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Road Safety in Developing Countries

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Abstract

Rapid growth in vehicles has been observed in many developing countries in recent years. The number of vehicles has grown but non-motorized vehicles have not disappeared. The presence of dissimilar modes of travel results in unsafe roads. Additional factors that exacerbate the traffic problem in these countries are the tendency of users to not observe traffic rules and the lax enforcement of traffic rules by law enforcement agencies. The combination of these factors can be deadly for road users. For example in India, a total of 134,513 people lost their lives to road accidents in 2010 compared to 32,885 road fatalities in the US during that year. Are roads in developing countries unsafe? Such questions are explored in this paper.

Researchers who have studied road safety problems in developing countries have suggested measures to improve safety. Specifying interventions alone will not be sustainable in the long run. Road safety is a complex matter with multiple dimensions. One of the prerequisites for interventions to be effective and sustainable is better institutional management of the safety problem. The paper explores the factors that indicate whether a lead institution to manage the road safety problem will need to be set up before interventions are implemented and safety targets are set.

Keywords: Road safety; Developing countries; India; Crashes; Fatalities

Introduction

Road traffic in developing nations is usually unruly and ill-managed leading to stressful and unsafe travel [1-4]. The traffic problem has intensified because of the high economic growth experienced in recent years by some developing countries such as India, which has resulted in a higher rate of growth in motorized vehicles relative to population [5, 6]. Even though some segments of the society have upgraded their mode of transport to motorized vehicles, many more are dependent on non-motorized modes such as walk or bicycle [7,8]. The use of the road by two dissimilar groups of modes of travel increases the chances of accidents.

Various researchers have analyzed road traffic safety issues in developing countries. Examples include [1-3,8]. These researchers have studied road safety problems in different countries spread across the globe and have provided recommendations for interventions to correct the problems that they have reported. They have, however, failed to address the many complexities of this multi-faceted problem. As such, their recommendations are too narrow and do not address the root cause of the safety problem.

Safety Net [9] treats the road safety problem in a more comprehensive manner. It states that safety should be produced like any other good or service. The production process to produce safety is viewed as a management system with three levels. The first level is said to contain the "institutional management functions" that produce the "interventions". Interventions constitute the second level of the safety management system. The interventions produce "results" which are at the third level.

The treatment of road safety by Safety Net is a significant improvement over other efforts reported in the literature. However, the institutional management functions that SafetyNet describes as being the first level of requirement for the "production" of safety are the missing elements in developing countries. As a result, the production system cannot move to the other two levels to produce a safe system. In contrast, the treatment of the road safety problem presented in this paper is tailored to the needs of developing countries. The paper uses India as the context in which to present its discussion, but many of its recommendations are applicable to developing countries in general.

In this paper the road safety problem developing countries has been analyzed with India as the example. India is a prime example of a developing country where growth in motorized vehicles has followed the economic growth and has negatively impacted road safety. This paper analyzes such impacts from five different perspectives: infrastructural, institutional, socio-economic, psycho-social/behavioral, and educational. In recent years, India has invested heavily on road infrastructure but it is still inadequate. For example, the National Highways (NH) network, which constitutes only 1.75% of the total road network in India and carries 40% of the total traffic, is only 2 lanes wide or narrower for 75% of its extent [10]. The NH network accounted for 30% of total road accidents and 36% of fatalities in 2010 [11].

While the distribution of road accidents in the NH network by road width is not available, certainly the existence of only 2 lanes or less in the NH network does not help make Indian roads safer. Additionally, there are many other unsafe features in the road network, such as open drains with steep side slopes, in adequate design of intersections, and lack of separation between slow-moving or non-motorized vehicles and heavier or faster motorized vehicles.

There is no institution in India at any level of government that is entrusted with the sole responsibility of ensuring that minimum safety standards are met when planning, designing, and constructing roads or during operation. In the case of the NH network, the National Highway Authority of India (NHAI) oversees the planning, design, and construction of roads. There is no governmental body responsible for safety audits. Depending on how a particular road segment was financed, either NHAI or a concessionaire maintains and oversees traffic operation on the segment. Enforcement of traffic rules is entrusted to the respective state police. Violations of traffic rules are common and enforcement is lax.

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Regarding the socio-economic dimension, there is a wide disparity of income in Indian society, with a majority of the people in lower income categories. One consequence of the income disparity is the presence of a wide mix of vehicles with starkly different physical and operational characteristics. In 2008 there were a total of over 105 million vehicles registered in India of which 71.5% were two-wheelers, 13.2% cars, jeeps, and taxis, 1.4% buses, 5.3% goods vehicles, and the remaining 8.6% were other vehicles consisting of tractors, trailers, and 3-wheeled passenger vehicles [5]. These numbers do not include non-motorized modes of transport, which include walk, cycle-rickshaw, bicycle, animal-drawn vehicle, and handcart. In 2010 about 18% of all fatalities on Indian roads involved people on these non-motorized modes of transport [11].

The socio-cultural/behavioral aspect of safety is related to speeding, seemingly aggressive driving, and wide-spread non-observance of traffic rules. The rapid growth of motorized vehicles coupled with the absence of a commensurate growth in infrastructure has led to extreme congestion on Indian roads. Under these circumstances it appears that one needs to break traffic rules to reach one's destination in a reasonable timeframe. But not following rules and stay in line may also be exacerbating the congestion problem. No research has been done yet to ascertain what came first: congestion or breaking traffic rules to overcome the congestion. But what is known at this time is that traffic on Indian roads is chaotic.

In addition, there is no formal safe driving education as part of the curriculum for young people in India. There are private driving schools in bigger cities, but their high cost limits their availability to the affluent. Instead, the majority of drivers learn to drive with the help of their friends and relatives and by emulating others. Consequently, when unsafe and aggressive driving is ubiquitous, new drivers emulating more experienced drivers, the majority of whom have bad driving behavior, simply perpetuates the problematic driving practices.

To summarize, the road safety problem in a developing country like India is a complex issue with multiple dimensions. Guidelines are available to implement a road safety management system that can produce a safe system, but these guidelines evolved in the West. Developing countries like India exist in a very different context and will initially need their own set of guidelines before they can start thinking about setting targets such as "Vision Zero" in Sweden and "Sustainable Safety" in the Netherlands [9].

Materials and Methods

Since India is the developing country example used in this paper, a brief description of the magnitude of the road safety problem in India is described first. The investigation of the five dimensions of the safety problem is then discussed, followed by the findings from the investigation. The authors' recommendation is then provided in the Discussion section

Status of road safety in India

As depicted in Figure 1, vehicles have grown rapidly in India in recent years. There has been an exponential growth in vehicles since 2000 without a commensurate growth in infrastructure. Two wheelers have grown the most rapidly and constitute over 70% of all registered vehicles in 2008 [5]. So it is not surprising, as will be shown in Section 2 of this paper, that the highest proportion of road fatalities in India involved people on two-wheelers [11].

In 2010 there were 134,513 fatalities in India [11]. It is difficult to gauge the level of safety from absolute numbers of fatalities or injuries; other measures that incorporate the degree of exposure are also needed. When available, the total distance travelled can be used to normalize the total fatalities or injuries to get a rate relative to the degree of exposure. This is what is done in developed countries but such data is not available in most developing countries. Some researchers have suggested that population be used as the normalizing variable to get a rate such as fatalities per unit of population [3]. The argument for using this approach is that the number of trips made is dependent on the population because, irrespective of the level of vehicle ownership or the level of infrastructure development, people will need to make trips to satisfy their needs. Kopits and Cropper [12] also use fatalities/population (F/P) as a measure of fatality risk. In the absence of distance travelled data, using population to normalize fatalities is an option to relate fatalities to the level of exposure. However, there are some inherent flaws in using this measure.

The F/P measure assumes that everyone in the population generates trips at the same rate, has similar access to the road network, and has similar availability of modes of travel. Such assumptions may be valid for developed, high-income countries but questionable for countries like India where the rate of urbanization in 2005 was only 29% [13] and millions of poor people do not have the means or the need to use the highway network. The flaw in using the F/P measure is illustrated by the fatalities and injury accident data published by the International Road Federation in World Road Statistics 2010 as reported in [11] and shown in Table 1.

According to this table, roads in China and India are safer than those in the USA on the basis of the fatality rate and both countries have safer roads than the UK or USA on the basis of injury accidents. There is an order of magnitude difference in injury accidents between India and China on the one hand and UK and USA on the other. But several external factors could account for the lower injury accident rate in India and China, and be giving a misleading perspective of road safety in these countries: a) the very large populations in these countries, b) underreporting of accidents, and/or c) lower amount of road travel. It

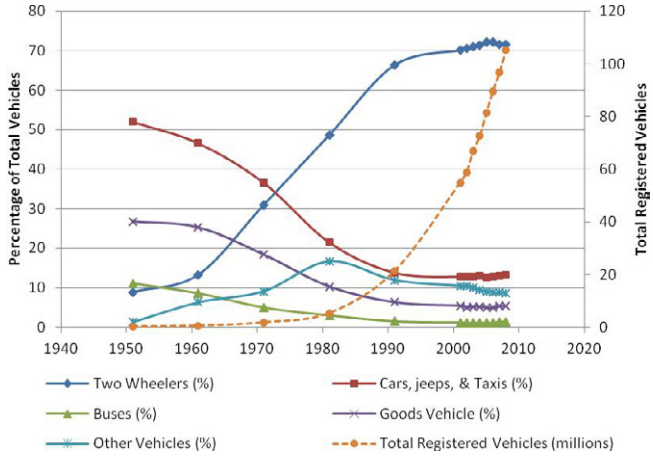

Figure 1: Registered vehicles in India.

Country	Fatalities/10^5 People	Injury Accidents/10^5 People
China	5.6	20.0
India	10.8	36.6
UK	4.1	287.9
USA	12.3	536.1

Table 1: Fatality and injury accident rates in selected countries in 2010.

is important to get more data, especially with respect to road travel, before concluding that roads are safer in India and China based on F/P analysis as Table 1 would indicate.

There is one other pertinent piece of post-crash information that can be gleaned from Table 1. Dividing the third column by the second we get the percentage of fatalities among injury accident victims. These percentages for China, India, UK, and USA are 28.0, 29.5, 1.4, and 2.3, respectively. These numbers indicate that once you get in an accident in India or China the chances of survival are much lower compared to the UK or USA. This may be due to: a) the severity of accidents in China and India is worse, b) the response time of emergency management service is lower, and c) hospital care is worse. In any case, the use of rates normalized by population does not appear to be appropriate for developing countries.

Figure 2 shows the trend in various fatality rates, vehicles per population, and fatalities in India. The rates are shown as dotted lines and measured by the vertical axis on the left.

The figure shows that the number of vehicles relative to population (V/P) has been growing steadily and the rate of that growth has been increasing with time. The fatality rate relative to population (F/P) has also been growing but the rate of that growth is low. According to Kopits and Cropper [12] the fatality rate, F/P, is a product of vehicles/population (V/P) and fatalities/vehicle (F/V). As the economy of a country grows, V/P will increase. So the only way fatality rate will decrease is when fatalities per vehicle (F/V) decreases. Figure 2 shows that F/V has been decreasing in India. By this reasoning, it appears that road safety in India has been improving. But this may not be true because, as Mohan et al. [3] note, out-of-use vehicles are never taken off the record. So the number of registered vehicles is accumulating over time and thus is overestimated and consequently F/V is underestimated.

However, the inaccuracy in the registered vehicle data will not affect F/P, since F/P is the product of F/V and V/P, and is thus independent of total number vehicles. But the argument that the population is not a good measure of exposure to accidents remains valid. An alternative measure of the exposure to accidents is the total length of road. A fatality rate measure can be derived by normalizing fatalities by road length. Figure 3 shows a plot of road length and fatalities per road length (F/R) in India for the years 1990 to 2008.

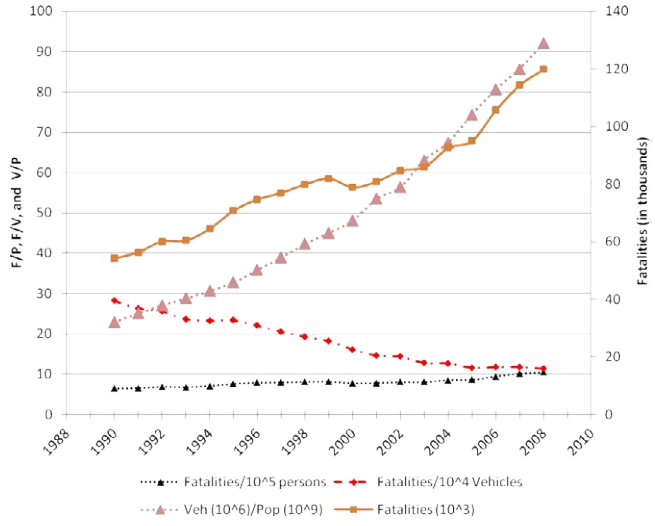

Figure 2: Trends in F/P, F/V, V/P, and fatalities.

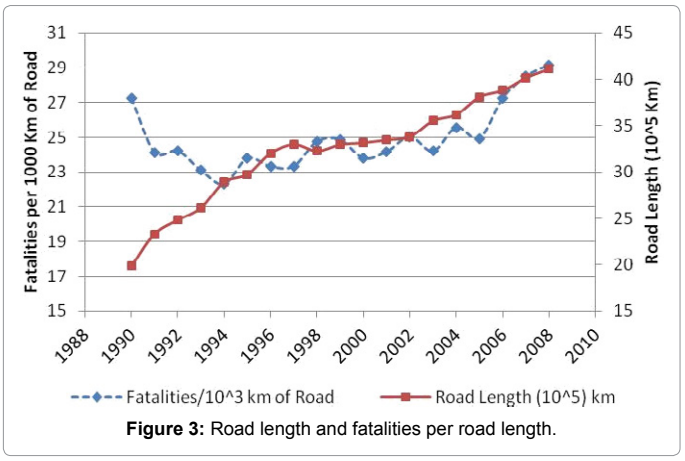

Figure 3: Road length and fatalities per road length.

Figure 3 shows that until about 1994 there was a decrease in F/R, after that it tracks the growth in road length. After 2005 the fatality rate grows rapidly. It should be noted from Figure 1 that after 1990 total vehicles in India started growing rapidly and after 2000 this growth was exponential. But as noted earlier, not all of the registered vehicles may be in use. Nevertheless an increasing numbers of vehicles are plying on Indian roads just as the road length is also increasing. Based on F/R, it can be concluded that the fatality rate in India has been increasing in recent years and road safety has been deteriorating. Road managers in India should explore ways to reduce that number.

Infrastructural aspects

There are three infrastructural elements that impact safety on Indian roads. First, even though the road infrastructure has been growing rapidly, it is inadequate. Second, there are many flaws in the completed infrastructure that can be deadly to road users. Third, road design has failed to consider the needs of users of all travel modes.

The length of the road network in India is 4.11 million km of which National Highways/Expressways and State Highways constitute 71,772 km and 154,522 km, respectively [10]. The remaining length is either district or rural roads. The width of a lane on National Highways is 3.75 m for single-lane and 3.5 per lane for multi-lane highways. Twenty one percent of National Highways are classified as single lane/intermediate lane, 54% as double-lane, and the remaining 25% are four-lane/six-lane/eight-lane roads. National Highways in India, although constituting only 1.75% of the total length, carried 40% of the total road traffic [10]. They also accounted for 30% of total road accidents and 36% of fatalities in 2010 [11].

The National Highways Authority of India (NHAI), which was set up in 1995 by an act of the Indian Parliament, is responsible for the national highway network and manages India's National Highways Development Projects (NHDP). The highway development projects are being implemented in phases. In Phases I and II about 14,000 km of national highways were upgraded to 4 or 6 lanes. There are a total of seven phases in the NHDP program.

Highway development in India is taking place at unprecedented levels; however, the supply of roads is still inadequate. An example of inadequate supply is the fact that 75% of the NH network is only 2 lanes wide or narrower, as mentioned in the Introduction section of this paper. Data on the distribution of the NH traffic across roads of different number of lanes are not available. Assuming an even distribution, a total of 30% of total road traffic in India is carried by roads in the NH network that are only 2 lanes wide or narrower.

In addition to a lack of adequate infrastructure, various flaws throughout the Indian road network are contributing to road injuries and fatalities. It should be noted that India is building the overall framework of a world-class road network, but these seemingly minor flaws can be deadly on a high-speed facility, and should therefore not be ignored. Figure 4 is an example of such a flaw. It shows an open median drain without any barriers on NH 67 in Tamil Nadu state. A vehicle that hits the raised kerbstone delineator of the drain at a high speed can be launched as a projectile and can land anywhere including the opposing lanes. Such an occurrence can be fatal not only for the vehicle that hits the kerbstone but also, potentially, for other vehicles in the vicinity. Other examples of flaws include inadequate length of acceleration/deceleration lanes, abrupt drop of lanes, low radii of curvature, and short lengths of weaving sections for merging traffic with heavy volumes.

Another infrastructural shortcoming in India is the design that has failed to take into account the needs of local traffic, especially those of non-motorized vehicles and pedestrians. Presence of dense human settlements by the roadside is not uncommon in India. Because of a lack of adequately designed service roads, people travelling short distances are seen travelling the wrong way on high-speed roads. Pedestrians are also seen crossing major roads unsafely. It is not clear whether it is lack of funds or poor design that has lead to this state of affairs. But it is clear that current road design practices do not account fully for the diversity of travel modes.

The task of designing safe roads in India is not trivial due to the presence of non-motorized and slower-moving vehicles such as, motorcycles, scooters, mopeds, and three-wheeled vehicles that are forced to share the road with heavier and faster-moving vehicles. Highway design in India is based on methods developed in the West. Roads have lanes of standard width with shoulders of varying widths, a portion of which may be paved followed by sections of gravel or dirt. On open sections of highways, these slower-moving vehicles try to stay as close to the edge of carriageway as possible. They may even move to the shoulder if they perceive that a vehicle is approaching from behind. When the shoulder is narrow or unpaved, the slow-moving vehicles prefer to travel on the carriageway. Such a situation creates a high potential of an accident.

Figure 4: Median drain with steep slopes on NH 67.

The distribution of fatalities among road users appears to be evenly divided as shown in Table 2 [11]. The third column in Table 2 shows the distribution of fatalities among the "vulnerable" group. Because they are more exposed compared to people in cars and buses, the users in this group are called vulnerable. It is not unreasonable to expect this group to bear a disproportionate share of the fatalities.

But the numbers in Table 2 indicate otherwise. The table shows that the share of fatalities among users in the vulnerable group is 51%. The share of fatalities by two-wheelers is actually lower than expected since they constitute over 70% of the total registered vehicles as seen in Section 2. Though further analysis is needed to explain this finding, a possible answer may be due to the different accident rates in urban areas compared to rural. Speeds on urban roads are lower. Severity of injuries increases with speed [14]. It is likely that the majority of two-wheelers operate on urban roads only, and this may be why fatalities among two-wheeler riders are lower relative to their proportion among all registered vehicles.

Institutional aspects

As road safety is an outcome of a number of factors associated with a multitude of complex dimensions of society, it calls for a concerted effort from all concerned agencies including government, non-government, and private sectors. Ideally, the lead agency to lead such efforts is the government. But in India there is no centralized governmental body responsible for road safety and there is no systematic auditing of road safety.

An example of a weak institutional arrangement is the presence of disabled vehicles without proper warning signs on Indian roads. Overturned trucks can be found lying on their side occupying part of the carriage way and demarcated by rocks and branches of shrubs or

User Category	Fatalities		Vulnerable Users
	Number	Share	
Pedestrians	11,754	8.7%	8.7%
Bicycles	6,203	4.6%	4.6%
Two-Wheelers	35,313	26.3%	26.3%
Auto-Rickshaws	8,275	6.2%	6.2%
Car, Taxis, Vans and Other Light and Medium Motor Vehicles	20,892	15.5%	
Trucks	17,955	13.3%	
Buses	11,134	8.3%	
Other Motor Vehicles*	16,201	12.0%	
Others**	6,785	5.0%	5.0%
Total	134,513	100%	51%

*Fatalities that were not broken up by categories were combined into the other motor vehicle category
**Includes: animal drawn vehicles, cycle rickshaws, handcart, and other persons.

Table 2: Distribution of fatalities by user category in 2010.

trees. There are also instances of disabled, heavy vehicles just parked on one lane of a two-lane highway without any warning signs. It is hard for approaching vehicles travelling at 80 km/hr to realize on time that it is a disabled vehicle on a travel lane which they will need to somehow avoid. That they are not able to do so all the time is evidenced by the high incidence of rear-end collisions on highways. In a study completed in 1999 on 14 selected highway locations in India by Tiwari et al. [3], 19% of all fatal crashes on 4-lane divided highways were rear-end crashes. Corresponding figures for 2-lane without shoulder, 2-lane with 1.5 m paved shoulder, and 2-lane with 2.5 m paved shoulder were 31%, 16%, and 25%, respectively. Similar situations exist in work zones. There are inadequate or non-existent barriers and signs on many highway constructions sites in India. There must be an institution assigned the task of road operations management for every road segment, but it is either understaffed or not doing its job.

Many countries in the West have policies and strategies along with strong coordination and implementation of road safety plans. In Asia, countries like Malaysia are actively involved in implementing various measures of road safety through well-coordinated institutional arrangements [15]. The interventions relate to conducting studies and evaluating current procedures on road safety to generate information that will form the core of its evidence-based intervention programs to enhance road safety. In India, there is no effort in this direction. Presently, the sole responsibility is vested in the Ministry of Road Transport and Highways and the Police at both the Central and State level governments. Road safety is just one of the many responsibilities handled by these agencies. There is no progress towards building a safe road transport system.

Recently the Government of India [16] formulated and approved a Road Safety Policy to address issues related to road safety. The Policy makes various statements related to many aspects of road safety. One of the policy statements is related to strengthening of the legal, institutional, and financial environment, which the Government of India hopes to achieve through active participation of all stakeholders including the community at large, the private sector, academia, and non-governmental organizations (NGO).

In an effort to build awareness and to emphasize the need for an institutional arrangement for the reduction of road fatalities in India the International Road Federation [17] organized a conference in New Delhi on 25-26 November 2010.The aim of the conference was to highlight the need for setting up an Institutional Arrangement for road safety in India. The following emerging ideas were part of the recommendations of this conference:

- Set up a Road Safety Cell in all agencies involved in road development in the municipal corporations, states as well as the centre for non-urban and urban roads similar to the one set up by NHAI for national highways.
- Since capacity building of stakeholders on road safety is a non-trivial, an urgent task is to develop a road safety culture in those organizations.
- Strengthen the traffic police and state transport departments as well as public works departments (PWD) to realize an effective road safety delivery.

Socio-economical aspects

The key socio-economical aspect highlighted in this section is that a wide disparity in income leads to a similar disparity in modes of travel. Poverty leads to unsafe use of vehicles, such as unmaintained vehicles, overcrowded buses, and rickshaws/carts going the wrong way. This causes hazards in road sharing not seen as often in the developed world. Hence, safety metrics and recommendations for the developed world do not readily apply to the developing world.

India's GDP is the ninth largest in the world [18], and its economy grew at an average rate of over 8% between 2000 and 2009 [19]. In terms of purchasing power parity, India has the third largest economy after the USA and China [20,21]. It is believed that there are many middle-class Indians who have enough income to buy a motor vehicle. At the same time, there are millions who have to struggle each day just to survive. This situation is reflected in the mode split for daily trips in major cities. According to Chhikara [7], the mode split in Delhi on a typical weekday is 34% walk, 27% bus, 14% two-wheelers, 9% cars, 5% cycle-rickshaw, 5% bicycle, 3% metro, and 2% auto-rickshaw. Though some people who can afford other modes of travel may choose to walk or ride a bicycle, the majority of the trip makers in Delhi who walk or ride a bicycle is most likely from low-income families and have no other choice of mode.

The poor are also engaged in various labor-intensive professions which include hauling goods in human-driven carts or other non-motorized modes of transport. It is a common sight in Indian cities of people pushing or pulling these carts through wide, busy intersections with multiple approaches and hundreds of motorized vehicles. At night the situation is even worse, as these non-motorized vehicles do not have headlights or reflectors in the rear. In addition, to cut down on the distance travelled, carts and rickshaws frequently travel the wrong way.

Another road safety consequence of a large segment of the low income population is the type, use and condition of vehicles operating on Indian roads. It may appear sensible for many to defer maintenance and repair of their vehicles when there are other more pressing needs for scarce rupees. It is a common sight to see vehicles in various states of disrepair travelling on Indian roads. Vehicles are routinely overloaded with people and goods. Overloading may also prevent the driver from using the rear view mirror. Side mirrors, when they are in working condition, may be folded in so that the vehicle can be maneuvered through tight spaces between other vehicles on the road.

Another common sight is people sitting on top or on the side of goods and material on truck beds. The goods are usually unsecured and the possibility of goods crushing people exists when there is rapid acceleration or deceleration of the truck and on sharp turns. People also travel routinely on top of buses. At the other end of the spectrum is the group of rich or newly-rich people who can afford to buy vehicles, many of which are powerful, expensive vehicles, which the drivers often choose to drive aggressively. The combination of fast-moving, powerful vehicles with slow, non-motorized means of transport can result in conflicts. The disparity in socio-economic levels of people in India is partly responsible for a wide variety of dissimilar modes of transport, which results in conditions not conducive to improving safety on Indian roads.

India has seen in recent years a rapid growth in motorized vehicles. The average annual growth of vehicles between 2001 and 2008 was 9.8%; the corresponding growth rate in population was only 1.5%. The growth in road fatalities during this period was 5.8%. As shown in Table 2, there were 134,513 persons killed in road accidents in 2010; 18.3% of those were pedestrians, bicyclists, or people on cycle-rickshaws or pushing/pulling carts. So even though many people are switching from non-motorized modes of transport to motorized modes, there remains a sizeable proportion that uses the former category. As shown earlier, in Delhi 71% of commuters on a typical day are walking, bicycling,

or travelling on a bus or cycle-rickshaw. Bus riders are relatively safe during the major leg of their travel but need to be on the street when getting to or from a bus, and hence remain vulnerable to accidents.

Freemark [22] analyzed the US Census Bureau's American Community Survey data on commuting behavior at city centers of the 30 largest US cities and concluded that the percentage of carpooling had declined over 25% between 2000 and 2009. The increases in biking, walking, and driving alone during that period were 58.5%, 1.8%, and 1.5%, respectively. Freemark also analyzed the 2009 mode shares for selected US cities. Even though the share for biking increased significantly the overall share of this mode in US cities is almost negligible. According to Freemark, the average shares of biking and walking in eight selected cities were only 0.9% and 4.6%, respectively. The share for driving alone and carpooling were 64.0% and 9.7%, respectively. In comparison, the mode shares for biking and walking in Delhi are 5% and 34%, respectively. The relatively high share of biking and walking in India is most likely due to the large segment of the populace that is economically disadvantaged.

Socio-cultural/behavioral aspects

There are many drivers on Indian roads that do not want to wait in line or observe other traffic rules. Vrat [4] points out that in India "due to the utmost 'concern for self' and 'very little concern for others', the transport system is plagued by all avoidable ills of congestion, crime, pollution, costly travel, accidents, road rages, etc., and needs to be attended to on priority". This behavior does not seem to be related to lower economic or educational status. On the contrary, the well-off appear to be even less likely to adhere to driving rules. McGarva and Steiner have found that higher social status causes more aggressive driving [2].

Lane discipline on Indian roads is rare. Drivers honk their way into any little gap they see between vehicles. The heterogeneity of traffic on Indian roads exacerbates this problem. In addition to motor vehicles, trucks, buses, motorcycles, scooters, three-wheeled motorized auto-rickshaws, there is an assortment of all kinds of non-motorized vehicles vying for space. This is prevalent on urban roads, but not uncommon on inter-city, high-speed roads as well. As a result of such behavior, traffic is unorganized and can be defined as chaotic. Some researchers, however, have taken exception to such characterization of traffic on Indian roads and maintain that such behavior constitutes an optimization of road space and is logical [23]. Motorized 2-wheelers moving into gaps between cars and buses at urban intersections is one thing, but such behavior by cars, jeeps, buses, and trucks on rural and intercity highways leads to crashes and near-misses that can make travelling on these roads very stressful and unsafe.

Extensive research has been performed in the West on aggressive driving. For example, Jovanovic et al. [24] define aggressive driving as a form of driver behavior that has an intention to harm or cause damage to other users. The examples they cite as aggressive driving include tailgating, honking, weaving in traffic, excessive speeding, headlight flashing, and red light running. All of these examples of aggressive driving can be seen on Indian roads, but the motive, in the majority of instances, may not due to an intention to harm or cause damage. According to Baron and Byrne [2] aggression can be of two types: instrumental and hostile. Speeding, running a red light, and weaving in out of traffic, are examples of instrumental aggression. Based on this classification, aggression seen on Indian roads is largely instrumental. Horn honking and cutting someone off are classified as hostile aggression by Baron and Byrne. These types of behavior are also common on Indian roads; but it is not clear whether the intention of drivers who resort to such acts is hostile. Lajunen et al. [25] also identify two types of driving violations: aggressive and ordinary. Aggressive violation is said to have the intention of aggression to another road user. Lajunen et al. [25] cite Lawton, Parker, Stradling, and Manstead to state that ordinary violations include behavior aimed at gaining advantage and maintaining progress. Simple observation of violations on Indian roads initially point to violations as ordinary or instrumental because such violations (e.g. horn honking, cutting off) are so widespread and most often not accompanied by heated exchanges or blatantly aggressive gestures between drivers; however, further research will be needed for more definitive conclusions.

Regarding the relationship between congestion and aggressive driving, Lajunen et al. [25] refute Shinar's belief that aggressive driving is primarily caused by congested roads. Lajunen et al. [25] study was carried out in Great Britain, Finland, and the Netherlands. The study was based on self-reported responses rather than observed behavior. Balogun et al. [2] report that in a subsequent study Parker, Lajunen, and Summala came to the conclusion that traffic density may indeed provoke aggressive driving. So the same group of researchers upon further study concluded that there is some relationship between traffic congestion and aggressive driving and other driving violations.

All of the research reported in these studies was carried out in the West. The findings from these western studies may not transfer to developing countries as noted by Warner et al. [26]. They found that aberrant driving behaviors differed across countries. This should be especially true between countries in the developed and the developing world. Just as there are so many differences in other factors between two countries in the developing and the developed worlds, driving behaviors should also differ. The meaning of aggressive driving is quite likely widely varying among different cultures. It may be advisable to link the definition of aggressive driving to the cultural background of a country before conducting further research on the causes of aggressive driving in a developing country such as India.

It is also useful to explore the effect of gender on aggressive driving. Krahe and Fenske [27] have analyzed the relationship between aggressive driving and macho personalities of men, the age of the driver, and the power of car. They found that aggressive driving behavior increased as a function of macho personality and horsepower of the car and decreased with age. Since macho behavior is believed to be more prevalent among men, an analysis of distribution of the Indian population by sex was conducted. (Figure 5) shows the distribution of the male and female populations of India in 2011 by age.

The figure shows that the age of more than 50% of the population

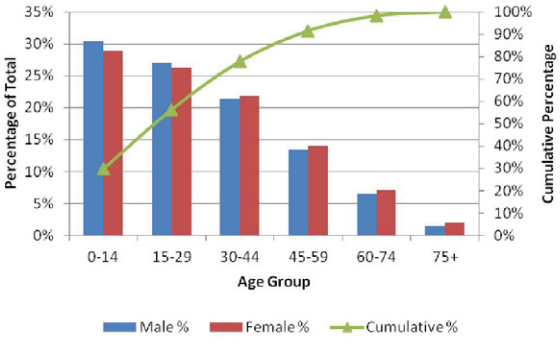

Figure 5: Population distribution in India by age and sex in 2011. (Source: U.S. Census Bureau).

was less than 30 years and among this group there were more males than females. So based on Krahe and Fenske's [27] findings there is a large segment of the population in India that may be prone to aggressive driving. Any steps taken towards enhancing safety on Indian roads will need to take these socio-cultural and behavioral trends into account.

Educational aspects

Some countries start inculcating safe behavior from an early age. For example, the US Federal Highway Administration has a Safe Routes to School Program that has five components called the five E's (http://safety.fhwa.dot.gov/saferoutes/guidance/). The five components are Engineering, Education, Enforcement, Environment, and Emergency. Characteristics that make school road safety education effective have been studied and researched. Some of the lessons learned from such research are to:

- Make road safety education part of the school curriculum so that lessons are continued over time and not done just once
- Provide teachers with proper training so that they can deliver road safety education
- Continue road safety education through secondary schools as well as in primary schools

Unfortunately, in India, no such programs to target people at an early age exist. Apart from this, driving schools that impart driving education to future drivers are not widely available and affordable to all segments of society. So the majority of people in India learn about safe and proper traffic behavior and etiquette by "learning on the job" and by emulating others. When there is a lot of unlawful and disorderly behavior on the roads, young, impressible minds will continue to perpetuate unsafe behavior resulting in a vicious cycle.

Another example of the lack of road safety education is illustrated by the experience of the National Highway Authority of India (NHAI). NHAI has made it a mandatory requirement to appoint a road safety auditor for all highway projects in the country. As a part of this endeavor, NHAI has made attempts to recruit road safety experts in these projects. But they have found that there is a huge shortage of experienced road safety experts in the country. So there is a need for road safety education at a large scale in the country.

Conclusion, Recommendations, and Discussion

Lack of adequate data is a problem across all developing countries; India is no exception. Data are not available in India to relate fatalities and injuries from road accidents to the exposure to the risk of accidents. Consequently, accurate estimates of the trends in fatality rates cannot be made and the rates cannot be compared to that of other more developed countries. However, estimates of the absolute number of fatalities by year are available. The numbers show that upwards of 134,000 people died on Indian roads from road accidents in 2010. These are all preventable deaths and India should make every effort to reduce these numbers.

All developing countries will need to set safety targets for the long, medium, and short terms. These targets should be achievable. Interventions will need to be specified to meet these targets. Interventions will not only cover the planning, design, and operation of the road network, which will work to prevent accidents, but they will also need to cover the post-accident management functions. Many deaths can be prevented when timely medical attention is provided to crash victims. As mentioned earlier, 29.5% of injury accident victims in India die, the corresponding numbers from UK and USA are 1.4% and 2.3% respectively.

Though they are important, developing countries should not just focus on interventions and results-focused target setting. Interventions are the first things that come to mind when thinking about road safety. But interventions alone are not sustainable, if institutions for managing safety are not built and a traffic safety culture is not developed. Traffic safety culture is almost non-existent in developing countries. Not enough money is set aside for safety in road projects. Safety is almost an afterthought. Once a lead agency is set up, it can take charge of all institution management functions and start developing a traffic safety culture in the country.

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