

Health and Environment Linkages Policy Series

Healthy Transport in Developing Cities



Health and Environment Linkages Initiative (HELI)

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1. Executive summary

Most of the world's population growth over the next thirty years will occur in cities and towns of developing countries (1,2). This trend is an indicator of the growing importance of urban environments to public health in general. Population growth and economic development have spurred rapid absolute increases in the number of motor vehicles in cities, with marked shifts of travel away from public transport, walking and cycling, to private motorized vehicles (3).

Growth in transport in developed and developing countries

Indicator	OECD (1980-1995)	OECD (1995-2010)	Non-OECD (1995-2010)
Population	+13%	+ 8%	+24%
GDP	+44%	+35%	+123%
Vehicle stock	+50%	+33%	+76%
VKT	+65%	+42%	+70%
Road fuel	+37%	+21%	+55%

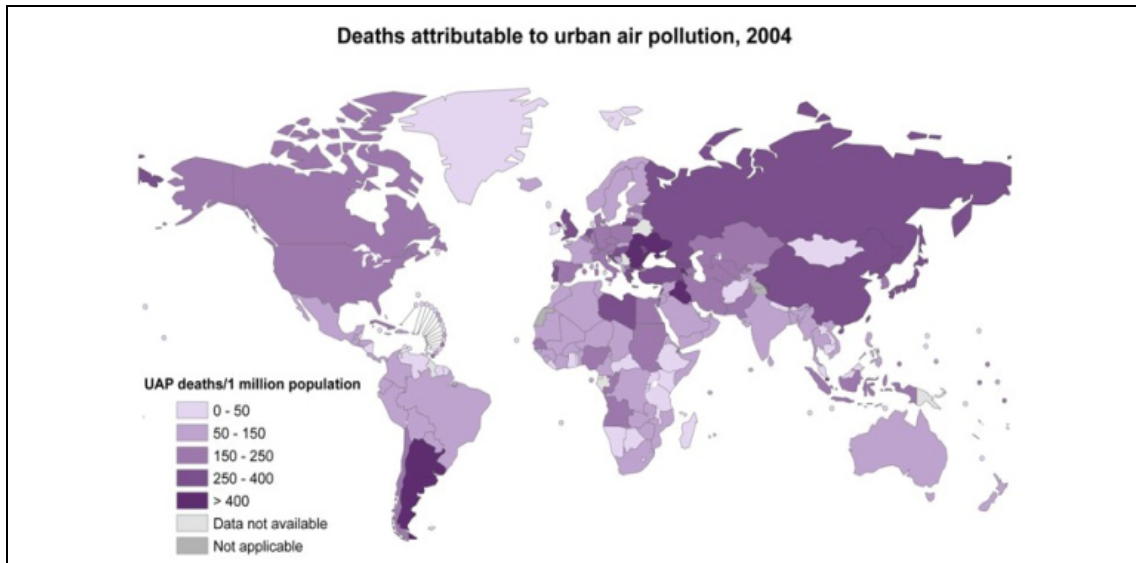
Source: OECD, 2001; IPCC, 2000; ICAO, 2005 (4-7).

Transport is responsible for some of the most serious environmental hazards and health risks faced by many developing cities. In the European context, transport-related health and environment risks have been a major focus of joint policy dialogue for more than a decade, e.g. in the Pan European Programme for Transport, Health and Environment (8).¹ But in many developing countries, transport-related health risks have not yet received priority attention, or stimulated joint policy actions by health, environment and transport sectors (9). Some key risks include the following.

Health risks associated with transport

- **Urban outdoor air pollution**, much of it generated by vehicles, is associated with higher rates of cardiovascular and respiratory diseases, among other conditions, and is estimated to kill some 1.2 million people annually around the world (10).
- **Road traffic injuries** are responsible for another estimated 1.3 million deaths, and pedestrians and cyclists are among the groups most at risk. A significant proportion of injury is related to environmental design of transport and land-use systems, including the lack of safe space for non-motorized transport (11).
- Motorization is a driving force in more **sedentary lifestyles**. Globally, insufficient routine physical activity is estimated to cause some 3.2 million deaths annually; it is a risk factor for cardiovascular diseases, cancers of the breast, colon and rectum, and diabetes mellitus (10), (12).
- **Poverty and inequalities** may be exacerbated by transport patterns when large gaps develop between the quality of private motorized transport and that of public and non-motorized transport, which are most accessible to the poor (13),(14).
- Transport is a driving force **shaping cities and communities**, affecting not only patterns of physical movement but also fundamental social interactions and patterns of social health and well-being (15), (16).

¹ For background on the PEP see: <http://www.thepep.org/CHWebSite/>



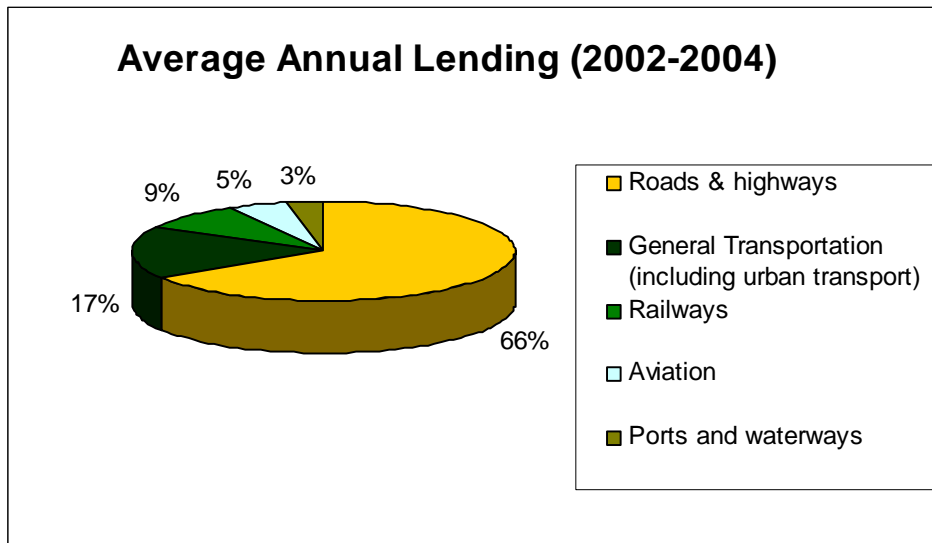
Source: WHO, 2009.

Transport trends and health linkages

Transport represents a very major form of international economic investment in developing regions, where improved mobility is associated with socioeconomic development. Over the past 10 to 20 years, public transport systems stagnated and non-motorized transport was neglected in many developing countries, trends that often coincided with the shift to privatization and more market-based economies. There is now increasing interest in development of public transport and non-motorized systems, particularly in urban areas, although transport investment overall still appears focused on roads (17, 18). In urban areas, as well, new mobility patterns have (or are rapidly becoming) established which have consequences for environment and health, including the following.

- **Public transport decline/reliance on private transport.** Certain poor or middle-income cities in the developing world have become highly reliant upon private motorized transport – even more so than developed cities that have invested heavily over the years in public transport systems. The resulting rapid growth in traffic volumes, in turn, increases air and noise pollution in cities.
- **Rapid growth in motorcycles.** Motorcycles have become a popular option in cities where cars remain unaffordable for many, exacerbating certain pollution and injury risks from motorized vehicles.
- **Barriers to non-motorized transport.** Pedestrian and non-motorized transport is severely limited by increased congestion and traffic, and NMT users are at high risk of injury.
- **Traffic in residential communities.** The invasion of traffic into urban residential communities and streets has erected barriers to physical activity, play and social interaction, making these communities less healthy and "liveable."
- **Sprawl-induced travel needs:** Poor land use management on the urban periphery generates excess sprawl, new demands for travel over longer distances, greater reliance on private motorized transport, and barriers to access among the poor lacking access to good public/private transport.

World Bank Transport Lending by Mode



Source: World Bank (18).

Healthy transport

Experiences in both developed and developing country settings reflect the potential of transport demand management policies to support a more managed and balanced mix of public, non-motorized modes and private modes of travel. These can contribute to lower levels of traffic-related pollution emissions, increased mobility and fewer risks of injury for non-motorized transport users, and more liveable urban communities with "friendly" spaces for children and adults to exercise and interact (15, 19). Healthy transport systems emphasize the efficient movement of people, not just vehicles. In large cities, such systems generally include:

- exclusive high-capacity networks and corridors for urban bus and rail
- modern, high quality networks for pedestrian and cycle transport
- integrated land use planning for healthy and liveable urban spaces.

Healthy transport can yield economic as well as human health benefits, reducing health care and social costs from air pollution-related respiratory and cardiovascular illnesses, traffic injury and degradation of urban communities (20). It can address vital quality of life and social equity issues among vulnerable groups -- improving access to jobs, services and education. Overall, multi-pronged strategies for "healthy mobility" can generate synergies and co-benefits for health, environment, development and equity (21).

With wide-ranging impacts and benefits, transport is an issue that needs to be addressed urgently by health, environment, transport and development actors in an intersectoral manner. This paper is intended to provide a broad overview for policy-makers, professionals and the informed public on the health impacts of transport; transport trends in developing countries that impact on health and the environment; the economic costs of those impacts; and case study experiences of healthy transport.

2. Transport trends: links to health and environment

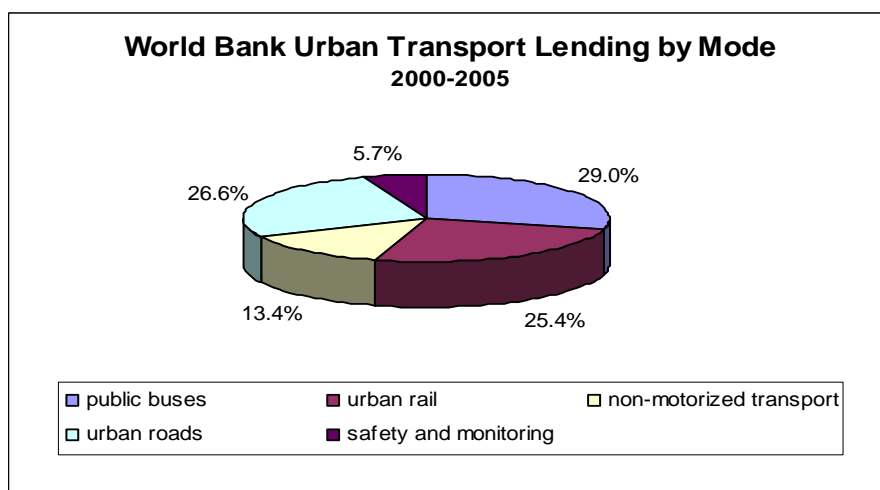
2.1 Road building: a dominant transport investment

Much of the urban transport investment in developing countries in the decade of the 1990s was focused on road improvements (18,22). One synthesis of data from 100 cities worldwide (1995-96) by Kenworthy and Laube provides the following indicators.

- Among the cities surveyed in developing regions, only **Latin American cities** invested, on average, a greater proportion of local GDP on urban public transport systems as compared to urban road development (23).
- In three of the **People's Republic of China's** five largest cities, as a proportion of local GDP, spending on road development and maintenance was 3.7 times greater than spending on public transport. The same three cities (Beijing, Shanghai and Guangzhou) also had less urban space dedicated to public transport infrastructure (i.e. high capacity bus or rail) than all other cities surveyed (23).
- In six major **African cities** surveyed, including Dakar, Cape Town and Casablanca, spending on urban road development was nearly twice the amount spent on public transport (as a proportion of local GDP) (23). In another survey of several major Kenyan and Tanzanian cities, 60% of municipal transport investment was spent on road infrastructure in the late 1990s; cars had an 8% share in kilometres travelled (13).

In developed countries, the manner in which road building actually stimulates new demands for private vehicle travel, longer journeys and the consequent new pressures of traffic, congestion, pollution and health impacts has been documented for nearly two decades (24-26). Some of those same trends of "induced traffic" are now being reported in developing city settings (27).

In the past five years, a greater emphasis appears to have been placed upon development of public transport and non-motorized modes in urban settings – at least in the context of activities and lending by development banks (see graphic). However, considering the existing patterns and historic trends, development of healthier and more sustainable urban transport systems remain one of the biggest challenges developing cities face.



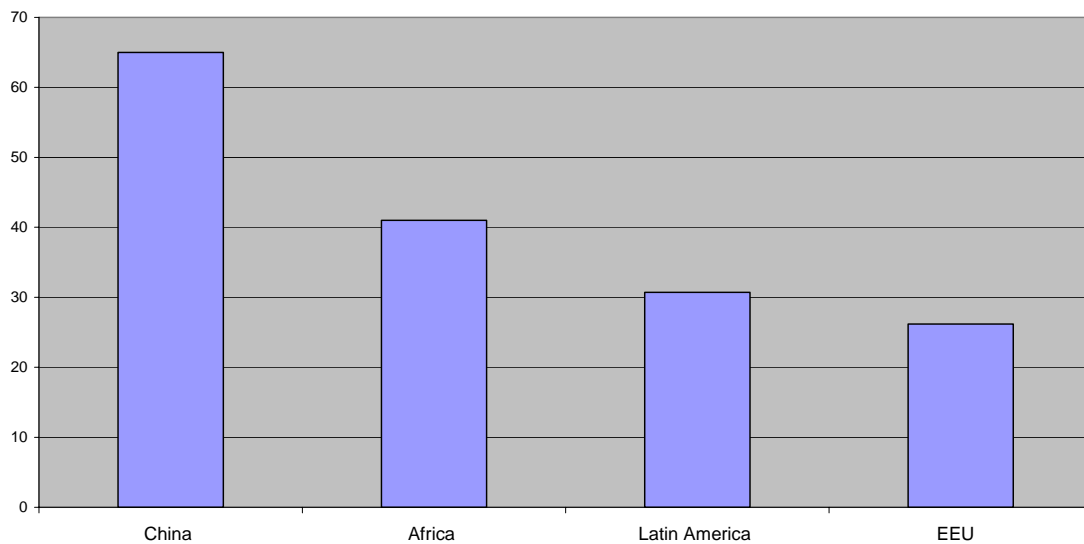
Source: World Bank & Sophie Bonjour, 2005 (18),(17).

2.2 Non-motorized transport (NMT) – no space to move

Urban experiences worldwide suggest that a healthy urban transport system must include a substantial component of walking and cycling systems (27,28). Walking and cycling networks support a range of positive and synergistic social, environmental and development benefits including: energy-efficient forms of mass/public transport; healthy physical activity; lower air and noise pollution emissions; reduced injury risks; and more socially vital commercial and residential neighbourhoods with a better quality of life overall (see Section 3).

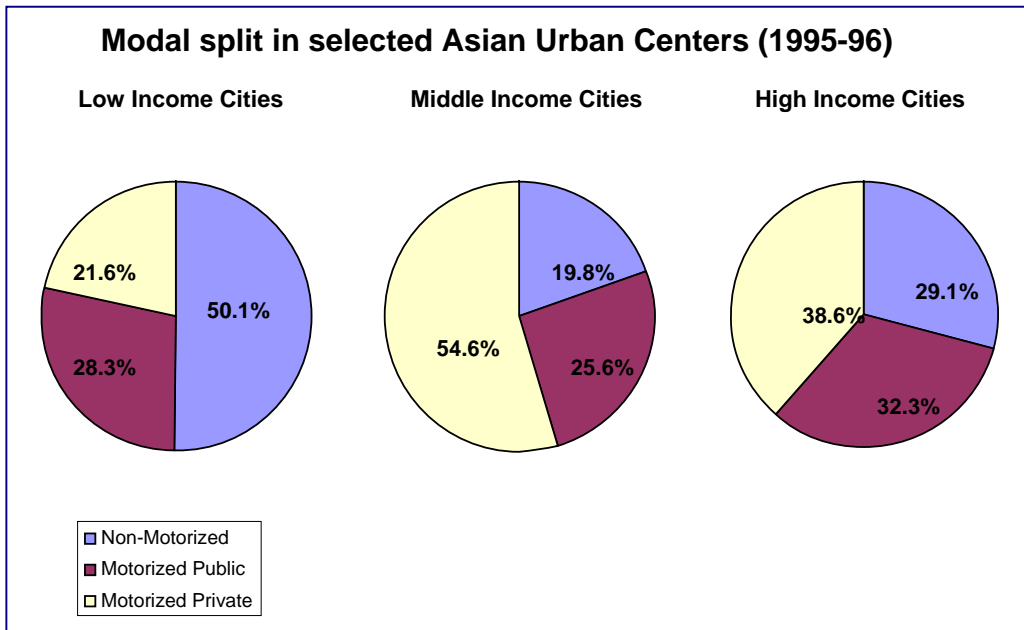
Walking and cycling remain important travel modes in developing cities of many regions – with cities in the People’s Republic of China still representing the highest rates of NMT travel.

Non-motorized transport in selected countries/regions % of total trips (1995-96)



Source: Kenworthy & Laube, 2002 (23).

However, over the past two decades, even as many developed cities were rediscovering the health and environmental benefits of walking and cycling, non-motorized travel in many developing cities was in decline. By the mid-1990s, certain middle-income cities in Asia (e.g. Taipei, Bangkok and Seoul) had lower rates of walking and cycling than more affluent Asian counterparts (e.g. Tokyo, Hong Kong and Singapore) (28),(29). In Bangkok, for instance, only about 10% of work journeys were made by walking or cycling; in Tokyo, one quarter to one third of journeys to work were by foot and bicycle (30).



Source: Kenworthy & Townsend (UNU/IAS-IIED, in press (28)).²

Through explicit action or mere neglect, public policy has broadly favoured cars over pedestrians. Cars encroach routinely upon sidewalks, parks and other pedestrian amenities like crossings, with lax or non-existent enforcement of parking rules. Streets may be widened at the expense of sidewalks and pedestrian alleyways. There may be deliberate attempts to restrict non-motorized travel on certain roads. Walking and cycling may be perceived as "inferior modes" in some developing cities – with pedestrians and cyclists hampering the smooth flow of motorized traffic and even "degrading" a society's image (13,31).

Travel by non-motorized means is often "invisible" to transport planners. Conventional transport planning typically monitors and projects travel needs **by motorized modes only**, and plans infrastructure improvements to optimize vehicular traffic flow and speeds rather than the movements of pedestrians and cyclists (32).

² Note: For the modal split and vehicle ownership analysis noted here, classifications of cities by "high, middle and low income" were made by the following criteria: high income - US\$ 16 000 per capita or more; middle income - US\$ 3000 to US\$ 15 999 per capita; and low income - US\$ 2999 or less per capita. These classifications deviate slightly from standard World Bank Atlas classifications, which groups cities by: high; upper middle; middle and lower, with an income cutoff of US\$ 9206 for high income. However this does not change the comparative observation made regarding greater or lesser use of public transport.

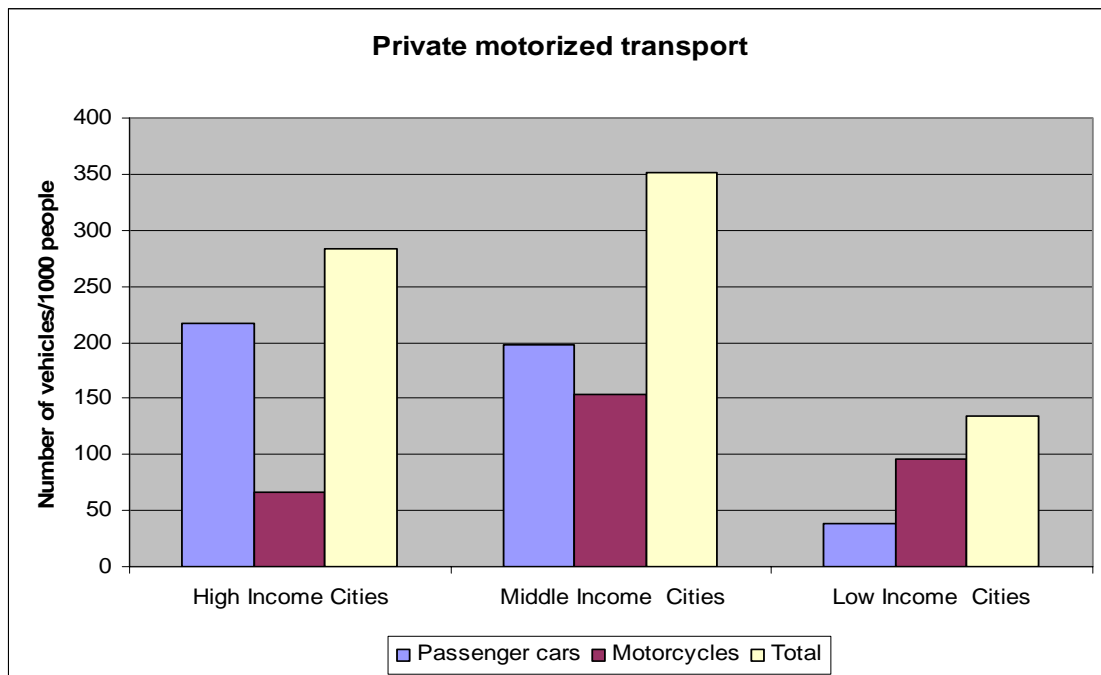
Cities considered high income, by the method used here, also are high income by World Bank methods and include: Tokyo, Osaka, Sapporo, Hong Kong and Singapore. Cities represented as Middle Income Asia here include: Taipei, Seoul, Kuala Lumpur and Bangkok, and low income: Guangzhou; Shanghai, Manila, Jakarta, Beijing, Ho Chi Minh City, Mumbai and Chennai. Most of these cities would be similarly classified using the World Bank system, with the exception of Seoul and Taipei, which would be added to the high income Asia cluster.

2.3 The crisis of public transport

Public transport systems also have deteriorated over the past two decades, often as a result of structural readjustment policies and the transition from state-controlled to market economies. In other settings, "public" transport may never have been managed systematically by public authorities, but rather by private operators. Lacking both investment capital and management capacity, public transport operators cannot compete with the speed and efficiency of private transport. Public transport patrons who can afford to do so, gradually opt for private motor vehicles, reinforcing a vicious cycle (23,28,33).

Motorcycles have become a popular option in cities where cars remain unaffordable for many. In Hanoi, for instance, in the mid-1990s roughly 61% of trips were made by motorcycle, 30% by bicycle and only 3% each by bus and car (34). Since then, the growth in the motorcycle fleet has continued to outstrip that of cars and at an even faster rate. The pollution and injury risks from two- and three-wheel motorized vehicles have been a recent focus of policy discussion in Asia and other developing regions.

Private motorized transport in selected Asian cities (1995-96)



Source: Kenworthy & Townsend (UNU/IAS-IIED), in press (28).

As in the case of walking and cycling, some of the most affluent cities of Asia (e.g. Hong Kong, Tokyo and Singapore) boast higher rates of public transport use, and lower rates of private vehicle ownership, than their less affluent counterparts (see graphic). Some of the same cities (e.g. Tokyo and Singapore) also had among the lowest levels of health-damaging fine particulates (PM_{10}) among major cities in Asia (1996-2003), according to data collected by the Clean Air Initiative for Asian Cities (35).

The emerging dependency on private motorized transport in many developing cities has potentially severe environmental, health and social impacts which have not been quantified systematically. In the European setting it is estimated that passenger travel by car uses an estimated two to three times more energy than bus or rail transport, at equal capacity of utilization

(36). Per *passenger kilometre of actual travel*, private vehicles typically generate greater health and environmental impacts than either non-motorized or public modes, through air pollution, noise, injuries, climate change and urban impacts (e.g. space consumed by roads and parking) (14,26,36,37). However, certain variables can shift dramatically depending on the technologies involved (e.g. an old bus operated on diesel fuel emits more pollutants than a modern bus running on alternative fuels).

When public transport stagnates "captive users" become the primary patrons. Captive users are people with no other transport alternatives, most often including: the poor, women, children and the elderly. The mobility gap may thus exacerbate existing social divisions. Access to jobs, health, education and welfare services, as well as to shopping and leisure activities may be very different among rich and poor – as may be the proportion of household income allocated to basic mobility needs. These issues are explored further in Section 3.

3. Health and environmental impacts of transport in developing cities

Patterns of transport and land use generate measurable crosscutting health impacts in developing cities through traffic injury; air pollution and noise; and certain patterns of physical activity. Transport also impacts community social interactions, social equilibrium and well-being in a variety of ways that are more difficult to measure, but which have been documented in qualitative research. For instance, even in poor neighbourhoods and informal settlements, the maintenance of good pedestrian networks and alleyways where adults and children can move easily may support physical activity and social connectivity, and thus health and well-being. A description of health and environmental impacts, with reference to developing cities, is given below.

3.1 Road traffic injury

Every day, almost 3000 people in low- and middle-income developing countries die from road traffic injuries. Already the ninth leading cause of mortality and morbidity, road traffic injury is projected to become the third most significant global factor in death and morbidity by 2020, due to rising motorization, unsafe road and urban design, unsafe vehicles, lack of effective law enforcement and increased exposure of vulnerable populations. *Roughly 1.3 million deaths and 20-50 million cases of injury occur annually, 90% in low- and middle-income countries (10,11,38,39).*

Pedestrians, cyclists and motorized two- and three-wheeler riders are among the groups most vulnerable to traffic injury (38,39). For instance, in Delhi these three groups comprise approximately 75% of road traffic fatalities (40). Environmental factors that may increase vulnerability (particularly where there is weak or non-existent investment in infrastructures, regulations and policies supporting NMT) include: rapid growth in motor vehicle traffic; the lack of separation between non-motorized and motorized traffic; poor control or connectivity at pedestrian crossings; traffic encroachment into pedestrian space; and policies that increase the speed of motor vehicle traffic, at the risk of pedestrians (27,40).

In order to reduce road traffic injury, the *World report on traffic injury prevention* recommended more assertive action on a range of injury prevention measures, including "smart growth" urban policies. Such policies foster compact, mixed-use development and easy pedestrian or cycle access to major activity centres. Private vehicles may be discouraged from entering city centres and other vulnerable areas. As far as possible, motorized vehicle traffic should be channelled away from pedestrian and cycle routes and traffic calming measures used to slow speeds where mixing is inevitable. This is in addition to greater use of technological safety measures, such as seat belts and traditional forms of policing, as well as education for driver and pedestrian safety. The report also noted that safer modes of travel must be encouraged, and trip distances reduced. For instance, on the global level, travel by public transport (e.g. bus or train) is usually the safest mode of passenger travel, per person kilometre (38). In the European setting, the external costs of rail-traffic injury are estimated to be one-tenth of those for cars, per passenger kilometre (37).

3.2 Traffic and air pollution

In developing cities, reliance on trucks, buses and motorcycles using older technology and lower-quality fuels, in settings of very high urban density, with very rapid private vehicle motorization and public transport stagnation tend to "amplify" the public health impacts of transport-related pollution emissions.

Some of the highest concentrations of transport pollution emissions, per hectare of urban area, may be found in the lower-income cities of developing countries. In three major Asian cities surveyed in the 1990s, transport emissions averaged 11 920 kg per hectare (kg/ha), compared to the United States' average of 3600 kg/ha in the mid-1990s (23,41).

Programmes to convert vehicles to newer fuel technologies, improve fuel quality and enforce vehicle emissions standards/vehicle inspection routines, appear to have helped to curb increases in ambient air pollution in some developing cities and improve air quality. At the same time, traffic growth also may erode or offset potential gains (35,42). In Europe, for instance, PM₁₀ emissions from traffic decreased during most of the 1990s and ambient air pollution concentrations declined in certain cities, but between 1999-2003 ambient air PM₁₀ concentrations across Europe remained about the same or even increased slightly (43).

Health impacts of air pollution

In an update of earlier work, WHO estimated that urban air pollution results in 1,152,000 deaths annually for 2004, largely as a result of cardiopulmonary disease, acute respiratory infections and lung cancer (10). About 65% of urban air pollution deaths are estimated to occur in developing countries of Asia³ (44).

Particulates

Among the wide range of air pollutants generated by vehicle traffic, small and fine particulates appear to be linked most directly to quantifiable impacts on health. Small particles of less than 10 microns in diameter (PM₁₀) and fine particles of less than 2.5 microns in diameter (PM_{2.5}) are linked most closely to quantifiable impacts on public health. Such particles bypass the body's usual defences against dust, penetrating and lodging deep in the respiratory system. Small particles emitted by road vehicles may be comprised of elemental carbon or carbon compounds, heavy metals and sulfurs, and also carcinogens e.g. benzene derivatives. In many developing countries, old and poorly performing diesel vehicles often are responsible for the greatest proportion of small particle emissions from vehicles and visual assessments of "black smoke" emissions from trucks and buses can be a rapid and inexpensive "proxy" indicator of excessive tailpipe particle emissions (43).

Cumulative, long-term exposure to elevated levels of small and fine particulates is associated with reduced lung function, increased incidence of respiratory disease and quantifiable rates of reduced life expectancy. However, to date, long-term studies of such health impacts in large urban populations have been conducted only in the United States of America and Europe (45-47).

Public health impacts from short-term exposure to particulate pollution (measured most frequently as mass concentration of particles below PM₁₀) have been quantified in both developed and developing countries. Short-term increases in levels of fine particulates have been associated with increased rates of daily mortality and hospital admissions, mostly as a result of chronic respiratory and cardiovascular conditions (45).

³ This refers to the proportion of global deaths from urban air pollution in developing countries of the WHO South-East Asian and Western Pacific regions (see World Health Report 2002 for countries in each region).

Particulate pollution and health: reviewing the evidence

A systematic review of air pollution and health impact studies in Asia, found that daily mortality increased by an average of 0.4% to 0.5% for every 10 $\mu\text{g}/\text{m}^3$ increase in PM_{10} concentrations, in a subset of data examined. The review by the Boston-based Health Effects Institute was undertaken in the framework of the Clean Air Initiative for Asian Cities (CAI-Asia), a partnership of the Asian Development Bank and the World Bank. While other representative settings in Asia still require examination, the mortality increase noted was similar in scale to the results of large American and European multicity studies using comparable statistical methods (48).

A recent WHO-sponsored health impact assessment of air pollution in eight major Italian cities, found about 4.7% of all mortality (excluding accidental causes) attributable to PM_{10} concentrations above 30 $\mu\text{g}/\text{m}^3$. Average annual PM_{10} levels during the two-year time frame of the study ranged between an estimated 44.4-53.8 $\mu\text{g}/\text{m}^3$ – lower than the concentrations reported in many developing cities (47).

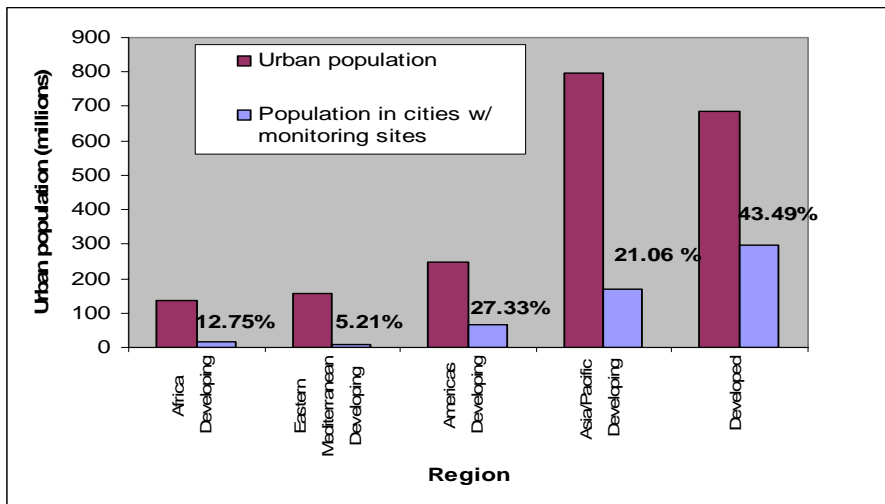
A European Commission-sponsored study, involving 39 million residents of 23 cities across 12 countries found average annual PM_{10} levels ranging from 17 $\mu\text{g}/\text{m}^3$ to 85 $\mu\text{g}/\text{m}^3$ in the cities studied. It was estimated that the sustained reduction of annual PM_{10} concentrations to an average of 20 $\mu\text{g}/\text{m}^3$ could avert approximately 21 000 premature deaths per year (49).

Health effects from fine particulates have been observed at all ranges of the observed annual average concentration levels e.g. from concentrations as small as 8 $\mu\text{g}/\text{m}^3$ for $\text{PM}_{2.5}$ and 15 $\mu\text{g}/\text{m}^3$ for PM_{10} (45). In response to the growing body of evidence regarding the health impacts of particulates, new WHO *Air Quality guidelines* issued in 2006, set guideline values for $\text{PM}_{2.5}$ and PM_{10} , for the first time ever. For $\text{PM}_{2.5}$, the guideline value is 10 $\mu\text{g}/\text{m}^3$ annual mean, and for PM_{10} , the guideline value is 20 $\mu\text{g}/\text{m}^3$ annual mean (46). The United States Environmental Protection Agency (USEPA) has, meanwhile, a standard of 50 $\mu\text{g}/\text{m}^3$ annual mean for PM_{10} ambient air levels, while the annual mean limit value set by a European Union directive is 40 $\mu\text{g}/\text{m}^3$ (50,51). In general, particles emitted by fuel combustion processes may contain or carry more toxic compounds (e.g. metals) than particles from natural sources such as dust storms. But at present, total PM_{10} or $\text{PM}_{2.5}$ mass concentrations per volume of ambient air are considered to be the best indicators of potentially health-damaging exposures for risk reduction purposes (45,46).

Environmental monitoring of particulates

There are sizeable gaps in knowledge about particulate pollution concentrations in many cities around the world. Out of 200 major cities, only 3 in Africa were reported to monitor particulates in 2000 (44).

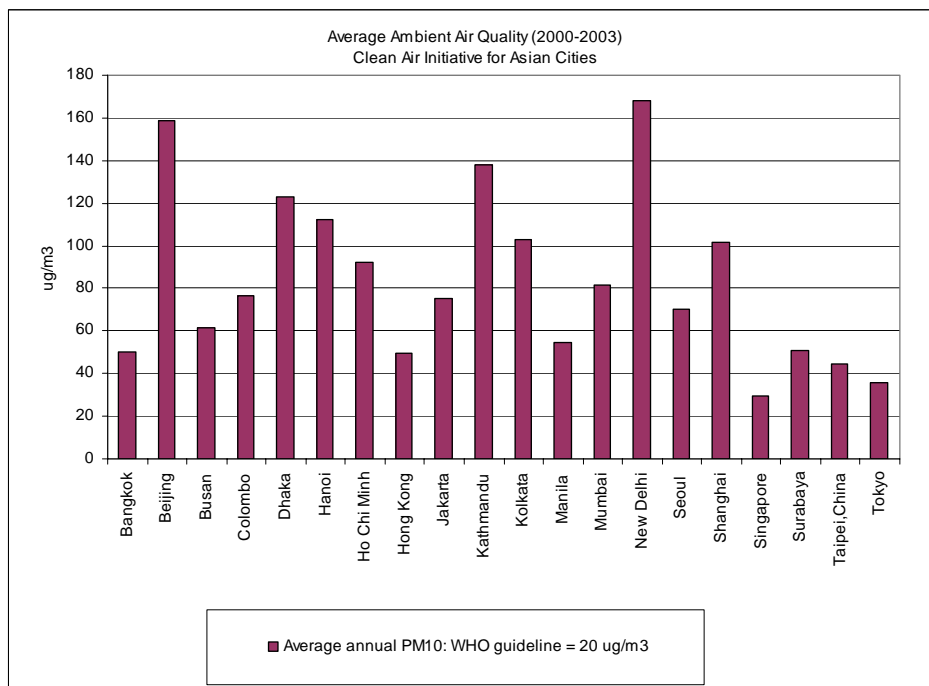
Particulate monitoring for urban populations



Source: Cohen et al., 2004 (44).

Note: Definitions of WHO Member States' regions are found in the World Health Report. 'Africa Developing' denotes all countries of WHO African region. 'Americas Developing' includes all countries from WHO subregions AMR-B and AMR-D. 'Asian/Pacific Developing' includes all countries from WHO subregions SEAR-B, SEAR-D and WPR-D. 'Developed' includes all countries in the European region, and the WPR-A and AMR-A subregions.

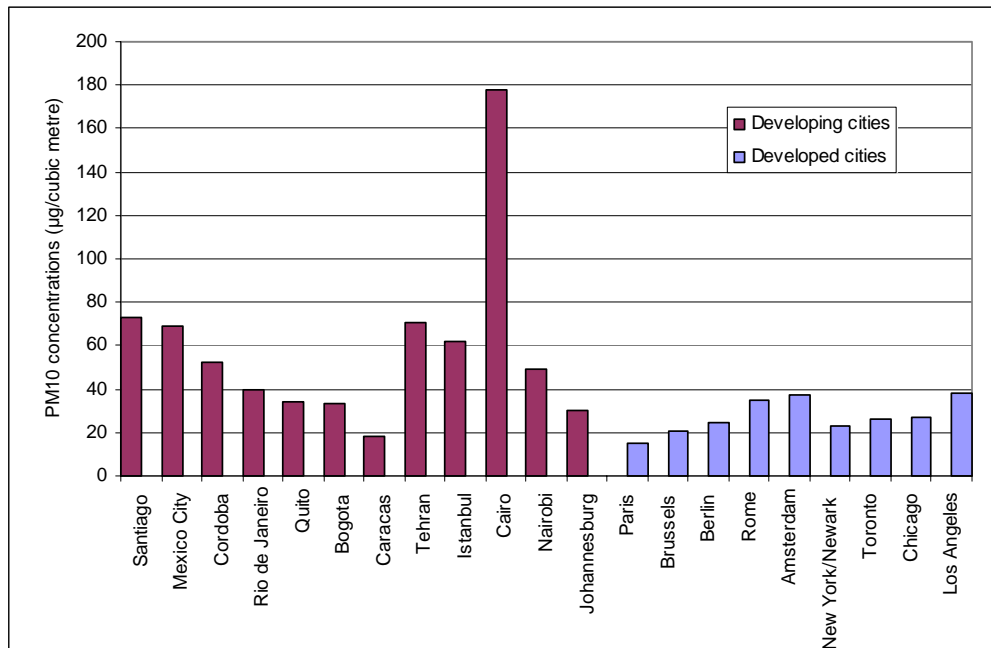
Where routine monitoring does take place, some of the highest levels of particulates are found in Asian cities. Total suspended particulates (TSP) may exceed concentrations of $100 \mu\text{g}/\text{m}^3$ and average PM_{10} concentrations may well exceed North American and European standards (52).



Source: Compiled by the Clean Air Initiative for Asian Cities (35,53).

There are inconsistencies in data measured in different regions and by different agencies too. The average annual PM₁₀ concentrations in residential and mixed urban/residential areas of selected cities in Latin America, Africa, Asia and North Africa are set out in the graphic below. These exclude pollution "hot spots" e.g. traffic corridors, and thus are not directly comparable with the Asian data cited above (54).

Average annual PM₁₀ concentrations in residential areas: micrograms/m³ (1999)



Source: World development indicators (54).

Transport's contribution to particulate pollution

"Emissions inventories" to estimate the relative contribution of pollution from various mobile and stationary combustion sources have been developed in some cities of Asia and Latin America, usually by national or municipal environment agencies. Estimates of transport pollution emissions typically are based upon standardized models developed in Europe or North America. These models estimate grams of pollution per kilometre of travel for various vehicle types and model years, and in different driving conditions.

Gaps in knowledge about the actual size, age and nature of urban vehicle fleets; fuel quality; and vehicle performance in local driving conditions greatly complicate any assessment of vehicle pollution emissions. Only some developing cities and countries consider such variables in making estimates of vehicular pollution. In addition, the proportion of particulates emitted by vehicles may not translate directly into the same proportions of ambient air pollutants from vehicle sources. For instance, secondary particles of ammonium nitrate and ammonium sulfate are formed in the atmosphere from nitrogen oxides and sulfur dioxides emitted by both vehicles and industry (43). Yet despite the uncertainties, emissions inventories provide at least a tentative indicator of the degree to which transport may contribute to air pollution and, by inference, to health impacts.

Estimated mobile source contributions to particulate emissions: emissions inventories

City	PM	PM ₁₀
Seoul ^a	96%	--
Hong Kong ^a	--	50%
Bangkok (1997) ^b	53.9%	18 %
Busan (2002) ^a	--	90%
Jakarta (1998) ^c	--	71 %
São Paulo (2001) ^d	51.6%	40%
European average (rural and urban) ^e	--	22% (primary PM ₁₀ emissions and gases forming secondary PM ₁₀)

a. Haq et al., 2002 (41); b. Suksod, 2001 & World Bank, 2002 (55,56); c. Asian Development Bank, 2002 (57); d. Guttikunda and Johnson, 2004 & Vicente de Assunção, 2002 (58,59); e. Kryzanowski et al., 2005 (43).

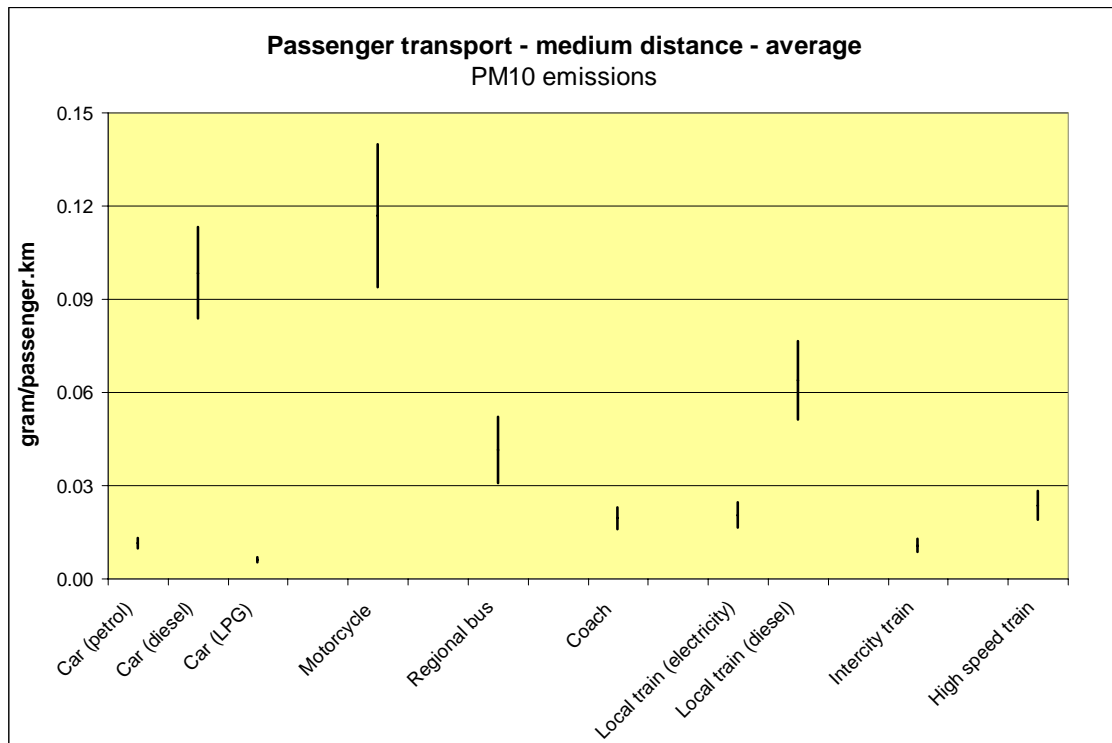
Chemical analysis of ambient air pollution samples has been undertaken in a number of developing cities. Such analysis, sometimes referred to as source apportionment, can improve understanding of the relative contributions to actual ambient air pollution made by various sources, not only emissions. In many developing cities, for instance, particles stirred up by road dust and produced by solid fuel combustion and burning of agricultural refuse, are important sources of particulate pollution. These may not be captured accurately in a standard inventory of emissions from vehicles and factories. At the same time, the precise origin of certain particles captured in a sample may be difficult to identify. Also there are evident seasonal variations in traffic's contribution to particulate pollution – due to the increased burning of solid fuels in the winter and more road dust in dry seasons.

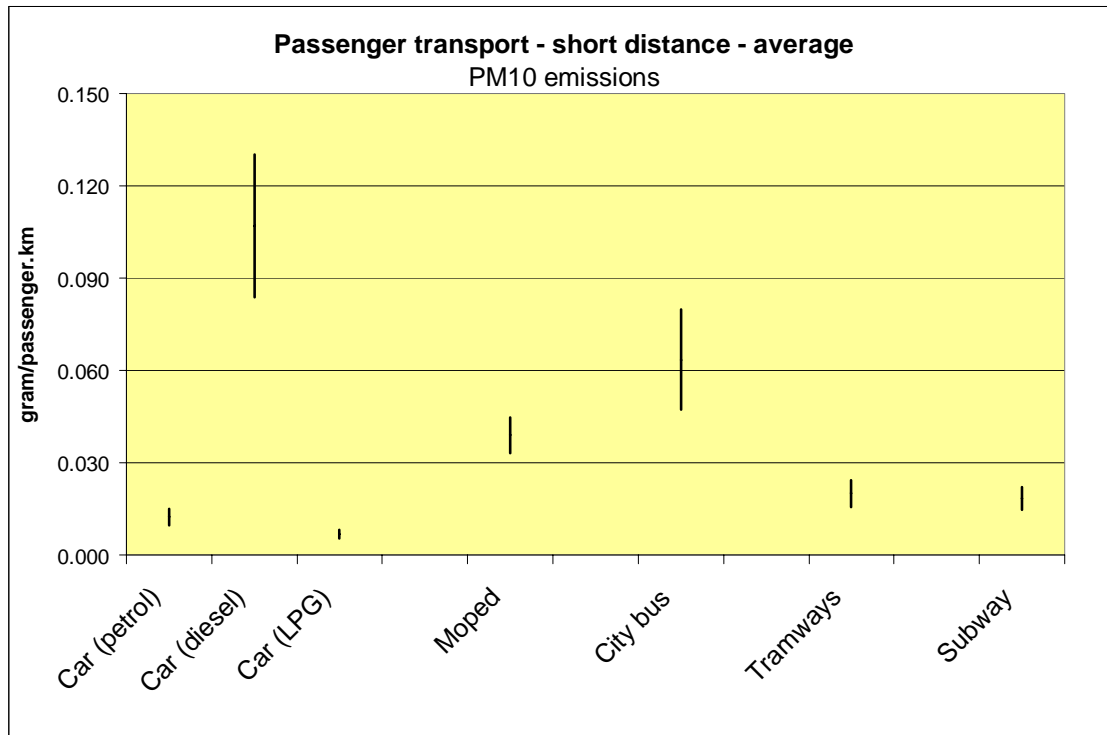
Particulate air pollution sources: source apportionment case studies

City	Proportion of mobile source contribution to total ambient PM _{2.5} concentrations
Kolkata ^a	24-69% - vehicle exhaust 4-40% - road dust
Delhi ^a	19-23% - vehicle exhaust 4-40% - road dust
Mumbai ^a	22-28% - vehicle exhaust 16-38% - road dust
Dhaka, Bangladesh ^b	45-50% - vehicle exhaust
Shanghai ^c	12-17% - vehicle exhaust 2-3% - road dust
Sao Paulo ^d	28-24% - vehicle exhaust
European urban average ^e	25-50% - primary traffic emissions only
Beijing ^f	13% - vehicle exhaust 18.7% road dust (source inventory)

a. Haq et al., 2002; Guttikunda & Johnson, 2004; UNDP/World Bank-ESMAP, 2004 & (41,58,60); b. Begum et al., 2004 & 2005 (61,62); c. Guttikunda & Johnson, 2004 (58); d. Guttikunda, 2005 (63); e. Kryzanowski et al., 2005 (43). f. Zhang Y, Zhu X, and Zeng L, 2006 (64) .

In developing country conditions, diesel vehicles often generate the highest proportions of vehicular particulates, particularly older trucks and buses which may be poorly-maintained. Motorcycles and three-wheeled vehicles powered by old fashioned two-stroke engines also represent a disproportionate share of particulate emissions due to lower fuel efficiency, as compared with conventional four-stroke engines (60). However, modern three-wheeled vehicles using four-stroke engines with catalytic converters can be as clean as cars. In Dhaka, Bangladesh, a significant decline was observed in airborne concentrations of fine particulates at two experimental monitoring sites following new government policies that removed two-stroke engines from the road and began to upgrade or convert diesel trucks and buses to cleaner fuels e.g. compressed natural gas (CNG) (60,65). In European conditions, where new diesel technologies are used, buses may even rival electric rail modes for their low emissions of PM₁₀ and other air pollutants (e.g. CO₂) – particularly in medium distance journeys of 10-250 kms. In short journeys under 10 km, however, electric rail modes may still be the least polluting, on average, per passenger kilometre of travel (66).





Source: (Essen H. et al, CE Solutions, 2003) (66)

Other pollutants

Other key pollutants of concern to health include: nitrogen oxides (NO_x); carbon monoxide (CO); volatile organic compounds (VOCs) such as benzene; benzene derivatives in the form of polycyclic aromatic hydrocarbons (PAHs); and various metals, particularly lead.

CO and NO_x

Carbon monoxide in ambient air forms a bond with haemoglobin and impairs the oxygen-carrying capacity of blood. Health impacts from short-term exposure to the levels of CO typically found in ambient air pollution may include cardiovascular effects, such as the aggravation of angina symptoms during exercise, and impaired exercise performance (67). Health impacts of exposure to NO_x include reduced lung function and increased probability of respiratory symptoms (45).

In Asian cities, transport has been estimated to contribute 40-98% of total CO emissions and 32-85% of total NO_x emissions (41,55,57,68-72). In Mexico City and São Paulo, mobile sources were estimated to comprise 97-98% of CO emissions and 55-97% of total NO_x emissions (59,73). In Europe, vehicles are the main contributors to NO_x (43).

For gasoline-powered vehicles catalytic converters can reduce CO emissions very significantly, as well as reducing NO_x (43). However, in many developing cities the use of catalytic converters still is not as widespread as in developed cities, due to the age of the car fleet and local policies e.g. where leaded gasoline is still used. Catalytic converters also are not efficient during the short trips typical of many urban journeys and they require regular maintenance.

Estimated mobile sources' contributions to CO and NOx emissions

City	CO	NOx
Beijing (2000) ^a	76.8%	40%
Guangzhou (2000) ^a	83.8%	45%
Mumbai ^b	92%	60%
Delhi ^c	76-90%	--
Busan (2002) ^d	97%	87%
Bangkok (1997) ^e	75.4%	80.4%
Ho Chi Minh City ^f	84%	61%
Jakarta (1998) ^g	~100%	71 %
São Paulo (2001) ^h	96.4%	97.7%
Mexico City (2001) ⁱ	98%	55%

a. Zhongan et al., 2001 (68); b. Haq et al., 2002 & Bose, 2004 (41,69); c. Bose, 2004 (69); d. Haq et al., 2002 (41); e. Suksod, 2001 (55); f. Asian Development Bank, 2002 (72); g. Asian Development Bank, 2002 (57); h. Vincente de Assunção, 2002 (59); i. Landa, 2001 (73).

Volatile organic compounds (VOCs) and polyaromatic hydrocarbons (PAHs)

Vehicle fuel contains a variety of carcinogenic compounds including benzene, a VOC. In the air, benzene may react to form the PAH benzo[a]pyrene, which attaches to fine particles and is thus absorbed into the lungs (43).

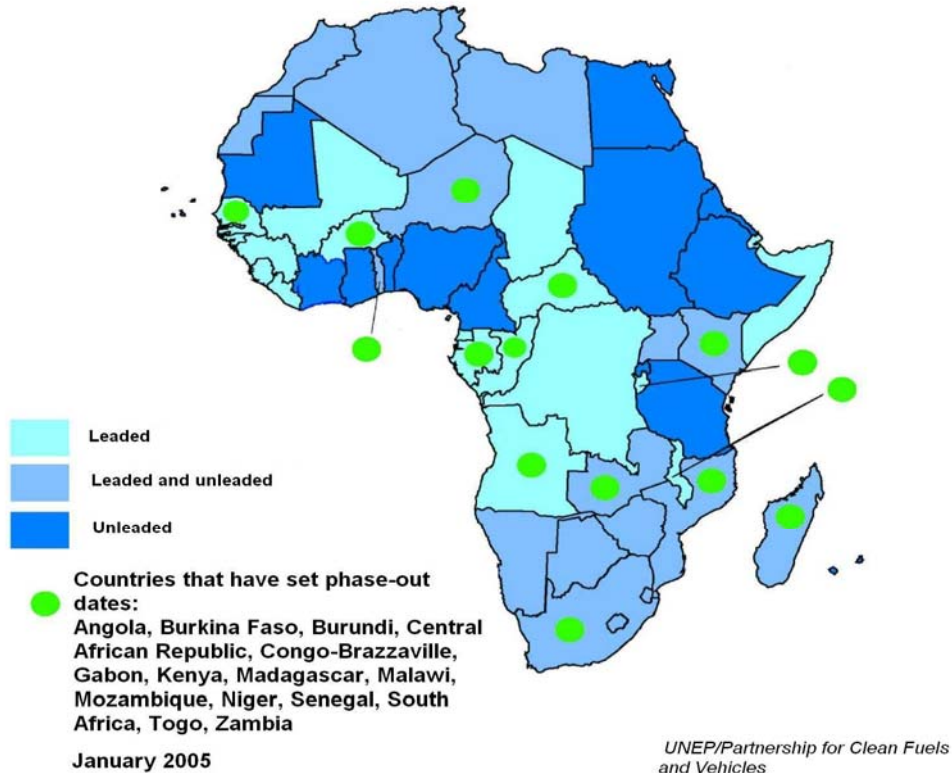
Occupational exposure to diesel and gasoline engine exhaust has been linked to increased cancer risk (19,74). An association between childhood leukaemia and living near busy roads has been noted in a number of population-based case-control studies (42). However, a WHO systematic review of the health impacts of air pollution in Europe did not find conclusive evidence that traffic-related air pollution levels common in Europe lead to an increased risk of childhood cancer (45).

Atmospheric reactions involving VOCs and nitrogen oxides also lead to the formation of tropospheric ozone. Excessive short-term exposures to ozone can have adverse effects on pulmonary function and increase lung inflammatory reactions, adverse respiratory symptoms, medication use, hospital admissions and daily mortality (45).

Lead

In many developing countries, leaded gasoline remains a critical health hazard (75). Lead emissions are extremely harmful to children under the age of six, interfering with brain and organ development and contributing to learning disabilities (45). Every year an estimated 234 000 people die from exposure to lead, through air, soil and other media (10,76). In 2002, only one African country had phased out leaded fuel (Sudan) and, today, 50% of gasoline sold in Africa is unleaded (77).

Leaded gasoline phase-out sub-Saharan Africa



Children and air pollution

Children are among those most at risk from the adverse effects of air pollution. Their bodies are more vulnerable due to the growth and development processes they undergo. A few studies have indicated a link between air pollution and infant mortality as well as between air pollution and birth weight, pre-term birth and retarded intrauterine growth (45,76).

Studies of lung function in children suggest that living in areas of high air pollution is associated with reduced lung function. Long-term exposure to air pollution is associated with lower rates of lung function development; the level of lung function is one of the strongest predictors of mortality in adults. Exposure to air pollution also is associated with increased frequency and severity of childhood upper and lower respiratory illness (45).

3.3 Traffic and physical activity

Like developed countries, most developing regions face an epidemic of non-communicable diseases. Many of these are associated with increasingly sedentary lifestyles and obesity (10,11,78).

In most regions of the world today, some 65-80% of adults are physically inactive – failing to meet the minimum recommendation of 30 minutes of moderate intensity physical activity per day. This problem may be particularly acute in urban areas (79,80). Based on very recent evaluations of obesity evidence and trends, some experts have recommended even longer periods of moderate daily physical activity for those who have been, or are at risk of, becoming obese and for children (81).

Physical inactivity increases the risk of cardiovascular disease, Type 2 diabetes, colon and breast cancers, and also is associated with obesity, high blood pressure, lipid disorders, osteoporosis, depression and anxiety (12,82).

While more research is needed, many scientists and policy-makers agree that the built environment can either facilitate or constrain physical activity essential to health (83-85). Further, some studies have shown relationships between the built environment and health outcomes. For example, studies have documented a direct, positive relationship between urban sprawl and higher levels of obesity and obesity-related illnesses (16,86). One population-based case-control study in Shanghai found that colon cancer risk was reduced significantly in proportion to the greater time subjects spent in physically-active commuting (87).

Integration of physical activity into daily travel routines, which are generally quite fixed, is viewed as a reliable means of supporting physical activity in diverse socioeconomic groups of urban residents (88). For instance, one cross-sectional survey of nearly 4000 men and women in Tianjin, China, conducted in the mid-1990s, found that most physical activity occurred during routine walking or cycling to work, not as a result of leisure-time activities. The average duration of leisure-time physical activity was only 10 minutes per day, average commuting time on foot or bicycle was about 30 minutes. Leisure-time physical activity was more frequent among highly educated, high-income people or those commuting on foot or by bicycle (89).

Over the past decade, a range of transport studies in developed countries established that certain mixes of land use and transport services have a quantifiable influence on the modal split – that is the share of travel by NMT, public transport and private vehicles. Typically, metropolitan areas with measurably higher levels of sprawl have much higher rates of private vehicle use (23,85,86,90). Transport and land use patterns that contribute to higher levels of travel on foot, by bicycle and public transport generally include (91):

- compact, mixed-use urban development of residences, businesses and services
- high quality pedestrian and cycle networks with good connectivity
- good public transport networks that indirectly stimulate walking and cycling, e.g. to and from stations.

Many developing cities have high population densities and mixed land-use patterns favourable to walking and cycling. Residents of very poor cities still tend to walk, cycle and use public transport more than their developed country counterparts. But in most cases, facilities for walking and cycling are poor or non-existent, leaving NMT-users to mix with motorized traffic. Increased exposure to roadside air pollution and risk of injury may offset many of the gains of healthy physical activity (13,40). Socially, walking and cycling may be viewed as forms of travel that are inferior to private motorized transport (13).

Promotion of physically-active commuting and travel patterns, therefore, is best accompanied by improvements in NMT-friendly facilities and policies. Such policies can yield other benefits, improving the prestige and profile of non-motorized modes and easing access to public transport. Indeed, when high-quality public transport and non-motorized modes are developed as an integrated package, synergies between environmentally sustainable urban development and healthy physical activity can be created in poor cities, as in more affluent settings (13).

3.4 Traffic, community health and equity

Transport is a very intensive consumer of urban space and, per kilometre of travel, car traffic consumes far more urban space than either public transport or non-motorized modes – through parking and on the road. Per passenger, a fully occupied car may consume more than two to three times the road space of a fully-occupied bus or a light rail vehicle, travelling at similar speeds (26,36).

Those with no access to private motorized vehicles (including women, children, the elderly, the poor and even sectors of the middle class) may find movements to jobs, services and schools increasingly difficult, due to the proliferation of motorized traffic (92). Crowded urban neighbourhoods faced with an influx of motorized traffic suffer from not only direct health impacts of increased exposures to pollution, noise and risk of injury, but also indirect social impacts that may include a weakening of community relationships, loss of social equilibrium, erosion of property values and gradual urban flight to more desirable residential locations (14,93-95).

In many developing cities, a larger proportion of urban residents may live in central city areas, as compared to developed cities, where business activities predominate. Urban residents of developing cities are thus likely to be more directly exposed to all of the impacts of urban transport, from air pollution and noise, to risk of injury and constraints on physical activity. For instance, in developing Asian central city areas, it has been estimated that about 50% of the "activity density" (combined population and job density per hectare) is residential, as compared to employment-oriented. In developed country cities of Asia, Europe and North America, only 8-18% of central city "activity density" is residential (29).

Usually, it is the stronger socioeconomic groups that can afford to flee congested and polluted urban centres for more peripheral communities. However, over time this pattern of flight may generate new demands for travel to and through older, and potentially less affluent, urban areas. Poor urban residents pay a double "health penalty" for the congestion, noise and air pollution that they have not generated combined with risks and limitations to their own healthy mobility as a result of suburban commuters passing near or through their communities (26,95-97).

For children, in particular, exercise and a degree of outdoor free range of movement is critical to physical fitness and the development of motor and cognitive skills (98,99). Those who are unable to explore their neighbourhood safely are denied a vital experience – the chance to test themselves socially, mentally and physically in small real-life situations that prepare them for the wider world (100). Particularly in developing countries, children are among the groups most vulnerable to traffic injury (38). While data is not collected systematically, an Asian Development Bank survey of vulnerable road users in the Asia-Pacific region indicated that roughly one third of pedestrian casualties involved children under the age of 16, in countries reporting the age distribution of casualties (101).

3.5 Traffic and noise pollution

Traffic generates noise. Excessive noise pollution is associated with sleep dysfunction, impaired school performance and communication, hearing impairment and increased annoyance and aggression. In addition, there is increasing evidence linking loud noise to hypertension and ischaemic heart disease. WHO noise guidelines classify background noise levels above 55 dB LAeq in community settings such as playgrounds or outdoor living areas as a serious annoyance. Above this level, voices have to be raised and concentration is interrupted. Noise thresholds for indoor spaces and night-time sleeping areas are much lower (30-35 dB LAeq) (19,102).

Anecdotal evidence of traffic noise and health impacts is reported in developing cities worldwide. Poor people often are most exposed to traffic noise as housing at street level directly adjacent to very busy roads may be less expensive. In studies in India, Pakistan and Thailand, hearing loss has been reported in certain population sectors as a result of urban noise, particularly from traffic (102).

4. Some principles of healthy transport

The goal of healthy and sustainable transport is to maximize access, personal mobility and healthy physical activity. Technical components of a healthy and sustainable transport network vary by locale, local needs and travel patterns. However, the following policy components are considered to be some of the most important.

- **Vision of social equity.** Urban transport systems should provide high quality mobility to all urban residents who need access to jobs, schools and commercial districts, regardless of whether they own a private vehicle. Such mobility should minimize health risks from pollution and injuries, and enhance opportunities for healthy physical activity and communal interactions across all sectors (32,97).
- **Transport demand management.** Rather than "predicting and providing" more road capacity for economic development, demand management asks: "what are the mobility needs of people and goods, and how might those be answered in the most healthy, efficient, equitable and environmentally sustainable manner?"
- **Integrated transport.** Integrated systems optimize connectivity between, and comparative advantages of, different modes e.g. NMT for dense urban areas; public transport for high-volume travel to high-demand destinations; and private transport for very low volume, point-to-point trips served inefficiently by other modes (24,25).
- **Prioritizing non-polluting modes.** Public transport and NMT generate fewer health and environmental impacts per unit of travel. These can be prioritized in a demand management policy using both physical design and economic measures (25,103).
- **Separated NMT networks.** High quality pedestrian and cycling networks, separated from vehicular traffic, can help reduce injury risk and enhance the mobility of poor and vulnerable populations, such as children. Good NMT networks also provide additional incentives to use public transport since usually this is accessed by those modes.
- **Dedicated public transport corridors.** This is a key spatial design feature that can improve public transport service and efficiency in crowded urban areas. Dedicated public transport can include light rail or rapid bus transit (the latter may be less expensive and faster to implement); or a mix of rapid bus transit, light rail and metro services – as appropriate to local travel needs and volumes, needs for connectivity and mobility, and urban land-use patterns (25,27,40,103). When separation is impossible, traffic-calming measures should be used to slow motorized vehicle speeds so that the lives of pedestrians and cyclists are not endangered (13,27,92).
- **Active community environments.** Urban space should be allocated to community social and activity space (e.g. parks, squares and playgrounds, pocket gardens, pedestrian alleys and rights of way). These support mobility, physical activity and social interactions in a safe and non-polluted environment (97,104).
- **Managed, integrated land use.** Land-use policies that cluster and integrate new housing, services and activity centres around public transport/NMT networks can help to reduce the excessive "trip generation" that often accompanies urban development, thereby enhancing sustainability and health (105).
- **Improved vehicle standards and technology.** Policies that support unleaded fuels, lower-sulfur fuel; alternatives to diesel, such as CNG; improved standards or retrofitting of older vehicle engines; and better vehicle maintenance and monitoring, can help to lower

pollution emissions, particularly from the most polluting vehicles (77,106). Improved safety design of vehicle fronts, especially for cars and buses, can reduce pedestrian and cyclists' injuries significantly (107,108). Policies that encourage the phasing out of older vehicles can help to remove vehicles that are among the most polluting and at greater risk of break-downs which can, in turn, be a factor in traffic accidents and injuries.

- **Economic tools.** Economic tools such as fuel taxes, congestion charging or parking pricing may be used to generate revenues for less polluting modes and to raise the price of polluting modes to reflect health and environment "externalities" that the market typically does not capture (25,103). Also these tools may be used as incentives to phase out older vehicles.

5. Economic valuation of healthy transport

Unsustainable patterns of transport generate health and environmental costs, or "externalities," for which the user of the mode seldom pays. Urban dwellers breathe the pollution generated by car commuters entering the city. Pedestrians become injury victims in traffic-congested streets. Many such environmental and health costs are not internalized into conventional fuel and vehicle taxes. Some environmental impacts are indirect. If highly-polluted streets become unpleasant for pedestrians, residents and businesses, real estate values may decline and crime may rise – with economic consequences (26).

There are gaps in the quantification of transport externalities in developing countries. However, it has been estimated that the external costs of transport in the European Union, while large and uncertain, amount to about 8% of GDP. The externalities of private car travel, including accidents, noise, air pollution, climate change, nature and urban effects, are estimated to range between €45 and €86 per 1000 passenger kilometres, compared to €20 to €24 per passenger kilometre for rail (20).

Conversely, there is much qualitative evidence to indicate that healthier transport systems may be beneficial to the macroeconomic development of cities – reducing unwanted externalities and capitalizing on a synergistic range of potential social, economic and health benefits. Cities with excellent public transport and NMT networks may be more energy efficient, experience less sprawl and pollution and spend a smaller overall share of GDP per capita on transport services (26, 105, 109). Investments in efficient mass transit, as well as pedestrian and cycling networks, may enhance not only public health but also a city's attraction as a place to live and do business (92, 110). And on the micro-level, modest improvements in neighbourhood mobility can help poor residential areas.

Healthy neighbourhood transport

Improvement programmes in Indonesian urban neighbourhoods, or "kampungs", integrated healthier transport with community social and economic improvements in traditional low-rise, high density urban neighbourhoods. Networks of alleyways were reclaimed as pedestrian enclaves and "greened" with tiny pocket gardens and benches. Incremental improvements to water and sewage infrastructures were supported along with cottage industries and housing rehabilitation. These modest investments helped support the continued social and economic vitality of these traditional working-class neighbourhoods (111).



Photo: Jeff Kenworthy

Healthier transport investments can be affordable, even for poor cities. Visionary policies spurred the development of high capacity bus systems in Latin American cities such as Bogotá and Curitiba (see case studies), based largely on revenues raised locally through petrol taxes and other economic instruments (92).

Poverty reduction

Poor people tend to be the most vulnerable to environmental pollution – often they live in areas of very high traffic volumes and as pedestrians or cyclists may be more exposed to risk of injury. Also they may be the most damaged economically by urban transport development that emphasizes only private modes:

As average incomes grow and car ownership increases, the patronage, financial viability, and eventually quality and quantity of public transport diminishes. Motorization, which is permitted by the growth process, may thus also make some poor people even poorer. In particular, in the absence of efficient congestion pricing for road use, piecemeal investment to eliminate bottlenecks will almost certainly benefit the relatively wealthy at the expense of the poor (103).

By providing better mobility to all population sectors, sustainable transport can have direct benefits for poverty reduction. Healthier transport can spread the health and environmental costs and benefits of transport more evenly across different population sectors.

Owning a motor vehicle requires substantial capital investment and a significant portion of a household's monthly budget to cover fuel and vehicle maintenance, so good public transport can be cheaper for daily travel. Households that have difficulty affording even a bus or tram ticket can enjoy a reasonable range of mobility when cycling is a safe and accessible option. Safer travel can reduce a breadwinner's risk of sudden injury or disability that could trigger a family's decline into poverty. Economic measures that reduce the cost of public transport and ensure access to safe and efficient NMT (e.g. through reduction of duties/increased credit for cycling), may thus support poverty reduction goals (13).

User travel costs by travel mode - Morogoro, Tanzania

Means of transport	Travel cost per km (US\$)	Travel cost per hour (US\$)	Average speed (door to door kph)	Time cost per km (US\$)	Total journey cost per km (US\$)
Walking	0.002	0.17	4.0	0.042	0.044
Bicycle	0.010	0.17	10.0	0.017	0.027
Bus	0.033	0.17	10.0	0.017	0.050
Car	0.300	0.68	15.0	0.045	0.345

Source: I-ce & the Association of Dutch Municipalities VNG, 2000 (110).

Cost-benefit analysis of health and environment factors

Cost-benefit analysis of health and environmental impacts can improve understanding of trade-offs inherent in different kinds of transport investments. Over the past decade, case studies have been conducted in both developed and developing cities to estimate the health and environmental benefits of reducing air pollution levels. Generally these are based on the body of epidemiological evidence about quantifiable links between PM₁₀/PM_{2.5} pollution and mortality. In Mexico City, for instance, it was estimated that every 1 µg/m³ reduction in average annual PM₁₀ concentrations would save approximately US\$ 100 million per year, largely as a result of reduced hospitalization and health costs (112).

One important challenge is the integration of health and environmental factors into more routine economic valuation about choices regarding transport investments and management strategies, and greater use of sustainable transport. Transport models that estimate pollution emissions and traffic injury impacts of alternative policy and design choices, and epidemiological evidence about the quantifiable health costs of pollution and traffic injury, provide a scientific basis for valuing the health and environmental impacts of policies. Increasingly such valuations are being integrated into policy considerations in developed country settings. However, while this has been piloted in some developing country settings (see table), the health and environmental benefits (particularly those of public and non-motorized transport) typically are not quantified and valued economically. ***More routine measurement of such costs and benefits may enable more informed choices about alternatives and trade-offs (13).***

Health and environment valuation of NMT and public transport investments

City	Investment US\$ million	Benefit	Benefit: Cost	Time frame	Health and environment factors included
Bogotá, Colombia Cycling infrastructure	186 m	1302 m	1:7.3	1999-2009	Pollution; traffic injury; user costs
Morogoro, Tanzania Cycle paths, traffic calming;	1.3 m	14 m	1:5	2000-2010	User costs; travel time
Delhi, India High capacity bus and cycle	5 m	100 m	20:1	2000-2025	Traffic injury; pollution; travel time

Source: *Interface for Cycling Expertise (I-ce)*, 2000 (110).

6. Barriers to healthy transport

"The car is a status symbol everywhere and more so in developing countries. To own one shows you are successful. It is like wearing jewels".— Enrique Peñalosa, former mayor of Bogotá, Colombia (113).

Social perceptions

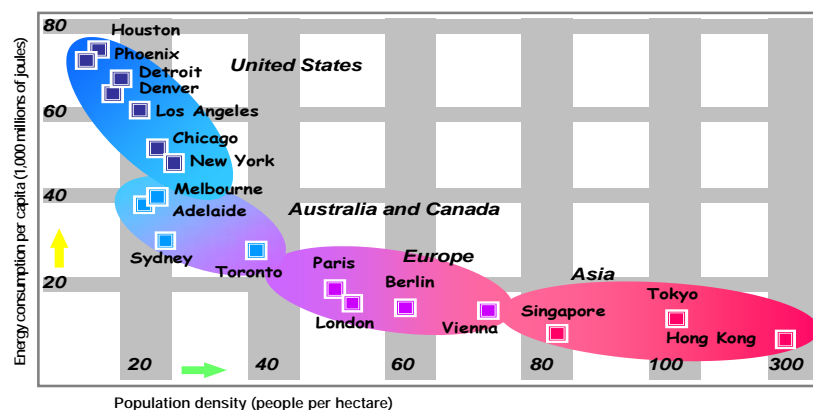
Since private motorized transport is most accessible to wealthier socioeconomic groups, car ownership may be perceived as a symbol of personal and social success. It is probable that vehicle owners represent the most politically powerful social sectors and therefore are likely to resist policy attempts to curb private car use *if the health and environmental benefits of "managed transport" are not well-communicated and understood.*

Conversely, walking or cycling may be associated with lower status. Often public transport patrons represent weaker socioeconomic sectors and may feel too powerless to advocate for system improvements. In some countries, women face gender barriers to the use of public transport and cycling. In some Latin American countries and in Africa most cyclists are men, elsewhere equal proportions of men and women cycle e.g. China and Viet Nam. For women, cycling can promote gender equity by enhancing their sense of social safety and easing weight-bearing tasks which can result in musculoskeletal illnesses and disabilities (13).

Land use: the challenge of sprawl

A wide body of evidence from developed countries indicates how lower density, single purpose and/or spatially disconnected forms of land use may generate longer trips and greater dependency on private transport, as well as new patterns of travel. Suburban shopping centres and residential communities, accessible primarily by car, are increasingly common in developing countries, as well. Such land use patterns may pose a powerful emerging barrier to healthy transport. Compared to more compact areas built around defined urban centres, such land use creates barriers to efficient non-motorized and public transport. This in turn has direct and indirect impacts on health and the environment, in terms of energy consumption air and water pollution; physical activity in daily travel; and preservation of agricultural land and green spaces on the urban periphery.

Transport Energy Consumption and Population Density in Major Metropolitan Areas, 1990



Source: Kenworthy & Laube, 1999 & Rodrigue et al., 2005 (29,114).

Gasoline use (MJ per capita) by urban density

Urban region	Gasoline use (MJ per capita)	Urban density (persons/ha)
Central New York	11 860	251
City of New York	20 120	107
Tri State New York Metro Region	44 033	20
Outer suburbs	59 590	13

Source: Newman & Kenworthy, forthcoming (115).

Since only a small proportion of the population in most developing cities has direct access to private cars, spatially disconnected commercial and residential developments also may be a powerful generator of equity gaps in mobility and access to housing, jobs and services.

Implementation of healthier transport policies requires a strong policy vision, not only for the transport system per se, but also for urban land use. Generally, compact, mixed-use developments linked to walking, cycling and public transport networks ensure maximum accessibility between homes and services for all social sectors, minimal travel distances and a minimum of health and environmental impacts such as air and noise pollution (105).

7. Case studies of healthy transport

Bogotá and Curitiba

Curitiba, Brazil and Bogotá, Colombia were pioneers in the development of bus rapid transit with systems running along exclusive corridors, or rights of way. These were designed with features similar to urban light rail but they required less initial capital investment and could be implemented more rapidly.

Curitiba's system evolved in the 1970s and today accounts for about 55% of passenger trips in the city. Despite one of the highest rates of car ownership nationally, per capita fuel consumption in Curitiba is about 30% less than that in eight other Brazilian cities of comparable size. The city also has one of the lowest rates of ambient air pollution in Brazil. Curitiba's 1.6 million residents spend only about 10% of their income on travel - low relative to the rest of Brazil (116). A green urban centre with extensive parks, lakes and wooded areas has been integrated with sustainable transport design; in 1970 there was less than 1 m² of green space per person, today there are 52 m² (109).

Bogotá's 'TransMilenio' high capacity bus system, which began operating in 2000, was inspired by the Curitiba experience. An outdated, polluting and chaotic system of privately-run buses was reorganized into a streamlined network of Euro II-compliant diesel vehicles operating on exclusive busways and in cooperation with private bus contractors. By 2003, the TransMilenio system accounted for more than 540 000 trips per day, 9% of which formerly were made by car. A 20% petrol surcharge helped the city to finance infrastructure investments, while a new car tag system was instituted to limit private automobile travel during peak hours.

Concurrent with the mass transit initiatives, both Bogotá and Curitiba have developed extensive systems for pedestrian and cycle mobility. More than 300 km of protected bicycle paths have been built in Bogotá. The city also created one of the world's most successful programmes of car-free day events, building upon a local tradition of Sunday street closures. A regulatory campaign was launched to move cars off sidewalks and return the space to pedestrians. The direct health benefits of such strategies have been measured: on car-free days traffic injury rates have plummeted and carbon monoxide and particulate levels declined substantially. Long-term health and environmental benefits are the subject of follow-up studies. In polls taken after the car-free day in 2002, 82.7% of the population supported the concept – reflecting growing awareness of the advantages of sustainable transport (117,118).

Delhi

An estimated 30-40% of daily trips to work in Delhi are on foot or via bicycle. While 60-70% of daily trips to work are by motorized modes, about 60% of these are by public bus transport (119). Cyclists, pedestrians, cars, buses, motorcycles and street vendors with pushcarts all compete for the same urban road space – a struggle that has social and poverty dimensions, as well as health and environmental implications.

Road improvements using conventional engineering designs failed to allocate space to non-motorized users. These have exposed significant sectors of the population to increased risks of traffic injury and imposed greater constraints on their mobility.

Now, Delhi is developing a new 62 km-long metro system, the focus of major federal government and foreign investment. Politicians have hailed this as a second significant step in urban air pollution reduction in Delhi, following the conversion of buses to CNG fuel. However, many of the air pollution and congestion gains from these two new measures are being lost due to continued increases in private vehicle traffic on surface roads. Also, while metro ticket prices will be

controlled, they will not be as inexpensive as the bus. In terms of social equity, new high-density developments that may be created alongside the metro corridor may displace many of the poor who live in the area without formal rights of tenancy. Traffic safety experts at the Indian Institute of Technology (IIT) therefore are advocating integration of the metro development and a more extensive network of high capacity busways and NMT corridors. This may guarantee safer and healthier mobility for all social sectors as well as controlling air quality. Mass transit transport development also should be integrated with land-use strategies that ensure security, safety and health for poor urban residents, as well as the social and human diversity of urban spaces.

In order to realize this vision, IIT Delhi transport planners have secured government approval in principle for a planned 13 200 km high-capacity bus project. The government has approved the implementation of funding for the first 18 km. The bus corridors would incorporate space for non-motorized users in order to enhance mobility and reduce injury risks and pollution exposures for pedestrians, cyclists and street vendors (120, 121).

8. Taking action on healthy transport policies

8.1 What countries and cities can do

A. Develop a vision

A vision for a transport system requires all stakeholders to discuss and agree how a city should look in 5, 10 and 20 years. This may include the following health and environmental aspects (93,97).

- Transport systems should be designed to minimize air and noise pollution, risk of traffic injury, congestion and other health and environmental impacts.
- Transport systems must make efficient use of land and other natural resources.
- Health and environmental impacts from transport pollution emissions should be integral to policy considerations, with reference to internationally recognized guidelines for ambient air quality e.g. WHO guidelines for air quality and noise (46).
- Impacts on injuries, physical activity and social well-being should be considered, with reference to quantifiable and qualitative evidence as well as relevant international guidelines.
- The poor pay proportionately more of their income and time for basic mobility, and experience greater barriers in accessing many destinations. Transport policies that facilitate safer and healthier mobility for all population sectors may yield co-benefits in terms of poverty reduction.
- Cities should be designed around the needs and activities of people, not vehicles. 'Active community environments', networks for routine physical activity and spaces for community interaction, should have a strong claim to urban space (104).
- Stakeholders need to be fully engaged in transport decision-making processes.
- Taxation and economic policies should support, not undermine, healthy transport.

B. Build strategies

The *European charter on transport, environment and health* discusses the strategies that may be useful in promoting sustainable transport, often at relatively low cost. Some excerpts are given below (122).

- Reduce the need for motorized transport and car dependency by orienting land-use policies and urban and regional planning towards shorter transport distances and providing easier access to health-promoting modes of transport.
- Shift transport volumes to environmentally sound and health-promoting transport.
- Implement best available technologies and best environmental and health standards.
- Apply health and environmental indicators and impact assessments as a basis for transport, water and land-use policies, urban and regional development planning, location decisions, infrastructure planning and investment programmes, with the full involvement of environment and health authorities.
- Resolve market distortions by internalizing transport-related environmental and health costs and benefits; and by implementing economic instruments to stimulate health-promoting mobility behaviour and shifts in use of different modes of transport.
- Raise awareness of health-promoting transport and mobility.
- Establish partnerships at international, national, regional and local levels between government and intergovernmental bodies; the public environmental, health and transport NGOs; industry; the private sector; etc.

- Launch and promote pilot projects and research programmes on sustainable transport for health and the environment.
- Provide broad public information on the environmental health impacts of transport and promote public participation in decision-making processes.

C. Environmental and health assessment of transport plans and scenarios

Impact assessment of transport/land use plans or policies is one way to take account of health and environmental concerns (19). This should be conducted at the *strategic level*, where cumulative, long-term health and environmental impacts of *alternative transport scenarios* can be assessed over an entire city or region -- and different mixes of public, NMT and private transport examined.

The quantifiable health and environmental costs of increased exposure to air pollution, noise, congestion and traffic injury risk should be considered, using accepted methods for estimating the burden of disease from traffic-related risks and for economic valuation of their health and environmental costs, as well as the quantifiable benefits of reduced injury rates and lower pollution emissions from alternative transport and land-use scenarios. *Qualitative* input from stakeholders and experts about the social, public health, community and quality-of-life impacts also should be incorporated. Stakeholders should work in partnership with government and private interests from the beginning of the process development of the impact assessment -- not asked to respond to a fait accompli.

D. Take action based upon best available evidence

Already there is much evidence about the environmental and health benefits and costs of transport, and best practice solutions. Increasingly, what is required is a broad recognition by policy-makers that *all population* sectors have a right to enjoy safe, healthy mobility -- and that overdependence on polluting modes generates health and environmental impacts *for everyone*, including private transport users. Finally, cities with integrated transport systems that include high-quality non-motorized and public transport are more healthy, safe and pleasant, and likely to be more attractive places to live and work.

8.2. International support for healthy mobility

There is a range of international initiatives relating to transport and injury, air pollution, physical activity and other urban issues. The next step is for national governments, stakeholders and development agencies to bring together such experiences in a coherent manner to support healthy and sustainable urban mobility and development. Coordination among international actors allows best practice urban transport experiences to be replicated elsewhere. Some relevant initiatives are described here. A more complete listing is to be found on the HELI transport directory: <http://www.who.int/heli/risks/urban/urbanenv/en/index.html>

PEP - Transport, Health and Environment Pan-European Programme

(<http://www.thepep.org/CHWebSite/>)

In 1999, the European Union approved a Charter on Transport, Environment and Health. With WHO support, a pan-European policy process linking transport, health and the environment was launched in 1999 at the Third Ministerial Conference on Environment and Health. This resulted in

European policy actions and ongoing dialogue between the three sectors, known as the Transport, Health and Environment Pan-European Programme (PEP). Managed jointly by WHO and the United Nations Economic Commission for Europe (UNECE), PEP facilitates scientific study of health and environment impacts from transport and policy dialogue about solutions. It promotes strategic alliances, dissemination of good-practice models, and guidance. Recently, a PEP-sponsored web-based clearing house has been created, bringing together resources in the European arena (8). In 2002, the European Parliament also adopted a resolution calling for “stronger integration of health considerations into transport policies, including by carrying out Health Impact Assessment of major transport projects.” WHO is now working to apply lessons learnt through the European experience in developing country settings.

Clean Air Initiative for Cities Around the World; Clean Air Initiative for Asian Cities (CAI-Asia) and Air Pollution in the Megacities of Asia (APMA)

www.cleanairnet.org & <http://www.york.ac.uk/inst/sei/APMA/APMA.html>

The Clean Air Initiative for Cities around the world is co-sponsored by the World Bank and includes a wide range of international, non-governmental and governmental partners in Asia, Latin America, Sub-Saharan Africa, and Europe. CAI-Asia and CAI-Latin American are currently active in both assessing and promoting health and environment policy linkages on urban transport-related issues. UNEP, in collaboration with WHO, the Stockholm Environment Institute (SEI) and the Korea Environment Institute (KEI), initiated the APMA project in November 2000, with financial support from the Ministry of Environment, Government of Korea. APMA worked jointly with CAI-Asia of the Asian Development Bank, World Bank and the United States Asia Environmental Partnership (a USAID programme) to prepare a *Strategic framework for air quality management (AQM) in Asia*. The twin initiatives aim to provide a regional approach to improving urban air quality and pollution monitoring. Currently, CAI-Asia and APMA are finalizing benchmarking reports on urban air quality in 20 Asian cities (123).

UNEP Partnership for Clean Fuels and Vehicles

<http://www.unep.org/pcfv/main/main.htm>

Together with a wide range of international partners, government, industry and civil society, the United Nations Environment Programme (UNEP) established a Partnership for Clean Fuels and Vehicles at the 2002 World Summit on Sustainable Development. This works with developing countries in Africa, Asia, Latin America and the Mediterranean region to continue phasing out leaded gasoline; facilitate adoption of lower-sulfur diesel fuels; retrofit older diesel vehicles; and test alternative vehicle fuel technologies. Such improvements can help reduce local health-damaging pollution emissions, as well as controlling greenhouse gas emissions (76). UNEP also is participating in a one-year Air Quality Monitoring Project in sub-Saharan Africa that will establish baseline data for key pollutants in several African cities (Dar es Saalam, Tanzania and Accra, Ghana) (77).

UN Road Safety Collaboration

<http://www.grsproadsafety.org/>

WHO and World Bank's *World report on road traffic injury prevention*, launched in 2004, has forged a new recognition that road traffic injury prevention requires transport systems and land use to be rethought in order to reduce exposure to the risk of road traffic injury, particularly among vulnerable road users such as pedestrians and cyclists (38). In the same year, the United Nations General Assembly approved Resolution 58/289: Improving Global Road Safety. Since then, WHO has been coordinating road safety activities within the UN system, in the framework of the UN Road Safety Collaboration. As of March 2005, this group comprises 42 agencies,

including 11 UN entities and 31 other international, non-governmental, research, donor and private sector agencies. Also, road safety activities are ongoing around the world under the auspices of the Global Road Safety Partnership, an initiative of the World Bank, International Federation of Red Cross and Red Crescent Societies and other partners (124). On a regional level, the Asian Development Bank has produced *Road safety guidelines for the Asian and Pacific region* (125).

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