TRAFFIC SAFETY AND HEALTH IN INDIAN CITIES

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INTRODUCTION

A sustainable transport system must provide mobility and accessibility to all urban residents in a safe and environment friendly mode of transport. This is a complex and difficult task when the needs and demands of people belonging to different income groups are not only different but also often conflicting. For example, if a large proportion of the population cannot afford to use motorised transport - private vehicles or public buses - then they have to either walk or ride bicycles to work. Provision of safe infrastructure for bicyclists and pedestrians may need segregation of road space for bicyclists and pedestrians from motorised traffic or reduction in speeds of vehicles. Both measures could result, though not inevitable, in restricting mobility of car users.

Similarly, measures to reduce pollution may at times conflict with those needed for reduction in traffic crashes. For example, increases in average vehicle speeds may reduce emissions but they can result in an increase in accident rates. But, most public discussions and government policy documents dealing with transportation and health focus only on air pollution as the main concern. This is because air pollution is generally visible and its deleterious effects are palpable. It is easy for most people to connect the associations between qualities of motor vehicles, exhaust fumes and increased morbidity due to pollution. However, most individuals are not able to understand the complex interaction of factors associated with road accidents. Health problems due to pollution are seen as worthy of public action whereas those due to injury and death in accidents as due to individual mistakes. Therefore, policy documents dealing with sustainable development for cities always include options for pollution reduction but rarely for road traffic injury control.

In this paper we discuss some of the issues concerning public transport, safety and the environment. We illustrate that unless the needs of non-motorised modes of traffic are met it will be almost impossible to design any sustainable transportation system for urban areas. We show that pedestrians, bicyclists and nonmotorised *rickshas* are the most critical elements in mixed traffic. If the infrastructure design does not meet the requirements of these elements all modes of transport operate in sub-optimal conditions. However, it is possible to redesign the existing roads to provide a safer and more convenient environment for non-motorised modes. This also results in improved efficiency of public transport vehicles and enhanced capacity of the corridor when measured in number of passengers transported per hour per lane.

COMPLEXITY IN URBAN TRAFFIC AND HEALTH

Dealing with technology and health in the public space is much more complex than we think. If your stress test shows that your heart muscles have become weak, you can panic and demand a single magic pill to solve all your problems. However, your doctor will only

laugh at your demand. Instead, he will tell you to change your diet, do a set of prescribed exercises every day, alter your life style, *and* take a set of medicines every day. In addition, he will also ask you to monitor your health status periodically and change your drugs accordingly. Tackling traffic flow, vehicular pollution and road accidents are no less complex. These problems require the same level of scientific expertise, interdisciplinary cooperation, and long-term attention as any other public health problem.

To solve problems of vehicular pollution we need to work from first principles. Quite obviously, the most long lasting solution would be if people travelled less. This depends mostly on how your city is organised. Mixed land use helps. Homes, businesses, hospitals, schools, entertainment areas, all need to be intermixed in localities. This is happening more by default than policy in our cities. *Thelawalas* going house-to-house selling things reduce trips; vegetable shops, *dhobis*, *mochis*, *paan* shops, and *tandoor* stands in neighbourhoods eliminate thousands of scooter and car trips. Presence of hawkers on city streets makes it safer for pedestrians and bicyclists, especially women, as crime on those streets reduces. The hawkers serve as permanent eyes of the street and the police officers use them for obtaining information on criminals. Potential criminals are quite aware of this! Even the existence of poor neighbourhoods cheek by jowl with rich ones may be reducing motorised trips and increasing employment. When you shift low-income people to the periphery of a city you have to provide bus transport to the formally employed. But the others become unemployed and may take to crime.

The second long term solution is to encourage non-polluting modes of travel. There is only one -- human-powered travel. We should be designing our streets so that walking, bicycling and the use of *rickshas* becomes safer and much more pleasant. If it were so, many more people would be using these modes, especially younger people. City planning experience from Beijing in China to Portland in the USA suggests this is true. Street designs are available which show that segregated paths can be provided for bicycles and *rickshas* on existing arterial roads in most cities. When you do this even the motorised traffic benefits, because friction reduces, flow becomes smoother and pollution reduces further. Surveys show that even in a city like Delhi almost fifty percent of the trips are less than 5 km long. If walking and bicycling were safer, more children would not need to go by bus or in their parents vehicles. And parents would be free from chauffeuring their children around. Such policies would not only reduce pollution but also deaths and injuries due to traffic crashes. At present all our policies are doing exactly the opposite. There is no place on our roads for the walkers and the bicyclists; you have to walk long distances to cross a road; and free left turns at crossings don=t allow for any safe period for pedestrians to cross.

The third strategy is to make public transport affordable, convenient and safe. No Indian city has improved bus transport in the last decade. Urban buses are still following designs of the 1950s. The service is unreliable and unsafe especially for children, women and the elderly. However, recent developments in communication and computer technology have made it possible to optimise bus operations and provide customer-friendly services at very low cost. It is now possible for buses to Acommunicate@ with traffic lights so that they get priority at intersections. Modern urban buses have low floors only 350 mm high from the road. These buses make entry and exit much safer and faster. None of these options is being planed for our cities.

The fourth strategy is to reduce the pollution from vehicles. This is the only area where the government has taken some significant steps. Lead has been removed from petrol.

This will save millions of children from brain damage. In Delhi two wheelers are sold petrol premixed with oil at pumps. This prevents bad and excess oil use and reduces pollution. The diesel being sold in Delhi is less polluting than before. Cars being sold in Delhi now follow more stringent pollution norms. Two wheeler pollution standards in India are among the most stringent in the world and our two wheeler manufacturers are doing a good job of meeting these standards by their R&D in this area. However, much more needs to be done. Such measures must not be Delhi-centric. They must apply all over the country. After all, according to the Central Pollution Control Board, Delhi is *not* the most polluted city in India. There are many more which are more polluted.

It is easy to list the above principles but not so easy to make and implement effective policy. All policies, like drugs, have side effects. Before prescribing a drug you have to be certain that the side effects are not worse than the disease! For example, our simple calculations show that all the effects of reducing pollution from buses would be *nullified* if only 10-15 percent of bus users shift to using two-wheelers or cars.[1] This shift would also increase congestion. Greater use of two-wheelers would also increase injuries due to accidents. Therefore, before we make new laws that might increase the cost of buses, we have to make arrangements for cross-subsidy of public transport. This follows from the Apolluter and user pay@ principle based on the idea that those who pollute more should pay for the harm they cause others. Since car users pollute the most per passenger kilometre, use the most road space and injure more people per person transported, they must pay for their comfort that harms others. Two wheeler users come next and bus users a low third. A pollution and road tax paid by private vehicle users could help pay for better buses so that we avoid a migration from buses to two-wheelers and cars.

It is quite clear that cleaner air and safer streets will come at a price, and only if we have well thought out long term policies. The future committees which deal with these issues would be well advised to consider all the complex issues, consider the Aside effects@ and perform cost effectiveness studies before issuing edicts. If we don=t do this, the air will not be cleaner and a lot of people will be angry.

ROAD SAFETY IN INDIA

According to official statistics 76,732 persons were killed in road traffic crashes in India in 1998.[2] According to these statistics, 324,377 persons were injured in 1998. However, this is an underestimate, as not all injuries are reported to the police. The actual numbers are likely to have been in the region of 1,150,000 persons with injuries requiring hospital treatment and 5,370,000 persons sustaining minor injuries in 1998. The basis for these estimates is given in later section. The situation in India is worsening as shown in Table 1. Road crash fatalities and casualties have been increasing over the past twenty years. This is partly due to the increase in number of vehicles on the road and partly due to the absence of a coordinated official policy to control the problem. These data show that the number of fatalities have continued to increase at approximately the same rate of about five percent a year over the past two decades and the total number of fatalities in the year 2000 can be approximated at about 85,000 persons. The fatality rate per million vehicles have remained around 2 for the past two years, whereas, the rate per million population continues to increase and is around 82 at present.

Table 1. Number of vehicles, population and road traffic fatalities in India.

Year	Vehicles, million	Population	Fatalities Thousands	Fatalities per 1,000 vehicles	Fatalities per million population
1971	1.865	548,159,652	15.0	8.04	27.36
1975	2.472	625,246,123	16.9	6.84	27.03
1981	5.391	683,329,097	28.4	5.27	41.56
1985	9.170	772,196,737	39.2	4.27	50.76
1991	21.374	843,930,861	56.6	2.65	67.07
1992	23.507	861,693,859	59.7	2.54	69.28
1993	25.505	879,279,448	60.6	2.38	68.92
1994	27.660	897,223,927	64.0	2.31	71.33
1995	30.295	915,534,620	70.7	2.33	77.22
1996	33.558	934,219,000	71.9	2.14	76.96
1997	37.231	949,200,000	75.0	2.01	79.01
1998	N.A	965,600,000	80.0	NA	82.85

Source: Ministry of Surface Transport: Motor Vehicle Statistics & Statistics of Road Accidents in India

Table 2 shows the total number of vehicles registered in India and three highly motorised countries (HMCs) and Table 3 the road users killed in traffic crashes in HMCs and less motorised countries LMCs. These data show that car population as a proportion of total motor vehicles is much less in India than in the HMCs (12% vs 56-80%) and that the proportion of motorised two-wheelers (MTW) much higher (69% vs 5-18%). These differences in fleet composition affect the traffic and crash patterns enormously. Table 3 shows that pedestrians, bicyclists and MTW riders constitute a larger proportion of road crash victims in LMCs than in HMCs. Pedestrians, bicyclists and MTW riders, who constitute the vulnerable road users (VRU), constitute 60-80 per cent of all traffic fatalities in India. This flows logically from the fact that this class of road users forms the majority of those on the road. In addition, because metallic or energy absorbing materials does not protect VRUs, they sustain relatively serious injuries even at low velocity crashes.

Table 2. Vehicles registered in India, Germany, U.S.A and Japan

Country	Two wheelers	Cars, jeeps & taxis	Buses	Trucks	Other	Total
India	23,111,385	4,189,367	448,970	4,362,723	1,445,081	33,557,526
1996	(68.8)	(12.4)	(1.3)	(13.0)	(4.3)	(100)
Germany	2,470,450	40,987,547	89,954	2,273,473	1,899,800	47,721,224
1996	(4.9)	(82.0)	(0.2)	(4.5)	(3.8)	(100)
U.S.A.	3,816,000	138,203,000	701,000	64,756,000	1,356,000	208,832,000
1996	(1.8)	(66.2)	(0.3)	(31.0)	(0.6)	(100)
Japan	15,120,000	47,000,000	244,000	22,000,000	118,000	84,482,000
1996	(17.9)	(55.6)	(0.3)	(26.0)	(0.1)	(100)

* *Numbers in parentheses represent row percentages*

The issues summarised above show that India is experiencing a new phenomenon in road traffic patterns and crashes for which there is little precedence. The same road space gets used by modern cars and buses, along with locally developed vehicles for public transport (three-wheeled scooter taxis), scooters and motorcycles, bicycles, tricycle *rickshas*, and animal and human drawn carts. The infrastructure design based on homogeneous traffic models, has failed to fulfill the mobility and safety needs of this traffic.

Table 3. Proportion of road users killed in various modes of transport as a per cent of all fatalities.

City, nation (year)	Pedestrians	Bicyclists	Motorised two-wheelers	Motorised four wheelers	Others
Delhi, India (1994)+	42	14	27	12	5
Thailand (1987)+	47	6	36	12	-
Bandung, Indonesia	33	7	42	15	3
Colombo, Sri Lanka	38	8	34	14	6
Malaysia (1994)+	15	6	57	19	3
Japan (1992)#	27	10	20	42	1
The Netherlands (1990)#	10	22	12	55	-
Norway (1990)#	16	5	12	64	3
Australia (1990)#	18	4	11	65	2
U.S.A. (1995)#	13	2	5	79	1

+ LMCs # HMCs

Non-motorised transport (NMT) constitutes a significant share of the total traffic in Indian cities and all have a relatively high rate of bicycle ownership and a high proportion of bicycle traffic. In Indian cities, the share of NMT at peak hour varies from 30-70%. The proportion of trips undertaken by bicycles range between 15 and 35 per cent, the share tending to be higher in medium and small size cities. The patterns of NMT use change with growth in city size. In most NMT dependent cities, bicycles are used for the entire trip (e.g., commuting, shopping). Every motorised public transport trip involves access trips by NMT at each end. Thus, NMT including walking continues to play a very important role in meeting the travel demand in Indian cities.

In HMCs a very large proportion of the population owns motorised vehicles. These countries can also afford to have roads parallel to limited access expressways and the former are used by local traffic and by vehicles not allowed on expressways. In India, highways pass through rural areas with high-density populations where most of the people do not have access to motor vehicles. Four lane divided highways in India do not have parallel road links for slow and non-motorised traffic. This forces slow and non-motorised traffic to use these highways and to cross them under very hazardous conditions for all concerned. It is not surprising that a majority of the victims of road crashes on inter city highways are the vulnerable road users. Highway planning standards provide for services needed by motorised vehicle users, but there are no standards for providing services needed by NMT. These services mushroom along urban or inter-city highways to fulfil the demand of road users, however their existence is viewed as "illegal encroachment" on the designed road space.

The HMCs have never experienced road traffic that includes such a high proportion of motorcycles, buses and trucks sharing the same road space with pedestrians and bicyclists. When the present HMCs had low per capita incomes in the earlier part of the last century, motor vehicles (including motorcycles) were relatively more expensive and not capable of as high velocities and accelerations. Therefore, speeds were lower and number of vehicles using the roads was less than that seen today. In a sense, motor-vehicle technology, roadway quality and social systems were more compatible. On the other hand, in India new designs have to be developed for use of technologically advanced vehicles using relatively “less advanced” roadways and enforcement systems. The fact that these patterns are new and that

they need to be understood through careful scientific research is not realised by most policy makers. If we just depend on HMC standards and research results to solve problems in India, we may find the outcome very unsatisfactory.

ESTIMATE OF TRAFFIC CRASH INJURIES IN INDIA

According to official statistics 76,732 persons were killed and 324,377 persons injured in road traffic crashes in India in 1998.[2] However, a study done in Bangalore shows that while the number of traffic crash deaths recorded by the police is reasonably reliable, the total number of injuries is grossly underestimated.[3] According to this study, deaths were underestimated by 5% and the number injured who needed treatment in hospitals by more than a factor of two. In this study, the ratio of injured people reporting to hospitals to that killed was 18:1. It is important to note that even this ratio would be an underestimate as among those injured many others would have taken treatment at home or from private medical practitioners. Another detailed study done in Haryana (India) recorded all traffic-related injuries and deaths through bi-weekly home visits to all households in 9 villages for a year.[4] This study showed that the ratio between critical, serious and minor injuries was 1:29:69. In 1998 in U.S.A. 41,471 persons were reported killed and 3,192,000 injured, giving a ratio of 77:1 for recorded fatalities:injuries. Other studies from HMCs for ratios between deaths:serious-injuries:minor-injuries give statistics of 1:13:102 [5] and 1:14:80 .[6]

Using the epidemiological evidence from India and other countries where better records are available, a conservative estimate can be made that the ratios between deaths, injuries requiring hospital treatment and minor injuries to be 1:15:70 in India. If the estimate of road traffic fatalities in India in year 2000 is taken as 85,000, then the estimate of serious injuries would be 1,275,000, and that for minor injuries 5,950,000.

ROAD SAFETY IN METROPOLITAN CITIES OF INDIA

Some salient statistics regarding road crash fatalities in cities are given in Table 4. The issues regarding traffic crashes in urban areas may be understood by the fact that at present less than one in 40 families owns a car in India. The car ownership level in India is so low that even at reasonable economic growth rates (say 5-7% per year) most families are not likely to own a car in the year 2020. Consequently, a majority of the population in India is not likely to use cars for surface travel for the near future. This low ownership level of cars determines the distribution of fatalities by class of road user. Table 5 shows the proportion of road users killed in different parts of India and Table 6 the proportions of vehicles involved in fatal crashes. The data presented in these tables are based on available national statistics and on reports available. The data show that VRUs are the main victims both on urban and rural roads. A study by Kajzer, Yang and Mohan also shows that in India buses and trucks are involved in a greater proportion of crashes than they are in HICs.[7] Analysis of crash patterns show that the self-segregation of the modes is not sufficient to ensure the safety of vulnerable bicyclists. While mid block crashes are not usually a serious concern in homogenous regimented traffic conditions, this category dominates in Indian cities. The overall statistics for bicycles fatalities in Delhi show that 60% of bicycle fatalities occur off-peak time when traffic volumes are lower but motor vehicle speeds are high. Forty per cent of the fatal bicycle crashes are during peak hours when volumes are significantly higher and speeds are lower (20 to 30 km/h). Of the peak hour bicycle fatalities, 62% involve collisions with buses or trucks. And, of all bicycle fatalities, 73% occur at mid-block. Buses and trucks are

involved in higher proportion in fatal crashes with pedestrians and bicyclists than in non-fatal crashes. Motorised two wheelers and cars have a higher involvement in non-fatal crashes than in fatal crashes. This is generally true for urban and rural areas. These data show that in India safety policies must focus on issues concerning the safety of VRUs and their interactions with trucks and buses.

Table 4. Number of road accidents & persons killed and injured in Indian cities.

Cities	Persons Killed		
	1996	1997	1998
Ahmedabad	215	239	218
Bangalore	715	704	726
Calcutta	474	471	454
Chennai	615	749	682
Cochin	144	142	47
Delhi	2361	2342	2123
Hyderabad	342	377	370
Jaipur	263	303	302
Mumbai	405	401	370
Nagpur	217	387	204
Pune	283	329	369
Coimbatore	179	198	N.A.
Indore	174	171	151
Ludhiana	162	N.A.	N.A.
Madurai	110	203	334
Surat	133	152	152
Vadodara	141	142	144
Viskhapatnam	158	218	216
Total	7091	7528	6862

Table 5. Proportion of road users killed at different locations in India

Location	Type of road user, per cent								
	Truck	Bus	Car	TSR	MTW	HAPV	Bicycle	Pedestrian	Total
Mumbai	2	1	2	4	7	0	6	78	100
Delhi	2	5	3	3	21	3	10	53	100
Highways[+]	14	3	15	~	24	1	11	32	100

TSR: Three-wheeled scooter taxi; MTW: Motorised two-wheelers, HAPV: Human and animal powered vehicles; + Statistics summary of 11 locations, not representative for the whole country (tractor fatalities not included).

Source: Evaluation of capacity augmentation projects of National Highways and State Highways (2000), Final Report, Ministry of Surface Transport, GOI, New Delhi

Table 6. Proportions of vehicles involved in fatal crashes*

Location	Vehicles involved, per cent					Total
	Truck	Bus	Car	TSR	MTW	
Mumbai	52	16	24	3	5	100
Delhi	40	33	16	4	7	100
Highways	65	16	15	1	3	100

* *Only those cases included where details were known, totals for these vehicles only, others not included.*

Source: Evaluation of capacity augmentation projects of National Highways and State Highways (2000), Final Report, Ministry of Surface Transport, GOI, New Delhi

These issues may be summarised as follows:

(a) Around 15% of the total road traffic fatalities in India occur in 23 metros.
(b) In the metros, MTW comprise approximately 70% of all vehicles and constitute 20-30% of fatalities.
(c) Heavy vehicles like trucks and buses are associated with 50-70% of fatal road crashes both in urban and rural areas.
(d) The non-motorised transport road users consisting of pedestrians, cyclists and other slow moving vehicles are the most vulnerable group and account for 60-80% of the
(e) fatalities.
(f) Between 8:00 pm at night and 4:00 am in the morning, crash rates are high compared to the density of traffic. This may be due to prevalence of higher vehicle speeds, low visibility, low conspicuity of vehicles and alcohol.
(g) The issues concerning safety of non-motorised transport have not been given adequate importance. Policies need to be developed so that these groups are included as an integral part of traffic in the planning of new highway and area planning schemes.
(h) Inadequate work is being done to analyse the characteristics of road traffic crashes involving NMT users so as to understand and design suitable countermeasures.

SAFETY ON INTERCITY ROADS

All road and highway design guidelines and standards in India are issued by the Indian Roads Congress (IRC). These are recommendatory standards and the IRC does not have any role to oversee whether these are followed or not in practice. The IRC constitutes many committees to oversee the need for development of a new standard or revision of an old one. The responsible committee then requests its members or an outside expert to prepare a draft of the standard, which is discussed in the committee, distributed for comments and

Table 7. Percentage share of fatalities on different categories of roads(1991)

Road Type	Fatalities (%)
National Highways	25.3
State Highways	22.2
Lower Categories Roads	52.5

Source: Statistics of Road Accidents in India - 1983 – 1992,MOST (Road Safety Cell) January, 1994.

then finalised by the committee. All this work is voluntary in nature. Table 7 shows the percentage share of fatalities on different categories of roads in India.

Improvement of national highways in India is being given a great deal of importance as a part of national efforts to become economically competitive globally. However, the guidelines for highway development generally follow specifications, which are not yet tailored to India specific situations as far as road safety is concerned. This is because detailed crash data have not been available which could be used to understand the causal factors associated with road crashes and which had a bearing on road design issues. Perceptions about highway crashes formed by highway users may not reflect the reality about the problem. Everyone sees damaged vehicles stranded on the highways and thus believes that these kinds of crashes would constitute the main problem. However, a recent study sponsored by Ministry of Highways and Road Transport shows that though these types of accidents do cause large economic, time, and efficiency losses, they do not result in a majority of the fatalities.[8] Tables 5 and 6 show the type of road users killed on highways and the impacting vehicles respectively. Data from Mumbai and Delhi are included to compare the situation in urban areas with that on highways. Table 5 shows that in urban areas motor vehicle occupants constitute 5-10 per cent of the fatalities and the rest are vulnerable road users. On highways, the proportions are 32 and 68 per cent respectively. Though the motor vehicle fatalities are higher on highways than in urban areas, as would be expected, the differences are not as high as in western countries. A vast majority (68%) of those getting killed on highways in India comprise vulnerable road users and this fact should be the guiding factor in future design considerations.

The above aggregate data indicate that crash patterns on rural and urban roads are more similar than would be expected based on western experience. This is probably because there is high density of settlements all along the highways and this probably results in the use of many sections of the highway like an urban arterial road. Therefore, safety would be enhanced mainly by separating local and through traffic on different roads, or by separating slow and fast traffic on the same road, and by providing convenient and safe road crossing facilities at frequent intervals to vulnerable road users and by making sure that the design guidelines regarding issues like super elevation, etc. are observed strictly.

Table 8 shows the crash statistics by categories of highways. It is interesting to note that there are no major differences in overturn type of crashes on 2-lane and 4-lane roads. Similarly, there are no major differences in head-on collisions on differences in different types of 2-lane roads. However, it is very surprising that on 4-lane divided roads head-on collisions comprise 19% of the crashes. Divided 4-lane roads are justified on the basis that these would eliminate the occurrence of head-on collisions. This means that many vehicles are going the wrong way on divided highways. This is probably because tractor and other vehicle owners go the wrong way when they exit from roadside businesses, farms or homes and the cut in the median is too far away in the other direction. This issue needs to be taken up seriously to develop guidelines for the placement of cuts in the median or for providing under/overpasses for vehicles at convenient locations.

Rear end collisions (including collisions with parked vehicles) are high on all types of highways including 4-lane highways. This shows that although more space is available on wider roads rear-end crashes do not reduce. This would probably have to do more with the visibility of vehicles rather than road design itself. Countermeasures would include making vehicles more visible with the provision of reflectors and roadside lighting wherever possible.

Table 8. Road traffic crashes by categories of highways.

Highway Type	Crash type in per cent						
	Overturn	Head-on	Angle	Rear-end	Pedestrian and bicycle	Fixed object	Other
Intermediate lane	~	13	13	13	~	13	48
2 lane w/o shoulder	7	14	2	31	23	5	18
2 lane + 1.5m paved shoulder	5	11	~	16	45	11	16
2 lane + 2.5m paved shoulder	5	17	2	25	19	13	17
4 lane divided	4	19	7	19	35	2	13

Source: Evaluation of capacity augmentation projects of National Highways and State Highways (2000), Final Report, Ministry of Surface Transport, GOI, New Delhi

Impacts with pedestrians and bicycles have a high rate on all roads including 4-lane divided highways. The rate seems to be lower on 2-lane highways with wider (2.5m) paved shoulders. These findings suggest that wider shoulders reduce conflicts between slow moving traffic and motor vehicles but do not eliminate them. For these type of crashes to be reduced the following countermeasures need to be experimented with:

(a) Physical segregation of slow and fast traffic
(b) Provision of 2.5m paved shoulders with delineation devices like cats eyes, studs, rumble strips (300 mm in width) between the main carriageway and the shoulder
(c) Provision of frequent and convenient under-passes (at the same level as surrounding land with highway raised to provide clearance) for tractors, pedestrians, bicycles and NMT
(d) Traffic calming in semi-urban and areas and villages.

Collisions with fixed objects are low only on 4-lane divided highways. Provision of adequate run-off area without impediments is very important on highways and better road markings to indicate the alignment of the road would help also. We need to develop standards for provision of convenient tunnels and other crossing facilities in terms of designs and frequencies. In addition, there would also be a need for provision of "service roads" along the highways for short distance trips for local traffic. At present, there are no such guidelines to help the local designer and planner.

VEHICLE DESIGN ISSUES

The operation and safety of motor vehicles of India are controlled by the Motor Vehicles Act (1988) and the Central and State Motor Vehicle Rules. The safety standards for motor vehicles are included in the section on *Construction, Equipment and Maintenance of Motor Vehicles* of the Central Motor Vehicle Rules. These standards set technological requirements for motor vehicle parts and structures and are issued by the Ministry of Road Transport and Highways.

Most automobiles are traded internationally these days. Therefore, it would make sense for such vehicles to conform to some minimum international standards. This would apply most importantly to automobiles. India should also apply additional standards to make the vehicles more suitable for their specific traffic conditions. Some of these issues could include the possibility of making turn indicator lights more conspicuous and more easily visible to pedestrians, motorcyclists and bicyclists, and impact standards for pedestrians, bicycles and motorcycles with cars. Vehicle design issues that might need special consideration in India are summarised below.

Country specific vehicles

There has been a growth of vehicles in India that have been designed locally and do not conform to international safety standards. There is a wide variety of these vehicles but they can be broadly classified into three groups: (i) three-wheeled vehicles, (ii) four wheeled vehicles, and (iii) trailers pulled by tractors or other similar vehicle s. Construction methods, materials used and economic considerations will not allow for the imposition of international car safety standards on these vehicles. It will also not be very easy to design very efficient crash attenuating frontal structures for them. However, design changes can be attempted in the following areas: (i) improvements in rollover characteristics of the vehicles; (ii) body designs which restrict passenger ejection from vehicles; (iii) removal of all pointed and sharp objects from the inside surfaces of the cabin (eg. bolts, rivets, etc.); (iv) provision of impact absorbing padding in areas where passengers are likely to hit the vehicle surfaces during a crash; (v) improvements in conspicuity of the vehicles and lighting arrangements. The types of changes mentioned above will not require heavy investments in research and can be implemented with local initiative. A crash modelling exercise to improve the safety of three-wheeled scooter taxi has been attempted in India, which indicates that this is possible.[9]

Design of less aggressive buses and trucks

During the past decade, the pedestrian safety problem for impacts with private cars in HMCs has been studied using mathematical models, epidemiological studies, and impact tests with mechanical dummies and biological materials. Various recommendations for the front structure design of vehicles (mainly private cars) have been made. However, the fronts of buses and trucks have not been designed to be "forgiving" in impacts with VRUs. Preliminary studies show that it is possible to design fronts of buses such that impact forces in a bus pedestrian impact can be reduced significantly.[7] A similar study has been done for fronts of trucks also.[10] Much more work needs to be done to optimise properties for impacts at different velocities and for different age groups of pedestrians. Once these material properties are determined, then designs will have to be developed for retrofitting old vehicles also. Standards will have also to be developed for crashworthiness of buses and trucks for impacts with motorcyclist and bicyclists.

Bicycles and motorised two-wheelers

Since bicycles and motorcycles constitute a significant proportion of vehicles in India, and their riders a large proportion of road crash victims, there is a need to invest much more on research for the safety of these road users. Areas which need attention are conspicuity of these vehicles, design changes to make them more stable, and work on making helmets lighter, and more comfortable at high ambient temperatures.

MOTOR VEHICLE RULES AND LEGISLATION

The operation of motor vehicles and the rules regarding traffic control are also set in the Central and State Motor Vehicle Rules. This is because traffic and transportation are state subjects in India. However, there is a great increase in interstate vehicular traffic in India and there is a trend toward homogenisation of traffic norms internationally. Therefore, it may be desirable to review the situation in India and evolve new guidelines which suit the Indian requirements but in keeping with the international norms.

Traffic is regulated and offenders apprehended according to the provisions of the Motor Vehicle Rules and the Criminal Procedure Code of India and the various states. The provisions of these codes and rules need to be re-examined in the light of international trends where many traffic offences are being decriminalised and moved to the civil domain. The effectiveness of policemen on the street also depends on the road infrastructure, technological support given to the policemen and the socio-economic environment of the country where they operate. To make suitable changes all these issues will have to be examined in depth by professionals so that they can suggest suitable changes.

STANDARDS AND INSTITUTIONAL ISSUES

The following measures that have already been adopted may be considered as ones in the right direction:

1. Enactment of mandatory helmet laws for motorised two-wheeler riders (MTW). However, the law is not being enforced in all states of the country because of resistance from small vociferous groups.
2. Seatbelt equipped cars along with other safety features like laminated windshields, etc., and enactment of seatbelt use laws. The use law is not being enforced in any state. No motor vehicle crash test requirements are mandated presently.
3. Law against use of cell phones in moving vehicles in some locations.
4. Fronts and backs of trucks and buses and three-wheeled scooter taxis are painted yellow in some states to make them more conspicuous. The effectiveness of this measure has not been evaluated.

However, the expertise available in India in traffic management and safety research at all levels (central, state, city and departmental) is not adequate for the task at hand. There are no well funded and functional road safety departments at any level any where in the country. The funds allocated for road safety work, audits and research are also critically sub-optimal. Very few academic and research institutions in India have dedicated road safety professionals at present. This is because the subject has not been given any importance and no specialised groups have been set up which have the critical mass necessary to produce meaningful work on a sustainable basis.

The traffic conditions in India are very different from those experienced in western countries. The latter countries also have never experienced our problems in their past. Investing time and effort to come up with traffic management techniques is therefore very important for road designs and vehicle standards that suit our new reality. Nevertheless, our

present safety policies are only statements expressing concerns. Safety targets are not based on an analytical understanding of data. Data recording and analysis are not reflected in various improvement measures undertaken by various implementing authorities. Improvement schemes or new schemes are not evaluated to understand their impact on safety and "lessons learned" are not documented. Implementing authorities that include the Public Works Department and the Police Departments do not have the expertise and exposure to interdisciplinary analysis methodologies and research findings from other regions of the world. Sustained efforts and coordination are required between policy makers, implementing agencies and researchers to understand and control the safety situation from further deterioration.

The *real* issues and problems which road users face and which are associated with road safety must be identified and understood. Institutions, both governmental and non-governmental, have to be set up and funded so that road safety programmes can be set and implemented on a sustainable basis. The identified road safety plans and strategies must have the acceptance of a wide range of community groups and new technologies and designs must be identified, developed and implemented.

In recognition of some of these facts a recent report published by the Planning Commission of the Government of India has included the following policy recommendation in the text of the Tenth Five Year Plan document on the road sector:[11]

> "To evolve suitable corrective measures and initiate actions it is imperative to have scientific analysis of accidents. To improve safety in the long run, safety audits must be undertaken on all the roads. To save the accident victims it is essential to strengthen trauma care centres and hospitals to exclusively deal with accident cases. Highway surveillance through automated cameras and police patrol may be enhanced. To address this serious problem of road accidents Road Safety Boards will have to be established at different levels namely, District, State and Central. These institutions will address this problem on rapid and sustained basis."

The Committee has suggested that a special budget be set aside by the Government for the achievement of these objectives. If the National Road Safety Board is set up as suggested, it will give the impetus needed for improving the road safety situation in India.

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