

Advocating for Safe and Healthy Public Transportation

Increasing Health Participation within a Multisectoral Framework



**Pan American
Health
Organization**

*Regional Office of the
World Health Organization*

PAHO HQ Library Catalog-in-Publication

Pan American Health Organization
"Advocating for Safe and Healthy Public Transportation"
Washington, D.C.: PAHO, © 2010

ISBN: 978-92-75-13092-6 (Print)
978-92-75-13195-4 (CD-ROM)

I. Title

1. TRANSPORTATION – legislation & jurisprudence
2. ACCIDENTS, TRAFFIC – prevention & control
3. COMPUTER SYSTEMS
4. ROADS
5. SECURITY MEASURES – standards
6. ACCIDENT PREVENTION – methods
7. ENVIRONMENT AND PUBLIC HEALTH – analysis
8. SAFETY – standards

NLM WA 275

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Published by

Pan American Health Organization

Pan American Sanitary Bureau, Regional Office of the
World Health Organization
525 Twenty-third Street, N.W.
Washington, D.C. 20037
www.paho.org

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Acknowledgments:

We are very grateful to Monica Spencer, Gustavo Bergonzoli, Edgar Pozo-Ore, Matts Ake Belin, Meleckidzedeck Khayesi, and Enrique Jacoby for their useful input and suggestions provided during the development of this document and to Roberta Okey for editorial contributions.

Suggested citation: Villaveces A. & Rodrigues, E.M.S. Advocating for safe and healthy public transportation: Increasing health participation within a multisectoral framework. Washington DC: Pan American Health Organization; 2009.

Front cover: Héroes station, Transmilenio bus rapid transit system. Bogotá, Colombia. (Photo by Andrés Villaveces).

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Transportation systems are very complex and require consideration of a large number of variables and approaches from different sectors as well as an understanding of multiple and interacting contexts. And while transportation systems are useful to and needed by society, they can be hazardous to human health.



Introduction

Transportation and human mobility are fundamental aspects of society. Efficient and healthy transportation systems that consider the well-being of populations are a desired and needed goal. A healthy and safe transportation system is one that is based on a legal framework which incorporates multisectoral work for its planning, design, and development; addresses equity at the population level; is affordable, reliable, and efficient; and has a low impact on the physical environment while providing safety to its users.

There are multiple concrete elements that comprise a transportation system. These include its physical infrastructure, the modes of transportation used, and the types of users. Each of these elements determines how the system functions. This document highlights general health consequences that are linked to transportation modes and focuses on the benefits of efficient and safe public transportation within an overall transportation system. At the same time, it urges health professionals to become involved in multisectoral teams and provide critical input and expertise that can lead to the development of more adequate and effective transportation systems.

The development, management, and sustainability of transportation systems should not only respond to economic targets and/or interests, but also reflect at their core a key understanding of the health implications these systems carry for individuals and communities alike. Structural designs should be based on concepts that reflect a clear understanding of how human health is affected by transportation, and they should foster healthy human behaviors and exposures rather than hinder them. Public transportation is presented within this context as an economically desirable alternative which, if integrated appropriately within the overall community transportation structure, has the potential to decrease social inequalities, improve the efficiency and reliability of human mobility, protect and even improve the physical environment, accommodate and compensate for human vulnerabilities and fallibility, and provide safety to its users.

With the aim of contributing to the improvement of health conditions among all populations in the Region of the Americas, this document highlights the negative health consequences of inappropriate transportation systems and presents useful strategies for overhauling and transforming them, while at the same time advocating for the continued development of well-designed, integrated, and economically viable public transportation systems that promote human health and overall quality of life.

The text opens with a discussion of the complex interactions that exist within transportation systems. It then describes how different modes of transportation produce distinct benefits as well as risks and proceeds to focus on how well-integrated multimodal public transportation systems can produce the greatest number of benefits.

Public transportation as a subset of overall transportation structure plays a unique role in the lives of community dwellers. The risks of not implementing proper public transportation systems are described by presenting a variety of negative health outcomes linked to design issues such as urban sprawl, which in turn brings increased road traffic injuries, noise levels, atmospheric pollution, and environmental de-gradation; more sedentary practices linked to larger amounts of time spent driving and the consequences of insufficient physical activity; heightened levels of stress and the development of other negative mental health conditions; and growing social isolation, feelings of depression, and an overall reduction in social cohesion.

Preventive or corrective actions are also presented for each of these problems with the aim of fostering cohesive health promotion strategies and responses, actively engaging health personnel in their formulation, and reducing the burden of transportation-related health issues on health care systems. It is the desire of the Pan American Health Organization that the information provided here, including the policy implications and suggested directions presented near the document's end, will contribute to enhancing the health sector's participation in the design of sound transportation policies, strategies, and systems throughout the Americas.

By raising awareness among decision-makers and the general public alike of key health promotion concepts and health concerns related to transportation systems, the health sector can play a leadership role within a multisectoral partnership whose work can improve the health status, quality of life, and physical environment of communities across the Hemisphere.

Transportation Systems and their Complexity

Transportation systems are very complex and require consideration of a large number of variables and approaches from different sectors as well as an understanding of multiple and interacting contexts. And while transportation systems are useful to and needed by society, they can be hazardous to human health. Within transportation systems, there exists a multiplicity of factors that include modes of transportation (i.e., motorized or non-motorized), roads and other physical infrastructure, and different types of road users, all of whom are imbedded in their physical, social, and economic environments and who have specific behaviors and needs. Some important characteristics of transportation systems are their efficiency, reliability, and population coverage, but the most significant consideration should always be their safety.

To understand the system as a whole and the interaction between its elements, as well as to be able to identify where there is potential for effective intervention, the active participation of health researchers and practitioners is essential. There are direct and indirect health consequences related to the multiple variables within the system. There are consequences related to the physical and environmental design of the system; there are those related to how the system works or is used by people; there are others related to the modes of transportation used, and, specifically, to each vehicle type; and there are health and social consequences that permit or impede individuals from actually accessing the different transportation services provided in their communities.

Because of this combination of health consequences related to transportation, it is of vital importance that health professionals share their knowledge and provide technical input at every stage—conception, design, implementation, and maintenance—of transportation systems. Specifically, this process requires the recognition that the human body is highly vulnerable to injury, pollution, noise, and other stressors; that certain exposures can increase or decrease the likelihood of occurrence of negative health events; and that humans make mistakes. A safe transportation system is therefore one that can accommodate and compensate for these human vulnerabilities and fallibility (1).

Incorporating the participation of public health professionals in all aspects of transportation systems facilitates the opportunity for the promotion of healthy behaviors, since this group can provide expert guidance in the prevention of negative health outcomes and a proper response to health events. A key concept is that many of the health consequences that come out of the design and use of transportation systems have multiple causes. Some of these are immediate, and most are frequently modified by more long-term structural causes (environmental design or system functioning) that can be examined and acted upon to improve human health.

Public Transportation within Transport Systems

From a public health perspective, there is ample opportunity to enhance health on a population-wide scale through involvement in the promotion of safe and healthy transportation systems. Within these systems, efforts should be aimed at improving the quality of public transportation modes by making them not only safe for passengers but also by properly integrating them into road infrastructures that consider the safety of unprotected users (i.e., those using non-motorized modes) by means of physical segregation. This is especially important given the trend toward increased usage of public transportation that has been observed in the Region of the Americas in recent years.

In 2000, for example, urban transit systems in Canada handled almost 1.5 billion passengers, an increase of 4.2% over the previous year (2). In the United States, there also has been a trend toward growing reliance on public transportation. In Latin America and the Caribbean as a whole, 33% of the population uses public transportation and 44% uses non-motorized means as their main mode of mobility (3). In Brazil, for example, 43% of Porto Alegre residents use public transportation; in Curitiba, this figure reaches 70%; whereas in Lima, Peru, it is 80% (4), the same as in Bogotá, Colombia.

Many Latin American cities are developing or integrating bus rapid transit (BRT) systems that carry high volumes of users across well-planned grids and networks to the metropolitan hub. For example, in Mexico City, the Metrobús BRT system moves approximately 250,000 passengers on average, every weekday (5). The Metrobús-Q system in Quito, Ecuador, transports some 440,000 passengers daily (6), while the highest volume—some 1,220,000 passengers—use the Bogotá TransMilenio system daily. The public health opportunity to have an impact upon these populations is huge, and participation by the public health sector—together with colleagues from other fields providing input to the process of continued development and extension of these systems into new locales—has never been more timely.

Crash Events and Public Health

To analyze the risks of injury and improve road safety and health related to transportation, several factors need to be taken into account. These include the number of people who are exposed to risk due to commute or travel times; the distinct risks to which different users are exposed; the population density; economic and demographic factors; the level of motorization; the different available modes of travel; the volume of unnecessary trips; land-use planning practices; the underlying probability of a crash given a particular exposure; behavioral risk factors such as excessive speed and drinking and driving, among others; unsafe vehicles,

unsafe road design, and lack of safety regulations and/or effective law enforcement.

In the case of a crash occurrence, public health professionals, in collaboration with experts specialized in transportation and environmental issues, need to consider the probability of injury given such an event and how the use of protective devices (e.g., seat belts, child restraints, crash helmets), elements related to vehicle design, and human tolerance factors can modify outcomes. Once injuries occur, public health professionals and their other multisectoral colleagues also need to consider the injury outcomes and risk factors that can modify them, such as delays in detecting a crash event, delays in promptly responding to an emergency and providing life-saving measures and/or psychological assistance, and delays in accessing health care services that can effectively treat and/or rehabilitate the injured (7). For each one of these factors, there are known preventive, protective, or rapid response measures that can be closely linked to transportation services. For these to be put into place, the expertise of the public health sector needs to be incorporated alongside that of others in the established multisectoral framework.

In environmental terms, the design, layout, and use of a community's physical structures—such as housing, businesses, transportation systems, and recreational resources—affect the patterns of living and behaviors of people, which in turn have direct effects on health (7). The use of land, whether for schools or parks, or for residential, retail, office, or other recreational purposes, should be integrated so as to facilitate connectivity between these sites and allow people to easily accomplish daily tasks and activities on foot or by bicycle. More compact physical spaces mixed with shops and services create a friendlier environment for pedestrians. By raising the profile of a pedestrian presence, streets also become safer. Public transportation that interconnects these spaces can facilitate use of multiple modalities of transport and improve the public's health by promoting more active forms of mobility (8).

Links of Different Modes of Transportation to Risks and Benefits

Different modes of travel carry different risks of injury and death. Among the non-motorized modes, pedestrians are subject to the highest risk because the lack of physical protection renders them the most vulnerable when involved in collisions with other modes of transport. Other high-risk modes include travel by motorcycle and bicycle. In Latin America, the density of motorcyclists has increased substantially in many cities. In São Paulo, Brazil, for example, the majority of land transport injuries occur among motorcycle users (9).

In highly motorized countries, most traffic injuries and mortalities occur among motor vehicle drivers. Within this group, males and younger age groups bear a disproportionate share of the burden. The density of motor vehicles, as well as individual driver factors, can increase the likelihood of crashes. These factors include speeding, aggressive driving, driving under the influence of alcohol or other substances, and not wearing restraint devices (7). The more drivers there are at a given place and time, the more influence these individual factors will have on the likelihood of an injury occurrence. With fewer drivers, more easily enforceable driver controls, and reduced speeds in urban areas, the public transportation mode—such as a bus or rail system with large vehicles—affords one of the safest modes of transportation (1, 10). However, to ensure optimum safety for this mode, appropriate and sustainable institutional integration, collaboration, and controls must be in place. In addition to its relative safety, this mode is also the most highly efficient in moving large volumes of passengers from one point to another, has fewer negative consequences for the physical environment, and contributes to addressing social inequalities by offering an easily accessible service. Universal mobility and accessibility, independent of the automobile, promotes and supports public health protection and advancement, whereas private

transportation forms carry many external and poorly recognized health costs (11). Evidence from a Health Impact Assessment (HIA) recently conducted in Edinburgh, Scotland, has shown that greater spending on public transportation and supporting sustainable modes of transport can be beneficial to health and offers considerable scope to reduce social inequalities (12).

Overall Consequences to Health Linked to Transportation

As noted earlier, transportation systems are complex and their structure and functions determine not only how people behave but also the types of risks and benefits to which they are exposed. The consequences of exposure to these risks lead to a myriad of individual health outcomes and also have serious economic and social implications. In this section, the main health risks associated with different modes of transportation are discussed.

The way in which communities are designed impacts directly on how people interact with one other and determines the risks and benefits to which individuals are exposed. In communities characterized by sprawl, irregular development, and segregated land use, there tend to be higher volumes of vehicular traffic, fewer other forms of viable transportation available, and public transportation that is often unreliable, of limited range, infrequent, not affordable, or nonexistent. These settings commonly are unfriendly to pedestrian use, and single-purpose commercial areas are usually segregated from their residential counterparts. As a consequence, reliance on the automobile is greatly increased.

These factors have direct and indirect effects on human health. As the amount of time spent in automobiles grows and interaction occurs among ever-larger volumes of vehicles, the risk of traffic crashes proportionately increases. The heightened likelihood of being involved in a traffic collision not only affects the rate at which events occur, but once they do will also af-

fect how quickly first responders are able to reach the scene. In communities characterized by urban sprawl, traffic congestion and the longer distances needed to be traveled translate into critical time lost in reaching and providing on-site critical care to those with life-threatening injuries and prevent a timely arrival at health facilities specialized in emergency care.

Increased traffic in overgrown, poorly planned urban areas not only leads to a greater probability of traffic crashes but also increases air pollution levels (8). Higher concentrations of pollutants in the atmosphere can exacerbate preexisting respiratory conditions, such as asthma and other lung disorders. The continuous increase in traffic density, the expansion of roadway infrastructure to accommodate growing volumes of motor vehicle traffic, and the need to provide adequate parking areas also lead to environmental decay. Throughout much of the last half of the 20th century, it was not uncommon for the designers and planners of large metropolitan areas to be more responsive to the needs of automobile commuters than to the plight of city dwellers. This way of thinking and acting had direct negative effects on the health of urban populations and resulted in a deteriorating quality of life (13).

A higher dependence on the automobile also fosters behaviors that lead to a more sedentary lifestyle, and, in turn, higher rates of obesity and associated cardiovascular conditions. Extended commute times have been linked with increased stress, annoyance, and anxiety among commuters. Such prolonged or chronic exposures have likewise been associated with hypertension, heart disease, and other negative health outcomes.

For low-resource populations living far away from centrally located and more economically active settings, commute times are even longer. When public transportation services are inadequate, limited, or nonexistent, the options open to this group are particularly restricted, given that its members oftentimes do not have the means to purchase an automobile. Likewise, individuals who are homebound for health or other reasons and do not have ready access to automobile transportation will

also find themselves more frequently in situations of social and physical isolation, thereby increasing the feelings of depression and presenting obstacles for rapid health care access when it is needed.

Other negative consequences of disorganized transportation infrastructures, particularly in urban settings, include reduced person-hours of work time and inefficient fuel use due to congestion and/or long commutes, poor environmental air quality, loss of productivity or premature death caused by road traffic injuries, and high hospital costs associated with these and other health outcomes. Other issues include loss of property value due to increased environmental noise, proximity to industrial hazards, loss of green spaces, increased crime, and a general reduction in quality of life (14).

Unplanned transport systems, in which private-use vehicles abound and where traffic density and congestion are highly prevalent, also cost society more money. Evidence from the World Bank suggests that in 2000, the estimated cost of congestion in the cities of São Paulo, Santiago, and Buenos Aires ranged between 1.4% and 3.4% of gross domestic product (15).

The following sections in this document highlight specific evidence about health problems associated with nonexistent, uncoordinated, or inefficient transportation systems.

Road Safety

Road safety and efficient transportation that serves the local needs of communities are imperative public policy and health issues in every country. The degree of road safety in any nation is related to the layout of its transportation systems and has considerable implications for the health of its inhabitants as well as for that of the environment. This layout not only refers to the actual physical structures that enable the system to function, but also to the different available modes of transportation, their efficiency, and the way people use them.

There is ample evidence that increased time and distance of travel are linked to a greater likelihood of being involved in traffic crashes (16–18). Current data also show that one of the most serious public health problems among young populations is related to road safety.

Global Magnitude of Road Traffic Injuries

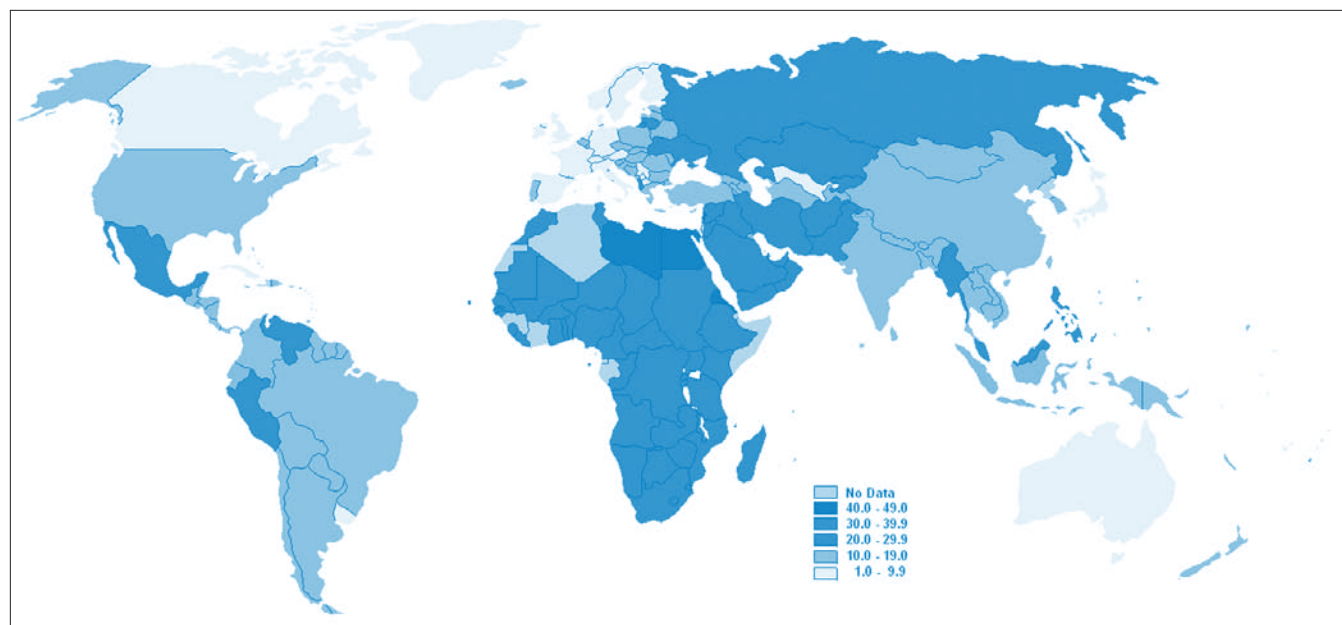
Approximately one-quarter of all injury fatalities that occur in the world are related to transportation (1). These are equivalent to about 2.1% of all causes of mortality. Globally, there are approximately 1.2 million deaths related to road traffic injuries on a yearly basis. This is equivalent to approximately 3,000 fatalities each day. In addition to these, the annual number of people with nonfatal injuries could be as high as 50 million (1). Of the total number of deaths, approximately 85% and 96% of child mortalities occur in low- or middle-income countries, respectively. More than half of all deaths occur in the 15–44-year-old age group (19). Estimates from the World Health Organization (WHO) indicate a trend of rising mortality rates if adequate measures are not taken. Estimates from the WHO Global Burden of Disease Project (20) and the World Bank's Traffic Fatalities and Economic Growth Project (21) suggest that global trends of road traffic injuries will rise significantly, but unequally, in different regions of the world. This rise will likely affect countries with fewer economic resources, given the high costs that it can generate. Current data show that while there is considerable regional variation (Figure 1, Table 1), that the South-East Asia and Western Pacific Regions are those where ab-

solute numbers of road traffic injuries are the highest (1), whereas fatality rates from injuries tend to be higher in the African and Eastern Mediterranean Regions.

Both the WHO and the World Bank data estimation approaches account for data underreporting, which also differs from country to country. While the largest increases in absolute numbers will most likely occur in the South-East Asia and the Western Pacific Regions (21), in the year 2000, the Region of the Americas—and, more specifically, Latin America and the Caribbean—had high fatality rates (26.1 per 100,000 population) and will continue to have them according to projections for the year 2020 (31 per 100,000 population).

Magnitude of the Problem in the Americas

Road safety measures and the nature of road traffic injuries vary widely in the Americas. The majority of overall injury fatalities in high-income countries of the Americas, such as Canada and the United States, are traffic-related, with younger populations being the most affected throughout the Region. When comparing traffic-related fatality rates of middle- and low-income countries in the Americas, with few exceptions, countries with less income and less motorization, as measured by motor vehicles per 1,000 population, tend to have higher traffic-related mortality rates (Table 2). The number of motor vehicles is not the only factor associated to injury rates, however, but rather one of many more that include educational, legal, behavioral, enforcement, and infrastructure factors.

FIGURE 1. Estimated road traffic injury fatality rates^a (per 100,000 population), by country, 2009.

^aConsidered to be a traffic-related fatality if occurring within 30 days of event.

Source: Adapted from the World Report on Road Traffic Injury Prevention (7) and WHO Global Status Report on Road Safety: A Time for Action (22).

TABLE 1. Modeled road traffic injury fatality rates^a (per 100,000 population), by WHO Region and income group, 2009.

WHO Region	High income	Middle income	Low income	Total
African Region ^b	–	32.2	32.3	32.2
Region of the Americas ^c	13.4	17.3	–	15.8
South-East Asia Region ^b	–	16.7	16.5	16.6
Eastern Mediterranean Region	28.5	35.8	27.5	32.2
European Region	7.9	19.3	12.2	13.4
Western Pacific Region	7.2	16.9	15.6	15.6
Global	10.3	19.5	21.5	18.8

^aConsidered to be a traffic-related fatality if occurring within 30 days of event.

^bNo high-income countries.

^cNo low-income countries.

Source: Adapted from WHO global status report on road safety: a time for action (22).

TABLE 2. Age-standardized road traffic mortality and motorization rates, by World Bank income level,^a selected countries^b of the Region of the Americas, latest data available.

Country	Income level	Mortality rate (per 100,000 population) ^c	Motorization rate (per 1,000 population)
Venezuela	Upper-middle	21.81	146 ^d
Peru	Lower-middle	21.51	55 ^e
Mexico	Upper-middle	20.75	211 ^e
Guyana	Lower-middle	19.92	173 ^d
Paraguay	Lower-middle	19.68	94 ^d
Suriname	Upper-middle	18.34	330 ^d
Brazil	Upper-middle	18.33	259 ^d
Saint Lucia	Upper-middle	17.58	301 ^d
Dominican Republic	Lower-middle	17.33	113 ^e
Bolivia	Lower-middle	16.74	73 ^d
Belize	Lower-middle	15.64	188 ^d
Trinidad and Tobago	High	15.53	295 ^e
Costa Rica	Upper-middle	15.40	201 ^e
Guatemala	Lower-middle	14.74	121 ^d
Bahamas	High	14.49	289 ^e
Nicaragua	Lower-middle	14.22	37 ^e
United States	High	13.94	779 ^f
Argentina	Upper-middle	13.73	180 ^e
Chile	Upper-middle	13.71	146 ^e
Honduras	Lower-middle	13.50	111 ^d
Panama	Upper-middle	12.80	112 ^f
El Salvador	Lower-middle	12.61	64 ^e
Jamaica	Upper-middle	12.31	118 ^d
Barbados	High	12.25	338 ^f
Colombia	Lower-middle	11.72	107 ^d
Ecuador	Lower-middle	11.69	56 ^e
Canada	High	8.79	585 ^f
Cuba	Upper-middle	8.56	58 ^d
St. Vincent and the Grenadines	Upper-middle	6.64	202 ^d
Uruguay	Upper-middle	4.34	160 ^c

^aIncome level classified according to 2007 gross national income per capita (23). ^bCountries have been ranked by order of magnitude of most recently reported overall traffic mortality rate. ^cData from (24). ^dData from (22). ^eData from (25, 26). ^fData from (1).

Modes of Transportation and Road Safety

A comparison of injury risks by mode of transportation in six European countries found that by calculating injury rates per kilometer traveled, pedestrians, bicyclists, and motorcyclists—relative to automobile occupants—were at increased risk, and bus passengers were at decreased risk (27). A study of school travel risks in the United States showed that teen drivers in passenger vehicles had the highest injury and fatality rates, while the lowest rates were found among students riding school or other buses. The study also revealed that the fatality rate of teenagers driving passenger vehicles was approximately eight times higher than the rate for adult drivers (28). Recent data from the United Kingdom similarly shows that the lowest rates of fatalities per 100 million passengers by mode of transportation occurs among bus riders (Table 3) (29).

This evidence has important implications for the countries of Latin America and the Caribbean, where public bus services and walking are common modes of transportation (30). It is important to reiterate, however, that vehicle/transportation mode is not the only factor in injury and fatality reductions. The design of transporta-

tion systems, their proper integration into communities, and coordination with other transport modes are also critical to this goal. It is also in these areas where the input of health professionals is so relevant, since the adequate incorporation of key health promotion concepts into the design and functional aspects of public transportation systems will ensure that human health and safety are optimally protected.

Transportation-related injuries and fatalities in the Americas are not equally distributed. Injuries tend to occur more among economically disadvantaged populations and specifically affect men, children, and older adults, most of whom are pedestrians. Transportation-related injuries also reflect who are the most likely to die from these injuries. In Cali, Colombia, for example, in 2006, more than 35% of fatal traffic injuries occurred among pedestrians. In Lima, Peru, the principal cause of death (72%) was due to pedestrians being run over by vehicles or involved in hit-and-run situations (31). The percentage of deaths related to public transportation ridership is considerably lower. All of these injury events and their negative consequences can be controlled or prevented. The absence of proper, coordinated, and integrated forms of public transportation can lead to many other health problems, as discussed in the following sections.

TABLE 3. Transportation fatalities, per 100 million passengers, by transportation mode, Great Britain, 2004.

Transportation mode	Per trip	Per hour	Per km
Motorcycle	100.0	300	9.7
Air	55.0	15	0.03
Water	25.0	12	0.6
Bicycle	12.0	60	4.3
Pedestrian	5.1	20	5.3
Automobile	4.5	15	0.4
Van	2.7	6.6	0.2
Rail	2.7	4.8	0.1
Bus	0.3	0.1	0.04

Source: Adapted from Victoria Transport Policy Institute data (29).

Characteristics of Public Bus Systems in Latin America

Historically in the Region of the Americas, transportation infrastructure has generally favored the use of the private automobile. Public transportation systems in most Latin American countries have been characterized by fragmented groups of companies that compete with each other to attract passengers. This competition frequently comes at the expense of the adoption of safe driving practices among bus drivers (32). With poor licensing practices and weak legal frameworks, there is little incentive for drivers to adopt safe behaviors. Consequently, service is usually of poor quality, and the passengers who use public bus systems are typically those who cannot afford to purchase private vehicles for their transportation needs.

Additionally, safety engineering and environmental requirements for these systems are often lax or poorly enforced. The adaptation of minivans for public use and poor engineering regulations for public vehicles further increase injury risks for passengers, given that safety devices (e.g., emergency exits, fire extinguishers, seat belts and other restraints, wheelchair accessibility for passengers with disabilities) are minimal or nonexistent. These types of bus systems have typically tended to function in unorganized patterns in which routes carry passengers from point to point, rather than within a network of primary and secondary routes. This situation has led to excessive services supply in large urban areas and only limited, insufficient service outside the confines of high-density commercial zones. In areas of excessive public transportation supply, safety—for both passengers and pedestrians—is further hampered by traffic congestion and poor or no proper separation of road users. As a consequence, injury and mortality risks and events are higher.

Noise and Health

There is ample evidence showing the adverse effects of noise on human communication, sleep, emotional disposition, school and work performance, hearing (33), and on cardiovascular health (34, 35). Increased traffic density is positively associated with noise, and noise levels can interfere with all types of communication. Children are especially sensitive to the health impact of noise, as well as those whose work exposes them to urban traffic coordination (33).

Excessive noise also produces sleep disturbances and annoyance by causing difficulty in falling and/or remaining asleep. The resulting reduction in sleep quality can subsequently lead to decreased task performance (36). A study in Canada found that respondents highly annoyed by traffic noise were significantly more likely to live closer to a heavily traveled road, to perceive annoyance to negatively impact health, and to report that traffic noise frequently interfered with their daily activities. The study reported that sex, age, education level, community size, and province had statistically significant associations with traffic noise annoyance. Respondents considered that reducing noise at night (between the hours of 10:00 p.m. and 7:00 a.m.) was more important than during the rest of the day (37). Similar findings were also reported in a study carried out Stockholm, Sweden (36).

Populations who are chronically exposed to excessive noise levels can become impaired in problem-solving tasks. These exposures can lead to elevated blood pressure and stress hormone levels. The HEARTS (health effects and risks of transport systems) study in Europe measured the effects of noise, including annoyance, sleep disturbance, and cardiovascular diseases such as hypertension and ischemic heart disease, and found that excessive noise can worsen these problems (38). A study in Slovakia found that preschool children attending kindergartens in areas where traffic noise was greater than 60 dB had higher blood pressure values and lower heart rate than their counterparts whose schools were

located in more quiet areas. In the former group, there also was a higher incidence of children with blood pressure values above the 95th percentile (35).

Observations at the population level also show that increased noise levels can be associated with more aggressive behaviors. Such behaviors can further impact cardiovascular health by increasing blood pressure. These effects can be mild, but when significant segments of the population are exposed, the public health impact can be considerable. Data from São Paulo, Brazil, indicate that workers exposed to road traffic noise can, over time, experience hearing impairment. The finding that prevalence was higher among those working in areas of greater noise levels (38%), as compared to that of those working in areas with lower noise levels (24.2%), suggests that long-term occupational exposure to urban noise plays an important role in the development of hearing impairment (33). A majority (73%) of respondents in a Curitiba, Brazil, study noted that the most disturbing noise source was that related to motor vehicle traffic (39). In the People's Republic of China, research on the health of traffic police revealed that this group was at a disproportionately high risk of incurring noise-induced deafness (40).

Pollution and Health (Respiratory Conditions)

Another negative health impact that is directly related to high traffic density, urban sprawl, and excessively long commutes is increased environmental pollution. Motor vehicle traffic is the main source of ground level concentrations of air pollutants. Human exposure to these pollutants is both inevitable and harmful. In northern Europe, motor vehicles contribute practically all carbon monoxide, 75% of nitrogen oxides, and about 40% of the particulate matter (i.e., particles $\geq 10\mu\text{m}$, or PM_{10}) concentrations. In Latin America and the Caribbean, air contamination is likewise largely due to emissions generated through transportation-related activities. The presence of high levels of sulfur in fuels; of numerous private vehicles and public buses that do

not meet current standards for fuel efficiency, safety, and environmental emissions; and of lax and inadequate pollution regulation, all take their toll on human health.

Inhalation of particulate matter, for example, can lead to more frequent respiratory symptoms linked to asthma, increased number of hospital admissions due to respiratory conditions and cardiovascular diseases, and mortalities from these causes. Evidence from the United States shows that recurrent cumulative exposure increases morbidity and reduces life expectancy and quality of life, and improvements in environmental controls with the resulting reduction in pollution, are associated with an increase in life expectancy (41, 42).

Ozone (O_3) is a noxious gas produced in areas with high traffic congestion where urban sprawl has led to long commutes by massive numbers of private vehicles. Ozone has been linked with reductions in lung function, increased bronchial reactivity, and increased admissions to hospitals. Persons experiencing asthma or other respiratory conditions tend to be the most affected by ozone exposure. In Latin America, the use of leaded gasoline likewise increases toxic exposures to this metal. There is ample evidence of the neurological impairment that lead exposure can produce among children.

Chronic exposures to atmospheric pollutants have also been associated with higher rates of lung cancer. Measures of pollution have likewise indicated that automobile users are more exposed to these gases and particulate matter. It is therefore desirable to reduce automobile use in favor of other transportation modes that pollute less or don't pollute at all. The health care costs associated with pollution-related morbidity are also extremely high. Occupational exposures are another area of concern. A study conducted in the People's Republic of China found that police officers working on city streets were more likely than those with indoor assignments to experience nasopharyngitis, photosensitive dermatitis, and eye diseases (40).

Studies have shown that proximity to roads is also linked to higher incidence of respiratory diseases. This

problem is of particular significance in Mexico City, Mexico; Santiago, Chile; São Paulo, Brazil; and Lima, Peru; the Latin American urban areas most affected by anthropogenic pollutant emissions. Pollution levels in Lima, for example, frequently far exceed the maximum allowed by WHO guidelines (31). Air pollution in Latin America has increased due to rapid urban development and, in particular, the accompanying increased motorization (43). In the 1990s, the population exposed to air pollutant levels exceeding WHO guidelines was estimated to be 81 million, or 26.5% of Latin America's total urban population, and 19% of its total population. These estimates included 30 million children aged 0–14, 47 million adults aged 15–59, and 4 million older adults aged 60 and over (44). More than a decade later, it is likely that these numbers are now much larger, due to increasing urbanization, motor vehicle use, and pollution levels.

Stress and Mental Health

High traffic density and long commutes have also been linked with increased levels of stress and other negative mental health consequences. A study of employees in U.S. industrial firms found that the distance and speed of the work commute accounted for significant proportions of variation in blood pressure levels. The longer the distance or commuting time, the higher these variations were found to be (45). Studies conducted in Canada have found that road rage is another consequence of prolonged, high-density commutes. Research in Toronto, for example, revealed that road rage perpetration increased significantly with the number of weekly kilometers driven and that victimization was significantly greater for drivers who were always on busy roads and lower for those who never drove on busy roads. Additionally, more road rage perpetration was reported among drivers of high-performance vehicles, perhaps due to the frustration they experienced when crowded urban roadways prevented them from taking full advantage of the engine capacity of their vehicles (46). Another study from Canada suggests that

prevention efforts might best be directed to long-term societal changes that emphasize structural modifications, such as reduced congestion on the roads, decreased driver stress, and promoting greater public transportation use (47).

In environments with long commutes and high traffic density, the likelihood of road traffic crashes also increases. Studies have shown that a large proportion of both adults and children involved in traffic crashes are likely to present symptoms of posttraumatic stress disorder (PTSD) (48). Approximately 14% of crash survivors experience PTSD, and 25% can develop psychiatric problems one year following a crash. As long as 18 months subsequent to these events, as many as one-third of those exposed to them can exhibit clinically significant symptoms, which include a sense of isolation and/or detachment, sleeping disorders, and mounting depression. With poor transportation infrastructures, such conditions can become more acute. A U.S. study of African-Americans with PTSD in Atlanta, Georgia, found that barriers to treatment included limited transportation and financial means, family disapproval, and unfamiliarity with mechanisms to access treatment, among others (49). In urban areas where sprawl is common, depression can also occur more frequently, even though the concrete environmental factors leading to this are not yet well understood (50).

Obesity and Health

In residential and commercial environments that have been designed principally around the use of motor vehicles and whose planning has not incorporated provisions that facilitate non-motorized transportation, walking and bicycling will be less viable options. Frequently in suburbs and sprawled urban areas, there is an absence of sidewalks or distances are too long for individuals to accomplish their daily tasks easily by foot or bicycle. Consequently, community members will be more likely to rely on automobiles for their transportation needs. This decision not only increases their exposure to traffic crashes, but also leads to less physically active lifestyles (30).

The consequences of a sedentary lifestyle in which exercise and walking are not encouraged or part of everyday life are overweight and obesity. Obesity increases susceptibility to illnesses and chronic health conditions. In the United States, as many as 300,000 deaths per year are attributable to obesity-related causes, with significant health care costs also being associated with the condition (51). In sprawling urban and suburban areas where few travel options exist, cars are now used for some 80% of trips less than one mile in distance. A U.S. study of Latin American females residing in the state of North Carolina found that one of the barriers to adequate participation in leisure-time physical activities was lack of transportation to places where exercise, recreational, and sports facilities could be easily accessed (52). A case study of 11 projects in predominantly low-resource communities in the United States found that environmental factors contributed to disproportionately high incidences of negative health outcomes, such as injuries and respiratory illnesses, in these locales, which are often also beset with structural and institutional inequities. For example, disenfranchised communities were more likely than wealthy communities to be the sites of environmental hazards and frequently lacked the infrastructure to support physical activity and the adoption of healthy eating habits (7).

Other Health Consequences

Social isolation is another phenomenon associated with community design, urban sprawl, and use of private automobiles versus public transportation, and in the current context may be described as a state in which individuals, certain social groups, or communities are faced with obstacles that hamper or prevent their access to labor markets, health care, education, and other basic community services. This social isolation is a common occurrence in environments where crime and unemployment levels are high and the quality of infrastructure (including transportation) is poor. Marginalized urban areas of Latin America and the Caribbean frequently suffer from a combination of inadequate infrastructure, high levels of violence, formidable chal-

lenges to mobility from one point to another, and poor community cohesion.

Traffic density can also directly affect social cohesion and communication among community members. In his book *Livable Streets*, Donald Appleyard found that on residential streets characterized by light traffic, people were three times more likely to develop friendships and social networks than on streets with heavy traffic (53). The increased presence of people on neighborhood streets has similarly been linked to reduced crime levels and general improved safety (54). Infrastructure development is therefore important, because it directly addresses structural inequalities and can contribute to improving community health status. In cities where sprawl has increased, close-knit communities have given way to residential areas where human interaction is less feasible, resulting in greater social isolation (53).

In countries with limited economic capacity, transportation costs can hamper access to timely health care. A study conducted in southwestern Uganda among individuals living with HIV/AIDS, for example, found that the need to locate funds for the monthly clinic visit was a constant source of stress and anxiety, and that lack of money for transportation was a key factor in cases of noncompliance with antiretroviral (ARV) regimens and missed medical appointments. Participants noted their struggles with competing demands between transportation costs and other necessities, such as food, housing, and school fees, which in turn compromised both ARV adherence and access to care (55). In India, failure to consider the broad spectrum of health effects that may result from transportation and land-use policies and investments has resulted in decisions that penalize the least affluent population sectors and make it more difficult for them to access to jobs, education, health care, amenities, and services (56). Such limitations of access can further hinder the development of personal independence and of sustainable social networks. The need for mobility and interconnectivity can also influence individuals' view of automobile transportation versus public and non-motorized transport modes.

The hazards of inappropriate and/or inadequate public transportation systems design, functioning, and oversight tend to have a multiplier effect, particularly in communities already struggling with poor socioeconomic and health status. The need for input by public health professionals working within a multisectoral team on how best to address health issues related to community transportation policies, standards, and regulation thus becomes quite evident. Public health experts can provide the necessary sound scientific and technical knowledge to promote and protect population health in general, and, specifically, can share evidence-based injury and disease prevention and safety interventions that can be effectively integrated with solutions contributed by other sectoral partners dealing with transportation issues at all levels.

Preventive Interventions

Public health professionals from a variety of academic fields can and should be incorporated into multisectoral teams applying their expertise to the development, design, implementation, and sustainability of effective and efficient public transportation systems. With enhanced community-wide access to transportation, opportunities for a more robust community health promotion strategy are also possible. At the same time, prevention messages and activities gain visibility due to the lowered risks of injury associated with public transportation use.

Enhancement of Road Safety: Focus on Safe Public Transportation within a Healthy Transport System

Preventive efforts can be aimed toward humans or at transportation systems. The former can be achieved through intervention strategies and behavioral modifications, while the latter is usually achieved through structural design. Both, however, must be supported by a legal framework. Control of behavioral issues related to transportation, for example, would include the use of restraining or protective devices, controls on the

use of alcohol and other psychotropic substances, and maximum vehicle speed limits.

In Latin America, as has already been noted, a significant proportion of human mobility is undertaken using public modes and a smaller proportion of the population utilizes private modes. Despite this situation, the necessary behavioral and legal controls to create a framework for safe and efficient transportation systems have been lacking. Fortunately, with the development in recent years of integrated mass transportation systems in various large urban metropolises, this issue is receiving more attention and the necessary controls are becoming more commonplace.

There is also evidence that use of public transportation is increasing among the population sector of private automobile owners. Curitiba, Brazil, provides one example of this: while the city has one of the highest rates of automobile ownership in the entire country, it also boasts one of the highest public bus ridership rates. As a matter of fact, recent surveys show that 28% of previous automobile commuters now rely on public transportation (4). Increased public transportation ridership reduces inner-city congestion and traffic density through the use of specially allocated bus routes, thereby permitting more rapid and efficient service. Numerous studies indicate that decreased travel time and effort and increased predictability and control reduce the stress levels and negative health effects that are, in contrast, associated with driving private vehicles. Connecting public transportation systems with non-motorized forms of mobility can, furthermore, also improve the walkability and pedestrian safety of large urban areas. The development of bus rapid transport (BRT) systems such as we have already described in Latin America and their combination and integration with a variety of other mobility forms can bring many health promotion benefits. But participation by health professionals in the emergence and implementation of these processes is crucial in order to ensure the protection of the population's health and well-being at all times.

A shift from private to public motorized transportation can diminish the likelihood of unwanted injury and

loss of human life by increasing road safety and decreasing traffic density and volume. According to 1994 data from the United States, public transportation trips result in 190,000 fewer deaths, injuries, and accidents annually than those by private automobile, providing US\$ 2–5 billion in safety benefits. Public transit has 0.03 fatal injuries per 100 million miles. This is equivalent to approximately 1/25th the rate for automobiles (57, 58). Both injuries as well as fatalities are reduced through the promotion and use of public transportation within a multimodal system that also respects the rights of vulnerable road users (e.g., pedestrians and bicyclists). The enhancement of security and the efficiency of mass transportation systems can also foster or increase its use. Riding the bus is 170 times safer than automobile travel, according to the U.S. National Safety Council (57).

In Latin America, as well, there is evidence of the effectiveness of public transportation in promoting human health and well-being. Within its first year of opening, Bogotá, Colombia's, high-speed, high-capacity TransMilenio system—which uses dedicated busways separating it from other traffic—registered a 32% reduction in average travel times by bus, a 93% drop in bus accidents, a 98% passenger approval rating, and improved property values along the busway corridor

due to lower crime rates and noise levels with all operating costs being covered through the farebox—thus eliminating the need for subsidies. Eleven percent of TransMilenio riders reported being former automobile drivers (59). Data suggest that the number of traffic crashes related to the public bus system of Curitiba, Brazil, is also very low (60).

Urban planning is crucial for reducing traffic deaths and injuries. In Bogotá, Colombia, a combination of traffic safety policies and public transportation initiatives cut road traffic deaths by almost one-half between 1996 and 2003 (61). The city's success in preventing injury and loss of human life demonstrates that these strategies are not only viable, but also necessary, even in cities where resources are more limited. Table 4 shows the significant decline in the number of traffic-related events that took place in Bogotá over less than a decade.

According to 2007 data from Colombia's National Institute of Legal Medicine and Forensic Sciences, of all modes of land transportation, the one associated with the lowest fatal injury rates was the TransMilenio BRT system (63). Despite the generally lower injury risks associated with public transport, however, more research on the effectiveness of public transport strate-

TABLE 4. Number of crash events, injuries, and fatalities related to traffic, Bogotá, Colombia, 1998–2007.

Year	Traffic crashes	Injuries	Deaths
1998	52,764	21,053	914
1999	52,327	22,035	872
2000	48,337	22,035	823
2001	42,776	24,265	764
2002	41,615	22,289	604
2003	40,175	22,884	759
2004	43,000	24,532	666
2005	35,838	17,249	564
2006	35,585	17,815	553
2007	31,083	15,029	486

Source: Adapted from data in Cohen J (62).

gies in reducing the incidence of road traffic injuries still needs to be carried out (1). While important advances have been achieved in Latin America—encouraging the use of public modes of travel, such as buses, as well as non-motorized cycling and walking, which pose fewer risks to others than do motor vehicles—the quality and safety of public transportation services nonetheless need to be ensured through sustainable regulation and legal enforcement mechanisms (64). The development of integrated, multimodal transportation systems not only has been associated with reductions in motorized-related injuries and fatalities, but the systems' environmental modifications (e.g., designated lanes to separate buses from motor vehicles and motorized from non-motorized traffic) have also reduced non-motorized-related injuries. In Bogotá, for example, there has been a 33% decrease in bicycle-related fatalities (from 115 in 2001 to 77 in 2004). These reductions have occurred despite increases in bicycle trips, because now riders use specially designed *CicloRutas* (dedicated bike paths connected to the Transmilenio BRT). Thus, bicycle-related injuries were reduced by 8.8% (from 2,754 in 2001 to 2,512 in 2004) despite a 38% increase in bike ridership (65).

In light of the disproportionate impact on underserved populations of problems related to pedestrian safety, general walkability, and access to services, local governments should consider strategies linked to engineering modifications, such as separation of road users and traffic-calming measures (e.g., speed ramps/bumps) (66), educational interventions including enhanced licensing requirements for public transportation drivers (66), and enforcement of regulations aimed at maintaining and improving safe engineering and environmentally friendly vehicular design. Structural and operational modifications in personal-use vehicles and public transportation infrastructure, combined with changes in human behavioral habits that take into account pedestrian movement and safety, will also lead to increased equity and benefit the common public good. Structural modifications aimed at reducing pedestrian injuries include street and sidewalk design (67); neighborhood planning and connectivity (68); proximity to jobs, schools, and services; and access to public

transportation (69). The pedestrian environment can be improved through inexpensive, short-term interventions as well as longer-term, more comprehensive infrastructure improvements (70).

The participation of public health professionals with other sectoral partners in a holistic approach that takes into account the health, social, and environmental consequences of transportation decisions will facilitate the identification of problems and populations at the highest risk of incurring traffic-related injuries and death. In this way, communities receive evidence-based input that enables them to adopt the best strategies for the development of walkable streets, connected streets, accessible streets, and, in essence, healthy streets. If a streetscape meets the needs of people of all ages, the visually impaired, and wheelchair users, then it likely offers a safer and more pleasurable walking experience for all *individuals* (70).

Creating communities where a diversity of human mobility options are available and viable can greatly reduce reliance on private motorized vehicle use, influence greater use of public transportation, and enhance awareness of non-motorized transportation alternatives, such as walking and bicycling, which not only provide mobility but also important benefits for personal health (71).

General Environmental Benefits

Noise Reduction

Studies in Sweden looking at traffic noise exposure suggest that, even at low levels, there is annoyance and sleep disturbance. Access to a quiet side of the street seemed to be a major protective factor for noise-related problems (36). In Curitiba, Brazil, a population survey revealed that the environmental noise sources found to be most disturbing were those related to motor vehicle traffic (73%) (39). BRT systems, by reducing urban congestion, also lower noise. In Bogotá, Colombia, for example, studies of the Transmilenio show that since the initiation of services, there has been a 30% reduction in the city's overall noise pollution (4).

Air Quality

Reducing urban traffic density by promoting the use of efficient public transportation leads to better air quality, which benefits both the physical environment and human health. According to figures available from the United States, public transportation produces, on average, per passenger mile, 95% less carbon monoxide, 92% fewer volatile organic compounds, 45% less carbon dioxide, and 48% less nitrogen oxide, when compared to private automobile emissions (57). Overall, public transportation is estimated to reduce carbon dioxide emissions by 37 million metric tons annually. It saves fuel, reduces an individual's carbon footprint, and reduces congestion. It provides an immediate option for people to reduce their energy consumption and greenhouse gas emissions (72).

A study of avoidable health effects produced by air pollution in three large Latin American cities—Mexico City, Mexico; São Paulo, Brazil; and Santiago, Chile—indicated that air pollution control policies would have vast health benefits. Among the numerous adverse health outcomes that could be averted by emissions reduction policies are more than 156,000 deaths, 4 million asthma attacks, 300,000 children's medical visits, and nearly 48,000 cases of chronic bronchitis in the three metropolises over a 20-year period. The economic value of the avoided health impacts would translate into between US\$ 21 billion and US\$ 165 billion (43). Many of these health benefits are obtainable through a stronger community health promotion focus on the role public transportation can play in safeguarding human health.

A study conducted by the Mexican National Institute of Ecology of the operation of Mexico City's Metrobús BRT system, for example, estimates that between 2005 and 2015, ridership along the busy Insurgentes Avenue corridor will reduce, on average, 144 tons of total hydrocarbons, 690 tons of nitrogen oxide, 2.8 tons of fine particulate matter, and 1.3 tons of sulfur dioxide annually. These emissions reductions prevent the avoidable loss of an average of 6,100 work days, 660 restricted activity days, 12 new cases of chronic bronchitis, and 3 premature deaths annually. The result-

ing health improvements are estimated to provide an average of US\$ 3 million in health benefits each year. Metrobús commuters traveling during peak hours along Insurgentes Avenue save more than 2 million hours in travel time each year, at an economic value of US\$ 1.3 million (73). Estimates for Bogotá's TransMilenio BRT suggest that for the period of 2001–2016, the system will reduce greenhouse gas emissions by some 4.86 million metric tons of carbon dioxide (74). Initial data suggest that there has a 40% drop in some air pollutants since operations began (for example, sulfur dioxide has dropped 43%, nitrogen dioxide 18%, and particulates 18%) (4).

While in Latin America public transportation ridership is high, the trend toward increased private motorization is competing with existing roadway and other public infrastructure. This situation presents both a challenge and an opportunity to transportation and public health planners and policymakers to drive home among the general public the specific health, economic, and environmental benefits that accrue from using public transportation. For example, promoting efficient public transportation use is in itself a beneficial health promotion strategy because it links the creation of multiple healthy behaviors—a more active lifestyle, increased exercise, and the use of non-motorized means of mobility—with injury reductions and better mental health status. Furthermore, public transportation can provide an affordable alternative to driving. In the United States, two-worker households that use public transportation instead of driving a car can save an average of US\$ 6,251 every year (72). Finally, promoting public transportation use also helps protect and preserve the environment and addresses climate change. Supporting a private automobile transportation system requires the allocation of a greater land mass area than that needed to support a public transportation system (75). Therefore, land devoted to public transportation use results in a smaller human impact on the environment, or ecological footprint (i.e., the amount of land required to produce the resources needed by a person annually), with buses and trains using a factor of 8 less land than private automobiles on a per person basis (76). Public transportation therefore increases land use effi-

ciency in urban areas that have chronic problems with high infrastructure density.

Physical Benefits of Increased Walking and Exercise

Well-designed, efficient, and affordable public transportation systems providing high connectivity and multi-modal access can facilitate the development of healthy behaviors and active lifestyles by providing opportunities for exercise (through walking and bicycling) as part of community members' daily lives. Transit-friendly and walkable communities tend to reduce reliance on motor vehicles and can lead to the increased likelihood and frequency of physical activity (77).

Evidence from Sweden suggests that public transportation is significantly negatively associated with overweight and obesity among men (78). A review of the benefits of public transportation related to obesity found that through active commuting, men who use public transportation to reach the workplace are significantly less likely to be overweight and obese (44.6%) (76). A 2006 study among students at the University of Western Australia reported that walking associated with public transportation use contributed to the students achieving higher levels of daily steps. It concludes that encouraging public transportation use could help increase and maintain community physical activity levels (79). Another 2004 study from Melbourne, Australia, found that factors influencing increased walking behavior included enhancing satisfaction with local physical and social surroundings and giving consideration to walkability, safety, and public transportation accessibility during environment planning processes (80).

Research in Portugal found that increased exercise among older adults contributes to better driver performance and improved safety. Properly designed environments promoting walking and public transportation could in turn facilitate safer driving among older populations when they are not using public transportation (81).

In general, the health benefits of regular sustained physical activity include reductions in the risk of devel-

oping coronary heart disease, hypertension, adult-onset diabetes, and overweight and obesity. People who exercise more frequently by using public transportation can also have reduced osteoporosis and fewer symptoms of anxiety or depression. Exercise can also contribute to reducing falls among older adults by strengthening joints and improving overall balance. Pedestrian-friendly environments integrated with public transportation infrastructure can facilitate opportunities for walking and bicycling, thereby increasing physical activity and contributing to the general population's quality of life and improve health status (82).

Overcoming Social Isolation and Inequalities

Specific projects in Latin America have addressed social isolation issues by increasing connectivity through public transportation systems. Examples of such measures can be found in Brazil through Line 4 of the São Paulo Metro, designed to connect a number of marginalized neighborhoods in the outlying suburbs with the city's more centralized commercial districts, and the Metro Cable project developed by the Medellín, Colombia, municipal government, which links depressed and remote mountain communities with the city's economic heart at the base of the Aburrá Valley through the use of air cable cars (83).

Social and Economic Benefits

There is considerable evidence that efficient, coordinated, and affordable public transportation improves health status. Studies in the United States, for example, have shown that the availability of public transit systems improves access to essential health and social services, provides important options for health care delivery, offers a vital link for the population with disabilities, and reduces Medicaid costs for low-income families by facilitating trips for nonemergency and routine care (58). Focusing on more disadvantaged or vulnerable populations is crucial. Yet there are important reasons to ensure access to and encourage public transportation use by all socioeconomic levels of society, thereby reducing inequity and providing opportunities for mobility for all. Studies have shown that public transportation use by social elites in developing countries can serve

to induce other segments of society to emulate their patterns and leads to better overall community use of public transit (84).

The availability of, and access to efficient, affordable, and reliable public transportation can have measurable positive impacts on the health of more vulnerable populations, such as children and older adults. Data from 2001 indicate that as many as 4 million U.S. children in families with annual incomes under US\$ 50,000 miss essential doctor appointments because of inadequate transportation (57). Public transportation enables seniors to maintain independence, continue to participate in the community and economy, and keep medical appointments and checkups (58).

Public transportation systems also save money. In Canada in 2000, urban transit companies accounted for 51% of the total bus industry revenues and urban transit systems earned gross revenues of just over US\$ 2 billion (2). In Colombia, the combined monetary annual benefits/savings of its various BRT systems, according to available Ministry of Transportation data, included US\$ 342.9 million in operating costs, US\$ 3.49 million in traffic-related injury reductions, and US\$ 3.88 million in pollution savings (85). In addition, researchers have shown that Bogotá's real estate market values proximity to BRT station locations and that the current value of the BRT system is capitalized into residential property rental prices (86, 87).

Like with any proposed community improvement, the most effective public transit systems are those that incorporate the local population's participation in their planning. Seeking a wide and diverse variety of potential approaches is not only desirable, but crucial, since the most effective modifications will be those whose design reflects vital input from neighborhoods and families who will be affected by them. Community participation efforts aimed at creating healthier environments should be based on sound health promotion principles, draw from first-hand community knowledge, and stress protective factors rather than focusing solely on interventions addressing risk factors. Participation

by key stakeholders can elicit innovative strategies and contribute in a more holistic way to transform evidence-based scientific findings and social policy objectives into actual practice. When communities are genuinely engaged in these habitat improvement processes, stronger and more long-lasting relationships between partner institutions and communities can be forged and the dialogue between governments and local populations is likely to be clearer and more equitable.

Like thousands of other unplanned *colonias* that have sprung up along the U.S.-Mexico border, El Cenizo in Web County, Texas, came into being through rapid urban and population growth, placing residents at high risk for chronic and epidemic diseases, and pedestrian injuries and fatalities, due to the challenging socioeconomic living conditions. El Cenizo voted to be incorporated as a city in 1989, and since then has established a record of active community involvement in all infrastructure improvements. A 2008 community assessment of El Cenizo identified a number of areas for future work that included the elimination of barriers to pedestrian mobility by removing unused cars and other debris, more frequent garbage collection, and addressing the issue of unattended dogs. Current plans of building a park will provide additional walking space and enhance already existing social interactions. Promoting the establishment of more local retail stores and supporting existing businesses may result in more utilitarian destinations within the *colonia*. Residents are likely to increase local consumption as they reduce reliance on automobiles to travel outside El Cenizo to access needed services. The installation of traffic signs (warning and regulatory) may also improve the perception of safety, particularly as regards children's access to an elementary school located on the *colonia's* edge. Finally, the study showed that residents were willing to increase their use of public transportation and that better designed routes that optimize travel times and provide reliable destinations would lead to higher usage for mobility outside the vicinity (88).

There is growing recognition that the built environment—the physical structures and infrastructure of communities—plays a significant role in shaping human health.

At the same time, a focus on the built environment in many ways complements public health approaches that (a) recognize that changing individual behavior involves changing social norms and environmental determinants of health and (b) concentrate on the community as the unit of analysis and action. The powerful influence of the built environment on health suggests that public health practitioners should be involved in planning and policy decisions related to land use, zoning issues, and overall community design. The participation of public health practitioners in collaboration with professionals from other sectors working alongside neighborhood residents themselves can synergistically promote and foster the creation of sustainable healthy behaviors (7).

As awareness grows among researchers of the importance of addressing health opportunities and challenges embedded in the social and physical environment, a new role for public health leadership begins to emerge. The first area for action focuses on assessing the health impact of land use and community design options—both before decisions are made as well as after improvements are implemented. The second focuses on catalyzing and facilitating inclusive partnerships with disciplinary expertise stretching far beyond the traditional public health and medical fields to plan community improvements and/or retrofit existing structures, while the third highlights the need for guidance by the public health sector in policy-making issues related to the built environment, such as protection from air pollution, access to services and ability to fulfill basic human needs, and the inclusion of green spaces for walking, recreation, and other forms of physical activity (7). Additional and ongoing roles for health professionals also include community education and health promotion activities and the provision of input into the development of legal frameworks to support human health and environmental preservation.

A growing number of communities of all sizes are turning to mass transit as a strategy to reduce urban congestion, propel economic development, and improve environmental quality and the population's health status. Within this framework of goals, the driving force should be the promotion of healthy and active lifestyles,

the fostering of social equity, and the removal of physical barriers to their achievement (70). In this sense, the cornerstone of transportation infrastructure improvements and modifications should be the needs of people and not automobiles; the development of safe, acceptable, and viable human mobility forms; and ensuring that urban design encompasses community goals and aspirations.

This strategy is especially important in Latin America and the Caribbean, where a significant proportion of the population relies on non-motorized means or public transportation services for their mobility needs. Here, as in other countries of the world where social inequity persists, pedestrian travel is a feature of everyday life, and for low-resource populations “active living” is not a choice, but a necessity: walking or bicycling to work, or walking to or from a transit stop, may constitute the only transportation option available to them.

In this scenario, the safety of non-motorized travelers and the quality of connectivity between the various public transportation structures should be a priority concern for urban planners and political decision-makers. Efficiency and safety features, such as frequent service, separation of motorized and non-motorized road users, dedicated bus lanes, and adequate lighting of bus platforms, as well as of sidewalks and bikeways feeding into stations, respond to human needs and encourage the population to turn to non-motorized and public transportation modes as part of their daily routine. The development of such services facilitating connectivity, as well as others—the inclusion of bicycle parking provisions in mass transit stations, the availability of bike racks on buses and trains, strategically placed shelters offering protection from inclement weather along walkways and bicycle paths, traffic calming measures, and adequate signage at busy street crossings—address users' safety concerns, provide comfort, reduce stress, and collectively build confidence in public versus private transportation use.

While many of these services currently exist in some of the world's most developed nations, it is interesting to

note the experiences and lessons being learned in Latin America are being heeded by other countries at all stages of development facing similar urban “traffic anarchy” (59) issues now or in the near future. According to Robert Cervero, an expert in city and regional planning and sustainable transportation policy, and currently director of the University of California Transportation Center, “the seamless interface of bicycle paths and pedestrian ways with major bus and rail lines” is a major factor in the high transit-mode share of many European and Latin American cities. Bogotá, Colombia, and Copenhagen, Denmark, stand out as cities that make transit easily accessible on foot or by bicycle (68).

In the next section, we will discuss Latin America’s achievements, the strategies used to secure them, the recognition these have received, and their implications for other countries around the world.

Policy Implications and Suggested Directions

Given the ever-growing body of data in support of the health and socioeconomic benefits that public transportation brings to communities in the midst of urban development, the time has come for others facing similar challenges to evaluate the price of inaction. Evidence to date from Latin America providing valuable guidance in this area includes Curitiba’s Integrated Transport Network in Brazil; Quito’s Metrobús-Q system in Ecuador; Guatemala City’s Transmetro in Guatemala; and Bogotá’s TransMilenio and Pereira’s Megabús networks in Colombia (4). These BRT systems have shown that well-designed and coordinated public transportation initiatives not only foster more active lifestyles and reduce the risk of traffic-related injuries at the general population level, but also improve air quality, protect the environment, and contribute to a more cohesive social fabric. In 2008, the Guatemala City and Pereira BTRs received honorable mentions

for the Sustainable Transport Award presented at the International Transportation Research Board’s Annual Conference. This distinction recognizes cities that have adopted innovative mass transit strategies that lessen the impact of climate change by reducing vehicular greenhouse emissions and have thereby enhanced the sustainability and livability of their respective communities (89). Bogotá’s TransMilenio system, as well, has received global kudos, including becoming the world’s first mass transport project to be approved for participation in the Kyoto Protocol’s Clean Development Mechanism (CDM); as such, it serves as a model for similar transport-related CDM initiatives in the pipeline worldwide (90).

Other BRT initiatives now under way in Latin America include Transantiago (Santiago, Chile); MIO Metro-Cali serving Santiago de Cali, TransCaribe serving Cartagena, Metrolínea (Bucaramanga Metropolitan Area), Metroplús (Valle de Aburrá and Medellín), and Transmetro (Barranquilla Metropolitan Area), all in Colombia; São Paulo 9 de Julho and Porto Alegre Assis in Brazil; Metrovía (Guayaquil, Ecuador); and Optibús (Ciudad de León) and Macrobus (Guadalajara) in Mexico. In several of Latin America’s larger metropolitan areas, BRT networks are interconnected with rail systems. To date, however, the BRTs have provided the highest degree of integration with non-motorized mobility forms.

These strategies have been shown to be not only feasible, but also desirable in countries with limited economic resources, and those nations which have demonstrated political will to make significant upgrades in their public transportation infrastructure have received financial and technical support from major multilateral institutions such as the World Bank and the Inter-American Development Bank.

In each case, the transformation and implementation of public transportation systems have needed to be based on sound scientific evidence. This process requires collecting relevant and reliable data, but also the

existence of specific skills sets within government and other partner organizations to analyze and interpret the data and apply the knowledge gained to policies and plans being developed. Proper coordination and the existence of a culture of true cooperation between all multi-sectoral partners working together in the various phases leading up to the implementation of the desired changes must be forged and then maintained to ensure sustainability of the improvements instituted. Emerging challenges, while at times complex, are not insurmountable if addressed in a timely manner and through the application of the proper types of expertise. Valuable lessons learned are being provided through the experiences of Brazil, Colombia, Ecuador, and Mexico, among others, to date. What these have shown is that while the development of BRT systems has not always been linear, the achievements attained have nonetheless demonstrated the efficacy of this approach in addressing human health and environment challenges related to urban mobility.

Policies directed toward urban containment and/or reducing urban sprawl can also become synergistic with those promoting safe and healthy transportation forms, resulting in reduced environmental degradation and improved health outcomes. Research conducted in 63 large metropolitan areas in the United States found that in cities where urban containment policies were strong, there was a higher likelihood of populations engaging in more leisure-time physical activities as well as walking or bicycling to work. This study found that residents of states with legislation mandating urban growth boundaries reported significantly more minutes of physical activity compared to residents of states without such policies (91). This evidence further suggests the importance of coordination and collaboration between the transportation sector and planning institutions at different levels of government and with civil society. Also, collaborations with policy researchers are likely to improve the translation of research findings regarding social and physical environmental influences into better policies and best practices models (92).

For over a decade, the importance of promoting public transportation and the use of multimodal urban

mobility systems has been highlighted in scientific literature produced by the Pan American Health Organization (PAHO), WHO's Regional Office for the Americas (13, 30). The reduction of automobile traffic and the substitution of alternative modes of transport are deemed by this Organization to be essential health promotion policies that should be incorporated into "healthy cities" programs and general economic strategies. In addition to reducing traffic density and environmental degradation, public transportation use, bicycles, and walking are also linked to decreased morbidity and mortality resulting from injuries and are crucial in reversing the trend toward increasingly sedentary lifestyles.

At the same time, lower traffic density implies decreased noxious gas emissions levels by motor vehicles, resulting in reductions in the concentration of atmospheric pollutants. These pollution reductions, in turn, not only benefit the environment directly, but also lower the incidence of asthma and other associated respiratory illnesses among the general population.

In March 2009, the first meeting of the Inter-Governmental Network on Air Pollution in Latin America and the Caribbean was held in Panama City, Panama. Hosted by the United Nations Environment Program in collaboration with the Clean Air Institute and the Global Atmospheric Pollution (GAP) Forum, the gathering noted that over the past 15 years, Latin American cities have played a leading role in the international debate through their willingness to experiment with innovative strategies to overcome the negative impact of transportation and motorization on health and the environment in urban settings (93).

The meeting also showcased pioneering BRT initiatives under way in the Americas and described the ways in which various African and Asian countries have adopted similar initiatives. The participating experts from countries and international agencies stressed, however, that the lessons learned emerging from these experiences require further analysis and review in order to determine the degree of replication and adaptability to local circumstances in other parts of the world. Thus,

while the knowledge base still remains incomplete, the body of evidence upon which decision-makers may draw in contemplating similar approaches at the local or national level in their own countries is steadily accumulating (93).

Conclusions

As the evidence base pointing to the health and environmental benefits of public transportation services grows, the public health community can play a vital role in promoting the advantages of reducing automobile reliance and incorporating alternative modes of transport into everyday life. Walking and bicycling—combined with use of public means of mobility, or alone—encourage a more physically active lifestyle, help prevent overweight and obesity and reduce the risk for associated chronic conditions (e.g., type 2 diabetes, cardiovascular disease, hypertension, stroke), and contribute to an improved sense of overall physical and mental well-being. Equally importantly, well-designed and coordinated public transit systems can lead to a significant reduction in road traffic injuries and deaths (30). Lower traffic density leads to lower environmental noise levels, improved air quality, decreased incidence of pollution-related respiratory conditions, and reduced levels of commuter stress, annoyance, and anxiety due to more efficient and predictable commuting times. Affordable public transportation with high connectivity facilitates universal access at all levels of society and reduces social isolation and inequalities. At the same time, it increases access to health care services and reduces medical costs by providing a viable alternative to reliance on non-urgent ambulance services. This is an especially important factor for disadvantaged and vulnerable populations. Thus, facilitating coverage of transportation services to all sectors of the population—while at the same time ensuring their safety, affordability, efficiency, and reliability—can bring immense savings not only to individuals and families, but also health care systems and local and national governments.

This is good news for a broad cross-section of policy- and decision-makers, whether urban planners, public health practitioners, economists, or political leaders: multimodal public transportation systems are an indispensable tool to promote healthy communities and social equity within a sustainable, nurturing physical environment. ❖

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