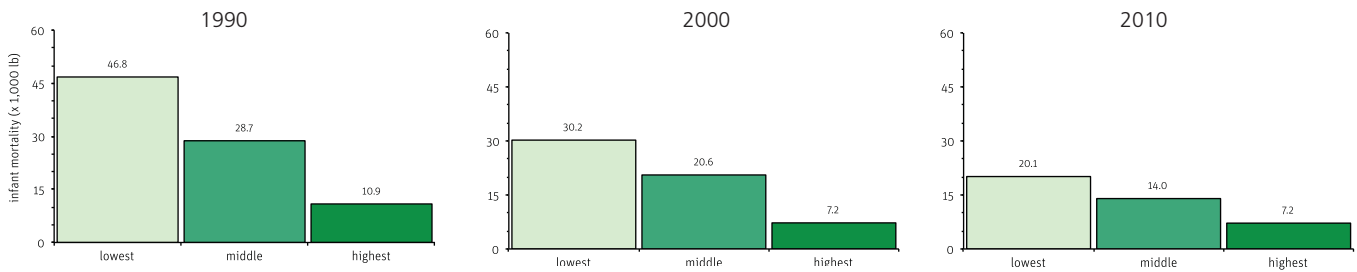
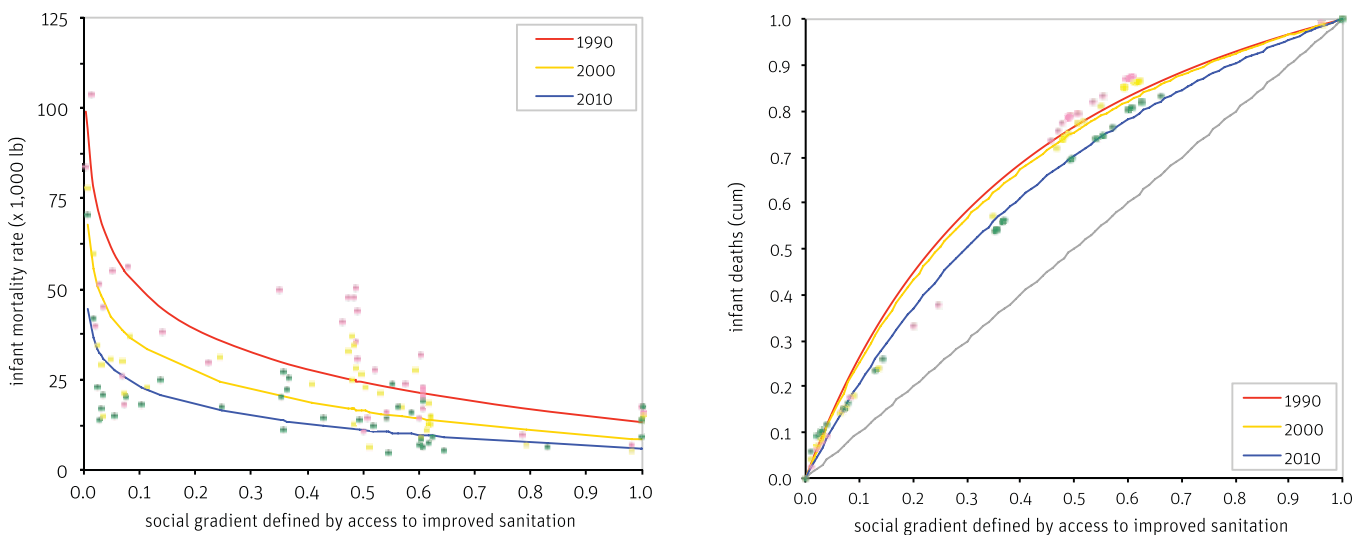


Figure 37 Weighted regression lines and concentration curves of inequality in infant mortality by access to sanitation. Countries of the Americas; 1990, 2000, and 2010



Inequalities in under-5 mortality

The under-5 mortality rate is also seeing a downward trend, from 36.1 per 1,000 live births in 1990 to 23.6 in 2000, and 16.3 in 2010, and there is also an inverse correlation with the relative social position as defined by access to improved WASH (Figures 38 and 40). This progress can be seen in the SII which, in the water gradient, it narrowed from -48.4 per 1,000 live births in 1990 to -31.2 in 2000 and -27.4 in 2010, while the HCI went from -0.34 in 1990 to -0.29 in 2000 and -0.29 in 2010. In turn, the SII in the sanitation gradient narrowed from -51.6 per 1,000 live births in 1990 to -34.2 in 2000 and -30.2 in 2010, while the HCI went from -0.39 in 1990 to -0.37 in 2000 and -0.32 in 2010. These figures, though, show the persistence of a wide social gap, both absolute and relative, between the worst-off and the better-off in terms of access to WASH. The inequality concentration curve shows that, as of 2010, 50% of the all deaths in children under-5 years old did concentrate in the lowest 29 and the lowest 26 percentiles of the population according to access to improved water and sanitation, respectively (Figures 39 and 41).

Figure 38 Gradients of under-5 mortality by country terciles of access to water. Region of the Americas; 1990, 2000, and 2010

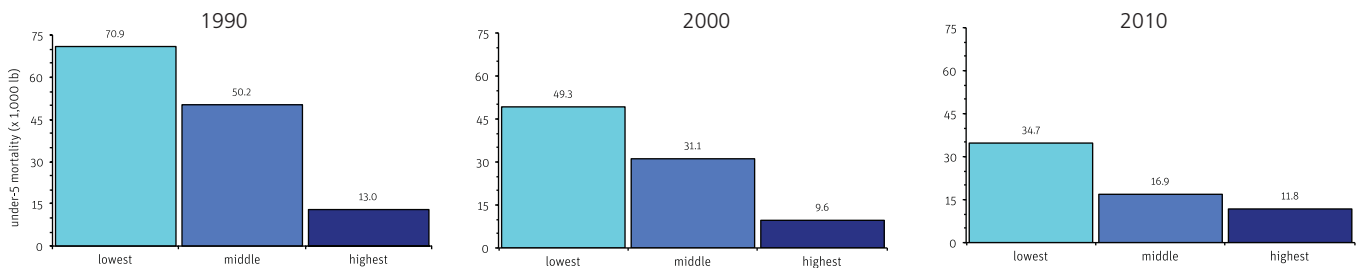


Figure 39 Weighted regression lines and concentration curves of inequality in under-5 mortality by access to water. Countries of the Americas; 1990, 2000, and 2010

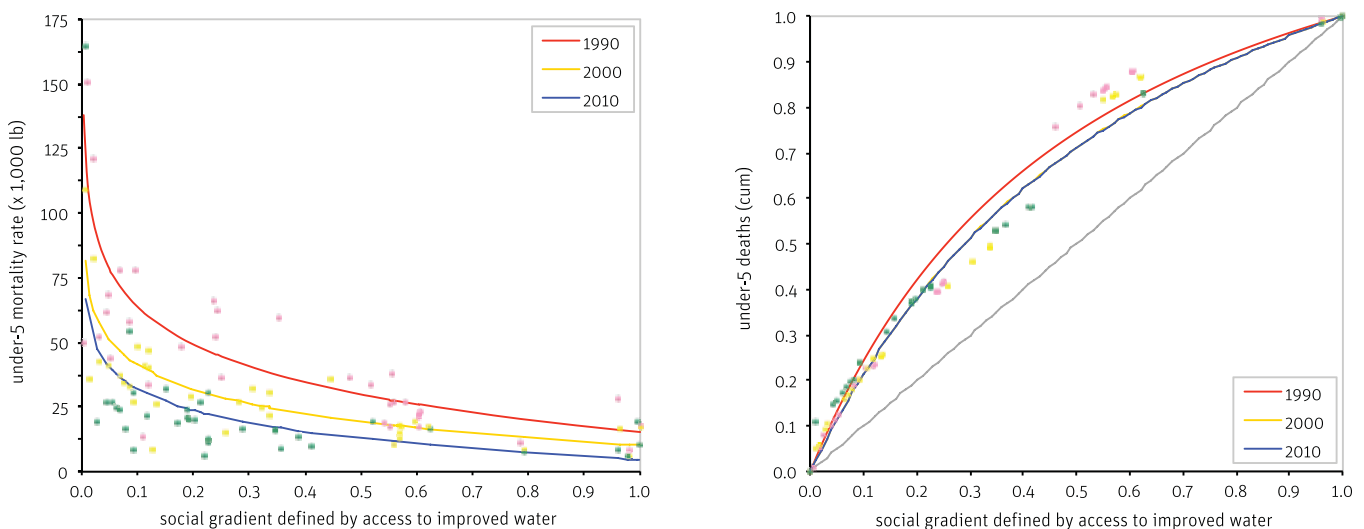


Figure 40 Gradients of under-5 mortality by country terciles of access to sanitation. Region of the Americas; 1990, 2000, and 2010

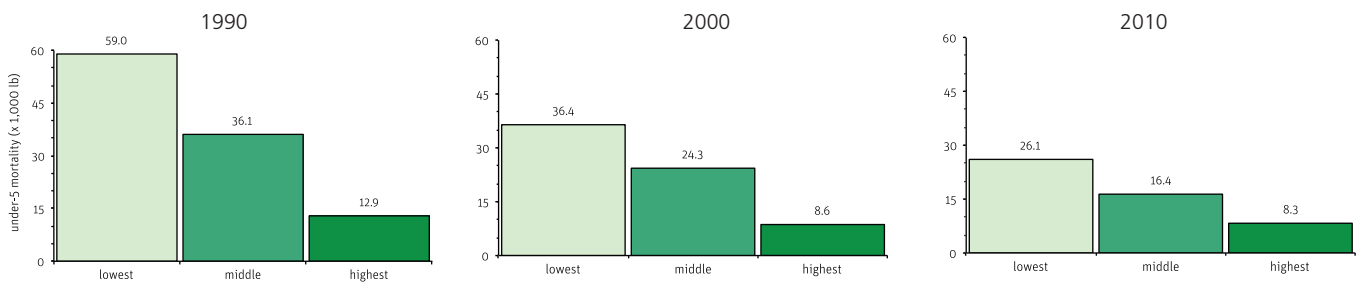
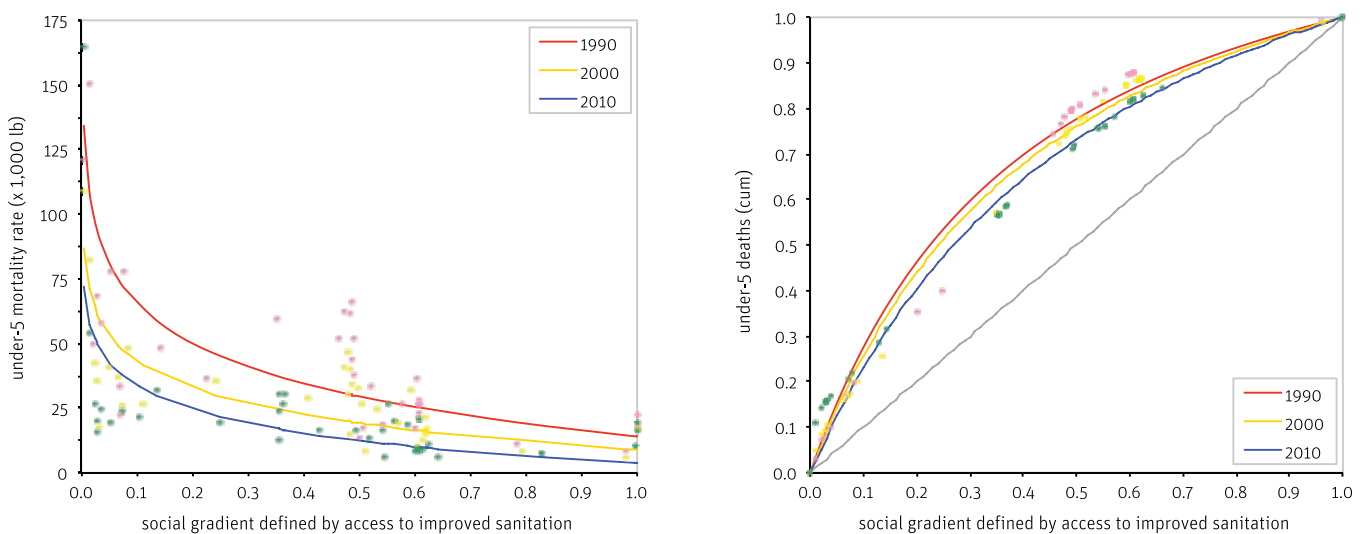


Figure 41 Weighted regression lines and concentration curves of inequality in under-5 mortality by access to sanitation. Countries of the Americas; 1990, 2000, and 2010



Inequalities in maternal mortality

Maternal mortality rate has been declining in the Region, from 86.7 per 100,000 live births in 1990 to 67.3 in 2000 and 58.9 in 2010, and it is inversely correlated with relative social position as defined by access to WASH (Figures 42 and 44). Both absolute and relative inequality are decreasing across the social gradient, albeit at a slower rate when defined by access to water: here, the SII narrowed from -182.1 per 100,000 live births in 1990 to -135.6 in 2000 and -83.6 in 2010, and the HCI went down from -0.44 in 1990 to -0.41 in 2000 and -0.30 in 2010. The SII in maternal mortality across the sanitation gradient, in turn, narrowed from -186.2 per 100,000 live births in 1990 to -131.5 in 2000 and -77.3 in 2010, and the HCI went down from -0.48 in 1990 to -0.43 in 2000 and -0.28 in 2010. In spite of these dramatic improvements, as of 2010, 50% of all maternal deaths still were concentrated in the lowest 28 and the lowest 30 percentiles of the population according to access to improved water and sanitation, respectively (Figures 43 and 45).

Figure 42 Gradients of maternal mortality by country terciles of access to water. Region of the Americas; 1990, 2000, and 2010

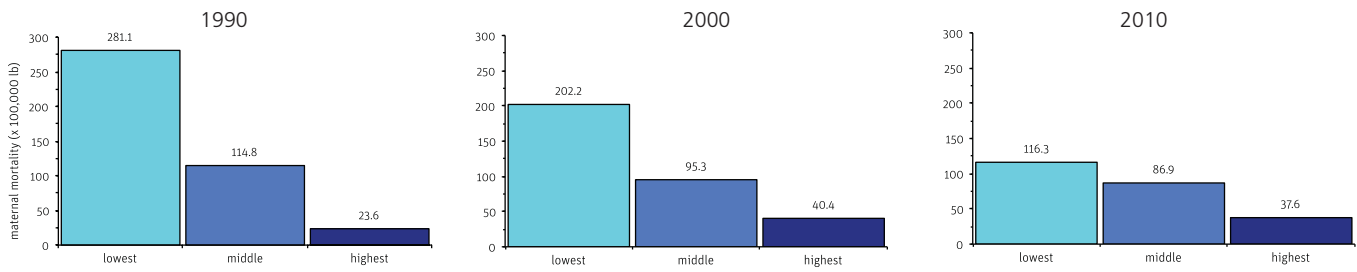


Figure 43 Weighted regression lines and concentration curves of inequality in maternal mortality by access to water. Countries of the Americas; 1990, 2000, and 2010

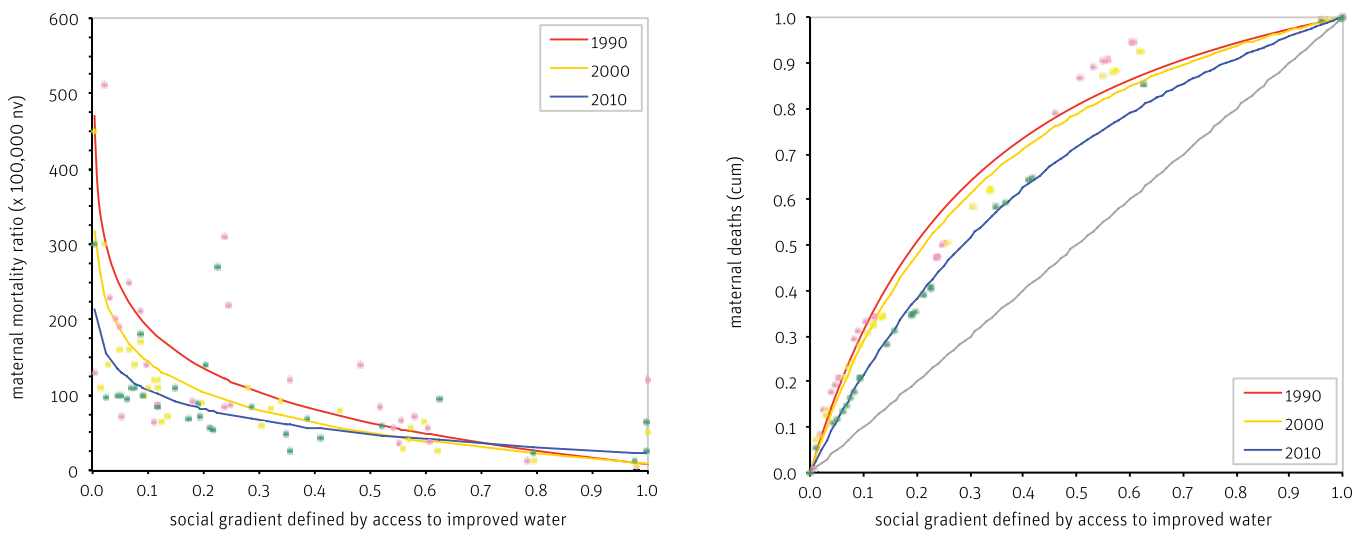


Figure 44 Gradients of maternal mortality by country terciles of access to sanitation. Region of the Americas; 1990, 2000, and 2010

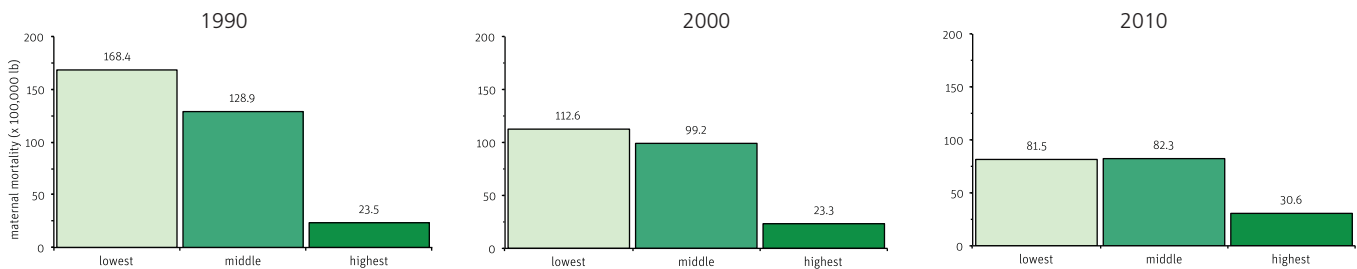
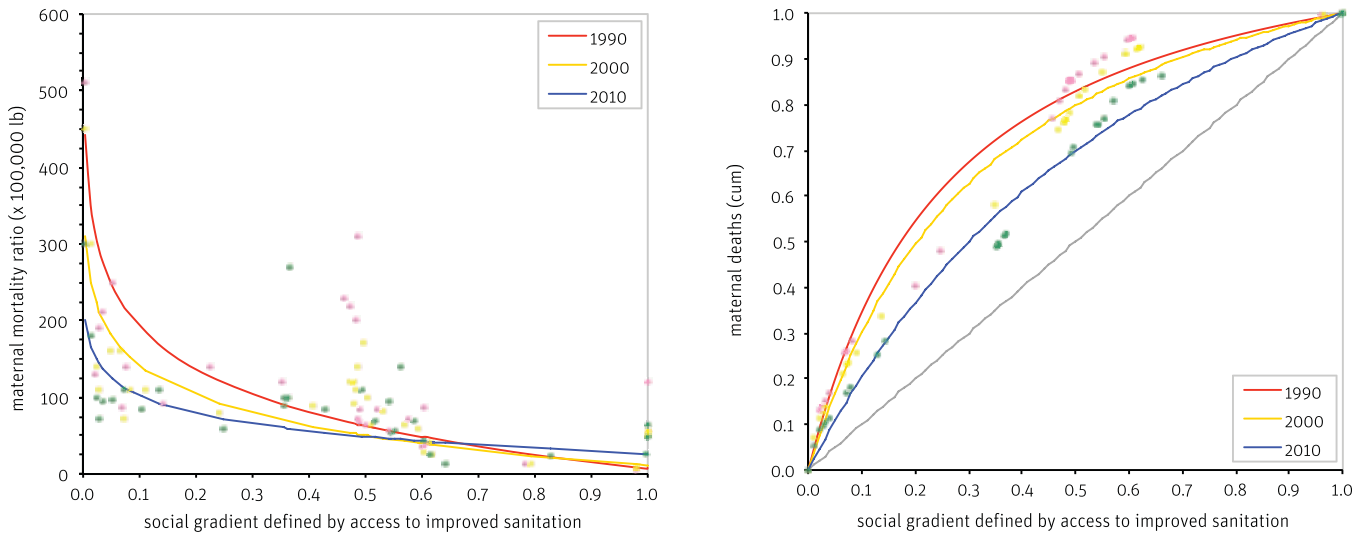


Figure 45 Weighted regression lines and concentration curves of inequality in maternal mortality by access to sanitation. Countries of the Americas; 1990, 2000, and 2010



Inequalities in the burden of disease attributable to unimproved water and sanitation

Since relative social position varies depending on access to improved water and sanitation and, since this access also shapes the health status of the population, one would expect to see social inequalities in the distribution of the burden of disease attributable to unimproved WASH.

The following graphs show the relationship between income level and burden of disease attributable to unimproved water and sanitation in AMRO countries, as assessed by the GBD 2010 Study. Specifically, these graphs analyze how mortality and the rate of disability-adjusted life years (DALYs) lost due to unimproved WASH systematically vary between countries depending on the relative social position as defined by income.

Income-related inequalities in WASH-attributable mortality

In AMRO, death rates attributable to unimproved water and sanitation decreased dramatically in the last two decades, from 3.2 deaths per 100,000 population in 1990 to 0.5 per 100,000 in 2010. At the same time, there was a strong inverse correlation between this rate and relative social position as defined by income (Figure 46). Because of the reduction in the total number of deaths, absolute inequality across the social gradient also declined, as seen in a decrease in the SII from -12.1 per 100,000 population in 1990 to -2.6 in 2010. Nonetheless, in terms of relative inequality, the problem has worsened, as shown in the HCI, which increased from -0.63 in 1990 to -0.78 in 2010. As of 2010, 84% of all deaths attributable to unimproved water and sanitation concentrated in countries comprising the poorest 20% of the regional population (Figure 47).

Figure 46 Gradients of mortality attributable to unimproved water and sanitation by country terciles of income. Region of the Americas; 1990 and 2010

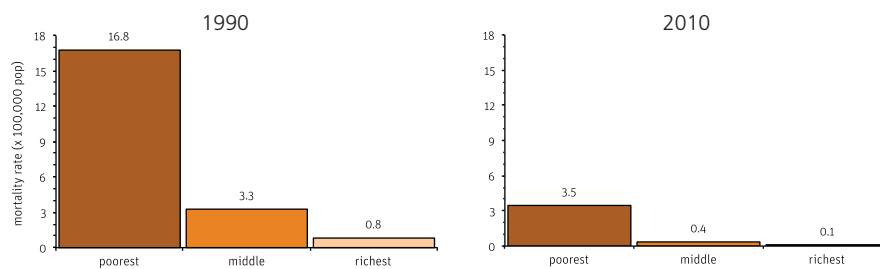
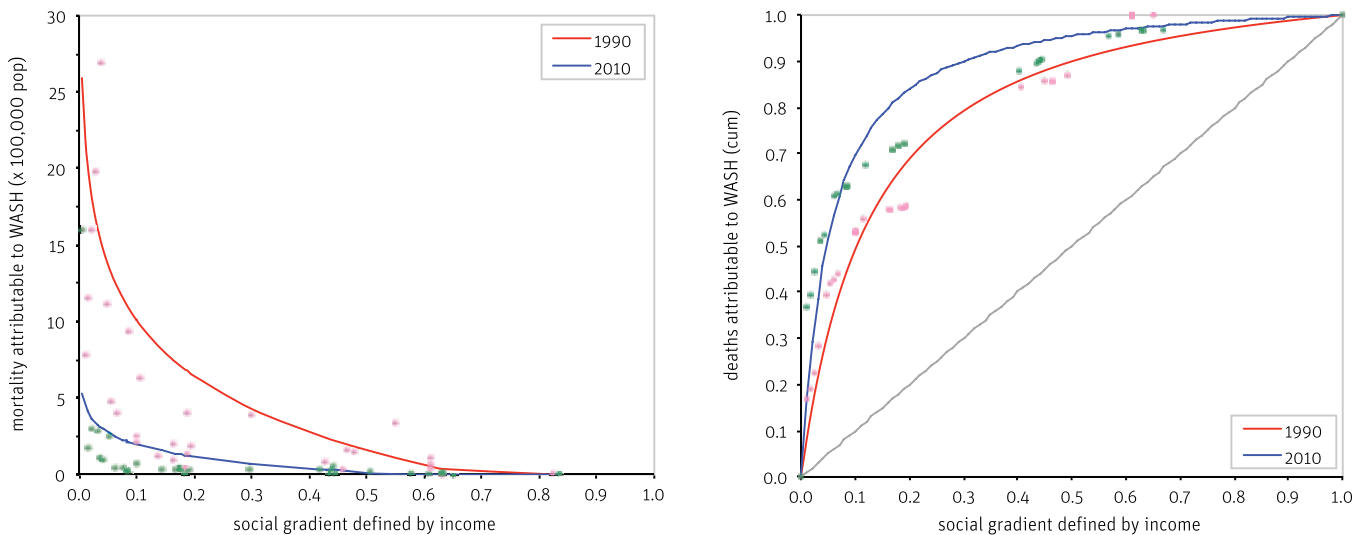


Figure 47 Weighted regression lines and concentration curves of inequality in mortality attributable to unimproved water and sanitation by income. Countries of the Americas; 1990 and 2010



Income-related inequalities in WASH-attributable DALYs

The same pattern appears with the disability-adjusted life years lost rate attributable to unimproved water and sanitation (Figure 48). While this rate dropped sharply in the last two decades, from 202.2 years per 100,000 population in 1990 to 27.9 years per 100,000 in 2010, with a parallel decline in absolute inequality, from a SII of –704 years lost per 100,000 in 1990 to –130 per 100,000 in 2010, relative inequality experienced a sharp increase, with a rise in the HCI from –0.58 in 1990 to –0.71 in 2010. In fact, as the inequality concentration curve shows, as of 2010, 77% of all DALYs lost attributable to unimproved water and sanitation occurred in countries comprising the lowest 20% of the population in the Americas (Figure 49).

Figure 48 Gradients of DALYs attributable to unimproved water and sanitation by country terciles of income. Region of the Americas; 1990 and 2010

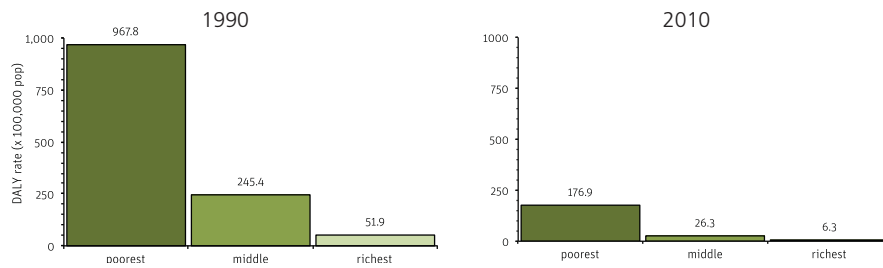
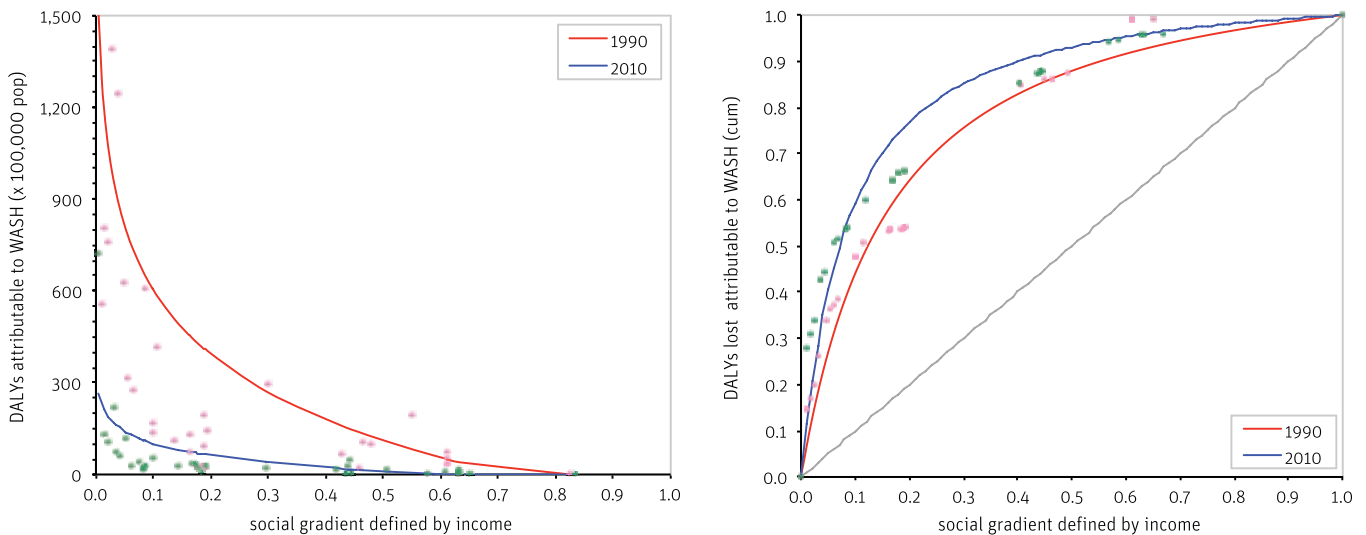


Figure 49 Weighted regression lines and concentration curves of inequality in DALYs attributable to unimproved water and sanitation by income. Countries of the Americas; 1990 and 2010



Country case-studies

The following case studies from Brazil and Peru illustrates the fact that health inequalities exist not only between but within countries. Environmentally determined inequalities in population health outcomes as defined by access to WASH can be seen between regions and subregions, reflecting the social determination of health at different levels of social organization. In the case of Brazil, the exploratory analysis considered correlations between access to prenatal care and access to drinking water and between life expectancy and access to improved sanitation. In the case of Peru, the analysis looked at correlations between infant mortality and access to drinking water and between under-5 mortality and access to improved sanitation.

Brazil

In Brazil, the percentage of mothers with lack of access to drinking water closely parallels the percentage of live births in which no prior prenatal care was received. In fact, there is a direct correlation between water network coverage and access to prenatal care, producing a social gradient defined by access to the water supply. The bulk of the burden lies with those who have the least access to water. In 2009, especially, gradients of lack of prenatal care were produced by quartiles of Federal Units stratified by water network coverage. The quartile with the least access to water coverage also had higher percentage of live births in which the mothers received no prior prenatal care: 6.7% in 2001 and 3.7% in 2009. By contrast, the quartile with the most access to the water supply had 2.3% of live births without prior prenatal care in 2001 and only 1.1% in 2009 (Figure 50). In terms of distributive equity, 50% of the live births without prior prenatal care occurred in the three population deciles with the least access to the water supply. The situation improved slightly by 2009, with 50% of the burden occurring in the first four deciles. Still, the burden continues to lie with those who are worse-off—i.e., those who have less access to water services. Although the absolute prevalence of live births with no prior prenatal care is decreasing, the inequity is not decreasing at the same pace (Figure 51).

Figure 50 Gradients of lack of prenatal care by subnational quartiles of access to drinking water. Brazil; 2001 and 2009

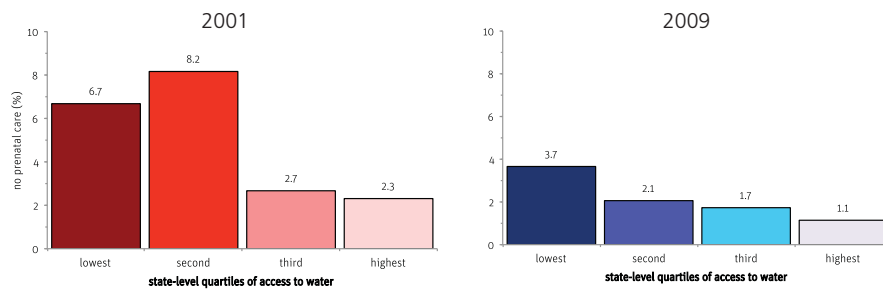
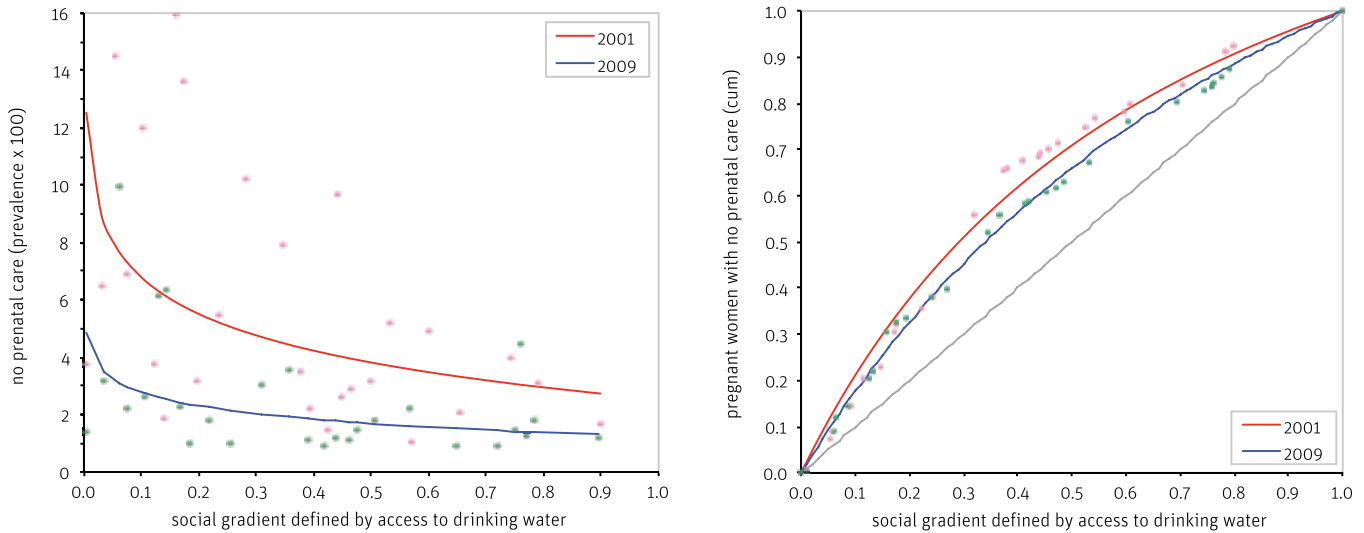


Figure 51 Weighted regression lines and concentration curves of inequality in prenatal care by access to drinking water. Federal Units of Brazil; 2001 and 2009



Also in Brazil there was a direct correlation between a rise in life expectancy at birth and a rise in access to sanitation services between 2001 and 2009, i.e., a social gradient defined by access to sanitation coverage. Still, the majority of the burden continued to lie with those who have the least access. Although average life expectancy rose from 70.9 years in 2001 to 73.4 in 2009, when stratified according to access to sanitation, large differences could be seen between the groups. The quartile with the least access to sanitation in 2001 had a life expectancy of 68.2 years, while in the quartile with the most access to sanitation it was 72.5 years. In 2009, the life expectancies for the lowest and the highest quartiles were 71.3 and 74.7 years, respectively (Figure 52). In terms of equity, there was little change between 2001 and 2009. The SII went from -5.8 years in 2001 to -5.0 years in 2009, while the HCI went from -0.33 to -0.31 in the same period. Fifty percent of the expected years of life lost were found in the lowest three deciles in both years. The concentration curve suggests that the burden of expected years of life lost is concentrated in the population worst-off in terms of access to sanitation coverage and that inequality is not decreasing at the same rate as life expectancy is increasing. Population health is improving in terms of life expectancy, but the inequality persists (Figure 53).

Figure 52 Gradients of life expectancy at birth by subnational quartiles of access to sanitation. Brazil; 2001 and 2009

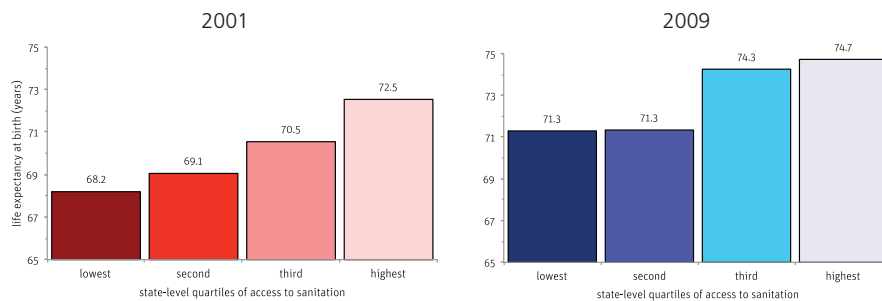
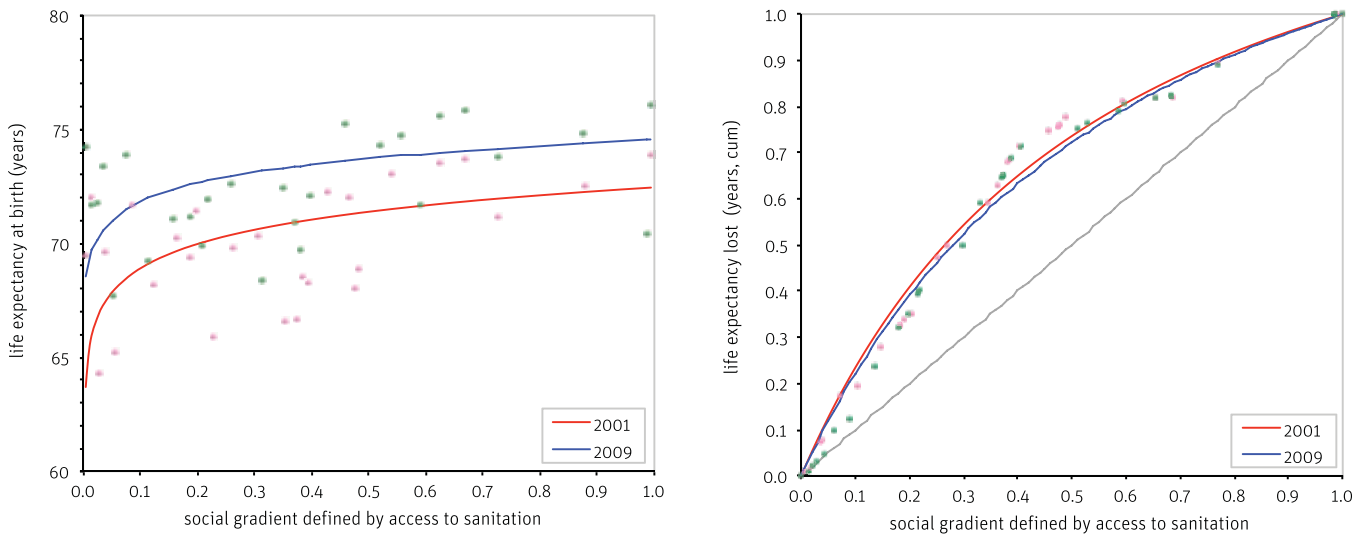


Figure 53 Weighted regression lines and concentration curves of inequality in life expectancy at birth by access to sanitation. Federal Units of Brazil; 2001 and 2009



Peru

There is a relationship between access to drinking water and infant mortality rates in Peru. Most of the infant mortality burden lies with those who have the least access to drinking water. In 2000, the infant mortality rate in the quartile of subnational units (*departamentos*) with the least access to drinking water was 55.3 deaths per 1,000 live births, as compared to 19.9 deaths per 1,000 live births in the quartile with the most access. In 2010, these rates were 33.5 and 14.4 per 1,000 live births, respectively (Figure 54). The graph shows a proportional reduction in the infant mortality rate with each quartile of increased access to drinking water. Thus, gradients in access to drinking water reproduce gradients of inequality in infant mortality. Between 2000 and 2010, the quartile with the least access to drinking water saw a reduction in infant mortality rate equal to 21.8 averted deaths per 1,000 live births, whereas the quartile with the most access gained only 5.5 averted deaths per 1,000 live births. As a result, absolute inequality dropped notably, from a SII of -43.9 infant deaths per 1,000 live births in 2000 to -26.3 in 2010, while relative inequality did not change significantly: as of 2010, around 50% of the infant mortality burden was still concentrated in the three population deciles with the least access to water (Figure 55).

Figure 54 Gradients of lack of infant mortality by subnational quartiles of access to drinking water. Peru; 2000 and 2010

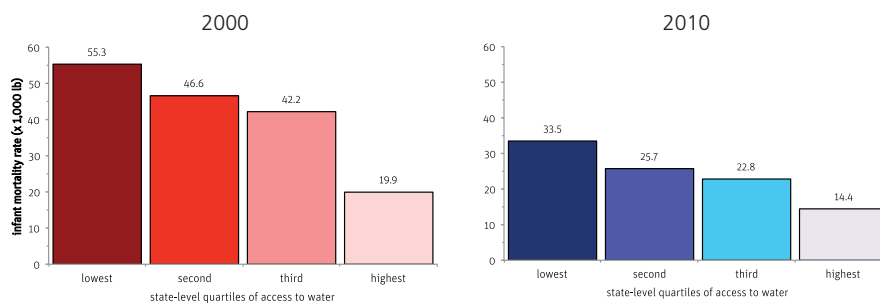
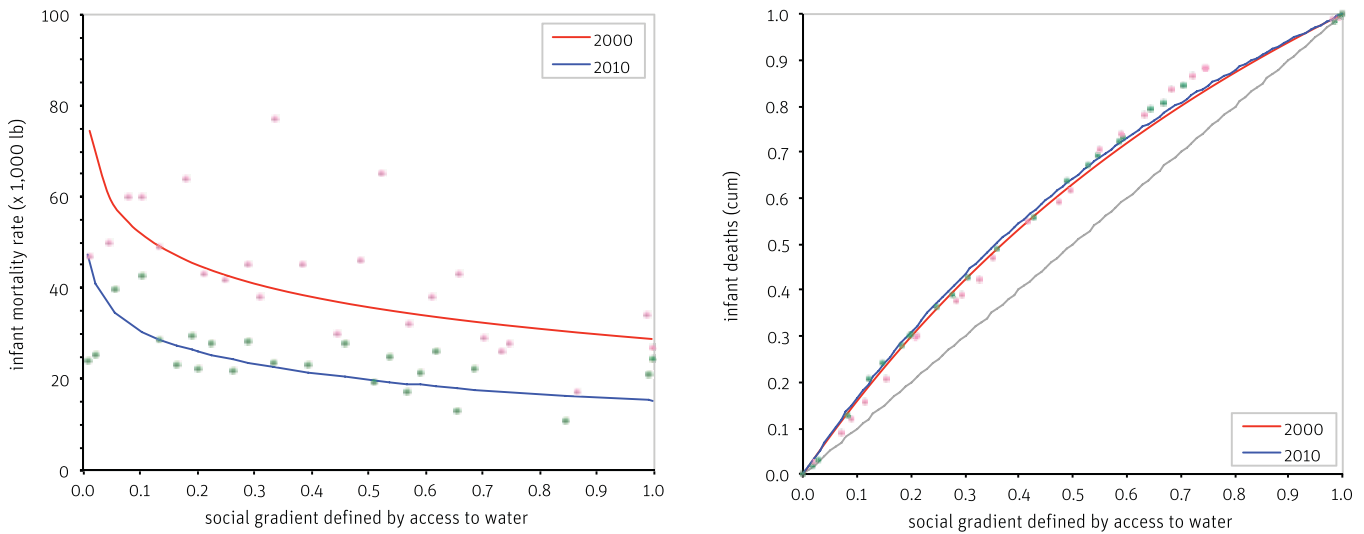


Figure 55 Weighted regression lines and concentration curves of inequality in infant mortality by access to drinking water. Departments of Peru; 2000 and 2010



Also in Peru, a correlation was found between increased access to sanitation coverage and a decrease in the under-5 mortality rate. Again, the bulk of the burden lies with those who have the least access. The absolute difference in the national average rates between 2000 and 2010 is noticeable, with a drop from 60.6 to 28.6 deaths in children under age 5 per 1,000 live births. However, when the subnational rates were stratified by access to sanitation, a social gradient was produced: those who have the least access to sanitation have the highest under-5 mortality, and those with the most access have the lowest (Figure 56). This situation was also reflected in the regression lines: as social position defined by access to sanitation increased, the under-5 mortality rate decreased. As a matter of fact, the SII was -78.6 under-5 deaths per 1,000 live births in 2000 and -34.6 in 2010, indicating a significant reduction in absolute inequality. On the other hand, the concentration curves also shown that the burden of mortality lies on those with the least access: both in 2000 and 2010, almost 50% of the under-5 deaths occurred in the three population deciles with the least access to sanitation. Although the rates have decreased in number, relative inequality, or concentration of under-5 deaths across the social gradient, has not significantly changed (Figure 57).

Figure 56 Gradients of under-5 mortality by subnational quartiles of access to sanitation. Peru; 2000 and 2010

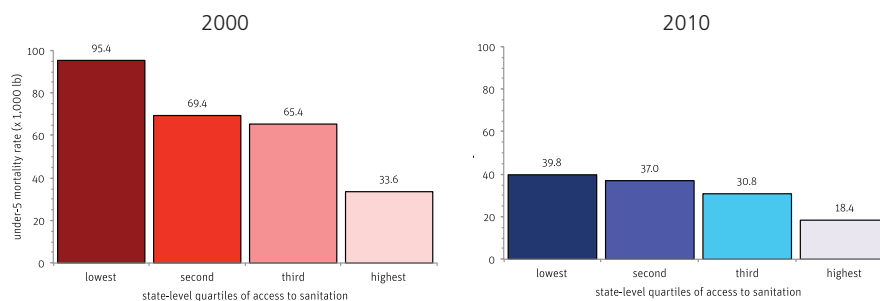
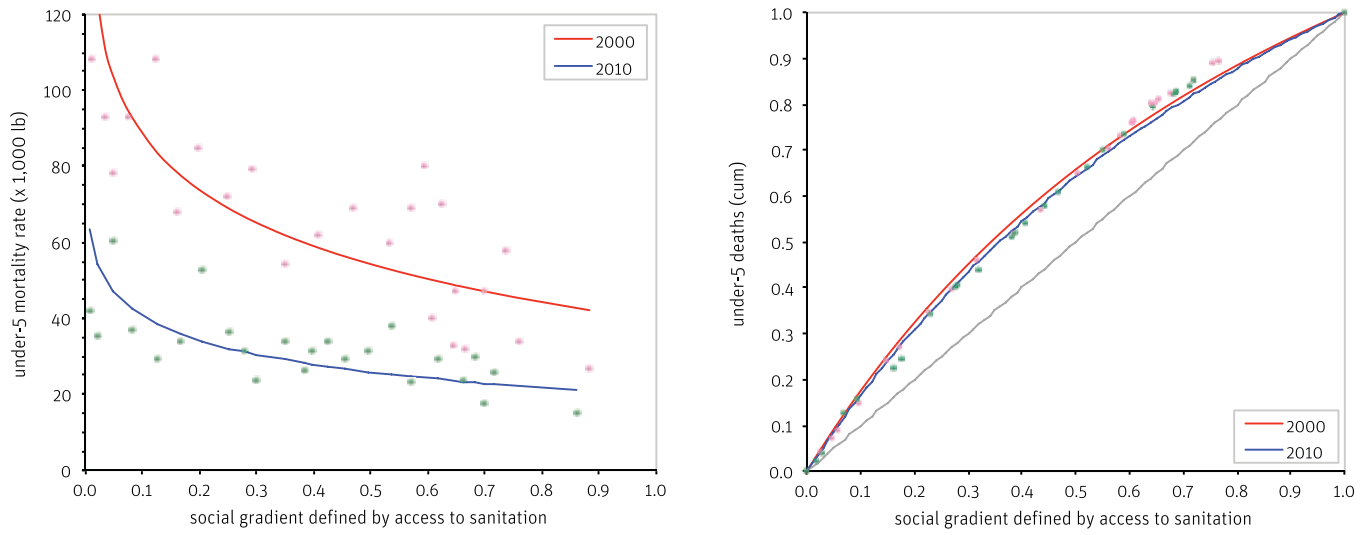


Figure 57 Weighted regression lines and concentration curves of inequality in under-5 mortality by access to sanitation. Departments of Peru; 2000 and 2010



The way forward: policy implications

Main findings

The aim of this report has been to provide systematic and original evidence on the presence, magnitude, depth, and trends of inequalities in the distribution of key health outcomes across social gradients at the country level in terms of the WASH variables and from the ecological perspective. The main findings of this analysis are:

1. The sex and age distribution of access to water and sanitation in the countries of the Americas correlates with the stages of demographic transition and population development.
2. Urban areas have higher rates of access to water and sanitation, while both urban and rural areas in some countries still have very low rates of access to both. The correlation between access to water and access to sanitation is high both in urban and rural areas. There are marked inequalities between countries, especially in access to improved sanitation facilities in rural areas.
3. Access to water and sanitation varies depending on the relative social position as defined by fertility rate, human development, income, mean years of schooling, and CO₂ emissions. Water and sanitation can be considered proxies of social position, acting as determinants of health both in themselves and as determinants of other social determinants of health. Quality access to water and sanitation is the very epitome of an environmental determinant of health. It plays a prominent role in establishing social position and shaping the social hierarchy, thus *determining* the distribution of health and well-being.
4. Access to water and sanitation strongly correlate with life expectancy at birth, healthy life expectancy, infant mortality, under-5 mortality, and maternal mortality. Over the period from 1990 to 2010, a gradient is seen in all of these variables. As access to both water and sanitation increase, life expectancy and healthy life expectancy increase and infant mortality, under-5 mortality, and maternal mortality decline. While both absolute and relative inequalities are decreasing for total life expectancy at birth, inequality for disability-free life expectancy is on the rise.
5. Access to water and sanitation correlate strongly with social position as defined by income and the burden of disease. Trends between 1990 and 2010 show that, although tremendous progress has been made, both mortality and DALY rates due to unimproved WASH are still concentrated in the poorest population and that the social gap between the better-off and the worst-off is widening.
6. Case studies from Brazil and Peru illustrate that WASH-related health inequalities exist not only between but also within countries and that the correlations at the subnational level are even stronger. Environmentally determined inequalities in population health outcomes defined by access to WASH can be seen between regions and subregions, since they are reflections of the social determination of health at different levels of social organization.

In summary, this report has illustrated the fundamental role of access to water and sanitation as environmental determinants of health and health equity in the Americas, pointing out specially the reproduction of social and environmental gradients into health gradients and inequalities, albeit from an ecological standpoint. A growing concern in the environmental determinants of health and environmental inequalities, in general, have been reflected in the research and policy literature lately (25-30), although the specific interest and inquiry on water and sanitation as determinants of health inequalities, and in the Americas, has been rather limited (4,6,31).

Although the Region of the Americas as a whole is on track to meet MDG 7 on water and sanitation, the study presented here shows that there are large and growing inequalities between and within countries hidden by the regional averages. In the words of Dr. Margaret Chan, Director of the World Health Organization: “The health consequences of poor water, sanitation, and hygiene services are enormous. I can think of no other environmental determinant that causes such profound, debilitating, and dehumanizing misery. [...] The world, as a whole, met the MDG target for access to water last year [2012] but, [...] worldwide, nearly 800 million people still do not have access to an improved water source. Progress towards the target for sanitation is the most off-track of all the MDGs and must command our urgent attention” (32). Furthermore, Dr. Chan has declared that WHO will concentrate on the vast and growing social inequalities that are so strongly demonstrated by differences in access to water and sanitation, and on the related sharp differences in health outcomes. Since the advances that have been made are not equally distributed throughout the population, inequity, in the form of unjust, unfair, and avoidable inequalities, needs to be addressed in order to achieve universal access to water and, more urgently, to sanitation services. Thus, priority attention should be given to the socially disadvantaged population groups. “Poverty can never be eradicated, or even greatly reduced, as long as so many millions of people cannot access safe water and so many billions are living in environments contaminated by faeces. Efforts to improve water, sanitation, and hygiene should be viewed as a pro-poor strategy on a massive scale. If poverty eradication is central to the post-2015 development agenda, then water and sanitation must be included” (32).

Priorities for action: access to water and sanitation in the post-2015 development agenda

The Budapest Water Summit, initiated at the United Nations Conference on Sustainable Development, was convened to review the steps taken toward formulating a water-related goal for the post-2015 development agenda. With a vision of fully achieving the MDG targets for water and sanitation and moving toward a new set of objectives, to be called Sustainable Development Goals, the Summit recommended the adoption of the goal A Water-Secure World. This new goal would include specific targets aimed at achieving universal access to safe drinking water and sanitation, as well as gender-responsive sanitation and hygiene services. The proposal was supported by policy recommendations based on recognition of the critical need for sound scientific underpinning and for the development of socioeconomic, institutional, technical, financial, and engineering capacity in water-related areas. The report of the Summit goes on to say: “To support the development of broader and more inclusive Sustainable Development Goals provides an even greater challenge to sciences. In this context, the lack of trained professionals and delivery capacities is a recognized limitation toward attaining meaningful goals.” Furthermore, the report calls for a robust intergovernmental institutional mechanism to regularly monitor, review, and assess progress toward fulfillment of the new goal. For this purpose, the meeting went on to recommend that appropriate institutional mechanisms be implemented soon and in an integrated manner (33).

The present analysis has shown that access to water and sanitation is a critical determinant of health and economic development and, as such, it should rank as a high priority for achieving health protection under the health authorities’ goal of universal health coverage and access. In this connection, PAHO conducted a systematic review of the effectiveness of water and sanitation interventions in improving the health status of the population and their implications for distributive policies. Dr. Luiz Galvão, Manager of the PAHO Special Program on Sustainable Development and Health Equity, has summarized the findings: Based on the investigation of the effectiveness of drinking water and sanitation interventions, the evidence is sufficiently consistent to confirm the importance of policies aimed at ensuring universal access to drinking water and sanitation, especially for children under 5 years of age living in low- and middle-income areas. In this regard, the studies show that interventions designed to improve the quality of water in the home have the greatest impact on the reduction of diarrhea in all age groups, including children under 5. Moreover, the improvement of basic sanitation, particularly adequate excreta disposal, is effective in lowering morbidity and mortality from diarrhea by 30% to 40%, especially when it is linked to community-level interventions to promote proper hygiene. With regard to the sustainability of initiatives to improve water and sanitation conditions, their

effectiveness depends strongly on behavioral changes in the population, such as hand washing. Hand hygiene reduces the frequency of gastrointestinal diseases. The available economic analyses show that improvements in access to drinking water and sanitation are cost-effective. The primary reason for the economic benefits obtained, contributing at least 80% of the gain, is time savings—that is, the reduced time required in order to access improved water and sanitation facilities. The recognition of water and sanitation as human rights, along with policy-making based on national and international human rights instruments, means that water and sanitation are no longer understood exclusively as commercial goods (34).

Achieving universal access to water and sanitation requires the collaboration of multiple agencies and sectors of government, especially because the health sector has limited incentives to finance expanded coverage of water and sanitation services. The real savings to the sector from improved coverage (mainly in reduced treatment costs) are small when compared with the annual costs of intervention. The health sector cannot and should not be expected to finance these interventions, but it does have an essential role to play in monitoring the quality of water for human consumption and in health promotion, health education, and disease prevention (35-38). The World Health Organization is currently working on aspects of water, sanitation, and hygiene where the health burden of disease is high, where interventions could make a major difference, and where the present state of knowledge is poor. Along with countries and other United Nations agencies, it monitors progress toward the drinking water and sanitation targets; reports on trends in policy on institutional and financial issues related to sanitation and drinking water; develops guidelines on drinking-water quality, safe use of wastewater in agriculture and aquaculture, and management of safe recreational waters; provides guidance, capacity strengthening, and good practice models for countries on drinking-water supply risk management, water resource management systems, and safe re-use of wastewater; manages networks of specialized issues; and ensures safe drinking water and sanitation to health facilities and vulnerable groups during emergencies and natural disasters (39). Furthermore, at the Budapest Water Summit, Dr. Margaret Chan proposed additional actions that should be implemented by the health sector. One of the most important of these is to monitor inequalities in access to water and sanitation and their health outcomes on a regular basis, including access to WASH in health care facilities. As Dr. Chan emphasized in her Budapest address: “The impact on socioeconomic development of diseases associated with unsafe water and poor sanitation needs to be measured by many metrics other than the number of deaths. League tables of top killers cannot capture the contribution these diseases make to stubborn poverty and human misery” (32).

In order to reduce existing environmentally determined inequalities in health it is mandatory, in the first place, to begin with measuring and monitoring them. The results of this report could be used as the benchmark from which the changes made by existing and new policies can be measured and compared through time.



Photo: PAHO

Annex: summary tables

Table 1 Gradients of access to improved water by equity stratifiers. Region of the Americas; 1990, 2000, and 2010

equity stratifier	year	terciles of the equity stratifier			index of effect
		lowest	middle	highest	
fertility	1990	71.9	88.3	97.6	-9.3
	2000	80.7	91.8	96.9	-9.5
	2010	86.9	95.4	98.0	-7.8
human development	1990	73.1	86.3	97.2	53.7
	2000	79.8	91.7	96.6	41.8
	2010	85.5	95.3	97.9	32.3
income	1990	73.6	87.8	95.0	8.9*
	2000	80.2	93.1	96.4	5.9*
	2010	87.2	95.0	98.0	4.3*
schooling	1990	86.8	81.1	97.2	1.8
	2000	90.9	88.7	98.0	1.4
	2010	94.5	94.1	98.4	1.0
CO ₂ emissions	1990	95.0	87.8	72.8	5.6*
	2000	96.4	93.5	83.6	4.2*
	2010	98.3	96.6	87.9	2.9*

* in logarithmic scale

Table 2 Gradients of access to improved sanitation by equity stratifiers. Region of the Americas; 1990, 2000, and 2010

equity stratifier	year	terciles of the equity stratifier			index of effect
		lowest	middle	highest	
fertility	1990	50.9	70.1	98.2	-19.8
	2000	61.0	79.1	90.5	-21.9
	2010	69.7	86.5	91.5	-15.6
human development	1990	49.2	66.7	97.2	129.2
	2000	55.7	74.9	93.3	118.8
	2010	61.4	80.5	95.5	117.5
income	1990	50.9	69.5	91.0	20.2*
	2000	59.6	74.6	93.2	16.3*
	2010	64.9	80.4	95.6	14.9*
schooling	1990	66.8	61.4	97.3	4.8
	2000	72.6	71.8	97.8	4.5
	2010	78.2	84.6	97.1	3.9
CO ₂ emissions	1990	90.9	69.6	50.1	13.1*
	2000	93.3	77.6	62.5	12.0*
	2010	98.3	83.1	68.0	10.8*

* in logarithmic scale

Table 3 Health inequalities as defined by access to water. Region of the Americas; 1990, 2000, and 2010

health dimension	year	terciles of access to improved water			regional overall mean	health inequality metrics			
		lowest	middle	highest		lowest-to-highest gap		whole gradient	
						absolute	relative	SII	HCI
life expectancy	1990	65.7	68.6	75.1	71.2	-9.5	0.87	7.35	-0.31
	2000	68.9	71.9	77.6	74.1	-8.7	0.89	6.55	-0.29
	2010	72.2	76.6	77.3	76.2	-5.1	0.93	5.75	-0.25
healthy life expectancy	1990	56.5	60.1	64.2	61.6	-7.7	0.88	5.17	-0.33
	2000	N/A							
	2010	60.5	64.4	65.0	64.2	-4.5	0.93	5.64	-0.29
infant mortality	1990	51.5	41.2	10.9	29.0	40.5	4.71	-34.53	-0.32
	2000	37.8	26.7	8.2	19.7	29.6	4.61	-23.01	-0.27
	2010	23.8	14.3	10.4	13.2	13.5	2.30	-14.67	-0.22
under-5 mortality	1990	70.9	50.2	13.0	36.1	57.9	5.47	-48.40	-0.34
	2000	49.3	31.1	9.7	23.6	39.6	5.11	-31.21	-0.29
	2010	34.8	16.9	11.8	16.3	23.0	2.96	-27.42	-0.29
maternal mortality	1990	281.1	114.8	23.6	86.7	257.6	11.93	-182.08	-0.44
	2000	202.2	95.3	40.4	67.3	161.8	5.00	-135.61	-0.41
	2010	116.3	86.9	37.6	58.9	78.7	3.09	-83.59	-0.30

N/A: not available

Table 4 Health inequalities as defined by access to sanitation. Region of the Americas; 1990, 2000, and 2010

health dimension	year	terciles of access to improved sanitation			regional overall mean	health inequality metrics			
		lowest	middle	highest		lowest-to-highest gap		whole gradient	
						absolute	relative	SII	HCI
life expectancy	1990	68.0	67.5	75.1	71.2	-7.1	0.91	7.94	-0.37
	2000	69.8	73.7	77.6	74.1	-7.8	0.90	8.03	-0.40
	2010	72.6	76.2	79.1	76.2	-6.6	0.92	7.00	-0.37
healthy life expectancy	1990	59.4	59.3	64.0	61.6	-4.7	0.93	5.57	-0.38
	2000	N/A							
	2010	61.7	64.7	66.1	64.2	-4.3	0.93	6.38	-0.38
infant mortality	1990	46.8	28.8	10.9	29.0	35.9	4.29	-36.71	-0.38
	2000	30.2	20.6	7.3	19.7	23.0	4.17	-26.01	-0.36
	2010	20.1	14.0	7.2	13.2	12.9	2.80	-17.09	-0.28
under-5 mortality	1990	59.0	36.1	12.9	36.1	46.0	4.56	-51.63	-0.39
	2000	36.4	24.3	8.6	23.6	27.8	4.22	-34.22	-0.37
	2010	26.1	16.4	8.3	16.3	17.8	3.15	-30.15	-0.32
maternal mortality	1990	168.4	128.9	23.5	86.7	144.9	7.17	-186.19	-0.48
	2000	112.6	99.2	23.3	67.3	89.3	4.84	-131.45	-0.43
	2010	81.5	82.3	30.6	58.9	50.9	2.66	-77.33	-0.28

N/A: not available

Table 5 Health inequalities as defined by access to water and sanitation. Brazil and Peru; circa 2000 and 2010

country-case and health dimension	year	quartiles of access to water or sanitation				national overall mean	health inequality metrics			
		lowest	second	third	highest		lowest-to-highest gap		whole gradient	
							absolute	relative	SII	HCI
Brazil; water no-prenatal care	2001	6.7	8.2	2.7	2.3	4.4	4.4	2.89	-7.60	-0.29
	2009	3.7	2.1	1.7	1.1	1.9	2.5	3.20	-2.43	-0.22
Brazil; sanitation life expectancy	2001	68.2	69.1	70.6	72.5	70.9	-4.3	0.94	5.81	-0.33
	2009	71.3	71.3	74.3	74.7	73.4	-3.4	0.95	4.95	-0.31
Peru; water infant mortality	2000	55.3	46.6	42.2	19.9	38.8	35.4	2.78	-43.92	-0.18
	2010	33.5	25.7	22.8	14.4	21.9	19.1	2.32	-26.35	-0.19
Peru; sanitation under-5 mortality	2000	95.4	69.4	65.4	33.6	60.6	61.8	2.84	-78.58	-0.21
	2010	39.8	37.0	30.8	18.4	28.6	21.4	2.16	-34.64	-0.19



Photo: Chandrashekar Reddy



References

1. WHO/UNICEF, Joint Monitoring Programme for Water Supply and Sanitation (JMP). See data at: <http://www.wssinfo.org/>.
2. World Health Organization. UN-Water Global Annual Assessment of Sanitation and Drinking Water (GLASS) 2010 report: targeting resources for better results. Geneva: WHO, 2010. Available at: http://www.unwater.org/downloads/UN-Water_GLAAS_2010_Report.pdf.
3. Pan American Health Organization. Health in the Americas: 1998 edition. Vol. 1. Washington, D.C.: PAHO, 1998.
4. Pan American Health Organization. Health in the Americas: 2002 edition. Vol. 1. Washington, D.C.: PAHO, 2002.
5. Pan American Health Organization. Health in the Americas: 2007 edition. Vol. 1. Washington, D.C.: PAHO, 2007.
6. Pan American Health Organization. Health in the Americas: 2012 edition. Vol. 1. Washington, D.C.: PAHO, 2012.
7. Marmot M. [Chair]. Closing the Gap in a Generation: Health Equity through Action on the Social Determinants of Health. Final Report of the Commission on Social Determinants of Health. Geneva: World Health Organization, 2008. See summary at: <http://www.coloradotrust.org/attachments/0002/0252/Marmot.et.al.SocialDeterminantsofHealth.pdf>.
8. Tukey JW. Exploratory Data Analysis. Menlo Park: Addison-Wesley, 1977.
9. Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, Adair-Rohani H, et al. 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.
10. Institute for Health Metrics and Evaluation Global Health Data Exchange. See data downloads from the Global Burden of Disease 2010 study, GBD 2010 results by risk factor 1990-2010. Available at: <http://ghdx.healthmetricsandevaluation.org/record/global-burden-disease-study-2010-gbd-2010-results-risk-factor-1990-2010>.
11. United Nations, General Assembly. The Human Right to Water and Sanitation. New York, 2010. Resolution 64/292. Available at: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/64/292.
12. Mujica OJ. Determinants of Health Model. In: Boslaugh S, ed. *Encyclopedia of Epidemiology*. Thousand Oaks, California: SAGE Publications, 2008. vol. 1, pp. 263-266.
13. Whitehead M. The Concepts and Principles of Equity and Health. Copenhagen: World Health Organization Regional Office for Europe, n/d. Document EUR/ICP/RPD 414 7734r. Available at: http://whqlibdoc.who.int/euro/-1993/EUR_ICP_RPD_414.pdf.
14. Dahlgren G, Whitehead M. Policies and strategies to promote social equity in health. Stockholm: Institute for Futures Studies, 1991.
15. Mujica OJ. Eco-Epidemiology. In: Boslaugh S, ed. *Encyclopedia of Epidemiology*. Thousand Oaks, California: SAGE Publications, 2008. Vol, 1, pp. 295-297.
16. Dahlgren G, Whitehead M. European Strategies for Tackling Social Inequalities in Health: Levelling Up. Part 2. Copenhagen: World Health Organization, 2006.
17. Acheson D. [Chair]. Independent Inquiry into Inequalities in Health: Report. London: HSMO, 1998. Available at: <http://www.archive.official-documents.co.uk/document/doh/ih/ih.htm>.
18. Institute of Medicine of the National Academies. The Future of the Public's Health in the 21st Century. Washington, D.C.: The National Academies Press, 2003.
19. Pan American Health Organization. Health Situation in the Americas Basic Indicators. Washington DC; 1995-2012.
20. Harper S, Lynch J. Measuring Health Disparities: Self-Learning Course. Ann Arbor: University of Michigan School of Public Health, 2006.

21. Schneider MC, Castillo C, Bacallao J, Loyola E, Mujica OJ, Roca A. Métodos de Medición de las Desigualdades de Salud. *Pan Am J Public Health* 2002;12(6):398-415.
22. Minujin A, Delamonica E. Mind the Gap! Widening Child Mortality Disparities. *Journal of Human Development* 2003;4(3):397-418.
23. Maddala GS. Introduction to Econometrics, 3rd Ed. Chichester: John Wiley & Sons, 2001.
24. Murray CJL, Lopez AD. The Global Burden of Disease. Cambridge: Harvard University Press; 1996.
25. Brulle RJ, Pellow DN. Environmental Justice: Human Health and Environmental Inequalities. *Annu Rev Public Health* 2006;27:103-124.
26. McMichael AJ, Nyong A, Corvalan C. Global Environmental Change and Health: Impacts, Inequalities, and the Health Sector. *British Medical J* 2008;336:191-194.
27. Bolte G, Tamburlini G, Kohlhuber M. Environmental Inequalities among Children in Europe – Evaluation of Scientific Evidence and Policy Implications. *European J of Public Health* 2009;20(1):14-20.
28. Braubach M, Martuzzi M, Racioppi F, Krzyzanowski M. Understanding and Addressing the Influence that Social Inequities have on Environmental Health. *European J of Public Health* 2010;20(1):12-13.
29. Bambra C, Gibson M, Sowden A, et al. Tackling the Wider Social Determinants of Health and Health Inequalities: Evidence from Systematic Reviews. *J Epidemiol Community Health* 2010;64:284-291.
30. World Health Organization, Regional Office for Europe. Environmental Health Inequalities in Europe. Copenhagen: World Health Organization, 2012.
31. Rangel Soares LC, Griesinger MO, Dachs JN, Bittner MA, Tavares S. Inequities in Access to and Use of Drinking Water Services in Latin America and the Caribbean. *Pan Am J Public Health* 2002;11 (5/6): 386–96. Available at: <http://www.scielosp.org/pdf/rpsp/v11n5-6/10723.pdf>.
32. Chan M. Universal Access to Water and Sanitation: the Lifeblood of Good Health. Keynote Address, Budapest Water Summit 9 October 2013. Available at: http://www.who.int/dg/speeches/2013/water_sanitation/en/.
33. Budapest Water Summit. A Water-Secure World: the Budapest Water Statement. Budapest, 2013. Available at: http://www.budapestwatersummit.hu/data/images/Budapest_Water_Summit_Statement_Final_11_October_2013.pdf.
34. Pan American Health Organization. Water and Sanitation: Evidence for Public Policies Focused on Human Rights and Public Health Results. Washington, D.C.: PAHO, 2011. Available at: http://www.paho.org/hq/index.php?option=com_content&view=article&id=5172&Itemid=3757.
35. Cook C, Bakker K. Water Security: Debating an Emerging Paradigm. *Global Environmental Change* 2012;22:94-102.
36. Bain RES, Gundry SW, Wright JA et al. Accounting for Water Quality in Monitoring Access to Safe Drinking-Water as part of the Millennium Development Goals: Lessons from five Countries. *Bulletin of the WHO* 2012;90:228-235A.
37. Onda K, LoBuglio J, Bartram J. Global Access to Safe Water: Accounting for Water Quality and the Resulting Impact on MDG Progress. *Int J Environ Research Public Health* 2012;9:880-894.
38. Hutton G, Haller L, Bartram J. Global Cost-Benefit Analysis of Water Supply and Sanitation Interventions. *Journal of Water and Health* 2007;05.4:481–502. Available at: <http://www.iwaponline.com/jwh/005/0481/0050481.pdf>.
39. World Health Organization. See Resources on Water, Sanitation and Health Policy at: http://www.who.int/water_sanitation_health/en/.

Future policies must consider the many populations that lack or have limited access to water, sanitation, and hygiene (WASH) and seek to eliminate their unfair impoverishment due to the cost of access, as well as their increased risk for disease and its related toll.

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