TRAFFIC SAFETY AS A PRE-REQUISITE FOR SUSTAINABLE URBAN TRANSPORT: AN INTERNATIONAL ANALYSIS

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Abstract: Nearly sixty percent of the world’s population lives in low and middle income countries (LMIC) and these countries include 62 of the largest 100 cities in the world. The urban growth rates in Asia, Africa and Latin America are higher than those in Europe and North America and so are the vehicle growth rates (World Health Organization, 1998). Data were collected for road traffic fatality rates for 56 cities to understand issues concerning road safety and sustainable transport issues. The results show that pedestrian fatality risk in LMIC is generally much higher than high-income countries. If risk for pedestrians is high, it will discourage walking and consequently use of public transport as the access trips are as pedestrians. This in turn will make it difficult to have cleaner air. Therefore, pedestrian safety becomes a pre condition for planning sustainable transport systems.

Key Words: Traffic safety, Sustainable transport, Urban area

1. INTRODUCTION

Nearly sixty percent of the world’s population lives in low and middle income countries (LMIC) and these countries include 62 of the largest 100 cities in the world. The urban growth rates in Asia, Africa and Latin America are higher than those in Europe and North America and so are the vehicle growth rates (WBCSD, 2004). Therefore, we can expect most of the megacities (> 5 million population) of the world to be located in LMICs in the future. Though, the per capita vehicle ownership in LMICs at present is much lower than that in high income countries (HIC) the air pollution levels in LMIC cities continue to remain unacceptably high. With increases in populations and vehicles, this situation can get worse unless concrete steps are taken to control the adverse health effects of road transport in these cities. Mobility, safety and environmental issues are inexorably interlinked and at times have conflicting requirements (OECD, 1997):

Measures that have conflicting requirements:

- **Size/weight/power of vehicles and engines:** Larger vehicles can provide greater protection for occupants but increase fuel consumption and emissions. Larger engines may increase speeds and result in higher road traffic injury (RTI) rates for vulnerable road users (VRU).

- **Infrastructure standards:** “Better” roads can have mixed effects: if they result in higher speeds then safety suffers and streets that give free passage to motor vehicles with measures like grade separated junctions make bicycling and walking more difficult and at times more hazardous.
• **Traffic management systems:** One-way streets increase driving distances resulting in higher pollution and RTI rates if speeds increase.

Measures that generally have converging requirements:

• **Density, zoning:** If zoning arrangements include mixed land use and the infrastructure specially designed to make walking, bicycling and use of public transport safe and convenient, then there should not be much conflict in safety and environmental issues.

• **Cycle tracks:** Separation of non-motorized and motorized modes can result in fewer RTI and smoother traffic, thus reducing emissions.

• **Roundabouts:** Reduce idling time of vehicles at intersections as compared to traffic signal controlled ones, and reduce incidences of RTI significantly (Elvik and Vaa Truls, 2004).

• **Efficient public transport systems.** Availability of widespread and efficient public transport systems can reduce emissions and RTI only if private vehicle use is restricted/discouraged and walking/bicycling facilities are made safer.

Many of these issues are not well understood and most cities are faced with serious problems of inadequate mobility and access, vehicular pollution and road traffic crashes and crime on their streets. Increasing use of cars and motorized two-wheelers add to these problems and this trend does not seem to be abating anywhere. However, many recent reports suggest that improvements in public transport and promotion of non-motorized modes of transport can help substantially in alleviating some of these problems (Bannister, 2005; Dora, 1999; European Commission, 2001; Mohan, 2005; Mohan and Tiwari, 1999; Wu Yong and Li Xiaojiang, 1999). The problem is that available evidence indicates that no society is successful in reducing passenger-km by car in inter-urban trips and for intra-urban trips in most locations (European Commission, 2001; U.S. Department of Transportation, 2003; World Business Council for Sustainable Development, 2001). Most efforts at reducing environmental pollution due to road transport, therefore, focuses on control of tail pipe emissions. This has produced some successes in reducing CO, SO₂ and NOₓ in a few locations, but not CO₂ anywhere. As long as we use fossil fuels for combustion this problem is unlikely to be resolved unless we can shift modal shares towards non-motorized modes and public transport.

Deaths and injuries due to road traffic crashes are a serious problem in LMICs (Peden et al., 2004). Even in HICs pedestrians and bicyclists generally face higher crash risks than car occupants (Jorgensen, 1996; Pucher and Dijkstra, 2000; Scientific Expert Group on the Safety of Vulnerable Road Users (RS7), 1998). According to one estimate the losses due to RTI in LMICs may be comparable to those due to pollution (Vasconcellos, 1999). The safety record of bus transit operations has been reasonably good in most cities of the world as compared to other modes of transport. Yet people prefer to use their cars and motorcycles if they can afford it and when it convenient to do so. The main problem of safety as perceived by commuters is not as a passenger inside the bus, but as a pedestrian or bicyclist on the access trip. A study of RTI risk faced by Copenhagen road users in different modes concluded: “There is no reason for a traveller to choose bus instead of car for the point of view of his own safety,” and that “From a social point of view there would be a safety benefit through a
change of car driving into bus driving” (Jorgensen, 1996). These conclusions were based on the fact that the risk of death per trip for a bus user was very high on access trips.

There is ample evidence to illustrate the mismatch between current urban planning methods and the growing transportation problems (Bannister, 2005; Dora, 1999; Preston and Raje, 2007). Unless we understand the basic nature of problems faced by our mega cities, the adverse impact of growing mobility on the environment and safety would continue to multiply in future. For users of public transport, each trip involves two access trips which have to be non-motorized modes – walking and bicycling. In addition to other concerns, commuters will choose to walk or bicycle by choice only if these modes are safer than other modes. Therefore, in this paper we attempt to understand the factors influencing safety of road users with special reference to pedestrians in large cities around the world.

2. METHODS

Road traffic fatality data were collected for 55 cities around the world for the period 2000-2003 from the following sources: official internet sites of respective cities/nations, journal publications in the same period and official city traffic and accident reports. An attempt was made to obtain data for cities representing a wide spectrum of per capita incomes - from the lowest to the highest income cities. Wherever available, data for motor vehicle occupant deaths and pedestrian deaths were also obtained along with city population and national per-capita income in US Dollars for each city.

Road user deaths per million population has been used as the index of the probability of an individual dying due to an RTI in each city. This study attempts to look at trends and the health risk of individuals over a life span. Therefore, other indices like deaths per 10,000 vehicles or deaths per passenger km have not been used, as these do not give an indication of road traffic injuries as a health problem (Mohan et al., 2006). Since the number of trips taken in a city are proportional to its population, this index also proportional to the risk of fatality per trip for that city. This is the risk that individual road users must minimize if they have to maximize their life spans. The risk per trip is the experience that individuals approximate internally for decision making regarding mode choice (Koornstra et al., 2002).

We have not differentiated data sets for different countries by definitions of death based on time elapsed after the crash. This is because research studies show that 65% - 75% of fatal crash victims die before reaching the hospital in most countries, LMIC or HIC (Lai et al., 2006; Peden et al., 2004). Therefore, the error introduced by not accounting for time of death will generally not exceed thirty percent, whereas the difference between different RTI rates between different countries and cities can exceed three hundred percent (Kopits and Cropper, 2005).

Three indices have been used for each city:

- Total RTI fatalities per million population.
- Motor vehicle occupant fatalities per million population.
- Pedestrian occupant fatalities per million population.
These three indices have been plotted against the per capita income in US dollars to examine the general influence of the economy in determining the average risk of an individual dying due to an RTI in each city. In the graphs, a code for each city is used to provide a unique identifier (List of city codes in Appendix 1).

3. RESULTS AND DISCUSSION
3.1 Data and reliability
We were able to obtain overall traffic fatality data for 56 cities with a range of incomes from about USD 300 to USD 40,000 per capita per year. Of these only 23 cities included data separately for motor vehicle occupant deaths and 31 for pedestrian deaths. Generally, RTI fatality statistics in cities are considered more reliable than overall country statistics or injury data because deaths are likely to be recorded officially in urban areas. City data form HICs are likely to be generally more reliable than LMICs and therefore detailed comparisons may not be fair. However, in this paper we have only attempted to diagnose general trends in fatality risks and, therefore, these data should be adequate for our purposes.

3.2 Motor vehicle occupant fatalities
Figure 1 shows road traffic fatality risk per million persons in different cities plotted against per capita income of the country in which they are located. These data show that the risk varies by a factor of 20 between the cities with the lowest risk and the highest risk. Detailed analyses for factors associated with crashes for different cities are not available. However, some general observations can be made for the patterns implicit in Figure 1. There are wide variations across income levels and within similar incomes levels. Some characteristics are summarized below:

![Figure 1: Road traffic fatality risk per million persons in different cities by per capita income in US dollars (city identifiers are respective airport codes).](image-url)
The highest fatality rates seem to be experienced by cities in the mid-income range of USD 2,000 – 10,000 per person per year. There is a great deal of variation even in those cities where the per capita income is greater than USD 20,000 per year. At highest levels of income the cities with the lowest rate, Tokyo (TYO), London (LON) and Hong Kong (HKG) have rates that are about 20 times lower than Phoenix (PHX) in the USA. In cities with very low per capita income the differences between the lowest and the highest is also a factor of about 20. The lowest and highest rates in LMIC and HIC cities seem to be similar.

### 3.3 Motor vehicle occupant fatality rates

Figure 2 shows that cities in LICs in general have lower vehicle occupant fatality rates per million population (total) than cities in HICs. This is to be expected because vehicle ownership rates are much lower in low-income countries than in high income countries resulting in much lower exposure rates in the former. For this reason, the cities with lowest incomes have the lowest. On the other hand, a middle-income city like Durban (DUR) has the highest rate of all cities. What is of interest is that the vehicle occupant fatality rates within high-income cities differ by more than a factor of 5. Houston is about 5 times worse than New York (NYC) in the same city. Clear evidence that just the presence of “safe” modern vehicles is not an adequate condition to minimize the health burden of road traffic injuries. Infrastructure, city form and vehicle speeds obviously play an important role in determining overall safety levels. Studies published over the past few years show conclusively that vehicle speed is very strongly related to both the probability of a crash and the severity of injury – a 1% increase in average speeds can result in 3-4% increase in fatalities (Peden et al., 2004).
This may be the reason why some middle-income country cities have high fatality rates because they have higher vehicle ownership than low income countries and roads encouraging unsafe speeds without adequate attention being given to road safety. Similarly cities that are considered to have greater traffic congestion (hence lower speeds) have lower fatality rates than those cities with less congestion though their incomes may be similar – in India Mumbai (BOM) with higher congestion has lower rates than Delhi (DEL) with lower congestion levels, and in the US, New York (NYC) has a lower rate than Houston (HOU).

### 3.4 Pedestrian fatality rates
Cities in HICs (> USD 20,000 per capita income) have pedestrian fatality rates which are consistently low (Figure 3). This could be because high-income countries may have much lower presence of pedestrians than low-income countries and also because there has been a conscious effort in the former to increase pedestrian safety (Select Committee on Environment and Regional Affairs, 2001). In LMICs (USD 300 – USD 10,000) the rate varies form very low to very high. On the other hand, vehicle occupant fatalities rates are generally higher in high-income cities as compared with low income cities.

If we consider the patterns in Figures 1, 2 and 3 jointly, it is possible to make some preliminary observations on these issues. Provision of “safely” designed roads by existing standards and modern safe vehicles may be a necessary condition for low road fatality rates in cities but not a sufficient one. The fact that there are wide variations for overall fatality rates among high income cities, where availability of funds, expertise and technologies are similar, indicates that other factors like land use patterns and exposure (distance traveled per day, presence of pedestrians, etc.) play a very important role also. This is probably why many European cities tend to have lower rates than those in the US.
However, the extreme variations in pedestrian fatalities within LMIC cities indicates that availability of finances may not a deciding factor in determining risk to pedestrians on the road. It should be possible to reduce pedestrian death rates at present levels of income by appropriate road design, speed control, traffic management and convenient facilities for pedestrians.

3.5 Safety and sustainable transport
A majority of people in all large cities around the world use motorized modes of transport for their work trips. This proportion is likely to increase in Asian and African cities as incomes increase. In Europe, road transport now makes up 44% of the goods transport and 79% of the passenger transport total market (European Commission, 2001). In the U.S. the car is most dominant for the work trip, accounting for 97% of all journeys to work in rural areas and 92% in urban areas (U.S. Department of Transportation, 2003). In LMIC large cities use of mortised transport is significant and is increasing (Tiwari, 1999).

However, the issue regarding road safety of pedestrians and its influence on use of public transport and ultimately clean air has not received adequate attention. Figure 4 shows the fatality rates per trip by different modes in Copenhagen, Denmark. The data show that bus commuters in Copenhagen face almost 15 times greater risk of fatality on the access trips as pedestrians than when inside the bus (Jørgensen, 1996). It is to be noted that the pedestrian risk in HIC cities is in the range of 5-20 per million population, whereas in LMIC cities it can be as high as 160 per million population. Figure 4 shows that if the access trip risk for bus commuters increases by a factor of 2 or more than the overall risk of traveling by bus or even metro systems would be greater than using a personal car!

This high risk of fatality and injury as a pedestrian deters people from using public transport if their income is high enough to own personal vehicles. Also, it is clear that unless pedestrian
risk is reduced to very low levels, is possible that modal shifts from cars to public transport could increase RTI fatalities in a city as total risk per trip by bus would be more than that by car. Therefore, ensuring safety of non-motorized modes of travel becomes a pre condition for encouraging public transport use, and ultimately cleaner air in our cities.

Since walking and bicycling trips are essential for use of public transport streets must be made safe from crime, disabled friendly and include public amenities including shops and restaurants (street vendors included). These conditions can be fulfilled only if special attention is given to speed reducing measures along with street designs fulfilling traffic calming designs.

The above discussion indicates that safety of road users in general and pedestrians in particular has not been maximized given the present state of knowledge. Land use policies that encourage greater use of cars per day and transportation policies that promote personal transport increase exposure rates and thus the overall risk of death and injury even though risk rates per km traveled may be low because greater travel distances offset lower risk per km (Elvik and Vaa Truls, 2004). This tends to offset the advantages gained by provision of safer cars and roads. Once these systems are in place, it is difficult to reduce death rates per capita.

These issues have to be examined in detail so that we can plan for safer cities in the future in addition to improving vehicle and infrastructure technologies. This would be essential for cities in low and middle-income countries where urbanization is still increasing. For sustainable transport policies, it would be essential that these cities are not locked into systems that encourage high speeds and greater use of personal car transport per day.

3.6 Public transport, bicycling, walking, safety and crime
If public transport use has to be promoted in large cities in LMIC, much more attention has to be given to the improvement in safety levels of bus commuters and the non-motorized transport segment of the road users. This is particularly important because promotion of public transport use can also result in an increase in the number of pedestrians and bicycle users on city streets. This is because every public transport trip involves two access trips that are mostly walking or bicycle trips. Unless people actually perceive that they are not inconvenienced or exposed to greater risks as bicyclists, pedestrians and bus commuters it will be difficult to reduce private vehicle use.

To solve problems of vehicular pollution we need to work from first principles. Quite obviously, the most long lasting solution would be if people traveled less. This depends mostly on how your city is organized. Mixed land use helps. Homes, businesses, hospitals, schools, entertainment areas, all need to be intermixed in localities (Ewing et al., 2003; Jacobs, 1961; Select Committee on Environment and Regional Affairs, 2001; Swedish Environmental Advisory Council, 2006). Safety of women and children even from minor crime on streets is essential for them to walk, bicycle or use public transport (Johnsson-Latham, 2007; Mehrotra and Viswanath, 2006). If streets are not safe, road users are likely to shift to motorized modes as soon as their incomes permit them to do so. For streets to be safe from crime, they must be busy with people and businesses (Jacobs, 1961). This requires the presence of street vendors or shop fronts on roads, good lighting systems and lack of hiding places. These issues have to be an integral part of designing bus stops and other road infrastructure.
For promoting sustainable transport and reducing global warming due to urban transport it is necessary to reduce use of fossil fuels for transportation purposes. Improvements in engine and vehicle technology will help, but these measures can be counter balanced by massive increases in personal vehicle use. Therefore, there is a need to promote walking, bicycling and use of public transport. The above discussion shows that unless roads are safe from road traffic crashes and crime we are unlikely to see cities with clean air either.

4. THE WAY FORWARD

4.1 Road safety promotion as a sustainability issue
Road safety in general and safety of vulnerable road users in particular has to given as much importance as vehicle emissions for ensuring cleaner and more livable cities. Unless cities are made safer for pedestrians and bicyclists on one hand, and women, children and the elderly on the other, it would be impossible to obtain optimal use of public transport facilities in the future. Therefore, road safety has to be included as a necessary condition for healthier life in cities.

4.2 Understanding urban settlements and transportation systems
The discussion in previous sections illustrates that we do not know enough about different factors influencing the health burden of road traffic injuries and deaths on societies. This is shown by the fact that cities with similar levels of wealth, knowledge and technologies have very different road fatality risk ratios per capita. It is essential that we promote international comparative studies of cities within similar income groups and across different income groups to understand influence of factors other than vehicle technology. Some of the issues that can be examined are:

- Location of low income neighbourhoods and their influence on travel patterns and road traffic injuries.
- Presence of street vendors and their influence on vulnerable road users and street crime rates.
- Influence of high rise versus low rise habitations.
- Presence of few large central business districts versus several smaller widely distributed smaller business districts.
- Influence very high capacity public transport systems (underground or elevated metro systems) versus high capacity modern bus transport systems.
- Role of dedicated bicycle lanes and use of non-motorized transport.
- Role of para-transit and micro-vehicles like three-wheeled scooter taxis, etc.

REFERENCES


**APPENDIX 1**

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