Reducing automobile traffic: an urgent policy for health promotion[1]

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ABSTRACT *In recent decades traffic injuries have become a leading cause of death and disability the world over. In congested urban areas, the noise and emissions from vehicle engines cause discomfort and disease. More than one billion people are exposed daily to harmful levels of atmospheric contamination.*

Because internal combustion generates carbon dioxide (CO_2), the automobile is a principal contributor to the greenhouse effect, which has significantly raised the temperature of the atmosphere. Scientists anticipate that in coming decades the greenhouse effect will produce alterations in climate that are very likely to be harmful and possibly catastrophic. Meanwhile, burgeoning traffic and rural and urban highway infrastructures are already among the principal causes of environmental degradation. Urban development, because it is nearly always "planned" to accommodate automobiles rather than people, reduces the quality of life and tears the social fabric.

In contrast to private automobiles, public transportation, bicycles, and walking produce little environmental contamination or injury-related morbidity and mortality. These modes of transport involve more physical activity, with its positive health effects, and avoid contributing to the greenhouse effect. The reduction of automobile traffic and substitution of alternative modes of transport are essential policies for health promotion. They should be incorporated in "healthy cities" programs and general economic policies.

Annual world production of automobiles increased from 11 million in 1953 to 53 million in 1995 (*1*, *2*). By recent estimates (1995), more than 600 million motor vehicles are in circulation worldwide, three quarters of which are automobiles and the rest trucks and buses (*2*). Of the 420 million automobiles in circulation in the early 1990s, about 330 million (80%) were in the industrialized countries of North America, Western Europe, and Oceania, which collectively are home to 18% of the world's population. The remaining 90 million motor vehicles (20%) were distributed throughout the remaining areas of the world, wherein lives 82% of the population (*3*). International differences in per capita automobile ownership are enormous, and differences in average usage are even greater (Table 1).

Traffic's harmful consequences can be summarized as: a) mortality, morbidity, and disability resulting from injuries; b) increases in general mortality and various diseases due to environmental contamination; c) promotion of sedentarism and obesity, with their associated adverse impacts on health; d) transformation of cities into settings where the automobile dominates, crowding out other uses for public spaces, dehumanizing the urban environment, and fostering social marginalization and disintegration; e) development of a rural and urban infrastructure of highways which consumes enormous public resources, causes extensive environmental deterioration, and compromises the economic viability of other, much more efficient and healthful modes of transportation; and f) carbon dioxide emis-

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TABLE 1. Population, number of registered automobiles, index of vehicle ownership, and automobile usage in 12 countries

Country	Population in 1995 (millions)	Automobiles in 1995 (millions)	Vehicles[a] per 1 000 population			Auto-km per person-year, approximately 1988
			1985	1991	Increment (%)	
United States	263.1	195.47	711	755[b]	6[c]	8 870
Germany	81.3	39.92	451	521	16	6 150
Japan	125.9	44.94	374	475	27	2 510
Italy	57.9	29.60	434	538	24	4 030
United Kingdom	58.1	23.83	348	415	19	4 730
Argentina	34.3	2.20	175	179	2	1 000
Poland	38.7	3.51	122	193	58	710
South Korea	45.2	6.50	27	97	259	210
Guatemala	10.6	0.04	24	20	–16	—
Cameroon	13.3	0.01	12	8	–33	120
Haiti	7.2	0.02	6	—	—	—
China	1 238.3	0.96	—	5[d]	—	—

Sources: Population and vehicles per 1 000 (*4*), automobiles (*2*), automobile usage (*5*); except when otherwise indicated below.
[a] Includes automobiles, trucks, and buses.
[b] 1994.
[c] Increment during 1985–1994.
[d] Calculated for 1995, using data from reference *2*.

sions, with their contribution to the greenhouse effect.

Because traffic's harmful consequences are directly related to its volume, reducing automobile use through mass transit and promotion of nonmotorized transportation is a key strategy for health promotion. This idea will likely provoke as much opposition and skepticism as anti-tobacco policies once did (and still do in many countries). Nevertheless, reducing the volume of automobile traffic is not merely reasonable, but necessary and even urgent. This article presents data in support of this conclusion.

CAUSE AND ACCIDENT: CONCEPTUAL CONSIDERATIONS

The concept of causality in public health is controversial (*6*), but in practice epidemiologists usually use Hill's (*7*) criteria and designate as causes any physical or circumstantial factors that increase the probability that a phenomenon will occur. Thus, tobacco, asbestos, and radon are causes of lung cancer because each increases its probability. This probabilistic concept of causality (*8*), which generally implies multicausality, justifies speaking of automobile traffic as a cause of mortality and morbidity because of the risks of injuries in collisions, pedestrian knockdowns, and other events. Moreover, there is a dose-effect relationship, since increasing traffic raises the number of unintentional events and, consequently, deaths and injuries (see below).

The kinetic energy of a moving vehicle creates potential for injuries. The risk of collision and the probability of injury or death if one should occur are mediated by factors as diverse as the time of day, the day of the week, the price of fuel, travel speed, the density of vehicular and pedestrian traffic, the physical characteristics of vehicles (type, mass, height, stability, presence or absence of safety devices, internal and external surface angularities) and the personal characteristics (age, sex, social class, psychosomatic condition, etc.) of drivers, passengers, and pedestrians (*9–21*). These factors figure in chains of causation whose final outcomes are neither more nor less "accidental" than a case of hepatitis or cancer, in whose production chance also intervenes more or less (*22*). Various authors (*10, 23–26*) have proposed the systematic elimination of the term "accident," whose connotations of unpredictability and inevitability are counterproductive from the point of view of prevention. Unfortunately, the term continues to appear time and again, even in epidemiologic contexts (*20, 27*). The 10th revision of the *International Classification of Diseases* (*28*), chapter XX, on the external causes of morbidity and mortality, still calls injuries produced by motor vehicles "accidents." The persistence with which unintentional events, deaths, and lesions continue to be designated "accidental" recalls to mind Jeremy Bentham's remark that error is never so difficult to eradicate as when it is rooted in language. Certainly, using an inappropriate term makes a difficult point of departure for good health policy.

MORTALITY DUE TO TRAFFIC INJURIES

The statistics concerning morbidity and mortality due to traffic injuries (TI) are problematic because there are different systems for classifying deaths and deficiencies in notification and registration (*10*). Mortality due to TI may be substantially underestimated in many countries (*29–31*). Globally, the estimated annual mortality due to these injuries is an ever-increasing number. The quarter million deaths that were calculated to have occurred in 1980 (*25*) climbed to 856 000 by 1990 (*32*) and 885 000 by 1993 (*33*).

In industrialized countries, TI are among the three top causes of death, along with heart disease and cancer. In the rest of the world, TI are the third most common cause of death among men in the economically active ages (*34*). In Kuwait and other oil-producing countries, TI are the leading causes of death at all ages (*35*).

While cancer and cardiovascular disease kill primarily older individuals, TI cause a great many deaths among adolescents and young adults. In the United States of America, TI are the primary cause of lost years of productive life as well as the most frequent cause of injury (*36*).

In countries with lower levels of car ownership, TI mortality is highest in older age groups. Given that most TI victims in these countries are pedestrians (*35*), it follows that the majority of those struck down are elderly. In countries with high levels of car ownership, the curve of TI mortality by age is bimodal, with one peak at around 20 years and another in the advanced ages (Figure 1).

In all countries, TI mortality is lower among females than among males at every age, but the difference tends to diminish as the index of automobile ownership rises. It has shrunk drastically in the United States (*37*). At the start of the 1990s, the mortality rate among U.S. males was slightly more than twice that among U.S. females, while in Germany and Brazil the male rate was approximately triple the female, and in Mexico, quadruple (*30, 38*). The predominance of TI mortality among males, including boys (see Figure 1), is a good illustration of the effects of sociocultural patterns, in this case crystallized in the construct of gender, on the profile of mortality. There does not seem to be any biological reason why males should be more disposed to die from traffic injuries.

NONFATAL INJURIES AND DISABILITY

Although existing data are very fragmentary, they demonstrate that in many countries TI are among the principal reasons for seeking medical attention, for hospitalization, and for disability. In the United States in 1992 there were 5 million injuries, affecting 1.9% of the population, and half a million hospitalizations (*39*). In Brazil in 1989, 450 000 individuals suffered TI, of whom 50 000 died (*31*). In Spain in 1993, 1.1% of the population required emergency medical care, and 1.2% required some kind of medical care (*20*). According to WHO estimates, for every adolescent who dies as a result of TI, between 10 and 15 others are left with serious sequelae, and between 30 and 40 require emergency care or rehabilitation (*40*). In so-called "developing countries," it is estimated that traffic produces one injury per 150 persons in the population (*35*).

Injuries resulting from collisions frequently affect the nervous system and cause paraplegia, quadriplegia, and other types of permanent neurological deficits. In the United States an estimated 20 000 new cases of epilepsy occur each year as consequences of TI (*25*). As victims are often young, the neurological sequela of TI entail many years of disability and associated expenditures for individual care. In 1981 the European Regional Office of WHO (*27*) estimated that worldwide, there were 30 million people with permanent disabilities resulting from TI.

THE RELATION BETWEEN TRAFFIC VOLUME AND INCIDENCE OF INJURIES

Using the annual rate of traffic-related deaths per vehicle as a measure of the perilousness of traffic, longitudinal studies show reductions over time, while cross-sectional studies indicate reductions with increasing indices of car ownership (*27, 34*). Thus in 1978, the mortality rates per vehicle were 50 times higher in Ethiopia and Nigeria than in the United States and the United Kingdom (*27*). This relationship was first described by Reuben Smeed in 1949, and is called "Smeed's Law" (*16*).

As an indicator of impact on public health, mortality per vehicle (which corresponds in another context to the rate of lung cancer cases per thousand cigarettes smoked) is of less interest than the total amount of mortality and morbidity and the corresponding population rates. In every country, these rates rise rapidly during the early growth of automobile ownership. Then, as higher levels of ownership are achieved, the increases in mortality rates slow, stabilize and, in many countries, start to fall (*41*). In the United States, mortality from TI peaked in 1972 (almost 57 000 deaths), then dropped little by little, but with repeated sharp oscillations. Since 1960 the TI mortality rate has never been lower than 40 000 deaths per annum, and it rebounds periodically in times of economic growth (Figure 2).

Eyer (*42, 43*) has shown that mortality due to TI fluctuates with economic cycles, decreasing in periods of recession and rising in periods of expansion (*9*). The curves of mortality due to TI or of the number of collisions mirror those of unemployment levels (see Figure 2). The volume of traffic presumably mediates this relationship, by waning markedly in recessions and waxing in periods of recovery. Greater alcohol consumption in periods of economic expansion may also contribute to this striking relationship (*43*).

Transversal studies show that rates of collisions and TI mortality are directly related to traffic volume (*44*) and gross national product (*34*), which is highly correlated with traffic volume. A direct relationship between traffic volume and child pedestrian deaths shows up in time series studies (*45*). These data are compatible with the observation that TI mortality drops markedly when there is a sharp reduction in traffic, as occurred after the Yom Kippur war (1973), which led to

FIGURE 1. Annual mortality per million population, by sex and 10-year age groups, due to traffic injuries (—■—), homicide (—+—) and tuberculosis (--□--). Data from eight countries, proceeding from lower to higher index of motor vehicle density (MVD, per 1 000 population). The scale of the Y axis changes from graph to graph, a fact that should be borne in mind when making comparisons

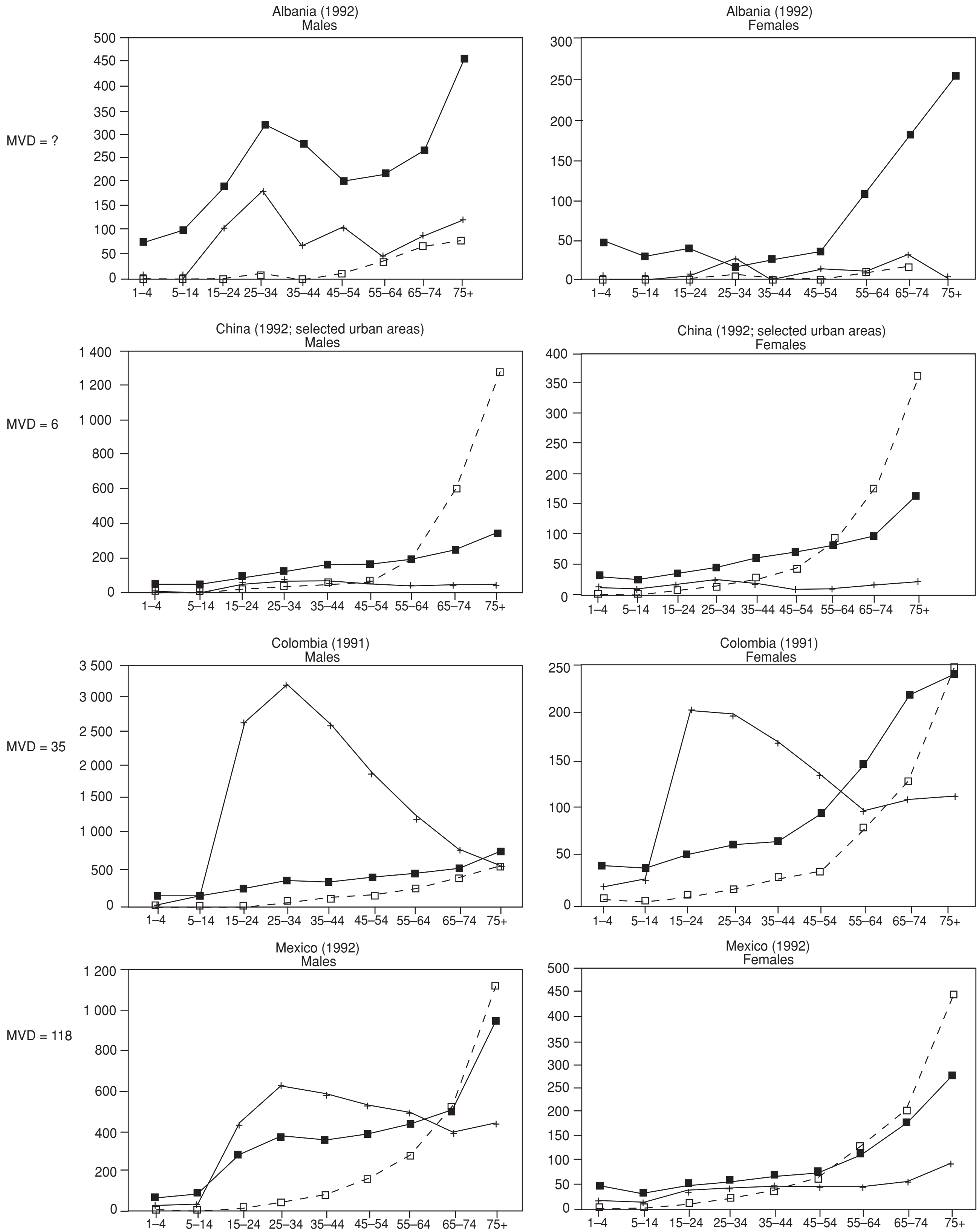
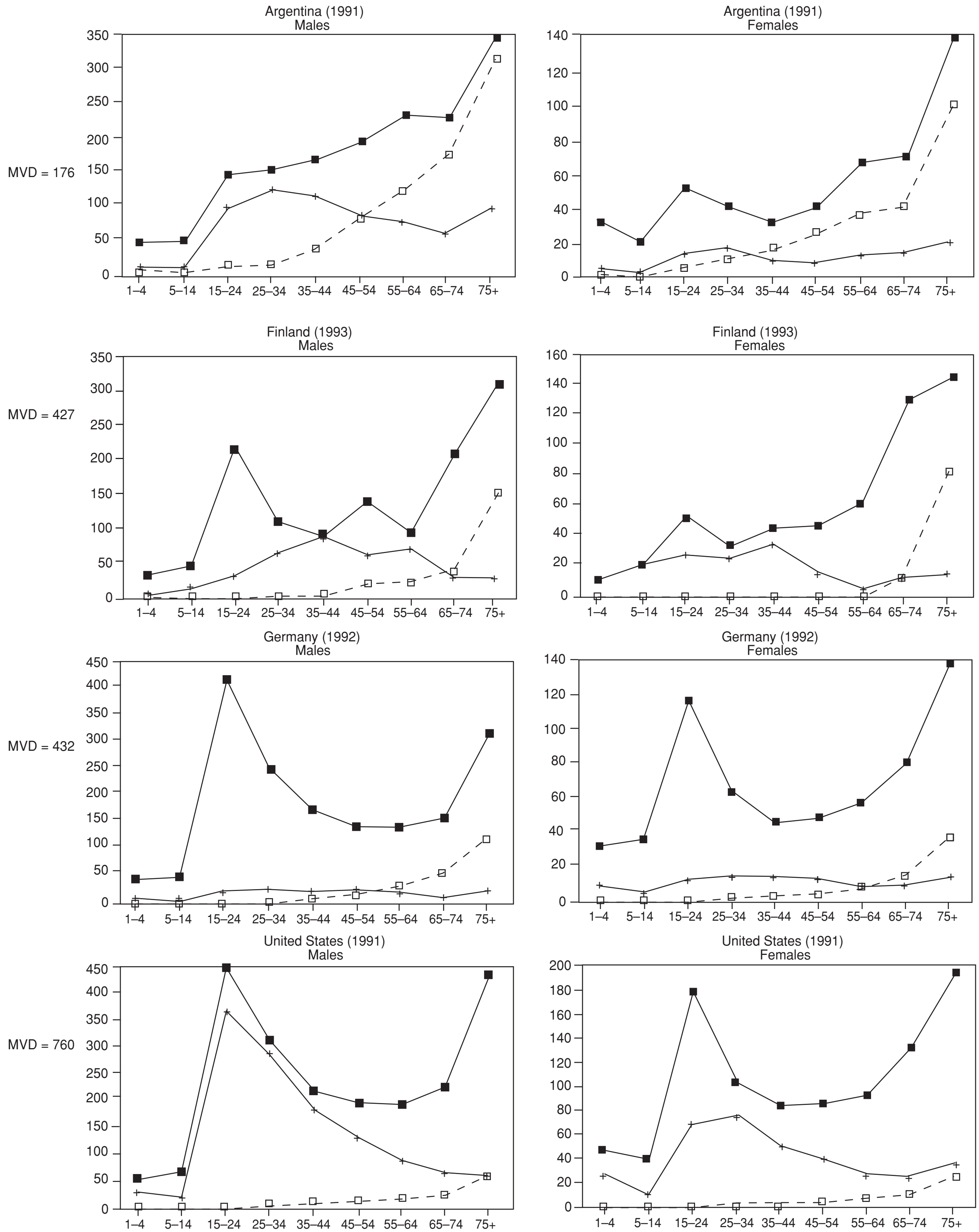
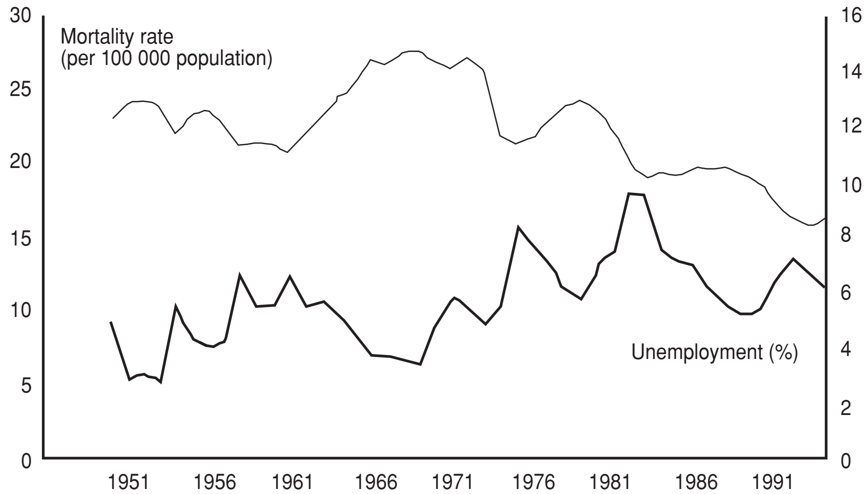


FIGURE 1. *(Continued)*



Source: WHO (*38*, Table B1).

FIGURE 2. Annual mortality from traffic injuries (per 100 000 population) and unemployment rate (economically active population) in the United States, 1950–1994. Traffic injuries and associated deaths increase in periods of economic expansion, when unemployment declines and traffic and alcohol consumption increase. Conversely, they decrease in periods of recession. See text for further details



Sources: Several editions of the *Handbook of labor statistics* (U.S. Bureau of Labor, Department of Commerce) and the *Statistical abstracts of the United States* (U.S. Department of Commerce, Bureau of the Census).

the Arab oil embargo, fuel price increases and rationing, and major economic recessions in many countries. In the United States in 1974, TI caused 46 000-plus deaths, almost 10 000 fewer than in 1973. That year maximum highway speed was reduced to 55 miles per hour (88.5 km/h) in order to conserve fuel supplies (*19*), which was probably an additional important factor in the reduced mortality (*9*). Automobile deaths in the Federal Republic of Germany decreased by half from 1973 to 1974, very likely for similar reasons (*46*).

The price of fuel affects automobile death rates through its relation with traffic volume. The lower the price, the more traffic and the higher the number of deaths (*18*). In 1980 the only country in Latin America with a TI mortality rate higher than that of the United States was Venezuela, where gasoline was approximately 10 times cheaper.

The continuous growth in the number of automobiles in Asia, Africa, and Latin America has led some authors to predict rapid rises in the regional burdens of TI deaths, injuries, and disabilities (*47*). In fact, between 1968 and 1983, TI mortality rose more than 200% in Africa and around 150% in Asia (*34*). In Thailand it rose almost 30% in every year from 1947 to 1982 (*35*). In Saudi Arabia, highway construction and a dizzying increase in the number of automobiles coincided with a 600% jump in TI mortality and morbidity, a clear indication that the danger of traffic is not a result of lack of resources to acquire up-to-date vehicles and highway infrastructure (*35*).

In Latin America, TI mortality stayed more or less constant throughout the 1980s (*48*), a period when economic crisis probably restricted car ownership and traffic a great deal. Thus the "lost decade" may have "spared" thousands of deaths and disabilities due to collisions *which did not happen*.

TRAFFIC AS A RISK FACTOR FOR USERS OF PUBLIC SPACE

Walking, bicycle riding, and traveling in vehicles drawn by animals are minimally dangerous in themselves, but carry a very high risk of injury when they are done on streets or highways shared with automobiles. In the United Kingdom (*49*), a pedestrian's risk of death per hour spent in transit is more than double that of a driver. For a cyclist, it is more than quadruple (Table 2). In light of data available from various countries, it is likely that worldwide, most TI victims are pedestrians and cyclists. According to WHO, in two-thirds of accidents that create victims, some of the injured are pedestrians, almost always children (*50*). Between 1990 and 1994, motor vehicle-pedestrian collisions caused 43% of all traffic deaths in Costa Rica, and vehicle-vehicle collisions only 23% (*51*). In Brazil 90% of traffic injuries are to pedestrians. Pedestrians accounted for

TABLE 2. Mortality associated with different modes of transport in the United Kingdom

Mode of transport	Deaths per 10^8 hours traveled	Deaths per 10^8 kilometers traveled
Bus	1.4	0.06
Train or tram	6	0.1
Automobile	12.4	0.4
Boat	16	0.8
Air travel	20	0.04
Pedestrian travel	27	7.0
Bicycle	64	4.6
Motorcycle	342	11.4

Source: Evans (*49*).

50% of all hospitalizations for TI; they were the group that most commonly died from TI nationwide; and they were the victims in 85% of TI deaths in Rio de Janeiro (*30, 31*). In Iraq 55% of those who die from TI are pedestrians (*34*); and in India in recent years 95% of TI deaths have been of pedestrians or cyclists (*52*).

In most of the world, daily travel is done on foot, public transportation, or bicycle, and automobiles constitute an enormous risk for the population. Attempts to solve the "traffic problem" often take the form of constructing highway infrastructure, improving vehicles, and using safety devices (seat belts, helmets, reflective materials, daytime use of headlights, and so on). In fact, some of these "technical solutions" increase the volume of traffic and problems of congestion (*53*) and can add to the risk for pedestrians, cyclists, and other users of public space. Eliminating traffic signals and widening streets to aid traffic flow raises the risk of collisions and pedestrian knockdowns. Although the point is much disputed (*9, 10*), some authors believe that safety devices such as seat belts, airbags, and antilock brakes generate a phenomenon known as "risk compensation." The driver of a vehicle equipped with such devices may feel so secure that he or she drives faster, takes fewer precautions, and thereby increases the likelihood of collision (*16*).

In the United States nearly 100 people have died, half of them children, when airbags inflated in low-speed collisions that would probably have been inconsequential had the airbags not been present (*54*). While airbag advocates claim that the devices have prevented hundreds of deaths in high-speed collisions, a device that saves hundreds of lives at the cost of taking tens of other lives is ethically questionable. Preliminary data from the National Highway Transportation Safety Administration suggests that TI mortality is higher among occupants of vehicles equipped with airbags than those without (*55*). This could be a typical example of risk compensation.

The approach in many road safety policies is to separate cars and people, creating "cars only" spaces (for instance "highways" and "freeways") that are barred to pedestrians and cyclists, who are forced to travel on secondary roads or to cross via elevated or subterranean passages. An example of this tendency is the recent prohibition of bicycle riding on many streets and highways in China (*56*). As automobile traffic increases, public space becomes less safe and more difficult for bicycle riding, walking, or playing (*16*). The recent decrease in pedestrian mortality in some countries has been interpreted by some authors (*16, 57*) not as an improvement in road safety, but as an index of the exclusion of these users from open public spaces.

The risk of TI is not randomly distributed among social classes. Like many other causes of illness and death, TI disproportionately impacts upon the poor and marginalized. In the United States between 1980 and 1985, black children under 10 years of age were twice as likely as their white counterparts to die from being struck by an automobile (*14*). In the United Kingdom mortality due to TI was 84% higher among men in social classes IV and V compared to classes I and II (in the five-class social scale that is used in that country) (*53*). Children in social class V suffer seven times more TI than those in class I (*58*). Moreover, not only do the lower income strata have more fatal and nonfatal TI, but once an injury is sustained, they have a worse prognosis and higher death rate, because of differences in surgical treatment (*57*).

MORBIDITY AND MORTALITY NOT RELATED TO INJURY

Motor vehicles are the principal source of toxic emissions with both local and continental effects, and are responsible for three-fourths of the atmospheric pollution attributed to the transport sector (*52*). Traffic is the main reason why more than 1 billion residents of large cities incur levels of pollutants that are considered inadmissible by WHO (*50, 59*). The megacities of Asia and Latin America have the worst atmospheric pollution in the world (*52, 60*). Pollution emergencies have already been declared in the capitals of Mexico and Chile (*40*).

Since a December 1952 episode of air pollution in London was held responsible for 3 500 to 4 000 deaths, it has been known that pollution, especially suspended particles of sulfur dioxide (SO_2), increases mortality from respiratory and cardiovascular diseases. Research into atmospheric pollution's association with mortality or morbidity demonstrates linear relationships without thresholds, as is also seen with tobacco and its health effects. There does not appear to be any minimum level of exposure below which harmful effects do not occur (*61–63*).

In six United States cities, a direct relationship was found between atmospheric pollution and general mortality as well as specific mortality due to cardiovascular disease and lung cancer. The mortality rate in the most polluted city was 26% higher (95% confidence interval: 8% to 47%) than the rate in the least contaminated (*64*). Mortality increases related to atmospheric pollution have been confirmed in Santiago, Chile, (*65*) and São Paulo, Brazil (*66*). In Paris, data have shown increments of up to 6% in cardiovascular mortality related to rises in the average daily levels of suspended particles (*63*).

Exposure to combustion products—in particular suspended particles, sulfur compounds (SO_2, SO_3), nitrogen oxides (NO_x), ozone (O_3) and carbon monoxide (CO)—causes reduced respiratory function parameters and increased frequency of respiratory symptoms, asthma attacks, and conjunctivitis (*40, 67*). In Mexico City and Santiago, Chile, students were found to have significant elevations of risk for cough and other respiratory symptoms, as well as school absences, related to pollution; and in Santiago there were estimated yearly excesses of 35 000 asthma attacks and 50 000 cases of pneumonia (*40*). Catalan authors discovered a direct relationship between the level of atmospheric contamination and the number of visits to hospital emergency rooms with aggravations of chronic respiratory disease (*61*). The same phenomenon has been observed in Mexico, Los Angeles, and London (*53*). In the United States, hospitalization rates and mortality from asthma have increased, possibly related to pollution, especially with O_3 (*68*).

Polycyclic aromatic compounds generated by fuel combustion may be responsible for the higher incidence of malignant neoplasia in urban zones (*50*). Several studies conducted in Europe, controlling for tobacco smoking and environmental contamination, strongly pointed to traffic density as an important risk factor for cancer (*64, 69*).

Combustion of leaded gasoline is still the source of more than 90% of the inhalable lead in many cities (*52*), the chronic effects of which include neurologic damage in adults and altered psychological development in children. Exposure to CO during pregnancy is associated with low birth weight and postnatal developmental delay (*59*).

Traffic noise provokes more than subjective discomfort. When it reaches certain volumes, either in itself or in combination with other noises, it causes deafness, deteriorated psychological and physical status, and increased aggression. Nocturnal noise to which people believe themselves to be habituated continues to stimulate cardiovascular responses even after 5 years of exposure (*50*). Continuous exposure to traffic noise increases heart rate, arterial tension, and adrenaline secretion, which together can produce chronic hypertension and cardiopathy (*58*). In many cities with high population density and car ownership and, often, considerable deterioration of vehicles and disregard for standards of upkeep, traffic noise significantly worsens the quality of life. To the horns and noise generated by traffic, there have recently been added antitheft alarms, whose frequent activation and irritation are well known to most inhabitants of cities.

THE TOTAL BURDEN OF MORBIDITY AND MORTALITY ATTRIBUTABLE TO TRAFFIC

Quantification of the combined morbidity and mortality due to any cause requires numerous suppositions, many of them very weak. Estimations are often based on "eyeball" calculations. For example, "disability-adjusted life years" (DALY) are estimated by summing real human "complete" deaths (people who have died) and hypothetical "partial" losses of life (by people living with illness or injury). It is a dangerous intellectual operation to equate a year lived with blindness or paraplegia with an arbitrary percentage of a year lived in "perfect health." Despite these difficulties and the fact that many countries, according to WHO (*33*), lack minimally reliable registries of causes of death, a recent report from the World Bank (*32, 70, 71*) gave an estimate of the "global burden of disease" corresponding to the total reductions in health due to death, illness, or disability attributable to definable causes. In the final results (*71*),[3] TI were responsible for 2.5% of DALY lost worldwide, making them the ninth most important cause of morbidity and mortality, ahead of malaria (2.3%) and AIDS (0.8%), and behind tuberculosis (2.8%), coronary ischemia (3.4%), and diarrheal diseases (7.2%). In "demographically developed" regions (using Murray and Lopez's terminology), TI are responsible for 4.4% of lost DALY, which puts them in fourth place behind cerebrovascular diseases (5.9%), depression (6.1%), and coronary ischemia (9.9%). In the rest of the world, TI occupy 11th place among the causes of lost years of healthy life, with 2.2% of the total missing DALY, behind tuberculosis (2.5%) and malaria (2.4%), but far ahead of AIDS (0.8%).

Worldwide, TI are the third leading cause of lost DALYs among 15–44 year olds of both sexes combined. Among men only, they are the second leading cause, in industrialized regions as well as the rest of the world (*71*).

While these estimations charge TI with an enormous portion of the world's burden of morbidity and mortality, other estimates appear to attribute an even greater amount. In Thailand, Malaysia, and Singapore, *deaths* resulting from TI account for more lost DALYs than tuberculosis and malaria combined (*29*).

The estimates of morbidity and mortality mentioned here refer only to loss of life and health resulting from injuries and deaths incurred in the events erroneously termed motor vehicle "accidents." They do not include cardiovascular and respiratory diseases, psychoneurological disorders, or malignancies attributable to traffic. Heart disease, cancer, and respiratory diseases are among the four most common causes of death in almost every country, and respiratory ailments are the primary causes of morbidity resulting in lost days of work. When a small amount of the morbidity and mortality related to these causes is added to estimates of the illness attributable to traffic (according to estimations like those of Dockery et al. [*64*] and Medina et al. [*63*] an addition of 5 to 10% *minimum* is not excessive) the total burden becomes enormous. The harmful effects of automobiles are not fully realized when they are perceived as consisting solely of injuries and deaths due to collisions, without taking into account diseases and deterioration in the quality of life due to pollution and noise.

TRAFFIC AND THE GREENHOUSE EFFECT

The Intergovernmental Panel on Climate Change (IPCC) was formed in 1988 under the auspices of the United Nations Program for the Environment and the World Meteorological Organization. According to the second IPCC

[3] The percentage that various causes were considered to deduct from a DALY differed considerably in different versions of the report (see ref. *71*, p. 269, and ref. *70*, p. 509 in the *Bull World Health Organ*).

report (1995),[4] prepared with the participation of 2 500 scientists, human activities since the start of the industrial revolution have significantly increased atmospheric concentrations of CO_2, methane (CH_4), and nitrous oxide (NO_2). As a result, the average temperature of the surface atmosphere has increased between 0.3 and 0.6 °C since the end of the 19th century, while sea level has risen approximately 10 to 25 cm, largely because of atmospheric warming. If CO_2 emissions remain at 1994 levels, the concentration of CO_2 in the atmosphere at the end of the 21st century will be double that of preindustrial times. The estimated average temperature of the surface atmosphere will be 2 °C higher. Sea level will rise for several centuries, causing flooding in low coastal areas and the disappearance of some island countries. Extreme temperatures will be more frequent, along with floods, droughts, and storms, causing serious agricultural damages.

The IPCC acknowledged much incertitude in these predictions, but also warned that clear proofs exist that human activity is changing the climate. They also noted that, given the natural complexity of the atmosphere, rapid changes in its makeup increase the probability of sudden and important climate changes (*72*). Apart from the health consequences of "natural" disasters, and declines in agricultural production, climate change may very well trigger a rise in the incidence of malaria (with up to a million additional deaths per year), dengue, viral encephalitis, and other infectious diseases (*73*).

The IPCC warnings are consistent with recent climatic phenomena that may be the first signs of change. Prolonged droughts, disastrous storms, and other "rare" atmospheric occurrences have been frequent in recent years (*72*). One of the worst was the cyclone that struck Bangladesh in 1991, causing 140 000 deaths and property losses estimated in excess of 10% of the nation's gross domestic product. Lately, insurance companies have paid out for climate-related disasters much more frequently compared to earlier epochs, and the industry is taking a serious interest in climate change (*74*).

At the 1992 United Nations Conference on the Environment and Development, representatives agreed to stabilize CO_2 emissions at the 1994 level by the year 2000. To put an effective brake on atmospheric warming, CO_2 emissions would need to be reduced by 60%. However, the growth of transport is expected to increase such emissions. According to estimates by the IPCC, in 1990 transport contributed 21% of total CO_2 emissions, industry 45%, and the residential-commercial sector 29%. In the last 20 years, emissions from transport have grown more rapidly than those from the other sectors (*74*).

In many countries, and especially in Eastern Europe and China, the demand for cargo and passenger transport has been met almost exclusively through adding to the number of trucks and automobiles (*52*). According to a British government report, the number of passenger-kilometers traveled in the United Kingdom nearly doubled from 1970 to 1996. Industrial and commercial energy consumption fell 40% in this period, while automobile fuel consumption increased 100% despite better engines and more efficient designs (*75*). A governmental commission concluded that it would be impossible to reduce the country's CO_2 emissions without addressing the growth in transport, in particular private automobiles (*76*).

The amount of CO_2 emissions directly reflects traffic, and each vehicle contributes to aggravating atmospheric warming. The distribution of automobiles per capita (see Table 1) clearly indicates how much world CO_2 emissions would rise if car ownership in China were to become what it is in the United States. The growth of international commerce (the so-called "globalization" of the economy) might intensify transport's contribution to the greenhouse effect even beyond that level.

AUTOMOBILES IN THE URBAN ENVIRONMENT

Today half the world's population lives in cities. Cities can be divided into three basic types (Table 3). In Africa and Asia, pedestrian cities predominate; they have high population density and few automobiles, and walking is the main mode of transportation. In Europe and Latin America most cities have relatively low population density and most transit is via buses and suburban trains. In the United States the car city is the rule, with low population density and scant public transportation (*77*).

Until the 19th century, cities everywhere were densely populated and walking was practically the sole mode of transport. During the 20th century

TABLE 3. Classification of cities by population density and predominant mode of transport

Type of city	Population per hectare (average)	Automobiles per 1 000 population	Annual consumption of gasoline	Use of public transport (trips per capita)
Car cities	10 to 30 (20)	400	870	90 (low)
Public transport cities	30 to 130 (90)	170	220	310 (high)
Pedestrian cities	130 to 400 (170)	20	60	180 (moderate)

Source: Newman and Kenworthy (*77*).

[4] Extensive excerpts from the second report of the IPCC can be accessed at the IPPC website (http://www.unep.ch/ipcc/syntrep/html). The complete report is published in three volumes by Cambridge University Press.

public transport has enabled cities to spread, especially in the industrialized countries, and wide use of automobiles has triggered a secondary expansion. In Europe urban centers were more or less rigidly structured, so that increases in the numbers of automobiles resulted in massive traffic congestion and many costly public works—which proved short-lived, rendered obsolete by further increases in automobiles.

In the United States many urban zones emerged practically contemporaneously with the automobile, and their low population density diminished even more with the development of suburbia. Of the 25 most populous cities in the United States in 1950, 18 lost population during subsequent decades. Saint Louis shrank from 857 000 inhabitants in 1959 to 397 000 in 1990 (*78, 79*). The flight of the upper and middle classes left only low-income working classes in the inner cities. Many parts of the urban center became ghost neighborhoods, where weeds grew between abandoned houses, and drug trafficking and other illegal activities provide ways out of unemployment and social deprivation. On the urban periphery, suburbs grew, scattered zones of single-family dwellings. Such sprawling urban infrastructures require much greater outlays for transport and necessitate large investments in road surfacing, telephone wiring, sewers, and systems for supplying water and electricity. As well, this type of urban development hinders the creation of communal linkages, since the lack of pedestrian spaces impedes cultivation of interpersonal relations and street life, a source of friendship and human ties (*18, 78*). In the suburbs as in the inner cities, large distances, scarce public transportation, the disappearance of small shops in the residential zones, and their replacement with large stores on the highways make automobile ownership all but obligatory. Every day the average American spends more than an hour in an automobile, a large portion of it in traffic. Various members of the nuclear family must travel daily, and because public transportation is so scarce, each one needs a car. Ownership of more than one automobile, once a luxury, is now a necessity (*80*). The percentage of families owning more than one automobile, less than 10% in 1960, was nearly 60% in 1990. Los Angeles, where two-thirds of the urban surface area is given over to automobiles (compared to less than 10% in many Asian cities and 20 to 25% in European cities) is the most extreme example of the effects of automobile usage on urban planning. In one study of 29 United States cities, Los Angeles had the worst traffic congestion and as a result the highest traffic-related expenses per capita (*53*). Although California promulgated the strictest laws to limit emissions in the 1980s, Los Angeles had the worst levels of pollution in the United States, with an average of 100 days per year in excess of national air quality standards (*81*).

Outside of the United States and Australia, cities continue to have high population density with transportation that is primarily collective, by foot, or on bicycle. Nevertheless, the rapid increase in the number of cars has created concerns about traffic and pollution in nearly every urban center (*52, 82*). Jakarta, Cairo, Buenos Aires, Mexico, São Paulo, Athens, Paris, and Warsaw are only a few of the many cities in which traffic jams and pollution are daily problems. In Bangkok, the average traffic speed is 10 km/h, falling to 5 or 6 km/h (walking speed) at rush hours (*52*).

Automobiles have the undeniable advantage of providing an enclosed space that protects drivers and passengers from unwanted interactions. Besides being a status symbol—especially where few people own one—automobiles give many people a sense of security. In cities with abysmal social differences, where wealth intermingles with marginality and hunger, automobiles provide "safe" personal transportation through "dangerous" areas. The effects are ultimately perverse. As automobile traffic increases, streets become more deserted. Children stop walking and riding bicycles to school and are driven instead, "for safety's sake," losing opportunities for social contact. Greater automobile use increases the risk of collision, which reaches very high levels as the distances traveled and the volume of traffic increase (*18, 53, 75*). Exclusive reliance on the automobile sharply reduces physical exercise and leads to obesity and poor physical conditioning (*83*). Moreover, the automobile enclosure limits personal interaction and weakens human relations. Many aggressive drivers are perfectly peaceable individuals when not behind the wheel (*53, 75*).

The urban transformation wrought by the spread of private automobiles leads to intense energy consumption (see Table 3). Four times more energy per capita is consumed in "car" cities compared to "public transport" cities—almost 15 times as much as in "pedestrian" cities.

THE AUTOMOBILE DEVOURS THE CITY was the slogan of a campaign to support public transport in a European city. In fact, the most pleasant and inviting urban centers for both residents and visitors are those with the most energy efficient transportation. As Newman and Kenworthy (*77*) concluded from their extensive study of cities on several continents, cities feel welcoming and humane in inverse degree to the predominance of automobiles.

TRAFFIC IN THE RURAL ENVIRONMENT

The construction of roads and highways has become one of the leading causes of rural environmental deterioration, loss of cultivable land, and destruction of nature. Landscapes become cluttered with billboards, engineering works, and great zones of erosion (*84*). Some of these effects can be reduced through appropriate policies to manage "environmental impact," but others are inherent in the roadway infrastructure, which requires huge tracts of land. A highway covers approximately seven times more surface area than a railroad track, although the latter can carry 67% more travelers (*53*).

In many "underdeveloped" areas, road construction is in the first phase of a process that leads to desertification in only a few years. In Northeast Brazil, roads opened forest zones to producers of rubber, coffee, and cocoa. When world prices for those commodities collapsed, the principal activity changed to cutting trees for wood to sell, resulting in total deforestation (*52*).

THE COST OF TRAFFIC'S HARMFUL EFFECTS

Calculating the costs resulting from a death or injury, through lost productivity and expenditures for care and other needs, is not the same as placing a price on a person's life or health.[5] By such calculations, each TI death in the United States costs four times as much as a death by cancer and seven times as much as a cardiovascular death. These higher costs are due to the lower ages of the deceased. Nonfatal TI deaths and disabilities involve enormous costs for long periods of intense treatment, especially in cases of paralysis or brain injury (*47*).

According to different estimates, the total cost of TI morbidity and mortality equals 0.5 to 1.5% (*13*) or 2% (*52*) of the gross national product. Total costs for morbidity, mortality, and material damages from traffic collisions in 1990 amounted to 137 billion dollars (*39*), or 2.4% of the U.S. gross national product (*85*).

In the United Kingdom, the Royal Commission for Environmental Protection (*52*) has estimated that traffic-related atmospheric pollution, noise, vibration, and climate change cost as much as 4.6% of the gross domestic product.

THE AUTOMOBILE AND THE NATIONAL ECONOMY

Reliance on automobiles requires an extensive infrastructure of roads that are usually financed through a country's general budgets (*52*, *53*). In most of the world, only a minority of people have automobiles, but the whole population pays taxes that are used for the infrastructure. These roadway infrastructures thus represent public works of an especially regressive type with respect to the redistribution of income (*80*). Moreover, the boom in road transport endangers railroads—a much more efficient and less polluting mode of transportation. As cars become more predominant, loss of passengers, cargo, and financial support can cut railroad incomes to the point where lines must close, as has happened in recent years in Argentina, Spain, the United States, and France (*52*).

Nondrivers do not pollute, and they also cede part of the public thoroughfare to automobiles (*86*). Clearly, to protect the public right to a healthy and tranquil urban space, high taxes should be levied on drivers and budgetary preferences given to those who use other modes of transport (*52*). According to calculations from the European Federation for Transport and the Environment (*52*), current prices for gasoline in Europe only cover 40 to 70% of outlays for externalities (that is, the harmful effects) related to traffic. Of note, European prices are approximately 1.5 times those in Peru and Bolivia, three times those in the United States, four times those in China, seven times those in Russia, and 60 times higher than those in Venezuela.

A MODERN FETISH THAT HARMS HEALTH

As noted by the economist Joan Robinson (*87*), ". . . many kinds of consumption that are chosen by some individuals generate *disutility* for others. The leading case is the spread of motor cars—the higher the level of consumption, the more uncomfortable life becomes; this fact is painfully obvious but orthodox doctrine has not been able to accommodate it."

By spending astronomic sums on advertising, the automobile industry has succeeded in depicting the car as a desirable object that every person who "matters" must possess. The "aura" around the automobile is such that, as an epistemologist has said, "Saints Auto and Television have more devotees than Saints Anthony and Cecilia" (*88*). In this as in other ways, advertising has an impact that is clearly harmful to the public health (*89*). The fake images and expectations that advertising foments frequently promote dangerous driving (by systematically concealing the risks of automobiles to their drivers and others), conceal the harmful impacts of traffic (by showing vehicles that "fly" to fantasy landscapes, rather than the daily reality of urban traffic jams), and inculcate an individualistic ideology that rejects collective solutions to the problems of transport (*16*). In reality, the automobile is a machine that facilitates travel but also causes significant individual and collective detriments (*84*). It is fortunate for humanity that most people do not have automobiles.

TRAFFIC REDUCTION: AN ESSENTIAL POLICY FOR HEALTH PROMOTION

Health promotion has been defined as a process that enables individuals and communities to maintain and improve physical, mental, and spiritual well-being. A fundamental component is the application of healthful general policies that often affect very diverse social sectors (*90*). Today transportation policy is as important as agricultural and education policy for our health and that of future generations.

In much of the world the private automobile is only within reach for a minority. However, given the current production rate of tens of millions of vehicles annually, high levels of automobile ownership seem bound to spread to the entire planet. Replacing the private automobile as the usual means of transportation in industrialized countries and avoiding its accession elsewhere are clearly desirable goals. They can not only reduce an important cause of death, injury, disease, and disability, but also serve as a focus from which development can proceed in sustainable directions.

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[5] This would be immoral or absurd in the opinion of many, myself included.

Historically, many good public health interventions have met with great opposition and been very difficult to put into practice. A policy that promotes public transportation with disincentives for the use of private automobiles will face great resistance. The beneficiaries are very diffuse (the general society and future generations), while the groups who are inconvenienced are concentrated (automobile makers first, and then drivers, who constitute large majorities in rich countries and powerful minorities in poor ones). Passing effective legislation is difficult in such circumstances (*91*).

Moving toward a society in which the use of automobiles is restricted to certain specific purposes will probably require repeated initiatives. In many cities, it has become obvious that traffic needs to be restricted, the use of the private automobile discouraged or prohibited, public transport promoted, and exclusive pedestrian zones created (*82*). The experiences are diverse, and many efforts have been insufficient. Mexico City has had a NO DRIVING TODAY program for years, which prohibits a portion of cars—those having certain digits in their license numbers—from driving on designated days. The program was intensified in February 1996, following a drastic rise in pollution.[6] For similar reasons, traffic circulation of a large portion of the automobiles in Santiago, Chile, was restricted in February 1992 (*40*). In the United States, only vehicles with three or more occupants are allowed to drive in lanes designated HOV, and many European cities have created central pedestrian zones that are off limits to private cars. Austria, Switzerland, and Hungary have taken measures to prevent pollution and conserve energy by shifting road traffic to railroads. Some Scandinavian cities impose tolls on cars that are en route to the city center (*52*). In the 1980s many Scandinavian and Dutch municipalities took measures to lower traffic speed and give priority to pedestrians and cyclists. The result has been the lowest rate of TI in Europe (*58*). In the 1980s Denmark adopted policies to discourage automobile ownership (*92*) and charges for public transportation were recently abolished in several Scandinavian cities. Singapore has a governmental plan in progress to drastically restrict vehicle imports, make all roads into toll roads in 1997, and simultaneously expand the public transportation system, already integrated through an extensive network of modern suburban trains and buses (*75*).

In the Brazilian city of Curitiba, urban planning has promoted public transportation by bus since the 1970s. With more than two million inhabitants, Curitiba today has lower rates of pollution and crime than cities of similar size with higher educational levels and proportions of green space. The urban policies of Curitiba have been taken as a model for public management, although the city's death toll from TI does not appear to support this idea (*30*).

Policies that promote modes of transport that are less polluting than the private automobile benefit public health and free up resources for other activities. Urban pedestrian zones, speed limits, and installation of obstacles in roadways to impose speed reductions improve the quality of urban life, save lives, and prevent disability. Speed limits—which also reduce fuel consumption and pollution—can advance these objectives, as can laws and fiscal measures to reduce alcohol consumption with severe punishments for those who drink and drive or otherwise fail to respect the rules of the road (*9, 10, 14*). In addition, policies for the integration of zones for work, dwelling, and recreational activities in cities of medium or high density serve public health because they lessen the volume of traffic and hence its associated risks and pollution (*94*).

The scientific consensus grows stronger every day on the harmful effects for humanity of accepting an economic model founded on exponential increases in energy consumption (*95*). The experience of the 20th century clearly demonstrates that the burden of vehicular disease and death is directly related to the volume of traffic. A policy to decrease this volume is essential to promote health, and may have the greatest implications for humanity in the medium and long term.[7]

[6] G. A. Silva, PAHO, personal communication.

[7] This article was in press when the World Conference on Climate Change convened in Kyoto, Japan—one more proof, in my opinion, of the importance of some of these issues. *(Author's note).*

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RESUMEN

La reducción del tráfico de automóviles: una política urgente de promoción de la salud

En las últimas décadas, las lesiones de tráfico se han convertido en una de las primeras causas de muerte y discapacidad en todo el mundo. En las zonas urbanas la congestión, el ruido y las emisiones de los motores de los vehículos causan molestias subjetivas y efectos patológicos detectables. Más de mil millones de personas están expuestas a niveles de contaminación atmosférica nocivos.

Por su motor de combustión que genera dióxido de carbono (CO_2), el automóvil es una de las fuentes principales de gases inductores del efecto invernadero. Este efecto ha generado ya un incremento de la temperatura media atmosférica y se estima que producirá en los próximos decenios alteraciones climáticas significativas de consecuencias inciertas, pero muy probablemente nocivas y posiblemente catastróficas. Independientemente del efecto invernadero, el crecimiento constante del parque automovilístico, del tráfico y de la infraestructura viaria urbana y rural es hoy una de las causas principales de la degradación del ambiente. El desarrollo urbano, casi siempre "planificado" en función del tráfico y no de las personas, hace que empeore significativamente la calidad de la vida, a la vez que fractura el tejido social.

Frente al automóvil privado, el transporte público o en bicicleta y el desplazamiento a pie contribuyen a reducir la contaminación, la congestión y el volumen de tráfico, así como la morbilidad y mortalidad por lesiones y por enfermedades relacionadas con la contaminación. El transporte no automovilístico promueve también la actividad física —con un efecto de mejora general de la salud— y contribuye a aminorar el efecto invernadero. La reducción del volumen de tráfico y el impulso de métodos alternativos de transporte son así una política integral de promoción de la salud que ha de incorporarse en el movimiento de ciudades saludables, así como en las políticas de transporte y en la política económica en general.