Road Safety in India

Status Report

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1. Introduction

NATIONAL ROAD TRAFFIC INJURY FATALITY RATE

According to official statistics 141,526 persons were killed and 477,731 injured in road traffic crashes in India in 2014 (NCRB, 2015). However, this is probably an underestimate, as not all injuries are reported to the police (Gururaj, G., 2006, Mohan, D. et al., 2009). The actual numbers of injuries requiring hospital visits may be 2,000,000-3,000,000 persons. The basis for these estimates is given in later section. The situation in India is worsening and road traffic injuries (RTI) have been increasing over the past twenty years (Figure 1). This may be partly due to the increase in number of vehicles on the road but mainly due to the absence of coordinated evidence-based policy to control the problem. These data show that the number of fatalities has continued to increase at about seven per cent a year over the past decade except over the last couple of years.

VEHICLE POPULATION

Figure 2 shows the growth of personal motor vehicles registered in India by year according to official data (Transport Research Wing, 2014). The official registration data over represent the number of vehicles in actual operation because vehicles that go off the road due to age or other reasons do not get removed from the records. This is because personal vehicle owners pay a lifetime tax when they buy a car and do not de-register their vehicles when they junk them.
The actual number of personal vehicles on the road is estimated to be 50%-55% of those on the records (Expert Committee on Auto Fuel Policy, 2002, Goel, R. et al., 2015, Mohan, D. et al., 2014). The number of cars and motorised two-wheelers (MTW) registered in 2012 was 21.6 and 115.4 million respectively. If we assume that 55% of them were actually on the road, then the actual number of cars and MTWs present on the roads would be 10.6 and 57.7 million respectively, and total ownership 6 per 100 persons in 2012. Table 1 shows the personal vehicle ownership and official road traffic fatality rates per 100 population for ten countries including India (W.H.O., 2015). This table shows eight countries with much higher vehicle ownership rates than India but lower RTI fatality rates. This indicates that increase in vehicle ownership need not be a reason for increase in fatality rates.

### Table 1. Personal vehicle ownership and official road traffic fatality rates per 100 population (Source: W.H.O., 2015)

<table>
<thead>
<tr>
<th>Country</th>
<th>MTW + light 4-wheelers per 100 population</th>
<th>Official fatality rate per 100 population</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>6*</td>
<td>11</td>
</tr>
<tr>
<td>Australia</td>
<td>71</td>
<td>5.1</td>
</tr>
<tr>
<td>Canada</td>
<td>61</td>
<td>6</td>
</tr>
<tr>
<td>Chile</td>
<td>45</td>
<td>12</td>
</tr>
<tr>
<td>Greece</td>
<td>60</td>
<td>7.8</td>
</tr>
<tr>
<td>Hungary</td>
<td>32</td>
<td>6</td>
</tr>
<tr>
<td>Japan</td>
<td>69</td>
<td>4.5</td>
</tr>
<tr>
<td>Portugal</td>
<td>56</td>
<td>6</td>
</tr>
<tr>
<td>Sweden</td>
<td>56</td>
<td>2.7</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>54</td>
<td>2.8</td>
</tr>
</tbody>
</table>

*Vehicle ownership rate adjusted for number of actual vehicles on road. See text.*
ROAD TRAFFIC CRASH AND INJURY DATA - NATIONAL LEVEL

Recording of crashes

As in most countries, traffic police are the source of official government statistics related with road traffic injuries in India. The main sources of traffic crash data at the national level are the annual reports published by the National Crime Record Bureau (Ministry of Home Affairs) and the annual publication of the Ministry of Road Transport & Highways (MoRTH) titled *Road Accidents In India*. The basic information for both these reports comes from all the police stations in the country based on the cases reported to them. A brief description of the process through which statistics are compiled at the national level is as follows. When the occurrence of a traffic crash is brought to the notice of a police station (by anyone involved in the crash; anyone who knows about the crash; or a police officer who comes to know about the crash) the information reported is recorded in a *First Information Report* (FIR). This sets the process of ‘criminal justice’ in motion and the police take up investigation of the case. After an FIR has been filed the contents of the FIR cannot be changed except by a ruling from the High Court or the Supreme Court of India. After the investigation is complete a case file is prepared which records the details of the crash as determined by the police department (which need not necessarily tally with those in the FIR) and the ‘offending party’ (as determined by the investigation) is charged with offences under provisions of the Indian Penal Code and the Motor Vehicles Act of India 1988 (Ministry of Road Transport and Highways, 1988). Some of the relevant provisions are:

**Indian Penal Code**
- Section 279. Rash driving or riding on a public way.
- Section 304A. Causing death by negligence.
- Section 336. Act endangering life or personal safety of others.
- Section 337. Causing hurt by act endangering life or personal safety of others.
- Section 338. Causing grievous hurt by act endangering life or personal safety of others.

**Motor Vehicles Act**
- Section 185. Driving by a drunken person or by a person under the influence of drugs.
- Section 184. Driving dangerously.

The above provisions are the deciding factor in how a police officer has to assign blame to one of the participants in a crash (usually one of the drivers). This is an important issue, as the ‘cause’ of the crash has to be recorded as a ‘fault’ of a driver under one or more of the above provisions in most cases. This procedure ensures that 80% or more of the cases get attributed to ‘human error’ and there is no place for understanding crashes as a result of a host of factors including vehicle, road and infrastructure design.
Reporting of crash data and analysis

Statistical tables that summarize key information about road traffic injuries are reported by police stations to their district’s Crime Records Bureau, from where aggregated statistical tables flow upwards to the state’s crime records bureau, and the National Crime Records Bureau (NCRB), which publishes the official statistics for the country (e.g. NCRB, 2015). Police-based statistics underreport road traffic deaths and injuries in many countries (Bhalla, K. et al., 2014, Derriks, H. M. and Mak, P. M., 2007, Rosman, D. L. and Knuiman, M. W., 1994, W.H.O., 2015). But, it has been usually assumed that in India while many injury cases may be taken to private hospitals and not get recorded, the police reports capture most road traffic deaths based on local investigations for the following reasons:

- For serious injury cases and deaths on the spot, or before arrival at a hospital, FIRs are filed with the police especially if those involved want to pursue a court case or claim insurance compensation.
- Under Section 165 of the The Motor Vehicles Act 1988 (Ministry of Road Transport and Highways, 1988), all State Governments have been authorised to set up Motor Accident Claims Tribunals for adjudicating upon claims for compensation in respect of road traffic crashes involving death, bodily injury or property damage. Claims can be made by the person who has sustained the injury, by owner of damaged property, and by legal representatives of the deceased. Victims or their legal representatives in the case of hit-and-run cases can also make claims. For this reason a large number of lawyers look out for such cases in hospitals or police stations and promise legal help to make the claim.
- When a RTI victim is admitted to a government hospital and declared as a RTI case, the patients’ details are recorded as a ‘Medico Legal Case’ by a police officer stationed at the hospital. If the victim dies in the hospital, irrespective of the length of stay in the hospital, the body is released only after a mandatory autopsy and the relevant details are provided to a police officer seconded by the relevant police station.
- Section 146 of the Indian Motor Vehicles Act 1988 (Ministry of Road Transport and Highways, 1988) requires that all motor vehicles (except those owned by the Central or State Governments) operating in a public space must be insured against third party risks.

Fatality estimates

However, the extent of underreporting of road traffic deaths in India is not well understood. For instance, such a record linkage study in Bangalore covering 23 hospitals found that police data only missed 5% of road traffic deaths (Gururaj, G., 2006). Recent studies that have estimated national road traffic deaths using data from the health sector suggest the possibility of higher underreporting by traffic police. The Global Burden of Disease (GBD) study estimates that there were 264,000 (95%CI: 214,000-321,000) deaths in India in 2013 almost twice the deaths reported by traffic police (GBD 2013 Mortality and Causes of Death Collaborators, 2015). GBD estimates of causes of death in India are based on estimates derived from comparative analysis of several national health data systems, including the Survey of Causes of Death (SCD), the Medical Certification of Cause of Death (MCCD), and the Million Death Study (MDS). With the notable exception of the MDS, the other data sources have large statistical biases (e.g. MCCD only tracks deaths from participating urban hospitals), and may not be a reliable source of information. The MDS, however, provides estimates of causes of death in India using a
large nationally representative mortality survey. The most recent data from the study is for the year 2001-2003 and includes over 122,000 deaths from all causes in 1.1 million homes (Hsiao, M. et al., 2013). The MDS estimated 183,600 (95%CI:173,800-193,400) deaths in the year 2005, about 47%-64% greater than the NCRB-reported official statistics for 2005.

In view of the reasons given earlier, it is possible that most of the critical and immediately fatal cases get recorded in crowded urban areas of India and those who die in government hospitals also enter the official statistics. Therefore, it is likely that the fatality statistic for urban areas in India may be underestimated by say 10%-20%. According to the MoRTH 61% of the RTI fatalities occur in rural areas and it is possible that a larger number of cases go unreported on rural roads. In a review of European and Japanese RTI data linkage, Lai, C.-H. et al. (2006) report that total RTI victims dying within 30 days of the crash are about 30% greater than those dying on the first day. If we assume that a significant proportion of fatalities that occur many days after the crash in rural areas are missed (that would reduce the number by less than 30% of the total deaths) and a smaller proportion of deaths on the spot or on the way to the hospital are missed, then we can expect underreporting to be around 50% of rural deaths. Overall, this would imply that the underreporting of fatalities in India may be less than 50%. This would indicate that the MDS estimate of RTI fatalities being about 47%-64% greater than the NCRB-reported official number may be closer to the truth than the W.H.O. or GBD estimates. However, this issue cannot be resolved to satisfaction until such time when the recording of traffic crashes is done in an manner open to public scrutiny and mechanisms are established to audit the quality of official statistics of road traffic deaths on a regular basis.

**Non fatal injury estimates**

While there is uncertainty among experts about the level of underreporting of road traffic deaths, all experts agree that police reports are a poor source of information for non-fatal injury statistics in India. Police databases typically report a small fraction of the non-fatal road traffic injuries that occur in most countries, including most developed countries (Derriks, H. M. and Mak, P. M., 2007, International Traffic Safety Data and Analysis Group, 2011). According to a recent IRTAD (2014) report police records alone are usually inadequate to carry out analysis on the nature and consequences of serious injuries because the reported number is underestimated. A report from France also states that under-reporting is inversely and strongly associated with injury severity: there is a clear gradient of decreasing probability of being police-reported with decreasing injury severity, 33-38% for severe injuries and 15% for minor injuries (Amoros, E. et al., 2008, Amoros, E. et al., 2006).

Studies from India also indicate similar trends. A study done in Bangalore shows that while the number of traffic crash deaths recorded by the police may be reasonably reliable, the total number of injuries is grossly underestimated (Gururaj, G., 2001). According to that 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 rural northern India recorded all traffic-related injuries and deaths through bi-weekly home visits to all households in 9 villages for a year and showed that the ratio between critical, serious and minor injuries was 1:29:69 (Varghese, M. and Mohan, D., 1991).
International experience is somewhat similar. In 2013 in the U.S.A. police-reported motor vehicle traffic crashes included 30,057 persons killed, 1,591,000 injured (probably an underestimate), and 4,066,000 damage only crashes giving a ratio of 1:53:135 respectively (National Center for Statistics and Analysis, 2015). Other studies report ratios between deaths:serious-injuries:minor injuries as 1:13:102 (Martinez, R., 1996) and 1:14:80 (Evans, L., 1991). A more recent report states that in Netherlands the ratio of the estimated number of fatalities and hospitalised persons for the year 2000 was 15.7 (Derriks, H. M. and Mak, P. M., 2007).

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 in India are likely to be about 1:15:50. If the estimate of road traffic fatalities in India (official) in the year 2014 is taken as 141,526, then the estimate of serious injuries requiring hospitalization would be 2,122,890 and that for minor injuries 7,076,300. The official estimate of non-fatal RTI in 2014 was 477,731, which probably underestimates injuries requiring hospitalisation by a factor of 4 and all injuries by a factor of 20.

The probability that a non-fatal injury is registered by police likely depends on whether there is a need to establish that the injury occurred due to the fault of a particular party, for instance, in order to claim financial compensation. This implies that the probability of a non-fatal crash being included in police reporting varies based on a wide range of factors (e.g. if multiple parties were involved, extent of property damage) that may have little to do with injury severity. Therefore police data should not be used for studying the epidemiology of non-fatal road traffic injuries in the country.

**Ranking in causes of death and population health**

Tables 2 and 3 show the leading causes of death and population health loss by age groups in India in 2013 (GBD 2013 Mortality and Causes of Death Collaborators, 2015). Population health loss is measured Disability Adjusted Life Years (DALYs) lost, which are defined as the sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability. These tables show that injuries resulting from road traffic crashes impose a substantial burden on the health of the population in India, especially among young adults. Road traffic injuries are the 8th leading cause of death in India and the 9th leading cause of overall health loss. Road traffic injuries impose a public health burden that exceeds that of many infectious diseases (e.g. malaria) and non-communicable diseases (e.g. diabetes) that are acknowledged to be important health issues for the country. The net health loss from road traffic injuries in India is approximately three times that from maternal disorders. Among young adults aged 15-49 years, road traffic injuries are the fourth leading cause of death and health loss. Men are injured at a much higher rate than women. Among young men aged 15-49 years, road traffic injuries are the leading cause of health loss.

Figure 3 shows that over the last two decades the burden of road traffic injuries in India has increased even while that due to many infectious diseases has declined. In 1990, road traffic injuries were the 16th leading cause of health loss. However, in 2013 they were ranked 9th due to an increase of
Table 2. Top 10 leading causes of death in India in 2013 (Source GBD 2013 Mortality and Causes of Death Collaborators, 2015)

<table>
<thead>
<tr>
<th></th>
<th>&lt;5 Years</th>
<th>5-14 years</th>
<th>15-49 years</th>
<th>50-69 years</th>
<th>70+ years</th>
<th>All Ages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Neonatal encephalopathy</td>
<td>Intestinal infections</td>
<td>Tuberculosis</td>
<td>Ischemic heart disease</td>
<td>Ischemic heart disease</td>
<td>Ischemic heart disease</td>
</tr>
<tr>
<td></td>
<td>Neonatal preterm birth</td>
<td>Intestinal infections</td>
<td>Ischemic heart disease</td>
<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
</tr>
<tr>
<td>2</td>
<td>Lower respiratory infection</td>
<td>Diarrheal diseases</td>
<td>Self-harm</td>
<td>Cerebrovascular disease</td>
<td>Cerebrovascular disease</td>
<td>Cerebrovascular disease</td>
</tr>
<tr>
<td>3</td>
<td>Neonatal sepsis</td>
<td>Drowning</td>
<td>Road Injuries</td>
<td>Tuberculosis</td>
<td>Diarrheal diseases</td>
<td>Tuberculosis</td>
</tr>
<tr>
<td></td>
<td>Diarrheal diseases</td>
<td>Road Injuries</td>
<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
</tr>
<tr>
<td>4</td>
<td>Intestinal infections</td>
<td>Leishmaniasis</td>
<td>Diarrheal diseases</td>
<td>Asthma</td>
<td>Lower respiratory infection</td>
<td>Road Injuries</td>
</tr>
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<td>Other neonatal diseases</td>
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<td>Fire &amp; heat</td>
<td>Hypertensive heart disease</td>
<td>Hypertensive heart disease</td>
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<td>COPD</td>
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<td>COPD</td>
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<td>6</td>
<td>Congenital anomalies</td>
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<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
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<td>7</td>
<td>Intestinal infections</td>
<td>HIV/AIDS</td>
<td>Diabetes</td>
<td>Diabetes</td>
<td>Self-harm</td>
<td>Self-harm</td>
</tr>
<tr>
<td>8</td>
<td>Congenital anomalies</td>
<td>Diarrheal diseases</td>
<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
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<td>9</td>
<td>STDs</td>
<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
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<tr>
<td>10</td>
<td>Protein-energy malnutrition</td>
<td>Skin diseases</td>
<td>COPD</td>
<td>COPD</td>
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</tr>
</tbody>
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Table 3. Top 10 Leading causes of health loss in India in 2013* (Source GBD 2013 Mortality and Causes of Death Collaborators, 2015)

<table>
<thead>
<tr>
<th></th>
<th>&lt;5 Years</th>
<th>5-14 years</th>
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<th>50-69 years</th>
<th>70+ years</th>
<th>All Ages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Neonatal encephalopathy</td>
<td>Iron-deficiency anemia</td>
<td>Tuberculosis</td>
<td>Ischemic heart disease</td>
<td>Ischemic heart disease</td>
<td>Ischemic heart disease</td>
</tr>
<tr>
<td></td>
<td>Neonatal preterm birth</td>
<td>Intestinal infections</td>
<td>Self-harm</td>
<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
</tr>
<tr>
<td>2</td>
<td>Lower respiratory infections</td>
<td>Diarrheal diseases</td>
<td>Ischemic heart disease</td>
<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
</tr>
<tr>
<td>3</td>
<td>Neonatal sepsis</td>
<td>Lower respiratory infections</td>
<td>Road Injuries</td>
<td>Tuberculosis</td>
<td>Diarrheal diseases</td>
<td>Tuberculosis</td>
</tr>
<tr>
<td>4</td>
<td>Diarrheal diseases</td>
<td>Skin diseases</td>
<td>Low back &amp; neck pain</td>
<td>Diabetes</td>
<td>Diabetes</td>
<td>Neonatal preterm birth</td>
</tr>
<tr>
<td></td>
<td>Malaria</td>
<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
<td>Neonatal encephalopathy</td>
</tr>
<tr>
<td>5</td>
<td>Congenital anomalies</td>
<td>Drowning</td>
<td>Migraine</td>
<td>Low back &amp; neck pain</td>
<td>Tuberculosis</td>
<td>Diarrheal diseases</td>
</tr>
<tr>
<td>6</td>
<td>Protein-energy malnutrition</td>
<td>Migraine</td>
<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
</tr>
<tr>
<td>7</td>
<td>Intestinal infections</td>
<td>Depressive disorders</td>
<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
</tr>
<tr>
<td>8</td>
<td>STDs</td>
<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
<td>COPD</td>
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</tr>
</tbody>
</table>

*Health loss is measured in Disability Adjusted Life Years Lost, DALYs.*
54% in disability adjusted life years (DALYs) lost to road traffic injuries. In contrast, overall health loss due to lower respiratory infections declined by 65% and diarrheal diseases by 65%.

INTERNATIONAL COMPARISON

The 2015 W.H.O. Global Status Report on Road Safety provides two sets of road traffic death statistics for every country. These are the official government statistics (usually based on police data) reported by each country to W.H.O., and estimates produced by W.H.O. through statistical analysis of national health statistics (including vital registration). Figure 4 shows the official RTI fatality rates for different countries plotted against per capita income of the countries and Figure 5 shows the rates for the same countries as estimated by the W.H.O. (W.H.O., 2015). These figures show that for more than half the countries the W.H.O. estimates are greater than 1.3 times the official rates reported by the countries. The ratio of the W.H.O. estimate and official rate for different countries is shown in Figure 6. This ratio for India is 1.5 as the official reported rate is 11.0 deaths per 100,000 persons and the W.H.O. estimate 16.6. These data indicate that some countries with similar incomes have possibly lower levels of under-reporting and some with higher income levels have also have higher levels of under-reporting. This suggests that country income level cannot be taken as excuse for inefficient data collection systems and it is possible for countries like India to set up professionally managed data collection systems that give a reasonably accurate estimate of RTI fatalities.

Both the official country data and W.H.O. estimates (Figures 4 and 5) show that there are countries with incomes similar to India that have RTI fatality rates lower than India. Again demonstrating that lack of finances does not necessarily mean that a society has to have absence of safety on the roads. At the same time, many countries much richer than India have much higher fatality rates. Therefore, we cannot
depend on growth in national income alone to promote road safety. It will be necessary to put in place evidence based national safety policies to ensure improvements in traffic safety.
DATA USED IN THIS REPORT

Injury and fatality data

Table 4 shows the different indicators generally used for assessing RTI issues (Mohan, D. et al., 2006). Out of all these indicators we only use number of fatalities and fatalities per 100,000 population for most of our analysis. Only fatality statistics from NCRB and MoRTH reports are used for analysis. We assume that though the Indian fatality statistics may suffer from some underestimation there may not be a systematic bias in recording of fatalities of specific road users. In such a situation the fatality statistics should be adequate for predicting trends and relative comparisons between different risk factors. Fatalities per 100,000 population is used for all comparisons because the population statistics are expected to be reliable and the index is a good indicator of the health burden on the population. Fatalities per population can also be used as proxy for risk of death per trip as international experience suggests that the average number of trips per person remains relatively stable over time, incomes and place (Knoflacher, H., 2007). Knoflacher further states that average trip rates in cities around the world vary from 2.8 to 3.8. That total trip rates do not vary much and generally remain between 3 and 4 trips per person per day has been supported by many studies around the world (Giuliano, G. and Narayan, D., 2003, Hupkes, G., 1982, Santos, A. et al., 2011, Transport for London, 2011, Zegras, C., 2010)

Non fatal injury data are not used at all in this report as they are not likely to give any useful insights. Injury and accident statistics suffer from a very high margin of underestimation as discussed in an earlier section. In addition, international experience suggests that injury and non-fatal crash data can suffer from many other biases such as relative under-reporting for pedestrian and bicycle injuries, night-

Fatalities per 10,000 vehicles and fatalities per vehicle-kilometre have not been used in this report except for a few specific comparisons. The official number for number of vehicles in India and cities are all overestimates (explained in an earlier section), and therefore, cannot be used for any calculations. In addition the indicator fatalities per 10,000 vehicles should not be used for comparison if the modal shares differ form place to place (Mohan, D. and Tiwari, G., 2000). The number of fatalities per 100,000 population always decrease as the number of vehicles per capita increase in a society even when no specific safety measures have been put in place (Adams, J., 1987).

Table 4. Examples of commonly used indicators of the road traffic injury problem
(Source: Mohan, D. et al., 2006).

<table>
<thead>
<tr>
<th>Index</th>
<th>Description</th>
<th>Use and limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of injuries</td>
<td>Absolute figure indicating the number of people injured in road traffic crashes</td>
<td>Useful for planning at the local level for emergency medical services</td>
</tr>
<tr>
<td></td>
<td>Injuries sustained may be serious or slight</td>
<td>Useful for calculating the cost of medical care</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not very useful for making comparisons</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A large proportion of slight injuries are not reported</td>
</tr>
<tr>
<td>Number of deaths</td>
<td>Absolute figure indicating the number of people who die as a result of a road traffic crash</td>
<td>Gives a partial estimate of the magnitude of the road traffic injury problem, in terms of deaths</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Useful for planning at the local level for emergency medical services</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not very useful for making comparisons</td>
</tr>
<tr>
<td>Fatalities per 10,000 vehicles</td>
<td>Relative figure showing ratio of fatalities to motor vehicles</td>
<td>Shows the probability vehicle involvement in fatal crashes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A limited measure for assessing safety in a society because it omits non-motorized transport and other indicators of exposure. Usually declines with motorization</td>
</tr>
<tr>
<td>Fatalities per 100,000 population</td>
<td>Relative figure showing ratio of fatalities to population</td>
<td>Shows the impact of road traffic crashes on human population as a public health problem</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Useful for comparing road traffic injuries as a health problem in different communities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Useful for estimating severity of crashes</td>
</tr>
<tr>
<td>Fatalities per vehicle-kilometre travelled</td>
<td>Number of road deaths per billion kilometres travelled</td>
<td>Useful for some international comparisons, decreases with motorization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Does not take into account non-motorized travel</td>
</tr>
<tr>
<td>Disability-adjusted life years (DALYS)</td>
<td>Measures healthy life years lost to disability and mortality</td>
<td>DALYs combine both mortality and disability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DALYs do not include all the health consequences associated with injury, such as mental health consequences</td>
</tr>
</tbody>
</table>
Data from NCRB and MoRTH reports

Table 5 shows a summary of the data that have been used for this report from the NCRB and MoRTH publications (NCRB, 2015, Transport Research Wing, 2015) and the reasons why some data have not been used. Since non-fatal crash and injury data and motor vehicle registration statistics are not reliable as explained in earlier sections, no table that includes these statistics has been used for analysis in the present report.

Items 4 and 5 in Table 5 for the NCRB report and items 16 and 17 in the MoRTH report refer to the following details:

1. Number of Persons affected by Road Accidents (Culpability vis-à-vis Fatality) during 2014 (Mode of Transport wise)
2. Number of Persons Died in Road Accidents and Mode of Transport (Culpability vis-à-vis Fatality) – 2014 (State/UT & City wise)
3. Total number of accidents, persons killed and injured based on the involvement by vehicle type during 2014
4. Total Number of Persons Killed in Road Accidents in terms of Road User Categories: 2014

The reader of these tables is not able to understand what these tables mean. In item 1 above (NCRB) the classification is done according to number of ‘Offending Driver/Pedestrian’ and number of victims who died by road user category. If we just take the case of fatal pedestrians in the table, there are 747 ‘offending’ pedestrians and 5,943 ‘victim’ pedestrians, giving a total of 6,690 pedestrian deaths (4.7 per cent of the total) who died in India in 2014. The table in item 2 above (NCRB) also gives the same number for offenders and victims as pedestrians. In item number 4 above (MoRTH) the report gives the total number of pedestrians killed as 8.8 per cent. These are very low proportions for pedestrian fatalities in India. Work done by independent researchers using police reports (same sources are used by above reports) from different cities and highway locations show very different results as shown in Table 6. In the nationally representative mortality survey of 1.1 million homes Hsiao, M. et al. (2013) reported that pedestrians and motorcyclists constituted 37 and 20 per cent of total RTI fatalities respectively. These data make it clear that the proportion of pedestrian fatalities in India cannot be as low as 8.8 per cent. In all probability the pedestrian fatalities may comprise around 40 per cent of all fatalities. If the pedestrian fatality proportions are so low in these official reports, then it stands to reason that proportions and numbers for all other road users will also be wrong. More data will be presented to strengthen this argument in subsequent sections of this report. The numbers and proportions of different road users killed and injured as mentioned in the NCRB and MoRTH reports are erroneous and cannot be used for any analysis.

Although it is clear that NCRB and MoRTH reports do not provide valid statistical tabulations on types of road-users killed, researchers have successfully generated reasonable estimates by inspecting detailed police reports. Such case files are paper-based and usually available at the police station with jurisdiction over the location where the crash occurred or at the district’s crime records bureau office. Researchers who are able to acquire requisite permissions need to undertake a tedious process of working with multiple police stations to acquire copies of all police reports and extracting information.
Clearly this cannot be done over a large region or prospectively to track changes over time without the use of substantial resources. Nevertheless, collecting such data even for a small region or a short period of time can provide valuable insights to researchers and policy makers interested in addressing local road safety issues.

The data regarding cause of crashes and persons responsible for crashes as reported in the NCRB and MoRTH reports is also not reliable. As mentioned earlier it is the IPC codes that decide how a police officer assigns blame to one of the participants in a crash (usually one of the drivers). This is an important issue, as the ‘cause’ of the accident has to be recorded as a ‘fault’ of a driver under one or more of the 4 or 5 provisions.

This procedure ensures that 80% or more of the cases get attributed to ‘human error’ and there is no place for understanding crashes as a result of a host of factors including vehicle, road and infrastructure design. For example the NCRB report attributes Driving under Influence of drugs and alcohol as 1.6 per cent of all crashes. Independent studies done estimate alcohol and drugs as a contributing factor in more than 20-30 per cent of the crashes (Arora, P. et al., 2013, Das, A. et al., 2012, Esser, M. B. et al., 2015, Gururaj, G., 2006, Mishra, B. K. et al., 1984). If one of the risk factors is underestimated by a large margin than the estimates for all the other ‘causes’ become unreliable. Therefore, tables dealing with cause of road traffic crashes should not be used for any analysis or policymaking.

The summary of data usability in Table 5 suggests that only about 20 percent of the tables in NCRB and MoRTH reports are usable for road safety analysis and policy making and the rest 80 per cent include unreliable information, which should not be used. This situation can only be improved by MoRTH with a complete revamp of the data collection systems in collaboration with the Ministry of Home Affairs and establishment of a professional data and analysis department (National Transport Development Policy Committee, 2014a).

**SUMMARY**

- According to official statistics 141,526 persons were killed and 477,731 injured in road traffic crashes in India in 2000 (NCRB, 2015). However, this is probably an underestimate, as not all injuries are reported to the police.
- The number of fatalities has continued to increase at about seven per cent a year over the past decade except over the last couple of years.
- The number of cars and motorised two-wheelers (MTW) registered in 2012 was 21.6 and 115.4 million respectively. The official registration data over represent the number of vehicles in actual operation because vehicles that go off the road due to age or other reasons do not get removed from the records. The actual number of personal vehicles on the road is estimated to be 50%-55% of those on the records.
Table 5. Summary of RTI data used (or not used) from Indian official reports.

<table>
<thead>
<tr>
<th>Data in Accidental Deaths and Suicides in India 2014 (NCRB, 2015)</th>
<th>Data used in report</th>
</tr>
</thead>
<tbody>
<tr>
<td>SN</td>
<td>Table</td>
</tr>
<tr>
<td>1</td>
<td>Growth in Number of Vehicles and Road Accidents in India (2010–2014)</td>
</tr>
<tr>
<td>2</td>
<td>Cases Reported and Percentage Change of Traffic Accidents during 2014 (State/UT &amp; City wise)</td>
</tr>
<tr>
<td>3</td>
<td>Cases Reported and Persons Injured and Died due to Traffic Accidents during 2014 (State/UT &amp; City wise)</td>
</tr>
<tr>
<td>4</td>
<td>Number of Persons affected by Road Accidents (Culpability vis-à-vis Fatality) during 2014 (Mode of Transport wise)</td>
</tr>
<tr>
<td>5</td>
<td>Number of Persons Died in Road Accidents and Mode of Transport (Culpability vis-à-vis Fatality) – 2014 (State/UT &amp; City wise)</td>
</tr>
<tr>
<td>6</td>
<td>Number of Traffic Accidents by Month of Occurrence during 2014 (State/UT and City wise)</td>
</tr>
<tr>
<td>7</td>
<td>Number of Traffic Accidents by Time of Occurrence during 2014 (State/UT &amp; City wise)</td>
</tr>
<tr>
<td>8</td>
<td>Road Accident Cases, Injuries and Deaths by Classification of Road during 2014 (State/UT &amp; City wise)</td>
</tr>
<tr>
<td>9</td>
<td>Distribution of Road Accidents by Causes and Unmanned Railway Crossing Accidents – 2014 (State/UT &amp; City wise)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data in Road Accidents in India 2014 (Transport Research Wing, 2015)</th>
<th>Data used in report</th>
</tr>
</thead>
<tbody>
<tr>
<td>SN</td>
<td>Table</td>
</tr>
<tr>
<td>1</td>
<td>Road Accident Parameters: 2013 and 2014</td>
</tr>
<tr>
<td>2</td>
<td>Number of Road Accidents per Lakh Population (1970-2014)</td>
</tr>
<tr>
<td>3</td>
<td>Number of Persons Killed per Lakh Population (1970-2014)</td>
</tr>
<tr>
<td>4</td>
<td>Number of Road Accidents per Ten Thousand Vehicles (1970-2013)</td>
</tr>
<tr>
<td>5</td>
<td>Number of Persons Killed per Ten Thousand Vehicles (1970-2013)</td>
</tr>
<tr>
<td>6</td>
<td>Number of Road Accidents per Ten Thousand Kilometres of Road Length (1970-2013)</td>
</tr>
<tr>
<td>7</td>
<td>Number of Persons Killed per Ten Thousand Kilometres of Road Length (1970-2013)</td>
</tr>
<tr>
<td>8</td>
<td>Month-Wise Classification of Accidents</td>
</tr>
<tr>
<td>9</td>
<td>Inter State Comparison of States (per cent accidents)</td>
</tr>
<tr>
<td>10</td>
<td>Severity of Road Accidents</td>
</tr>
<tr>
<td>11</td>
<td>Accidents classified according to type of Injuries (Grievous Injury and Minor Injury)</td>
</tr>
<tr>
<td>12</td>
<td>Percentage Share of 50 Million Plus Cities in Road Accidents &amp; Road Accident Profile of Million Plus Cities (2014)</td>
</tr>
<tr>
<td>13</td>
<td>Accident Severity in Million Plus Cities 2014</td>
</tr>
<tr>
<td>14</td>
<td>Percentage Share of National Highways, State Highways and Other Roads in Total Road Accidents, Persons Killed and Injured: 2002 to 2014</td>
</tr>
<tr>
<td>15</td>
<td>Total Accidents, Persons Killed and Injured in Rural &amp; Urban Areas during 2014</td>
</tr>
<tr>
<td>16</td>
<td>Total number of accidents, persons killed and injured based on the involvement by vehicle type during 2014</td>
</tr>
<tr>
<td>17</td>
<td>Total Number of Persons Killed in Road Accidents in terms of Road User Categories: 2014</td>
</tr>
<tr>
<td>18</td>
<td>Time of Occurrence of Road Accidents</td>
</tr>
<tr>
<td>19</td>
<td>Accidents classified according to Causes: 2014</td>
</tr>
<tr>
<td>20</td>
<td>Classification based on Age of Vehicles</td>
</tr>
<tr>
<td>21</td>
<td>Age of Persons Killed (Gender wise)</td>
</tr>
<tr>
<td>22</td>
<td>Total number of accidents, persons killed and injured based on Junction Type (2014)</td>
</tr>
<tr>
<td>23</td>
<td>Total Number of Road Accidents Classified based on various type of Traffic Control</td>
</tr>
<tr>
<td>24</td>
<td>Total Number of Road Accidents Classified based on persons driving the vehicle</td>
</tr>
<tr>
<td>25</td>
<td>Total Number of Road Accidents Classified based on</td>
</tr>
</tbody>
</table>
The extent of underreporting of road traffic deaths in India is not well understood. The Global Burden of Disease (GBD) study estimates that there were 264,000 (95%CI: 214,000-321,000) deaths in India in 2013 almost twice the deaths reported by traffic police. The Million Death Study estimate for fatalities is about 47%-64% greater than the NCRB-reported official statistics and may be closer to the truth.

- Police data should not be used for studying the epidemiology of non-fatal road traffic injuries in the country. The official estimate of non-fatal RTI in 2014 was 477,731, which probably underestimates injuries requiring hospitalisation by a factor of 4 and all injuries by a factor of 20.
- Over the last two decades the burden of road traffic injuries in India has increased even while that due to many infectious diseases has declined. In 1990, road traffic injuries were the 16th leading cause of health loss, however, in 2013 they were ranked 9th.
- Country income level cannot be taken as excuse for inefficient data collection systems and it is possible for countries like India to set up professionally managed data collection systems that give a reasonably accurate estimate of RTI fatalities.
- Lack of finances does not necessarily mean that a society has to have absence of safety on the roads. We cannot depend on growth in national income alone to promote road safety. It will be necessary to put in place evidence based national safety policies to ensure improvements in traffic safety.
- The numbers and proportions of different road users killed and injured as mentioned in the NCRB and MoRTH reports are erroneous and cannot be used for any analysis.
- Tables dealing with cause of road traffic crashes should not be used for any analysis or policy making
- Only about 20 percent of the tables in NCRB and MoRTH reports are usable for road safety analysis and policy making and the rest 80 per cent include unreliable information, which should not be used. This situation can only be improved by MoRTH with a complete revamp of the data collection systems in collaboration with the Ministry of Home Affairs and establishment of a professional data and analysis department.
- Since the ‘accident’ and ‘injury’ data are not reliable at all, it would be useful if the MoRTH and NCRB reports separate fatal and non-fatal cases in all tables included in the reports.

Table 6. Modal share of road traffic fatalities in Mumbai, Delhi and four rural highway locations in India.

<table>
<thead>
<tr>
<th>Location</th>
<th>Pedestrian</th>
<th>Bicycle</th>
<th>Motorised two-wheeler</th>
<th>Car</th>
<th>Bus</th>
<th>Truck</th>
<th>Unknown &amp; other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>58</td>
<td>2</td>
<td>29</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Mumbai (2008-2012)</td>
<td>47</td>
<td>10</td>
<td>26</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Delhi (2013)</td>
<td>32</td>
<td>11</td>
<td>24</td>
<td>15</td>
<td>3</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Highways (1998)</td>
<td>20</td>
<td>2</td>
<td>42</td>
<td>14</td>
<td>9</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>Rural highways</td>
<td>27</td>
<td>5</td>
<td>44</td>
<td>8</td>
<td>7</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>2lane NH6 2 (2010-2014)</td>
<td>34</td>
<td>3</td>
<td>10</td>
<td>6</td>
<td>5</td>
<td>41</td>
<td>1</td>
</tr>
<tr>
<td>4lane NH24 (2010-2014)</td>
<td>34</td>
<td>3</td>
<td>10</td>
<td>6</td>
<td>5</td>
<td>41</td>
<td>1</td>
</tr>
</tbody>
</table>

Notes: (1) Average of data 2008-2012, adapted from (Mani, A. and Tagat, A., 2013); (2) Source: (Delhi Traffic Police, 2014); (3) Data from locations on 34 national and state highways in India, (Tiwari, G. et al., 2000); (4) Source (Tiwari, G., 2015)
2. Analysis of national data

NATIONAL FATALITY RATES

Figure 7 shows the official estimates for total number of RTI fatalities and fatalities per 100,000 persons in India from 1970 to 2013 (NCRB). The total number of deaths in 2014 was 12 times greater than in 1970 with an average annual compound growth rate (AACGR) of 6%, and the fatality rate in 2014 was 5.2 times greater than in 1970 with an AACGR of 3.9%. There have been a few periods when the growth in RTI fatalities has decreased briefly and for a small amount, but the causes for the same are not known. However, it is known that motor vehicle crash rates have a tendency of decreasing along with a downturn in the national economy for the following reasons (International Traffic Safety Data and Analysis Group, 2015):

- Economic downturns are associated with less growth in traffic or a decline in traffic volumes.
- Economic downturns are associated with a disproportionate reduction in the exposure of high-risk groups in traffic; in particular unemployment tends to be higher among young people than people in other age groups.
- Reductions in disposable income may be associated with more cautious road user behaviour, such as less drinking and driving, lower speed to save fuel, fewer holiday trips.

This may explain the reason why the rate of growth in fatalities slowed down in India in the late 1990s and in the period 2010-2014 as these were also periods of low economic growth. There is no indication of a long term trend indicating that the increase in fatalities is going to reduce significantly in the near future. Two modelling exercises have attempted to predict the time period over which we might expect fatality rates to decline in different countries (Koornstra, M., 2007, Kopits, E. and Cropper,
Kopits and Cropper use the past experience of 88 countries to model the dependence of total number of fatalities on fatality rates per unit vehicle, vehicles per unit population and per capita income of the society. Thus, based on projections of future income growth, they predict that fatalities in India will continue to rise until 2042 before reaching a total of about 198,000 deaths and then begin to decline. Koornstra uses a cyclically modulated risk decay function model, which in a way incorporates the cyclically varying nature of a society’s concerns for safety, and predicts an earlier date of 2030 for the start of decline in RTI fatalities in India. If we assume the average growth rate of 6% per year declines to nil by 2030, then we can expect about 200,000 fatalities in 2030 before we see a reduction in fatalities.

The above models use the experience of high-income countries (HIC) over the past decades in calculating relationships between vehicle ownership levels and risk of death per vehicle. Therefore, the models presuppose the onset of decline at specific per-capita income levels if the past road safety policies of HICs are followed in the future in countries like India. Based on an analysis of RTI fatality trends in Europe and the USA, Brüde, U. and Elvik, R. (2015) suggest that:

- A country does not at any time have an “optimal” or “acceptable” number of traffic fatalities.
- In countries with a growing number of traffic fatalities, one cannot count on this trend to turn by itself; active policy interventions are needed to turn the trend.

If this is true, then the only way the decline of RTI fatalities can be brought forward in time is to institute additional India specific road safety policies that are new and more effective.

**MODAL SHARE OF RTI FATALITIES**

Table 7 shows estimates of the share of different road user fatalities by MoRTH (Transport Research Wing, 2015), W.H.O. (W.H.O., 2015), Hsiao, M. et al. (2013) and the authors of the present report. The MoRTH estimate is based on police records and the W.H.O. estimate on reports provided by the Indian government (based on police records). Hsiao et al. estimates are based on a nationally representative mortality survey of 1.1 million homes in India which reported 122,000 RTI deaths, and the author’s (of this report) estimate is based an analysis of police records obtained from 8 cities (Delhi Traffic Police, 2014, Mani, A. and Tagat, A., 2013, Mohan, D. et al., 2013) and a number of locations on rural roads around the country (Gururaj, G. et al., 2014, Tiwari, G., 2015, Tiwari, G. et al., 2000).

The MoRTH and W.H.O. estimates are similar because they come from the same source and suggest that pedestrian and bicycle fatalities constitute only 12%-13% of the total RTI fatalities in the country. The Hsiao, M. et al. (2013) and the authors’ estimates for share of pedestrian and bicycle fatalities is 45% and 39% respectively. This is a very large gap between the estimated share of fatalities.

<table>
<thead>
<tr>
<th>Road user</th>
<th>MoRTH data</th>
<th>Hsiao et al</th>
<th>WHO</th>
<th>Authors’ estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian</td>
<td>8.8</td>
<td>37</td>
<td>9</td>
<td>33</td>
</tr>
<tr>
<td>Bicycle</td>
<td>2.9</td>
<td>8</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>MTW</td>
<td>29.3</td>
<td>20</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Auto ricksha</td>
<td>5.1</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Car</td>
<td>16.3</td>
<td>9</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td>Bus</td>
<td>8.7</td>
<td>3</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Truck</td>
<td>12.3</td>
<td>4</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>Other</td>
<td>16.6</td>
<td>16</td>
<td>16</td>
<td>5</td>
</tr>
</tbody>
</table>
official and researcher’s estimates. Since Hsiao et al. have estimated the fatalities from interviews with a statistically representative sample of households in India, it is likely that their number is closer to the truth. The author’s estimate is made from detailed analysis of police reports from various parts of the country, and therefore, may be considered as based on official data, though from a smaller sample in the country. Since the Hsiao and authors’ estimates are similar, it is quite certain that these estimates are more reliable than those in NCRB, MoRTH and W.H.O. reports. The error in the official reports probably arises from wrong coding of the victims’ status and the procedure needs to reviewed carefully and revised. The error in the official reports probably arises from a wrong coding of the victims’ status and the procedure needs to reviewed carefully and revised.

AGE AND SEX DISTRIBUTION

Figure 8 shows the RTI fatalities and population distribution by age in India and USA (National Center for Statistics and Analysis, 2015, NCRB, 2015, Office of the Registrar General & Census Commissioner, 2015). In India the proportion of fatalities for the age group 15-59 is greater than their representation in the population and less for the age groups 0-14 years (1:7.9 of the population) and >59 years (1:1.4 of the population). In the USA children <15 years have a much lower representation in RTI fatalities as compared to their ratio in the population (1:5.1) but all the other age groups have a slightly higher representation.

It is not known why children’s (<15 years) and the elderly (>59 years) involvement rate in India is lower than that in the USA when a large number of children walk, cycle and travel on overloaded vehicles to school in India. It is possible that the exposure rate of the elderly in India is less than for those in the USA and this may explain their lower involvement. However, reasons for these differences need further study. As the health status of the Indian population improves the age structure would become more similar to that in the USA, and this would require that we focus more on policies for ensuring safety for older persons on the roads.

In India the ratio of female:male fatalities in 2014 was 1:5.9 and the ratio in the USA in 2013 was 1:2.4. One of the reasons why the female fatality ratio in India is lower than that in the USA is a lower

Figure 8. RTI fatality distribution and population distribution by age in India and USA (Source: NCRB, 2015 and National Center for Statistics and Analysis, 2015).
participation rate in formal employment in India (World Bank, 2015a). As the participation rate of women in formal work increases in India it may be necessary to understand if any specific safety measures have to be instituted to ensure women’s safety on the road.

STATE WISE ANALYSIS

Figure 9 shows the total number of fatalities by state and territory from 1971 to 2014. The states of Nagaland and Sikkim and Union Territories Lakshadweep, Daman & Diu, Andaman and Nicobar Islands and Dadra and Nagar Haveli have not been included in the chart as they reported less than 100 fatalities in 2014. Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura are small hill states, and the union territories of Andaman and Nicobar Islands, Dadra and Nagar Haveli, Daman and Diu, Lakshadweep, Puducherry, Chandigarh and Delhi union territories which are generally small and the last two are cities. Therefore, these regions can have different traffic and fatality patterns.

Andhra shows a decline in the number of fatalities between 2011 and 2014 because the state was divided in two states (Andhra and Telangana) in 2014. The total of fatalities in Andhra and Telangana in 2014 was 1,4814 as compared to 1,518 in undivided Andhra in 2011. In almost all the large states fatalities more than doubled between 1991 and 2014. In Maharashtra, Orissa, Rajasthan, Tripura fatalities increased by 4-6 times, and in Gujarat, Punjab, Haryana and Assam 8-10 times during the same period.

Figure 10 shows the fatalities per 100,000 population for states and union territories in 1996 and 2014. Fatality rates per million population increased in most regions except in the north eastern hill states and the cities of Delhi and Chandigarh (union territories). The increase was 40%-50% in Madhya Pradesh, Manipur, Tamil Nadu, Meghalaya, Uttar Pradesh; 60%-100% in Himachal Pradesh, West Bengal, undivided Andhra Pradesh, Rajasthan, Karnataka and Orissa; and more than 100% in Haryana, Sikkim, Assam and Punjab. The reasons for these differences are not known. However, these data do indicate that there are states with high rates and those with low rates in all regions of the country.

Figure 11 shows the association between fatalities per 100,000 persons (2014) and per capita income of states and union territories (2013-2014). These data show that many states with high per capita incomes have similar fatality rates as states with low incomes and that fatality rates do not seem to have a strong correlation with income.

Figure 12 shows the fatality rate per 100,000 persons (2014) as a function of population density in states and union territories. There does not seem to be any strong correlation of fatality rates with population density.
Andhra Pradesh was divided into two states (Andhra Pradesh and Telangana) in 2014, this is why Andhra Pradesh shows a decline in fatalities in 2014.

Figure 9. Total number of RTI fatalities by state and union territory from 1971 to 2014 (Source: NCRB).
Figure 10. RTI fatalities per 100,000 persons for states and union territories in 1996 and 2014 (Source NCRB).
Since the above data show that RTI fatality rates in states and union territories do not seem to be influenced strongly by location in the country, state income or density, it suggests that state RTI fatality rates may be more influenced by infrastructure availability, vehicle modal shares, road design, and enforcement. It appears that if fatality rates have to be reduced in India, much more attention will have to be given to street and highway designs and enforcement issues that have influence on vulnerable road user safety than has been the practice up to now. This will probably require a great deal of research and innovation as designs and policies currently being promoted do not seem to be having the desired effect in improving road safety.

SUMMARY

- The total number of deaths in 2014 was 12 times greater than in 1970 with an average annual compound growth rate (AACGR) of 6%, and the fatality rate in 2014 was 5.2 times greater than in 1970 with an AACGR of 3.9%.
- If we assume the average growth rate of 6% per year declines to nil by 2030, then we can expect about 200,000 fatalities in 2030 before we see a reduction in fatalities.
- The only way the decline of RTI fatalities can be brought forward in time is to institute additional India-specific road safety policies that are new and more effective.
- The NCRB, MoRTH and W.H.O. estimate of pedestrian and bicycle fatalities comprising 13% of the total RTI fatalities is not correct and the researchers’ estimates that this number may be in the range 39%-45% is more reliable.
- The error in the official reports regarding types of road users killed probably arises from a wrong coding of the victims’ status and the procedure needs to reviewed carefully and revised.
- It is not known why children’s (<15 years) and the elderly (>59 years) involvement rate in India is lower than that in the USA when a large number of children walk, cycle and travel on overloaded vehicles to school in India. Reasons for these differences need further study.
• In almost all the large states fatalities more than doubled between 1991 and 2014. In Maharashtra, Orissa, Rajasthan, and Tripura, fatalities increased by 4-6 times, and in Gujarat, Punjab, Haryana and Assam 8-10 times during the same period.

• Since RTI fatality rates in states and union territories do not seem to be influenced strongly by location in the country (culture), state income or density, it suggests that state RTI fatality rates may be more influenced by infrastructure availability, vehicle modal shares, road design, and enforcement.

• Much more attention will have to be given to street and highway designs and enforcement issues that have influence on vulnerable road user safety than has been the practice up to now. This will probably require a great deal of research and innovation as designs and policies currently being promoted do not seem to be having the desired effect in improving road safety.
3. Urban safety

CITY DATA

According to the MoRTH report (Transport Research Wing, 2015) 56,663 (40.6%) fatalities took place in urban areas and 83,008 (59.4%) in rural areas. These data suggest that the urban RTI fatality share is slightly higher than the estimated urban population share (32%) in 2014 (World Bank, 2015b). However, details of fatalities and vehicles registered are reported only for cities with populations greater than one million. The latest report includes details for 50 million plus cities recording a total of 16,611 fatalities (29% of urban RTI deaths). In this chapter we only use total fatality data for cities from the NCRB and MoRTH reports (other data are not reliable) and detailed analysis based on data reported in research studies.

Million-plus cities

Data for 50 million plus cities are reported in MoRTH and NCRB reports published in 2015 (NCRB, 2015, Transport Research Wing, 2015). Figure 13 shows total deaths reported in these cities for the years 1996, 2006 and 2014. Data for cities that did not have populations > 1 million in earlier years is not available. These data show that the number of deaths increased in almost all the cities between 1996 and 2006 and most cities between 2006 and 2014. Significant reduction in number of deaths are seen in large cities (> 5 m population): Bengaluru, Chennai, Delhi, Hyderabad and Mumbai. The reasons for these reductions are not known. It is possible that increases in traffic congestion leading to decreases in vehicle speeds may have contributed to this.

Figure 14 shows the annual RTI deaths per 100,000 population in million plus cities for 1991-2011. For some cities data for earlier years was not available as their population was less than 1 million. Data for 2014 are not shown as population estimates for all cities were not available. In 2011 the average death rate for all cities combined was 14.7 per 100,000. In 2011 the highest rates are indicated for Thrissur, Asansol and Kollam (> 40 deaths per 100,000 population) and lowest for Ahmedabad and Surat (<6 deaths per 100,000 population). The death rates for Asansol and Kollam are abnormally high at (> 60) and it is possible that these statistics may be in error and represent the whole district and not the cities. For 36 cities where the data can be compared between 2001 and 2011 only 12 saw a decrease in fatality rates. For most of them the decrease was less than 30%. This is quite an alarming situation, as in a third of these cities the death rate increased by more than 50% in a period of 10 years. Since a vast majority of the victims in these cities are vulnerable road users (see next section), one possible cause could be increases in vehicle speeds. The probability of pedestrian death is estimated at less than 10% at impact speeds of 30 km/h and greater than 80% at 50 km/h, and the relationship increase in fatalities and increase in impact velocities is governed by a power of four (Koornstra, M., 2007, Leaf, W. A. and Preusser, D. F., 1999).
Figure 13. Annual number of RTI deaths in million plus cities 1996–2011. For some cities data for earlier years not available as their population was less than 1 million (Source: NCRB). Continued on next page.
Figure 13 (Continued from previous page). Annual number of RTI deaths in million plus cities 1996-2011. For some cities data for earlier years not available as their population was less than 1 million (Source: NCRB).
Figure 14. Annual RTI deaths per 100,000 population in million plus cities 1991-2011. For some cities data for earlier years not available as their population was less than 1 million (Source: NCRB). Continued on next page.
Figure 14 (Continued from previous page). Annual RTI deaths per 100,000 population in million plus cities 1991-2011. For some cities data for earlier years not available as their population was less than 1 million (Source: NCRB).
DETAILS FOR SELECTED CITIES

Reliable data regarding fatalities modal shares and other details of road traffic crashes are not available from official reports. In this section we report data that have been obtained by researchers from police stations in different cities in India. These are official data as maintained in the records of police departments and analysed to obtain trends and relationships.

Modal share of RTI fatalities

Figure 15 shows the proportion of road traffic fatalities by road user type in six Indian cities (Mohan, D. et al., 2013). The total number of vulnerable road user deaths in the six cities range between 84% and 93%, car occupant fatalities between 2% and 4%, and occupants of three-wheeled scooter taxis (TSTs) less than 5% per cent, except in Vishakhapatnam where the proportion for the latter is 8%. Figure 16 shows that these total proportions are similar to those in the megacities Mumbai and Delhi (Delhi Traffic Police, 2014, Mani, A. and Tagat, A., 2013). Table 8 shows that these proportions are very different from those reported by NCRB (2015). Clearly the NCRB and MoRTH estimates for RTI modal shares suffer from erroneous coding and should not be used.

However, the relative proportions of pedestrian fatalities are smaller in these cities and motorised two-wheeler (MTW) fatalities greater than those in the megacities. This may be because the proportion of MTW ownership is higher in these smaller cities than that in the

Table 8. Proportion of pedestrian fatalities according to NCRB (2015)

<table>
<thead>
<tr>
<th>City</th>
<th>Per cent pedestrian fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agra</td>
<td>0</td>
</tr>
<tr>
<td>Amritsar</td>
<td>0</td>
</tr>
<tr>
<td>Bhopal</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Delhi</td>
<td>5</td>
</tr>
<tr>
<td>Ludhiana</td>
<td>3</td>
</tr>
<tr>
<td>Mumbai</td>
<td>10</td>
</tr>
<tr>
<td>Vadodara</td>
<td>6</td>
</tr>
<tr>
<td>Vishakhapatnam</td>
<td>17</td>
</tr>
</tbody>
</table>

Figure 15. Proportion of road traffic fatalities by road user type (vehicle occupants, bicyclists and pedestrians) in 6 Indian cities (* number in parentheses represents the official RTI fatality rate in the city in 2011).
megacities. Helmet use by MTW riders is not enforced in any of these cities though the use is mandated by the Motor Vehicles Act 1988 of India (Ministry of Road Transport and Highways, 1988). The high rate of MTW fatalities can be reduced significantly if the existing mandatory helmet laws are enforced in all the cities and laws introduced for compulsory daytime running lights for MTWs (Elvik, R., 1993, Elvik, R., 1996, Peden, M. et al., 2004, Radin Umar, R. S. et al., 1996).

Ludhiana and Amritsar have a higher proportion of bicyclists killed than the other cities. Anecdotal evidence suggests that these cities have higher bicycle use than the other cities surveyed, but we cannot confirm this.

**Road user victim type and impacting vehicle/object**

Figure 17 shows the data for the distribution of road traffic fatalities by road user category versus the respective impacting vehicles/objects for two of the six cities, Agra and Bhopal. These two cities are representative of the patterns in all the six cities and have been selected as the fatality rates per 100,000 persons are different with Vishakhapatnam at 24 and Bhopal at 14 in 2011. In both the cities the largest proportion of fatalities for all road user categories (especially vulnerable road users) are associated with impacts with buses and trucks and then cars. This is true for the other four cities also. The most interesting feature emerging from this analysis is the involvement of MTW as impacting vehicles for pedestrian, bicyclist and MTW fatalities in cities. The proportion of pedestrian fatalities associated with MTW impacts ranges from 8 to 25 per cent of the total. The highest proportion was observed in Bhopal. The involvement of MTWs as impacting vehicles in VRU fatalities may be due to the fact that pedestrians and bicyclists do not have adequate facilities on arterial roads of these cities and they have to share the road space (the curb side lane) with MTW riders.
Figure 17. Fatal RTI victim road user category and impacting vehicles/objects in Vishakhapatnam and Bhopal (numbers in bars represent number of cases).

Road traffic fatalities by type of road user and time of crash

Figure 18 shows the fatalities by road user category and time of day in Agra and Ludhiana. These two cities have been selected as they have different fatality rates and traffic characteristics were studied in greater details in these two cities. Pedestrian and bicycle fatalities have high rates earlier in the morning. This may be because this class of road users start for work earlier than those using motorised transport and vehicle speeds may be higher at this time. The total fatality rate remains somewhat similar between the hours of 10:00 and 18:00 and a strong bimodal distribution is not observed. This could be because school and working timings are reasonably staggered. Schools start around 08:00 in the morning and close at 14:00 and some of them have a second shift. Private offices open between

Figure 18. Fatal RTI victim road user category and impacting vehicles/objects in Vishakhapatnam and Bhopal (numbers in bars represent number of cases).
08:00-09:00, government offices between 09:00-10:00 and shops around 11:00. Most shops stay open up to 21:00 and restaurants up to 23:00. The data also show that MTW and pedestrian deaths are relatively high at 20:00-23:00 when we would expect traffic volumes to be low. The details of risk factors for high rate of vulnerable road user fatalities at night are not available for all cities but surveys done in Agra and Ludhiana suggest that due to lower volumes vehicle velocities can be higher at night, adequate street lighting is not present, and there is very limited checking of drivers under the influence of alcohol (Malhan, A., 2014). The situation would be similar in the other four cities except in Vadodara where there is prohibition of alcohol use by law.

**Age of victims**

In the detailed study done for six cities the data coders marked out the cases where ‘children’ were mentioned as victims in the text in the police reports. In general these would be persons younger than 4 years. For Agra, Amritsar, Bhopal and Vishakhapatnam (total fatal cases in sample: 2,788) a total of 78 cases (2.8%) were identified of which 13 were MTW occupants (0.5%) and 53 were pedestrians (1.9%). This is less than the national rate of 7% for persons 0-14 years. This may be partly because some of those below 14 years may not have been classified as children. Lower exposure rates for children may account for this, however, this explanation does not seem to be adequate enough to explain these very low rates, especially children on motorcycles. This phenomenon needs further study.

**Road user risk analysis**

Risk of fatality has been calculated using different indices to understand the role of different motor vehicles, personal risk per trip by different modes and the risk different vehicles present to society.

**Occupant risk per hundred thousand vehicles**

Figure 6 shows the number of motor vehicle occupant fatalities per 100,000 vehicles for four cities where the vehicle data were relatively reliable. This has been obtained by dividing the total number of occupant fatalities for each vehicle type estimated for 2011 divided by the number of vehicles of that type estimated for the city (corrected for overestimates). These data show that occupant fatalities per vehicle decrease in the following order – TST:MTW:Car. Occupant fatality rates for MTW and TST occupants are 2-3 and 3-5 times higher than for cars respectively. The high rates per vehicle for TSTs would also be because they carry a much larger number of passengers in the day as compared to MTWs and cars. The MTW fatality rate is not more than 5 times the fatality rate for cars in any of the four cities. For Europe and USA this ratio is reported to be in the range of 10-20 (Peden, M. et al., 2004). We do not have detailed data to explain with certainty why this risk ratio for MTW riders should be lower in Indian cities where the helmet law is not being
enforced. The possible reason could be that the majority of motorcycles sold are of low power (<150 cc), the riders are not motorcycling enthusiasts but regular commuters, and also the effect of safety in numbers (Bhalla, K. and Mohan, D., 2015).

**Personal fatality risk per 10 million trips**

The personal fatality risk has been calculated by dividing the vehicle specific occupant fatality rate by estimates of average number of occupants carried by each vehicle per day. The numbers assumed are (based on 3 trips per day for MTW and cars with occupancy of 1.3 and 2.3 per trip respectively): MTW – 4, TST – 60, Car – 7 (Chanchani, R. and Rajkotia, F., 2012, Mohan, D. and Roy, D., 2003, Wilbur Smith Associates, 2008). The results of these calculations are shown in Figure 20. It is clear that given the present trip lengths for each vehicle type, the MTW rider is 3-6 times more at risk than a car occupant. The MTW fatality rates per trip in Agra and Vishakapatnam are much higher than the other three cities. The reasons for this are not known at present. At a personal level, risk per trip seems to be lowest for TST occupants in all the cities for the assumed occupancy rates and number of trips per day.

**Fatalities associated with each vehicle type accounting for exposure**

Figure 21 shows all the fatalities that each vehicle type is associated with per 100,000-vehicle km per day. The following values have been assumed for distances travelled per day.

- Car: 50 km
- TST: 150 km
- MTW: 25 km

This includes occupant fatalities and those of road users other than the vehicle occupant. For example, if a motorcycle hits a pedestrian and the pedestrian dies, then the pedestrian death will also be associated with the motorcycle. This index gives a rough idea of the total number of fatalities that is expected for each vehicle type given the present traffic conditions and mode shares. These figures indicate that the relative low rate for TSTs as compared to cars is due to the higher exposure of TSTs per day. These indices appear to indicate that per km of travel TSTs, MTWs and cars are very roughly equally harmful for society under
present conditions. Out of these three vehicles motorcycle riders bear the highest risk and it is very important to focus on their safety (helmet use and daytime running lights). TSTs need improvement for safety of occupants as well as the VRUs it impacts.

**Conclusions from detailed city studies**

The total number of vulnerable road user deaths in the six cities range between 84% and 93%, car occupant fatalities between 2% and 4%, and TST occupants less than 5%, except in Vishakhapatnam where the proportion for the latter is 8%. These total proportions are similar to those in the megacities Mumbai and Delhi. Helmet use by MTW riders is not enforced in any of these cities though the use is mandated by the Motor Vehicles Act 1988 of India. The high rate of MTW fatalities can be reduced significantly if the existing mandatory helmet laws are enforced in all the cities and laws introduced for compulsory daytime running lights for MTW.

The largest proportion of fatalities for all road user categories (especially vulnerable road users) are associated with impacts with buses and trucks and then cars in Vishakhapatnam and Bhopal. This is true for the other four cities also. The most interesting feature emerging from this analysis is the involvement of MTW as impacting vehicles for pedestrian, bicyclist, and MTW fatalities in all the six cities. The proportion of pedestrian fatalities associated with MTW impacts ranges from 8 to 25 per cent of the total. The involvement of MTWs as impacting vehicles in VRU fatalities may be due to the fact that pedestrians and bicyclists do not have adequate facilities on arterial roads of these cities and they have to share the road space (the curb side lane) with MTW riders. Provision of separate and adequate pedestrian and bicycle lanes in all cities is a prerequisite for RTI control.

MTW and pedestrian deaths are relatively high at 20:00-23:00 when we would expect traffic volumes to be low. Surveys done in Agra and Ludhiana suggest that due to lower volumes vehicle velocities can be higher at night, adequate street lighting is not present, and there is very limited checking of drivers under the influence of alcohol. This suggests that traffic calming methods, better street lighting and alcohol control would be necessary to control RTI during night time.

Involvement of young children in fatal crashes appears to be low and the reasons for this are not clear need to be studied. Relative risk of occupants of MTW is the highest but not as high in the high-income countries. However, the estimated risk to society posed by cars as estimated from total involvement in fatal crashes seems to be greater than that posed by motorcycles and thee-wheeled scooter taxis. Further research is necessary to determine the veracity of these findings.

**SUMMARY**

- Data show that the number of deaths increased in almost all the cities between 1996 and 2006 and most cities between 2006 and 2014.
- Significant reduction in number of deaths were seen in large cities (> 5 m population): Bengaluru, Chennai, Delhi, Hyderabad and Mumbai. The reasons for these reductions are not known. It is possible that increases in traffic congestion leading to decreases in vehicle speeds may have contributed to this.
• In 2011 the average annual death rate for all cities combined was 14.7 per 100,000 persons.
• For 36 cities where the data can be compared between 2001 and 2011 only 12 saw a decrease in fatality rates. For most of them the decrease was less than 30%. This is quite an alarming situation, as in a third of these cities the death rate increased by more than 50% in a period of 10 years.
• The total number of vulnerable road user deaths in all eight cities studies range between 84% and 93%, car occupant fatalities between 2% and 4%. These proportions are very different from those reported by NCRB (2015). The NCRB and MoRTH estimates for RTI modal shares appear to suffer from erroneous coding and should not be used.
• In all the cities studied the largest proportion of fatalities for all road user categories (especially vulnerable road users) are associated with impacts with buses and trucks and then cars. The proportion of pedestrian fatalities associated with MTW impacts ranges from 8 to 25 per cent of the total.
• MTW and pedestrian deaths are relatively high at 20:00-23:00 when we would expect traffic volumes to be low. Surveys done in Agra and Ludhiana suggest that due to lower volumes vehicle velocities can be higher at night, adequate street lighting is not present, and there is very limited checking of drivers under the influence of alcohol.
• Occupant fatalities per vehicle decrease in the following order – TST:MTW:Car.
4. Intercity highways

INTRODUCTION

Government of India has launched a major programme to expand and improve highways in India since 2000. Seventy thousand kilometres of National Highways (NH) are maintained by the National Highway Authority (NHAI). Through the National Highway Development Programme (NHDP), NHAI is upgrading nearly 49,000 km of NH. Twenty four thousand km of highways have been upgraded. Upgradation includes increasing the number of lanes (e.g. from four to six), converting undivided roads to divided highways, and adding paved shoulders to 2 lane roads. The major motivation behind highway upgradation has been improving inter-city and interstate connectivity through capacity enhancement as well as improving highway safety.

TRAFFIC CRASHES ON INDIAN HIGHWAYS

Highway safety remains a major concern after nearly 50% of completion of NHDP projects. Figure 22 shows the proportion of RTI fatalities on different categories of roads and the proportion of road length for each category (MoRTH, 2015, Transport Research Wing, 2015). NH comprise only 15% of the total length of roads in India but account for 33% of the fatalities. Fatality rate per km of road is the highest on expressways (1.8 deaths per km per year) and NH come next with 0.58 deaths per km annually (Figure 23). The relatively high death rate on NH could be because they carry a significant proportion of passenger and freight traffic (MoRTH, 2015, Transport Research Wing, 2014). However, since details of vehicle km travelled on various categories of highways are not available, it is not possible to make a comparison based on exposure rates. Expressways had a length of only 1,000 km in the country in 2014 but a high death rate of 1.8 per km per year. This should be a cause for concern.

Recent research studies have reported fatal crash rates (fatalities per km) for three NH (NH-1, NH-8 and NH 2) as 3.08 crashes/km/year on six-lane NH-1, followed by 2.54 crashes/km/year on four-lane NH-
24 bypass, and 0.72 crashes/km/year on two-lane NH-8 (Naqvi, H. M. and Tiwari, G., 2015).

CRASH PATTERNS

A detailed study of 35 selected locations on highways reported traffic crash patterns using two different methods to collect road crash data (Tiwari, G. et al., 2000):

1. Analysis of road accident First Information Reports (FIRs) for a period of one year from the police stations in the area.
2. Analysis of data collected by specially trained informers for a period of three months for a 50-km section of the highway at each location. The informers were instructed to travel over the section every day and collect information on accidents occurring on that stretch.

The two methods of data collection gave the following insights:

1. The data available from the police records misses out many minor injury and single vehicle accidents.
2. The data collected by the informers missed many fatal accidents involving pedestrians and bicyclists. This is probably because the vehicles involved in these cases are often able to drive away because they do not suffer much damage. As such there is no evidence left at the crash scene and the informer may miss the case when he travels on the stretch of the highway after a day.

A more recent study investigated police reports of fatal crashes on selected locations on 2 lane NH8, 4 lane NH24, and 6 lane NH1 (Tiwari, G., 2015). The results for modal shares of those killed on these locations are given in Table 9. In the 1998 study of highways the proportions of motor vehicle occupants and vulnerable road users were 32 and 68 per cent respectively, whereas the numbers for urban areas were 5%-10% vehicle occupants and the rest were vulnerable road users (Table 9). 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. Data from three highway segments from 2009-2013 show a similar pattern. Pedestrian and MTW proportions are very high except on the six-lane highway where the proportion of truck

### Table 9. Modal share of road traffic fatalities in Mumbai, Delhi and four rural highway locations in India.

<table>
<thead>
<tr>
<th>Location</th>
<th>Pedestrian</th>
<th>Bicycle</th>
<th>Motorised two-wheeler</th>
<th>Car</th>
<th>Bus</th>
<th>Truck</th>
<th>Unknown &amp; other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highways (1998)</td>
<td>32</td>
<td>11</td>
<td>24</td>
<td>15</td>
<td>3</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>2 lane NH8 (2010-2014)</td>
<td>20</td>
<td>2</td>
<td>42</td>
<td>14</td>
<td>9</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>4 lane NH24 (2010-2014)</td>
<td>27</td>
<td>5</td>
<td>44</td>
<td>8</td>
<td>7</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>6 lane NH1 (2010-2014)</td>
<td>34</td>
<td>3</td>
<td>10</td>
<td>6</td>
<td>5</td>
<td>41</td>
<td>1</td>
</tr>
</tbody>
</table>

Notes: (1) Data from locations on 34 national and state highways in India (Tiwari, G. et al., 2000). (2) Tiwari, G., 2015
victims is much higher.

Table 10 shows the impacting vehicle in fatal crashes on highways. This shows that as far as vehicle involvement is concerned the patterns are very similar in both cases. Trucks and buses are involved in about 70% of fatal crashes in both rural and urban areas. This is again very different from western countries where there are significant differences in rural and urban crash patterns.

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 of the settlement patterns in our countryside where there is high-density habitation along the highways, which results in the use of many sections of the highway as urban arterial roads. 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 to vulnerable road users.

Table 11 shows the distribution of crash types by type of highway and type of crash (Tiwari, G. et al., 2000). The statistics for single lane may not be representative because of the small sample size. It is interesting to note that there are no major differences in the proportion of overturn accidents in 2-lane and 4-lane roads. Similarly there are no major differences in the proportion of head-on collisions on 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. The fact that head-on collisions are common on divided roads means that many vehicles are going the wrong way on divided highways. This is probably because tractor and other vehicles travel the wrong way when they exit from roadside businesses and the cut in the median is too far away. This issue needs to be considered seriously and guidelines need to be


<table>
<thead>
<tr>
<th>Highway Type</th>
<th>Overturn</th>
<th>Head-on</th>
<th>Angle</th>
<th>Rear-end</th>
<th>Pedestrian and bicycle</th>
<th>Fixed object</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single lane</td>
<td>50</td>
<td>~</td>
<td>~</td>
<td>~</td>
<td>~</td>
<td>~</td>
<td>~</td>
</tr>
<tr>
<td>Intermediate lane</td>
<td>~</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>~</td>
<td>~</td>
<td>13</td>
</tr>
<tr>
<td>2 lane w/o shoulder</td>
<td>7</td>
<td>14</td>
<td>2</td>
<td>31</td>
<td>23</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>2 lane + 1.5m paved shoulder</td>
<td>5</td>
<td>11</td>
<td>~</td>
<td>16</td>
<td>45</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>2 lane + 2.5m paved shoulder</td>
<td>5</td>
<td>17</td>
<td>2</td>
<td>25</td>
<td>19</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>4 lane divided</td>
<td>4</td>
<td>19</td>
<td>7</td>
<td>19</td>
<td>35</td>
<td>2</td>
<td>13</td>
</tr>
</tbody>
</table>
Developed for the placement of cuts in the median or for providing under/overpasses for vehicles at convenient locations.

Table 11 and 12 describe the types of crashes that occurred on different types of highways in 1997-2000 and in the last five years (2010-2014). The types of crashes that occur on hill roads, where run-off crashes dominate, are clearly different from those that occur on other types of highways.

Rear-end collisions (including collisions with parked vehicles) are high on all types of highways including 4-lane highways. This shows that even though more space is available on wider roads rear-end crashes do not reduce. This is probably due to poor 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.

Impacts with pedestrians and bicycles have a high rate on all roads including 4-lane and six-lane divided highways. The proportion is lower on 2-lane highways with wider (2.5m) paved shoulders (see Table 10). For these type of crashes to be reduced the following countermeasures need to be experimented with: physical segregation of slow and fast traffic, provision of 2.5m paved shoulders with physical separation devices like cats eyes, provision of frequent and convenient under-passes (at the same level as surrounding land) for pedestrians, bicycles and other non-motorised transport, and traffic calming in semi-urban and habited areas.

Collisions with fixed objects are low only on 4-lane divided highways. Provision of adequate run-off area without impediments and design of appropriate medians are obviously very important on highways.

**OTHER STUDIES**

Saija, K. K. and Patel, C. D. (2002) and Shrinivas, P. L. L. (2004) analysed road traffic crash data obtained from the police records for the state of Gujarat and Tamil Nadu respectively at a macro level but considered national highway data in combination with other roads. Kumar, R. P. et al. (2004) have done a study of crashes on Dindigul-Palani section of NH 209 and report that about 50% of the crashes involved buses and 25% of the victims were pedestrians and that two stretches of the highway had a higher number of crashes than other sections. A study of crashes on NH-8 passing through Valsad District found that crashes were increasing at a rate of 3.9% annually, rear end crashes comprised 40% and that heavy vehicles were involved in the largest number of cases (Saija, K. K. and Patel, C. D., 2002).
These studies inform us that highways have some stretches that can be identified as being associated with a higher number of crashes than other locations; heavy vehicles are involved in a larger number of crashes than lighter vehicles; and vulnerable road users comprise a significant proportion of those killed on national highways. However, none of these studies provide information on speeds, modal shares and highway design and their association with road traffic fatalities.

Shaheem, S. et al. (2006) have published two detailed studies on road traffic crashes on the Aluva-Cherthala and Pallichal-Kaliyikkavila sections NH-47 in Kerala. For the Pallichal-Kaliyikkavila section the authors evaluate the impact of four-laning of 38.5 km of the highway on road traffic crashes. They also report that heavy vehicles had a high involvement and pedestrians and cyclists were 28% of the victims. The most important finding of this study is that the fatality rate based on the volume capacity ratio is more than three times higher on the four-lane section compared to two lane sections. The fatality rate based on population density of the associated regions was higher on the four-lane section compared to two lane sections and conversion of two-lane to four-lane resulted in increase in the fatality rate from 41-51 % on the high crash rate sections.

In summary, it is clear that crash rates on intercity roads are high and not reducing. The construction of 4 lane divided highways (without access control) does not seem to have reduced fatality rates and vulnerable road users still account for a number of crashes. The mix of slow and fast moving vehicles on highways creates serious problems as speed differentials can account for significant increases in crash rates. High incidence of fatal rear-end crashes indicates a problem of lack of visibility and conspicuity of parked vehicles. There is clearly a strong case for redesign of intercity roads with separation of slow and fast modes. The needs of road users on local short distance trips will have to be accounted for to reduce the probability of head-on crashes due to them going the wrong way on divided highways by provision of safe road crossings at convenient distance. Solutions for many of these issues are not readily available and research studies necessary for evolution of new designs.

SUMMARY

• National Highways comprise only 15% of the total length of roads in India but account for 33% of the fatalities. Fatality rate per km of the road is the highest on expressways (1.8 deaths per km per year) and NH come next with 0.58 deaths per km annually
• Expressways had a length of only 1,000 km in the country in 2014 but a high death rate of 1.8 per km per year. This should be a cause for concern.
• 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.
• Data from three highway segments from 2009-2013 show a similar pattern. Pedestrian and MTW proportions are very high except on six-lane highway where the proportion of truck victims is much higher.
• Trucks and buses are involved in about 70 percent of fatal crashes in both rural and urban areas. This is again very different from western countries where there are significant differences in rural and urban crash patterns.
• 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. The fact this is not occurring means that many vehicles are going the wrong way on divided highways. This is probably because tractor and other vehicles go the wrong way when they exit from roadside businesses and the cut in the median is too far away.

• Rear end collisions (including collisions with parked vehicles) are high on all types of highways including 4-lane highways. This shows that even though more space is available on wider roads rear-end crashes do not reduce. This is probably due to poor 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.

• Following countermeasures need to be experimented with: physical segregation of slow and fast traffic, provision of 2.5m paved shoulders with physical separation devices like cats eyes, provision of frequent and convenient under-passes (at the same level as surrounding land) for pedestrians, bicycles and other non-motorised transport, and traffic calming in semi-urban and habited areas.

• 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 to vulnerable road users.
5. Status of research in road safety

INTRODUCTION

One way to understand the status of knowledge production in different countries is to examine the number of scholarly articles on different subjects originating from those countries. Five key areas in the field of transportation research are

1. Road Safety
2. Civil Engineering projects related to development in transport facilities
3. Emissions, covering air and noise pollution
4. Railways
5. Transportation planning, oriented towards developing the transport facilities

For each of the areas unique keywords were used and a search done on the online search engine Scopus™. The results of the search for the countries India, China and Brazil are shown in Table 13 and the output normalised for population (2011) shown in Table 14. These tables show that not only does India fare poorly in terms of total output, when normalised for population levels in 2011, India’s output appears poor in comparison with both Brazil and China. Even more worrisome is the fact that the gap between India and China has widened considerably in the past decade (Table 15) especially on topics dealing with railway technology.

If we assume that research output may have some relationship with per capita income and number of people in each society, even then these results show India is doing much worse than China and not even as well as Brazil.
It is possible that these data do not contain studies published from India which are not included in indexed journals, and that the quality of studies from India may be better than many originating from China. However, the gaps are so large that we need to take corrective measures on an urgent basis. The number of papers from China per-person per US$ per-capita income are more than three times greater than that from India in all areas. This means that if we want to catch up with China in ten years with their present levels of productivity, we will have to grow at more than 10 per cent per year. However, this would not be adequate enough for the kind of growth we need in knowledge generation and innovation to put in place systems in the next ten years that serve us well for the next thirty years. It would be safe to assume that we need to plan for a dramatic increase in human resource development, research output and creation of jobs for highly trained professionals.

**SYSTEMATIC REVIEW OF INDIAN RESEARCH REPORTS**

A systematic search was done using definitive road traffic accident keywords (road safety India, accident in India, and accident due to speeding in India, road accidents due to road geometry in Indian highways, vehicular growth and road safety in India) on Science Direct and Google Scholar. The papers were then classified into 4 broad themes - Urban areas, Highways, National Trends and Public transportation. The search found eighty-one studies that were published in peer reviewed journals, conference or institutional reports. Since 2000 the number of publications has shown an increasing trend and according to a report, India contributed only 0.7 per cent papers on road traffic injuries.

This review was undertaken to synthesize the available published studies on road safety done in India in the period 1970-2015 and categorize them according to four themes - urban, highways, national trends, public transport. This section includes a systematic review of the published papers according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher, D. et al., 2009). The electronic database searches included Google Scholar and Elsevier. A hand search enabled a look through the bibliographies of the retrieved articles. The search screened published and unpublished articles, working papers, dissertations, reports documented or published between 1970 and 2015. Only peer reviewed papers were selected. The search keywords were entered in all searchable, subjects’ specific fields (title, keyword, and abstract), medical subject heading (MeSH) and free-text terms, different for various search engines. The keywords that were used are: road

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**Table 14. Number of publications in the period 2006–2010 per 100 million population.**

<table>
<thead>
<tr>
<th>Topic</th>
<th>INDIA</th>
<th>CHINA</th>
<th>BRAZIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Safety</td>
<td>10</td>
<td>68</td>
<td>62</td>
</tr>
<tr>
<td>Railways</td>
<td>10</td>
<td>162</td>
<td>15</td>
</tr>
<tr>
<td>Emissions</td>
<td>1</td>
<td>4</td>
<td>27</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>12</td>
<td>92</td>
<td>10</td>
</tr>
<tr>
<td>Air Transport</td>
<td>3</td>
<td>24</td>
<td>15</td>
</tr>
<tr>
<td>Marine Transport</td>
<td>1</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Transport Planning</td>
<td>1</td>
<td>10</td>
<td>7</td>
</tr>
</tbody>
</table>

**Table 14. Ratio of journal papers published by China and India in the periods 1961-2005 and 2006-2010.**

<table>
<thead>
<tr>
<th>Topic</th>
<th>1961-2005</th>
<th>2006-2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Safety</td>
<td>1.1</td>
<td>5.5</td>
</tr>
<tr>
<td>Transportation Planning</td>
<td>1.4</td>
<td>12.9</td>
</tr>
<tr>
<td>Emissions</td>
<td>0.6</td>
<td>4</td>
</tr>
<tr>
<td>Railways</td>
<td>8.1</td>
<td>23</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>3.3</td>
<td>8.4</td>
</tr>
</tbody>
</table>
safety India, accident in India, accident due to speeding in India, road accidents due to road geometry in Indian highways, vehicular growth and road safety in India.

The references were included in the final review through discussions. Data were reviewed for duplication after the extraction was completed and entered in Microsoft Excel. The inference of data in a statistical manner could not be performed as the dataset obtained were heterogeneous in nature and hence qualitative analysis of the extracted dataset was instead undertaken in the study.

Results

Following outcome measures were noted:

- Prevalence of different modes/factors on accident rates in different environment.
- Exposure of RTA’s on different road users.
- Impact of RTCs and their related burden (i.e., number of accidents, fatalities, injuries, socioeconomic burden, etc.).

India despite having the distinction of being the second most populous country contributed only 0.7% articles on road traffic injuries. It had less than one article on road traffic injuries per 1,000 road traffic-related deaths (Borse, N. and Hyder, A. A., 2009).

Sixty one papers that met the above criteria were included for analysis. Table 15 shows the number of papers by publication type and Table 16 by year of publication. The reviewed papers had the following characteristics

- In urban theme 31 % of the studies had statistical analysis involving modelling.
- In highway theme only 36 % studies had statistical analysis involving modelling.
- In public transportation theme 25 % studies had statistical analysis involving modelling.
- In National trends 25% studies had statistical analysis involving modelling.

A summary of the papers is included in Appendix 1.

SUMMARY

- India despite having the distinction of being the second most populous country contributed only 0.7% articles on road traffic injuries.
- When normalised for population levels in 2011, India’s output appears poor in comparison with both Brazil and China. The gap between India and China has widened considerably in the past decade.
• The number of papers from China per-person per US$ per-capita income are more than three times greater than that from India in all areas. This means that if we want to catch up with China in ten years with their present levels of productivity, we will have to grow at more than 10 per cent per year.

• A review of peer reviewed papers on road safety published from India indicated that only about one third of them included statistical analysis and modelling.
## APPENDIX 1

### Highway Theme

<table>
<thead>
<tr>
<th>SN</th>
<th>Title/Year/Author/Journal (Conf/Report)</th>
<th>Objective</th>
<th>Recommendations/Results</th>
<th>Statistical Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Effect of road characteristics on accident rates on rural highways in India (Kadiyali, L. et al., 1983)</td>
<td>An investigation on a limited scale was undertaken to establish relationships between Accident rate and some roadway And traffic volume Factors. The study was taken up intensively on the Bombay-Pune road, which has a Mixture of road Geometry along its length.</td>
<td>Some of the factors responsible for Road Accidents on rural highways in India are Road geometry, pavement width, Traffic volume and number of intersections per unit length of road</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>Analysis of road accidents on national highways in Nasik district (Baviskar, S., 1998)</td>
<td>This paper discusses the high accident rates on National Highway (NH) sections in the Nashik District of India; The paper discusses: (1) the spatial trends of accidents on NH 3 and NH 50, both of which pass through Nashik; (2) the results of a traffic census on important roads in Nashik for 1981-90; (3) observations on the NH 50; (4) the time distribution of accidents on the National Highways; (5) the seasonal trend of fatal, serious, and minor accidents on the National Highways; (6) analysis of accidents for different Categories of roads; (7) observations of the physical features And road conditions of different sections of NH 3 and NH 50; And (8) the accident environments on the NH 3 and NH 50.</td>
<td>The results of the study emphasize that the main safety initiatives on Indian National Highways should be specific very local improvements of accident black spots, correction of short geometric curves, provision of paved shoulders, increase of sight Distance, removal of roadside Hazards, flattening sides and slopes, And placing guard rails on high embankment and bridge approaches.</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>Road safety considerations for national highways (Sharma, A. and Dua, L., 2000)</td>
<td>This paper aims to study the causes of road accident on National highways in India and provide recommendations.</td>
<td>Specific causes of accidents include: (1) median kerb stones in dual carriageways and poor visibility of kerb stones; (2) staged road construction; (3) lack of maintenance of road signs; (4) driver errors; (5) plantation of trees in rights of way; (6) depressed side shoulders; (7) contractor errors; (8) bridge railings; (9) poor drainage; and (10) haphazard crossing of roads by pedestrians and cattle. This article makes 20 recommendations for improving road safety, including three types of road design improvements, black spot identification and improvement, traffic barriers, road safety audit, advanced warning systems, road patrolling, training in first aid, uniform geometric design, and roadside amenities.</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>Characteristics of road accidents on lower category of roads in India (Mittal, N. and Sarin, S., 2001)</td>
<td>The objective Characteristics of road accidents on lower category of roads in India are not well documented.</td>
<td>From 1983-1989, lower category roads had the highest proportion of road accidents. Studies in the relatively prosperous state of Haryana in 1992 are described. Accidents involving vulnerable road users were higher on lower category roads than on state highways. Although speeds were lower on</td>
<td>No</td>
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</table>
lower category roads, the proportion of vulnerable road user was higher and injuries in this group were likely to be severe. Hit and run cases were more frequent on lower category roads.

Recommendations include better accident reporting, strengthening road shoulders, pavement repair, making cyclists more conspicuous, and educating road users. By-passes and better emergency services were also suggested.

Accident study on national highway - 5 between anakapalli to Visakhapatnam (Rao, B. S. et al., 2005)

The Institute has undertaken a study on NH-5 between Anakapalli to Visakhapatnam during the year 2003 and it runs through urban, semi urban and rural areas. The accident data for the last five years was collected from the concerned police station and analyzed thereafter. The aim of this paper has been to analyze the cause of accident and provide recommendations.

The most frequent accident involved two wheelers (35%) followed by goods vehicles (23%), cars (17%), autos (15%), Buses (9%) and unknown vehicles (1%). The reasons for the accidents can be attributed to the lack of signage, raised median cover with trees/bushes, making pedestrians not visible to driver, improper design of pedestrian crossing, frequent median openings, and lack of enforcement to control wrong side movements. Poorly designed access roads from the adjacent areas of the highway are also leading to frequent conflicts between local traffic (mostly two wheelers) and through traffic (goods vehicles).

Proper sign boards such as Informatory, warning and caution sign should be placed as per IRC specifications to guide the road user to perceive the situation. These include curve ahead, access road signs along with delineators and retro-reflective markers along the curve. Further it is suggested to provide acceleration and deceleration lanes. It was suggested to the National Highway Authority of India (NHAI) to close both the median openings to minimize the accident, as the fuel filling facility is available on both sides. Further, it is suggested to remove encroachment on National Highway and provide improved junction geometrics and high mast to improve illumination during night.

Minor improvements of highways for better road safety (Sarin, S. et al., 2005)

This paper discusses the Project types undertaken under minor enhancement objectives are described with reference to the situation in the UK and USA. Criteria for minor improvements are listed. The relationships between safety and key road features are considered. The planning and designing process for a minor improvement project is outlined.

Common road safety issues requiring minor improvements are described: roadway improvements (horizontal alignment, vertical alignment, sight distance, cross-sectional elements, channelisers, medians and service roads, intersections, surface pavement), roadside improvements (crash barriers, fixed objects, bridges and culverts, relocation of access, drainage) and operational road improvements.

Experience has shown that the following low-cost minor improvements could be highly effective: improvements in traffic control devices (signs, markings, delineators), minor physical alterations to the intersection layout, drainage improvements, provision of crash barriers and railings, improved access control, and improvements to median openings.
<p>| Page | Analysis of Road Traffic Accidents on NH45, Kanchipuram District (Tamil Nadu, India) (Rajaraman, R., 2009) | The primary objective was to collect and analyze India-based traffic crash data to begin to create a sound basis for decision making for improving safety on India’s roadways. A secondary objective was to establish a standardized methodology for collecting and analyzing crash data, specific to Indian roads. | Findings show that front-to-rear collisions, mainly involving heavy trucks and buses, caused due to slowing down, stopping, breaking down or overtaking account for 59% of the accidents. Front-Rear Collisions, which form a significant number of accidents, occurred mainly at U-turns and on General Roads. U-turns and sections of highways close to facilities/amenities are black spots for heavy truck accidents, as trucks tend to slow down or stop in these areas. Proper design of U-turns and implementation of acceleration and deceleration lanes, as per specifications and standards laid down, can help mitigate accidents and injuries. Providing sufficient shoulder widths, as per specifications, for heavy trucks to park safely will help reduce front-rear collisions due to stopped or parked trucks. Effective driver communication, through clear and well placed sign boards, warning signs and information signs, can help drivers make decisions well in advance and give proper indications to other vehicles around them. | No |
| 7 | Analysis of In-Depth Crash Data on Indian National Highways and Impact of Road Design on Crashes and Injury Severity (Padmanaban, J. et al., 2010) | Analysis of In-Depth Crash Data on Indian National Highways and Impact of Road Design on Crashes and Injury Severity Researchers carried out on-site crash investigations and in-depth crash data collection for a period of 45 to 60 days on four 2-lane undivided highways( NH47 , NH209 , NH47 Bypass , NH67 ) and a 4-lane divided highway( NH45). | Based on 76 crashes examined, researchers found a shift of crash pattern from head-on collisions on undivided 2- lane highways to front-rear collisions on divided 4-lane highways. The top three vehicle types involved in the crashes are: trucks (44), passenger cars (27) and motorized two-wheelers (24). M2Ws (22) are the highest vehicle type involved in crashes in which at least one rider was fatally injured or hospitalized. This indicates that M2W riders, pedestrians and bicyclists are the top three vulnerable road users. These crashes usually occurred at junctions with bus stops (58%) or near places of interest (38%) such as temples, shops, etc. Crossing was the pedestrian activity in 69% of the crashes. The factors influencing these impacts are speeding vehicles, lack of speed control devices and markings at pedestrian crossings, and lack of infrastructure to separate pedestrians and bicyclists from motorized vehicles. Apart from passenger cars (39%), minibuses/minitrucks (23%) and trucks (15%), pedestrian impacts also involved M2Ws (23%). Road design at junctions/gaps in median, entry and exits of highway amenities, and the availability of clear signage and advance warning to drivers needs to be looked into. The presence of paved shoulders seems to reduce the occurrence of head-on collisions, as the extra space allows vehicles to move out of the way of overtaking vehicles. No head-on collisions were observed on divided 4-lane highways due to the presence of a wide median, | No |</p>
<table>
<thead>
<tr>
<th>Page</th>
<th>Random parameter models for accident prediction on two-lane undivided highways in India (Dinu, R. and Veeraragavan, A., 2011)</th>
<th>The present study is an attempt to employ random parameter modeling for accident prediction on two-lane undivided rural highways in India. Three years of accident history, from nearly 200 km of highway segments, is used to calibrate and validate the models.</th>
<th>Indicating the effectiveness of medians/divided roads in preventing head-on collisions. When the front-side collisions were analyzed for common problems, road alignment and design came out to be the most predominant factor involved.</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>The present study is an attempt to employ random parameter modeling for accident prediction on two-lane undivided rural highways in India. Three years of accident history, from nearly 200 km of highway segments, is used to calibrate and validate the models.</td>
<td>Hourly traffic volume, length of highway segment, proportion of cars and motorized two-wheelers in traffic, driveway density, width of shoulder, and horizontal and vertical curvatures were found to be significantly influencing day-time accident frequencies. While increase in proportion of cars and width of shoulder were found to decrease the accident frequencies, increase in the other variables resulted in an increase in accidents.</td>
<td></td>
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<tr>
<td></td>
<td>In case of night-time accidents, hourly traffic volume, length of highway segment, proportion of buses, cars, and trucks, driveway density, and vertical curvature were found to be significant. Here the proportion of cars and trucks in traffic were found to cause a decrease in accidents, while all other variables had a positive coefficient, showing an increase in accident frequencies.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 10 | Road safety audit for four lane national highways (Jain, S. et al., 2011) | Objectives of study 
I. To develop a methodology for Road Safety Audit for four lane National Highways. 
ii. To develop a model for identification of safety influencing parameters in minimizing likelihood accident rate on selected section of four lane National Highways network. 
iii. To examine safety features adopted in the selected section of four lane National Highway-58 and find out deficiencies in the road network which led to accident and safety hazards to road users. 
iv. To identify the speed limits matching with the vehicles speed on existing road profile of the highway section. 
The stretch from Km 75.00 to Km 130.00 of National Highway 58 had been selected for candidate analysis. | From data simulation, it found that Road Markings, Condition of Shoulder, Traffic Volume, Spot Speed, Median Opening and Carriageway condition were main parameters for causing accidents. It was also seen that slow moving traffics were creating traffic hazards for fast moving traffic as it always occupied the innermost lane of highway |
| | Service roads should be provided for the entire length of four lane roads in order to separate slow moving traffic from fast moving traffic. All unauthorized median openings should closed and adequate provisions for crossing local people be made on priority. All undeveloped major and minor intersections must be developed with adequate lighting provisions as quickly as possible since maximum accidents were observed on these locations. Pedestrian guardrail should be provided all along the footpath of service road and at bus stops. |
| | Yes |
| 11 | IRAP India Four States Road Safety Report (Rogers, L., 2012) | The project was designed to assist the governments of four Indian states: Andhra Pradesh, Assam, Gujarat and Karnataka to assess road infrastructure-related risk on 3,000km of high-risk roads and identify economically viable road safety countermeasures for implementation under the World Bank financed upgrades. | The road attribute data shows that the majority of the survey was conducted along a two-lane, single carriageway rural network, with very little physical separation between opposing flows. Roadside hazards are numerous, with most of the survey length having hazardous objects within 5m of the running lane and limited road side protection. Provision for vulnerable road users is poor with no motorcycle or bicycle facilities present and insufficient footpath provision and crossing facilities where pedestrian numbers are high. |
| | No |
The recommendations primarily seek to improve facilities for vulnerable road users and to reduce the risk of head-on, run-off and intersection crashes for motorised users. Along with roadside safety improvements and the segregation of opposing flows, intersection upgrades also featured prominently in all Safer Roads Investment Plans (srips) with roundabouts, signalisation, turn lanes and improved delineation providing good returns on investment. Road surface upgrades, paved shoulder widening, lane widening and improved delineation, all of which had been independently identified by the design team for inclusion in the rehabilitation works using IRC (Indian Roads Congress) standards. This meant that the road safety component could be used to include improvements such as speed reducing features in urban areas, footpaths and pedestrian crossings, dedicated motorcycle lanes and turning lanes at intersections.

The analysis found that a combined investment for the four states of 27 billion rupees would prevent almost 125,000 deaths and serious injuries and save close to 120 billion rupees in crash costs avoided. This represents a 40% reduction in deaths and serious injuries based on current estimates.

| Pedestrian Accident Prediction Model for Rural Road (Sharma, A. and Landge, V., 2012) | The specific objectives of studies are:
- Development of Correlation between road accidents and geometric design parameters of highway along with traffic operating characteristics for pedestrian accident
- Evolving engineering remedial measures for improving safety on the selected stretch.
- Practical recommendations for improving traffic safety on the said highway.
Road geometry and traffic data was collected through field studies and traffic count survey for a road length of 100km between Amravati City and Nagpur City of Maharashtra State in India. | National Highway No 6 experiences the crash rate as high as 1.62 accidents per year per km. It has a very high rate of fatality 0.38 death/km/year. The highway share heavy vehicles, passenger cars, two wheelers, animal drawn carts, cattle, and pedestrians. Heavy vehicles are involved in 78% of the accidents, passenger cars are involved in 48% of accidents, two wheelers are involved in 62% of accidents and pedestrians are involved in 21% of accidents.

Pedestrian safety is greatly influenced by number of access points per unit length of the road. Each additional access point per kilometer of road length may increase accident rate by more than 100%. i. Shoulder width is also a highly influential factor affecting pedestrian safety. Additional 1m width of shoulder will reduce the accident by 50%. ii. Additional lane width of 1m may reduce the accident by 50%.

Some remedies are
- Access to main highways should be properly designed.
- Sufficient shoulder width or provision of safe walking places along the highways should be provided.
- Elevated and visible designated areas for crossing of roads in all possible places.
- Separation of pedestrian movement from heavy moving traffic in all possible places.
- Speed control by road design, traffic calming and enforcement on highways, near traffic generators.
Yes |
<table>
<thead>
<tr>
<th>No</th>
<th>Title</th>
<th>Details</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Characteristics of Fatal Road Traffic Accidents on Indian Highways</td>
<td>Characteristics of Fatal Road Traffic Accidents on Indian Highways. A total of 167 accident investigations have been carried out in the Coimbatore District of the state of Tamil Nadu over a period of one year. Data from crash investigations of 71 fatal accidents involving 80 fatalities (66 vehicle occupants and 14 pedestrians) is analyzed in this paper.</td>
<td>No</td>
</tr>
<tr>
<td>14</td>
<td>Crash Prediction for Multilane Highway Stretch in India</td>
<td>This paper documents the application of Bayesian modeling techniques for road traffic crash analysis on a sample of Indian National Highways. Poisson-Gamma Hierarchical Bayes and Poisson-Weibull Bayesian models were applied to the collected crash data. The stretch from Km 76.00 to Km 130.00 of National Highway 58 has been selected for candidate analysis. The selected highway stretch has been newly reconstructed and upgraded to four lanes. The two important obligatory points on the study area are Meerut and Muzaffarnagar of the highway in the state of Uttar-Pradesh, India. The following general conclusions are drawn. 1. Median opening has major influence on the occurrence of crashes. 2. The traffic flow is also showing direct impact on occurrence of crashes as justified practically. 3. From the analysis, it has been observed that as access roads to the main highway increases the chances of crashes on highways will be more which is as per realistic experience. 4. Road side developments also increase the movement and hinder the smooth traffic movement which is also justified. Whereas the commercial activities is showing negative impact as there is enough lateral clearance from the highway shoulder for ingress and egress of the vehicles.</td>
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<td>15</td>
<td>Accident Study on Identified Roads of Kurukshetra</td>
<td>A study has been taken up on a selected stretch of SH-6, the Saharanpur-Kurukshetra road, between Pipli to 3rd Gate of Kurukshetra University in Haryana to find out accident severity index, weighted accident severity index, accident prone areas, peak hour time of accident, total number of accident per year and involvement of different type of vehicles and pedestrians.</td>
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The pedestrians and the two wheelers seem to be the most affected section sharing a percentage of 39 and 43 respectively of the victims of total accidents. The bi-cycles and cars are equally affected by the accidents and their share in victims is 5% each. The percentage share of three wheelers is 4%. The 2-wheelers and cars have maximum involvement in accidents having a percentage of 32% and 28% respectively, which is more in comparison to other type of vehicles. The percentage of accidents by bus and truc ks are 10% and 11%. The minimum involvement is by three-wheelers and tractors having a share of 4% and 5%

Based on the study, main reasons for this large number of accidents are lack of traffic signals, parking areas, markings and geometric designs of road. To overcome these reasons, some suggestions are provided with conclusion to reduce the number of accidents and save the lives of human over the selected stretch

- Road design and geometric improvements to compensate for inadequacies of road users such as:
  - Designing of road profile network
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<th>Source</th>
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<td>16</td>
<td>An In-Depth Study of Motorized Two-Wheeler Accidents in India (Arjun, P. et al., 2014)</td>
<td>An In-Depth Study of Motorized Two-Wheeler Accidents in India (Arjun, P. et al., 2014)</td>
<td>Of these 670 crashes, 182 were M2W crashes for which injury records were available. 72% (134) of these M2Ws were motorcycles and 28% (48) were scooters and mopeds. The majority of the collision partners for motorcycle accidents were cars (36%) and heavy vehicles (36%), 22% of the riders were young (18-23 years old), and 83% of the motorcycle riders were not helmeted. It is expected that increased law enforcement, infrastructure development, proper helmet use training and design/safety standards for helmets would mitigate injuries to M2W riders in India.</td>
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<td>17</td>
<td>Burden, pattern and outcomes of road traffic injuries in a rural district of India (Gururaj, G. et al., 2014)</td>
<td>Burden, pattern and outcomes of road traffic injuries in a rural district of India (Gururaj, G. et al., 2014)</td>
<td>The ratio of fatal to nonfatal RTIs registered in the entire district was 1:5 for the year as per police reports. Motorcyclists (drivers and pillion) comprised the major category of road users injured and killed in road crashes constituting 45% and 34% of fatal and non-fatal crashes, respectively. This was closely followed by pedestrians to the extent of 20% and 29% of fatal and non-fatal crashes, respectively. Passengers and drivers of heavy vehicles (like lorry, buses and trucks) constituted 11% of fatal and 10% of non-fatal injuries. Among fatal crashes, nearly 10% were drivers and occupants of three-wheeled vehicles. Pedestrians were commonly hit by heavy vehicles like buses, lorries and trucks (61%), followed by motor cars (16%) and two wheelers (14%) in fatal crashes. The absence of traffic separators especially on the highways is a noticeable feature in the district particularly in select stretches.</td>
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<td>18</td>
<td>Effects of highway geometric elements on accident modeling/2014 (Garnaik, M. M., 2014)</td>
<td>Effects of highway geometric elements on accident modeling/2014 (Garnaik, M. M., 2014)</td>
<td>Statistical analysis indicated that, several highway geometric parameters are very significant to cause accident in the highway. Highway alignment geometric elements such as radius, superelevation, k-value, vertical gradient and sight distance/visibility are very significant in causing accident.</td>
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Two Highway Accident Rate Prediction Models (HARPMPRT and HARPMMST) were developed due to the complexity of geometric elements of rural highway on different terrain conditions which take horizontal radius, superelevation, K-value, vertical gradient and visibility as input variables and Accident Rate (AR) as output variables.

Findings show that the type of vehicles/road users most often involved in accidents on the highways were motorized two-wheelers, or “M2Ws” (32%), followed by cars (27%) and trucks (22%). The most vulnerable road users, pedestrians and motorcyclists, were involved in about 40% of all events recorded, and M2Ws impacted or were impacted by a truck or bus in about 18% of these.

Study findings show that human and infrastructure factors in combination (66%) had the highest influence on the occurrence of accidents, followed by human factors alone (23%).

Convert undivided road stretches on National Highways to divided roads; Implement a speed management program; Clearly mark traffic directions/instructions before and at intersections; Provide crash barriers to make rigid objects on roadside and median more crashfriendly and forgiving when impacted.

### NATIONAL TRENDS
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<th>No</th>
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<td>It shows that although the total number is low the annual rate of increase is very high, compared with other countries. The fatality rate per 1000 vehicles (8) was very high although the rate per 100,000 population (1) was low. Urban accident rates were much higher than in other countries The report stresses the need for countermeasures such as road and traffic engineering and propaganda, education and enforcement for road users.</td>
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<td>2</td>
<td>A review of road accidents in India - their causative factors and preventive measures (Hingorani, D. and Sarna, A., 1978)</td>
<td>Trends in fatalities, total accidents and motor vehicles in India for the period 1960-1974 are discussed.</td>
<td>Recommendations are presented on pedestrian safety, cyclists, vehicle safety, driver control and the education of children as suggested preventive measures.</td>
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<td>Over this period the number of motor vehicles increased from 604902 to 2411545, the number of road accidents increased from 55478 to 109657, and fatalities increased at the rate of about 12.4 per cent per annum. Traffic engineering, regulations, enforcement, education and vehicle safety as preventive measures are discussed.</td>
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<td>3</td>
<td>Accidental death and disability in India: A stocktaking (Mohan, D., 1984)</td>
<td>In this paper data from official sources and spot studies of small populations in India have been used to extrapolate for the whole country to get an estimate of the magnitude of the problem.</td>
<td>It is estimated that in 1978 India had a death rate of 57 per 10,000 vehicles. The Indian data show that pedestrians, bicyclists, and motorcyclists are the major road accident victims. Compulsory helmet laws or mandatory headlight-on laws for motorcycles are likely to be more effective than seatbelt use laws for car passengers so they should be implemented.</td>
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<td>4</td>
<td>Accident causative factors (Chand, M., 1995)</td>
<td>This paper analyses selected important causes of Indian road accidents.</td>
<td>It was found that the major causes of the accidents in 1985 were: (1) driver errors (57%); (2) pedestrians (5%); (3) vehicle defects (5%); (4) passengers (3%); and (5) bad roads (2%). The author considers: (1) the road factor; (2) the vehicle factor; (3) the month, day, and time of day factor; (4) contributory factors; and (5) the driver factor.</td>
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<td>5</td>
<td>Road safety for vulnerable road users: some issues and suggestions (Kumar, P., 2000)</td>
<td>This paper covers issues and suggestions relating to engineering measures to make Indian roads safer for pedestrians and cyclists.</td>
<td>Education and enforcement are seen as playing a key role in the enhancement of safety. Pedestrian safety concerns footpath obstructions; dropped kerbs at crossings; segregated footpaths in rural areas; pedestrian crossing aids including refuges and railings; and footbridges or subways. Facilities for cyclists and rickshaws should include segregated road channels and signaling. Many accidents could</td>
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<td>6</td>
<td>Spectrum analysis of road accidents - a case study (Saija, K. et al., 2000)</td>
<td>This paper presents a detailed analysis of the spectrum of road accidents in the Indian state of Gujarat, which is a rapidly developing part of India with a higher than usual road accident growth rate; it contains extensive tables. The Gujarat State traffic branch has collected road accident information since 1975 and in A-4 form since 1986; the data were collected and analysed in five broad classifications, the time, district, vehicle, road user, and road and environment spectra. The spectra in the latter category include road classification, road surface and width, type of crossing and traffic control, location pattern, collisions, traffic movement, and climate. The Gujarat State traffic branch has collected road accident information since 1975 and in A-4 form since 1986; the data were collected and analysed in five broad classifications, the time, district, vehicle, road user, and road and environment spectra. The spectra in the latter category include road classification, road surface and width, type of crossing and traffic control, location pattern, collisions, traffic movement, and climate. Road safety measures range from short-term low-cost to long-term high-cost solutions, and include phased programmes conducted according to available resources.</td>
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<td>7</td>
<td>Traffic safety and health in indian cities (Mohan, D., 2002)</td>
<td>This paper discusses some of the issues concerning public transport, safety and the environment. Around 15% of the total road traffic fatalities in India occur in 23 metros. In the metros, MTW comprise approximately 70% of all vehicles and constitute 20-30% of fatalities. Heavy vehicles like trucks and buses are associated with 50-70% of fatal road crashes both in urban and rural areas. 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 fatalities. 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. 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. 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</td>
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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.

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<td>8</td>
<td>The Road Ahead: Traffic Injuries and Fatalities in India (Mohan, D., 2004)</td>
<td>Overview of Traffic injuries and fatalities in India</td>
<td>Data show that the car population as a proportion of total motor vehicles is much less in India than in the hmc’s (13% vs 56-80%) and that the proportion of motorised two-wheelers (MTW) much higher (70% vs 5-18%). Pedestrians, bicyclists and MTW riders constitute a larger proportion of road crash victims in India than in hmc’s. Measure are discussed for Pedestrian and bicyclist safety, Motorcyclist safety, Motor vehicle occupants, Road measures – initiation of good practices; Pre-hospital care, treatment and rehabilitation (Short term) And in long term Traffic calming and speed control; Segregated lanes for vulnerable road users and buses in urban areas; Safer design of 4/6 lane highways; Vehicle safety; Drinking under the influence of alcohol and other drugs; Road user based strategies; Prehospital care, treatment and rehabilitation.</td>
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<td>9</td>
<td>Road accident models for large metropolitan cities of India (Valli, P. P., 2005)</td>
<td>The aim of the present paper is to develop models by analyzing the road accident data at an all India level as well as for major metropolitan cities. The data for the 25 year period from 1977 to 2001 were analyzed to build models to understand the nature and extent of the causes of accidents using the concept of Smeed’s formula and Andressen’s equations.</td>
<td>As compared to an all India level, the total road accidents in the seven metropolitan cities namely ahmedabad, bangalore, mumbai, kolkata, delhi, hyderabad and chennai were about 21.5% of the total accidents during 1977, which marginally came down by 5% to 16.9% in 2001. The fatalities and injuries during this period exhibit a declining trend significantly from 10.52% to 6% and from 23.28% to 8.96% respectively.</td>
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<td>10</td>
<td>Exploring the relationship between development and road traffic injuries: a case study from India. (Garg, N. and</td>
<td>Aim to study the trends in injury and death rates in a developing country, India, define sub-national variations, and analyse these trends in relation to economic and population growth. Public</td>
<td>There has been a steady decline in vehicle-based death and injury rates in India, but a growing trend in the population based rates of injuries and deaths. This seemingly divergent trend can be explained since vehicle-based rates are decreasing due to a disproportionate influx of vehicles on Indian roads, while population-based rates are increasing because</td>
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<td>11</td>
<td>Road Safety in India: Challenges and Opportunities (Mohan, D. et al., 2009)</td>
<td>The present report was designed to analyze the traffic safety situation in India, and to identify countermeasures for areas in which the total harm caused by crashes can be substantially and readily reduced.</td>
<td>It is pointed out in this analysis that fatality rates have increased both on highways and in urban areas during the past few years. Theoretical models suggest that the number of fatalities in India is not likely to start to decline for many years to come unless new policies are implemented. Based on the present analysis, the following six areas are identified as having potential for substantially reducing fatalities in India: (1) pedestrians and other non-motorists in urban areas, (2) pedestrians, other non-motorists, and slow vehicles on highways, (3) motorcycles and small cars in urban areas, (4) over-involvement of trucks and buses, (5) nighttime driving, and (6) wrong-way drivers on divided highways. Separation of motorized and nonmotorized traffic on arterial roads; Special facilities for slow and local traffic all along highways (Pedestrian detection technology Forward collision warning systems); Highway designs incorporating local needs Enforcement are proposed.</td>
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<td>12</td>
<td>Road accidents in India (Mohan, D., 2009)</td>
<td>This paper discusses the accident rate and fatalities and the causes in India.</td>
<td>The total number of fatalities from 1997 to 2007 increased at an average rate of about 4% per year in the period 1997-2003 and the rate has increased to 8% per year since then. The number of fatalities per million population remained around 79-83 in the period 1997-2003 and has since increased to 101. Data show that car occupants were a small proportion of the total fatalities, 3% in delhi and 15% on rural highways. Vulnerable road users (pedestrians, bicyclists, and motorized two-wheeler riders) accounted for 84% of deaths in delhi and 67% on highways. The study reported that trucks were the striking party in 65% of fatal crashes. Other studies done on national and state highways in 1990’s report that</td>
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| 13 | Evidence-based road safety practice in India: assessment of the adequacy of publicly available data in meeting requirements for comprehensive road safety data systems. (Barffour, M. et al., 2012) | To assess the availability and coverage of publicly available road safety data at the national and state levels in India. | 2 publicly accessible data sources in India Were reviewed the for the availability of data related to traffic injuries and deaths: (1) the National Crime Records Bureau (NCRB) and (2) the Ministry of Road Transport and Highways (MORTH). Using the World Health Organization (WHO) manual for the comprehensive assessment of road safety data, we developed a checklist of indicators required for comprehensive road safety assessment. These indicators were then used to assess the availability of road safety data in India using the NCRB and MORTH data. We assessed the availability of data on outcomes and exposures indicators (i.e., number of crashes, injuries, deaths, timing of deaths, gender and age distribution of injuries and deaths), safety performance indicators (i.e., with reference to select risk factors of speeding, alcohol, and helmet use), and cost indicators (i.e., medical costs, material costs, intervention costs, productivity costs, time costs, and losses to quality of life).

There is an urgent need to improve the publicly available road safety data in India. This will enhance monitoring of the burden of traffic injuries and deaths, enable sound interpretation of national road safety data, and allow the formulation effective road safety policies. | No |
| 14 | Road traffic crashes and risk groups in India: Analysis, interpretations, and prevention strategies (Ponnaluri, R. V., 2012) | The objectives of this work were to (a) present the national RTC framework and a case study of Andhra Pradesh (AP); (b) analyze and identify risk types; (c) discuss trends and data deficiencies; and (d) recommend prevention strategies. | During the period 1970–2009, the nation’s road length increased at a compounded annual growth rate (cagr) of 3.2%, whereas the number of registered vehicles, rtcs, and fatalities grew at 12%, 3.8%, and 5.7% cagr respectively. Exposure risk dropped from 103 to 11 fatalities per 10 000 vehicles but increased from 2.7 to 10.8 fatalities per 100 000 people. In 2009, 22% of fatal crashes in andhra pradesh were due to heavy vehicles, while motorized two-wheeler fatalities more than tripled during the | No |
### Determinants of Road Traffic Crash Fatalities across Indian States.

(Grimm, M. and Treibich, C., 2013)

This article explores the determinants of road traffic crash fatalities in India. In addition to income, the analysis considers the sociodemographic population structure, motorization levels, road and health infrastructure and road rule enforcement as potential factors. An original panel data set covering 25 Indian states is analyzed using multivariate regression analysis.

The rising motorization, urbanization and accompanying increase in the share of vulnerable road users, that is, pedestrians and two-wheelers, are the major drivers of road traffic crash fatalities in India. Among vulnerable road users, women form a particularly high-risk group. Higher expenditure per police officer is associated with a lower fatality rate.

Results suggest that India should focus, in particular, on road infrastructure investments that allow the separation of vulnerable from other road users on improved road rule enforcement and should pay special attention to vulnerable female road users.

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<td>15</td>
<td>Road traffic injury mortality and its mechanisms in India: nationally representative mortality survey of 1.1 million homes (Hsiao, M. et al., 2013)</td>
<td>To quantify and describe the mechanism of road traffic injury (RTI) deaths in India</td>
<td>A nationally representative mortality survey was conducted where at least two physicians coded each non-medical field staff's verbal autopsy reports. RTI mechanism data were extracted from the narrative section of these reports. Pedestrians (68,000), motorcyclists (36,000) and other vulnerable road users (20,000) constituted 68% of RTI deaths (124,000) nationally. Among the study sample, the majority of all RTI deaths occurred at the scene of collision (1005/1733, 58%), within minutes of collision (883/1596, 55%), and/or involved a head injury (691/1124, 62%). Compared to non-pedestrian RTI deaths, about 55,000 (81%) of pedestrian deaths were associated with less education and living in poorer neighbourhoods.</td>
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<td>Journal (conf/report)</td>
<td>This paper attempts to analyse 1987 accident data, relating to five bus transport corporations in Tamil Nadu, India, in order to reach reasonable inferences and practical recommendations.</td>
<td>Conclusions from the analysis of 1286 bus-related accidents include: (1) 37% of buses and 16% of drivers were involved in accidents, and this is a serious situation requiring detailed examination of possible counter-measures; (2) driver faults were considered to be the primary cause of nearly 37% of the accidents, so that additional training and refresher courses for drivers are indicated; (3) drivers tend to become involved in fewer accidents as their age and experience increases; (4) about 54% of the accidents were in built-up areas and bus stands; (5) the proportions of accidents on straight road stretches, curves and intersections were 81%, 11% and 5%, respectively; (6) over 90% of the accidents were attributed to bad road user behaviour. Remedies suggested are road safety education and effective driver training.</td>
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<td>An analytical study of bus-related accidents in India (Chand, M., 1999)</td>
<td>This paper examines the frequencies and trends of bus-related accidents with special reference to public road transport undertakings (PRTUs) in India. It also attempts to obtain statistical relationships between selected accident-related factors by using PRTU data. (Nothing else could be found.)</td>
<td>Buses are involved in about 10% to 35% of road accidents in different States of India.</td>
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<td>Analysis of Fatal Crashes of Chennai City’s Metropolitan Transport Corporation (MTC) Buses (Jeya Padmanaban, R. R., Swastik Narayan, Bharat Ramesh, 2010)</td>
<td>Using data for 283 fatal crashes, coded from detailed accident reports (dars) maintained by mtc, researchers determined that motorized two-wheelers (m2ws), pedestrians and bus passengers falling off footboards together constitute 89% of fatal road users. It was found that fatalities could be significantly reduced by preventing rear tire run over in buses (30%) using engineering interventions in bus design, using bus doors to prevent passengers from falling off the footboard (22%), helmet use (22%) by m2w riders, pedestrian friendly infrastructure at crossings (64%) and bus stops (30%), and by educating road users on precautionary driving measures. With 30% of pedestrian accidents having occurred at or near bus stops, these areas would be a good place to start an infrastructure intervention. Functional designs for bus stops and pedestrian crossings need to be looked into. In case of MTC bus crashes with M2Ws, front-rear collisions and sideswipes are common on divided roads indicating that infrastructure design, at least for new roads, should incorporate solutions which can separate buses and heavy vehicles from light vehicles.</td>
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This paper presents an analysis of the fatal crashes that involved public transport buses in Bengaluru, India.

Buses are involved in 12-20 percent of fatal crashes in Indian cities. Bus users face risks of road traffic injuries on access trips and buses also are associated with road traffic crashes with other road users. In absolute numbers, motorized two-wheeler riders constitute the largest share of fatalities (40%) and cyclists account for about 10 percent for being its accident victims.

Adequate Right-of-Way for All Modes of Transport; Installing Automatic Doors; Changing the Design of the Bus Body; Better Personnel Policies; Selective but Effective Enforcement of Regulations; Incentives for Drivers; Structural Changes for an Integrated Approach; are proposed.

The paper establishes that change in bus design with low floors, automatically-closing doors, safer bus fronts, and segregated infrastructure for bicycles and pedestrians would go a long way in reducing the number of fatal crashes on city roads involving public buses.

### URBAN SAFETY

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<th>Objective</th>
<th>Recommendations</th>
<th>Statistical analysis</th>
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<tr>
<td>1</td>
<td>Two-wheeler injuries in Delhi, India: a study of crash victims hospitalized in a neuro-surgery ward (Mishra, B. et al., 1984)</td>
<td>The present study was undertaken to determine the head injury patterns of two-wheeler riders admitted to a hospital in Delhi. A total of 87 crash victims were studied over a period of one year.</td>
<td>The results indicate that collision patterns, age distribution, average injury severity and driving experience of patients admitted were different from those reported in studies conducted in industrialized countries. The motorized two-wheeler population has increased in Delhi by more than 300% in the last decade (1970-80). Bicyclists and motorcyclists accounted for 244 traffic accident deaths in Delhi in 1980. A majority (83%) of the injured patients were mtw riders and the rest bicycle riders. A vast majority of the crashes were reported to have occurred on straight roads and only 16 were recorded as collisions with cars, trucks and buses.</td>
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<td>2</td>
<td>An analysis of road traffic fatalities in Delhi, India (Mohan, D. and Bawa, P., 1985)</td>
<td>This study is an attempt to understand fatal crash patterns in Delhi in 1980 using police data. The results indicate that fatality patterns in Delhi are very different from those in highly industrialized countries.</td>
<td>Pedestrians, two-wheeler riders and bus commuters comprise 80% of fatalities and motor-vehicle occupants a small minority. Buses and trucks accounted for 65% of the crashes, and cars and jeeps 7%. The rest were killed by impacts with MTWs, tractors, three-wheeler scooter rickshas, bullock carts, and tongas. Buses alone accounted for 29% of the fatalities. The high representation of buses and trucks is partly due to the fact that they have high exposure on the road. Only 18% of the pedestrian fatalities occurred at road junctions and 82% on the straight road. A large proportion (5 1%) of the fatalities at junctions occurred at T-junctions and only 28% at four-arm junctions and a total of 79% at uncontrolled junctions. On the</td>
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straight road 21% of the fatalities took place at pedestrian crossings. This means that 26% of all pedestrian fatalities on the straight road occurred at marked pedestrian crossings.

Small vehicles like motorcycles and bicycles and other slow-moving small vehicles should be painted only in combinations of conspicuous colours like white, orange and yellow, and greater use of reflective strips should be encouraged. This would make smaller vehicles more noticeable, especially at night. Speed limiters must be installed on public buses and trucks which operate within the city only.

A lower minimum age limit, of 25 years, should be established for bus and truck drivers.

Helmet use should be made compulsory for all MTW riders. Pedestrians and two-wheeler riders should be made aware of the advantages of wearing light-coloured clothing so that they are more conspicuous on the road. Road designs should discourage high speeds in the city. Pedestrian crossings on the straight roads should not be provided unless there are built-in methods of slowing down vehicular traffic on either side.

BUS designs should be evolved which allow large numbers to board the bus very quickly and then move through the bus while the latter is in motion. Low-powered small vehicles like three-wheeler scooters-rickshas may be encouraged for use as taxis, and safer designs evolved which are more comfortable for the driver and passengers; MTWs with engine capacities greater than 150 cc should be discouraged, as higher-powered MTWs riders tend to sustain more serious injuries. Design features on roads which keep vehicle velocities low consistently over long distances should be evolved. These could include combinations of road markings, ripples, serrations, and appropriate intersection designs.

| 3 | Road safety in and around vadodara city (Raichur, M. et al., 1993) | This paper presents accident statistics for Vadodara City, India, and the surrounding rural area, and proposes several safety improvements for them. Accident statistics tables are given for each of the years 1981 to 1990. The most important causes of road accidents are: motor vehicle driver (54%), cyclist (6%), other vehicle driver (10%), and pedestrian (6%). Urban road safety measures proposed are: (1) increasing the safety of accident black spots, of which six are named; (2) a variety of engineering measures, including junction improvement; (3) several enforcement measures; (4) proper use of media to educate the public, and proper traffic education for children. | Yes |
| 4 | Injury pattern among road traffic accident cases : a study from south | To know the prevalence of injuries present among the road. Traffic accident cases. Study was done in Pedestrians and drivers were 22% and 35% of rta victims respectively. The occupants of vehicles constituted the largest (43%) group of victims. Thirty-five pedestrians (21.9%) injured were involved in an rta | No |
India (Jha, N. et al., 2003)  Pondicherry.  with a truck. Buses caused injuries to 20 pedestrians (12.5%). Motorised two wheelers and four wheelers were involved in rtas in which 39 (24.4%) and 34 (21.3%) pedestrians were injured respectively. A total of 254 drivers were involved in rtas. Among the drivers of different types of vehicles, there were 38.6% bicyclists and 16.9% bullock cart drivers. Motorized two wheeler drivers were victims in 31.1% cases while bus and four wheeler drivers were victims in 5.1% and 3.5% cases respectively. Among motorized two wheelers 14 (5.5%) were scooter drivers. Occupants of trucks (12.6%). Among the motorized two wheelers (11.3%), the pillion riders of scooters were least involved (2%), other occupants were from four wheelers of 312 occupants, bus occupants were the highest numbers (48%) of victims involved in rtas followed by like jeep, car.

Among the motorized two wheelers, moped drivers were more commonly involved in rtas. This could be due to the higher speed, which can be achieved over short distances and less stability of the vehicle. One of the most common mode of transportation used by people is the bus and this is reflected by the fact that bus occupants constituted the highest number (48%) of rta victims.

Prompt and adequate ambulance service should be provided to the victims with the help of government and other voluntary agencies. Computerization and use of International Classification of Diseases code in the hospitals would help in preparation of a good database for future studies and other uses.

5  Deaths due to road traffic crashed in Hyderabad city in India: need for strengthening surveillance (Dandona, R. and Mishra, A., 2003)  Objective was to assess the utility of the available data on deaths due to road traffic crashes for road crash surveillance for a major metropolitan city of southern India. analysed the Department of Police database on deaths due to road traffic crashes for 2002 in Hyderabad, southern India and collected data from a leading newspaper for the same information using a standardized format.

Pedestrians and riders of two-wheelers were the most vulnerable. Collision with a vehicle caused 86.4% of all crashes and 60% of the victims died before reaching a hospital.

The available data have limitations and there is a need for strengthening the road traffic crash surveillance system to have reliable, accurate and adequate data on road traffic crashes and the resulting fatalities and injuries. These could then form the basis for planning effective intervention strategies to improve road safety.


In Patna fatalities related to pedestrian, two wheeler and cyclist accounted for more than 98% of cases which is very high. most of the accidents were due to buses and trucks (22 and 20% resp) Segregation of traffic is one of the solution given

7  A comprehensive study of motorcycle fatalities in South Ninety four cases of motorcycle fatalities received from South Delhi were

Motorcycle fatalities cases represented 5.38% of all autopsy cases during the study period. In a majority of cases offending vehicles were, the heavy weight motor
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<td>6</td>
<td>Delhi (Behera, C. et al., 2009)</td>
<td>studied during April 2007 to March 2008 at All India Institute of Medical Sciences, Delhi. Data was analyzed with regard to the age and sex of the victim, pattern of injury, use of helmet and presence of alcohol in victim, cause of death, time of accident, mode of transportation of the victims to hospital, and offending vehicles.</td>
<td>vehicle (34.04%) followed by the medium weight motor vehicle (19.14%). Most of the deceased on motorcycle were drivers (78.72%), out of which only 54.05% wore a helmet at the time of accident.</td>
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<td>8</td>
<td>Two wheeler accidents on Indian roads—a study from Mangalore, India (Jain, A. et al., 2009)</td>
<td>This study was undertaken to find the trend of two wheeler accidents over the five years (2000–2004) with respect to age and sex of the victim, type of injury sustained, type of vehicle involved and time distribution of accidents.</td>
<td>The rider was affected in maximum number of accidents (51.3%), the pillion and pedestrian were also affected, but to a lesser extent. The type of two wheeler mainly involved in accidents was the geared vehicle; the number of such vehicles being 865 (81%) compared to 211 (19%) non-gear vehicles. In the light of the findings of this study, it is recommended that education regarding road safety should be imparted especially to the young age group. They should be made aware of the traffic rules and urged to strictly follow traffic rules. Construction of properly planned roads and over-bridges to cope up with the increasing burden of vehicles with emphasis on lane driving will help the cause. Speed limit should be strictly enforced in accident-prone areas. Efforts should be made to reduce congestion on road particularly during rush hours and especially in the zones prone for accidents. Periodic surveillance and repair of roads especially after rainy season is suggested in this region. Use of helmets should be made mandatory not only for the rider but also for the pillion. For pedestrians, there should be complete segregation by providing sidewalks on both sides of the road. Measures like ‘zebra crossing’ and construction of over-pass or sub-way if feasible can go a long way in reducing morbidity and mortality among pedestrians.</td>
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<td>9</td>
<td>Analysis of fatal road traffic accidents in a coastal township of South India/ 2012 (Kanchan, T. et al., 2012)</td>
<td>With the aim of exploring various epidemiological characteristics of RTAs, this retrospective analysis of medico-legal autopsies was conducted between January 2005 and December 2009 in the Department of Forensic Medicine, Kasturba Medical College, Manipal in Karnataka, South India. The information was collected from post-mortem registers and inquest documents received from the investigating police officers.</td>
<td>Occupants of motorized two wheelers (43%) and pedestrians (33%) were the most common victims of RTAs followed by occupants of light motor vehicles (LMVs). The most common offending agents in road traffic accidents were heavy motor vehicles (35.2%) followed by light motor vehicles (31.7%).</td>
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<td>10</td>
<td>A Population-Based Study on Road Traffic Injuries in Pune City, India (Mirkazemi, R. and Kar, A., 2014)</td>
<td>This study was conducted with the aim of identifying the burden, pattern, and risk factors of RTIs in the population of Pune City. A population-based cross-sectional study was conducted among 9014 individuals in a randomly selected and representative sample of the population from 14 administrative wards of the city from March 2008 to April 2009.</td>
<td>Univariate analysis showed a significant association between rtis and age, gender, occupation, mode of transport, driving a vehicle, and alcohol abuse. Multivariate analysis showed that only age, driving a vehicle, and alcohol abuse were the factors associated with rtis. Injury occurrence was significantly more among the age group 15-30, males, and students and workers.</td>
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<td>11</td>
<td>Evaluating Safety of Urban Arterial Roads of Medium Sized Indian City (Prajapati, P. and Tiwari, G., 2013)</td>
<td>This paper estimates the safety performance of urban arterial mid-block of medium sized Indian city based on fatal crashes as a function of traffic level and road network features. The fatal crashes on arterial mid-blocks are analyzed separately from junction crashes. The accident prediction models developed are based on 126 fatal crashes occurred in 6 years (2005-2010) in Vadodara, India on 263 mid-block arterial road segments.</td>
<td>It was found that number of fatal crashes increases as the traffic level and length of road segment increases and decreases as the number of junction per kilometer increases on the road segment. These findings have important bearing on the design of urban arterial roads. In the absence of facilities for pedestrians and bicyclists, arterial roads with wider carriageway and higher number of lanes increase the risk of fatal crash for pedestrians and bicyclists. Presence of medians may result in higher speeds of motorized vehicles and in the absence of facilities for pedestrians and bicyclists the crash risk increases. The impact of other geometric design parameters should be evaluated to improve the road safety.</td>
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<td>12</td>
<td>Epidemiology of road traffic accident deaths in children in Chandigarh zone of North West India (Singh, D. et al., 2015)</td>
<td>Present study was carried out to provide a baseline data to policy makers to plan safer transportation routes and in setting up of health care centers in areas that report a higher number of accidents. The present study is an analysis of postmortem records of 709 RTA-related deaths in children (≤18 years) in Chandigarh zone, undertaken at Post Graduate Institute of Medical Education and Research (PGIMER), Chandigarh between 1974 and 2013. The autopsies on these cases were conducted by the department of Forensic Medicine.</td>
<td>Maximum fatalities were reported among the pedestrians (47.8%) followed by two wheeler occupants (33.1%). The proportion of pedestrians and heavy motor vehicle (hmv) fatalities decreased from 64% to 46% and 14% to 5% correspondingly in the years 1974–78 and 2009–13. However, the proportion of two wheeler and light motor vehicle (lmv) fatalities increased from 18% to 39% and 0% to 7% respectively in the years 1974–78 and 2009–13. The least commonly affected was the three wheeler group. To bring the mortality rate down, children, especially with rural background should be made aware about the importance of strict compliance to traffic rules and regulations. One of the best ways to do it is to include road safety issues in school curriculum. Those children who ride bicycles should be made to wear helmets as it is expected to reduce the severity of injury to the head. Drivers should avoid talking on mobile phones while on roads.</td>
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The present study has highlighted the urgent need to frame road safety policies like separate lanes for different vehicles as the traffic in India in general and this region in particular consist of all kinds of automobiles including two wheelers, three wheelers and four wheelers thus increasing the chances of accidents. Installation of red lights and marking of zebra crossings on the roads near schools and playgrounds would be a welcome decision. The government should also ensure that the vehicles follow speed limits.

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<td>13</td>
<td>Pattern of Road Traffic Accidents in Bhubaneswar, Odisha (Kar, S. et al., 2015)</td>
<td>Objectives was to (1) To estimate the incidence and distribution of RTA in the year 2012. (2) To determine the epidemiological variations of accidents in the city. (3) To suggest recommendations to the traffic police and administration.</td>
<td>The epidemiological trends that emerged were that 84% occurred in urban areas and mainly on the National Highways (46.7%); 18% of RTA occurred during rainfall, though no significant association could be made out and much is attributed to under reporting of data; motor cars (37%) and trucks (19.1%) were predominately involved. Majority of the victims were in the productive age group, 18–24, years and mainly constituted males (68%). Reporting of the accidents should be made as per the formats generated at the national level. - A mapping of accidents area wise should be done by police to identify vulnerable points and patrolling reinforced in those areas. - Strict reinforcement of laws for rash driving, as side and head-on collisions have been identified as the major causes of RTA. - As the productive age group is being affected, especially the teens, some counseling programs and Awareness Drives should be initiated regarding this. - There should be a yearly assessment in liaison with the health facility so that other concerns can be brought out and effective management of the injured can be planned. - Timings of accidents should be kept in mind while deputing traffic personnel, and for the late timings also, a back-up plan should be devised. - Urban and rural plans should be made, as problems are different in both.</td>
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<td>14</td>
<td>Why do three-wheelers carrying schoolchildren suffer very low fatal crashes? (Pandey, G. et al., 2015)</td>
<td>The objective of the study was to investigate the hypothesis that drivers behave differently while following or overtaking three-wheelers carrying children. This paper investigates the possible causes of low fatalities in three-wheelers (autorickshaw) carrying schoolchildren in India. The data was collected in the form of First Information Report (FIR) from local police stations from 2007 to 2012 and video-graphic surveys</td>
<td>It was found that heavy vehicles maintain more gaps while following or overtaking three-wheelers carrying children as compared to those not carrying children. It was also found that this effect is more prominent at speeds higher than 40 km/h. On the other hand lighter vehicles keep the highest lateral and longitudinal gaps to heavy vehicles and three-wheelers without children respectively.</td>
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were done on four arterial roads running through Ludhiana, Punjab, India.
6. Way forward

INTERNATIONAL KNOWLEDGE BASE FOR CONTROL OF ROAD TRAFFIC INJURIES

International road safety research has involved a large number of very well trained professionals from a variety of disciplines over the past four decades. Some very innovative work has resulted in a theoretical understanding of road traffic crashes as a part of a complex interaction of sociological, psychological, physical and technological phenomena. The results could be exchanged and solutions transferred from one high-income country to another because the conditions in these countries were roughly similar. This understanding of injuries and crashes has helped high-income countries design safer vehicles, roads and traffic management systems. A similar effort at research, development and innovation is needed in India and similar countries. A much larger group of committed professionals needs to be involved in this work for new ideas to emerge.

International cooperation in the area of road safety should focus on exchange of scientific principles, experiences of successes and failures, and in scientific training of a large number of professionals in India. The scientific principles of road safety can be exchanged for the benefit of everyone. However, the priorities in road safety policies cannot be global in nature because of the differing patterns of traffic and crash patterns around the world. We analyse below the risk factors and the availability of known road safety countermeasures in the context of concerns specific to India.

Results of systematic reviews

Legislation and enforcement

Most attempts at enforcing road-traffic legislation periodically will not have any lasting effects, either on road-user behaviour or on accidents. Imposing stricter penalties (in the form of higher fines or longer prison sentences) will not affect road-user behaviour, and imposing stricter penalties will reduce the level of enforcement (Bjornskau, T. and Elvik, R., 1992).

Increased normal, stationary speed enforcement is in most cases cost-effective. Automatic speed enforcement seems to be even more efficient. However, there is no evidence to prove that mobile traffic enforcement for speed control with patrol cars is cost-effective (Carlsson, G., 1997).

The only effective way to get most motorists to use safety belts is with good laws requiring their use and sustained enforcement. When laws are in place, education and/or advertising can be used to inform the public about the laws and their enforcement (O’neill, B., 2001).

In general, the deterrent effect of a law is determined in part by the severity and swiftness of the penalty for disobeying it, but a key factor is the perceived likelihood of being detected and sanctioned. Laws against drinking and driving are effective when combined with active enforcement and the support of the community (Elder, R. W. et al., 2004, Koornstra, M., 2007, Sweedler, B. et al., 2004).
Policing methods and enforcement techniques have to be optimized for India to be effective at much lower expenditure levels. There are no systematic studies evaluating different techniques followed around the world. Research needs to be done on the effectiveness of professional driver education, driver licensing methods, and control of problem drivers in Indian settings.

**Education campaigns and driver education**

Road-safety campaigns often aim to improve road-user behaviour by increasing knowledge and by changing attitudes. There is no clearly proved relationship between knowledge and attitudes on the one hand and behaviour on the other (O’neill, B., 2001, OECD, 1986). Most highway safety educational programmes do not work. They do not reduce motor-vehicle crash deaths and injuries (Robertson, L. S., 1980, Robertson, L. S., 1983, Robertson, L. S. et al., 1974). Only a few programmes have ever been shown to work, and contrary to the view that education cannot do any harm, some programs have been shown to make matters worse (Robertson, L. S., 1980, Sandels, S., 1975)(Robertson 1980; Sandels S. 1975). Driver or pedestrian education programmes by themselves usually are insufficient to reduce crash rates (Elvik, R. and Vaa, T., 2004). They may increase knowledge, and even induce some behaviour change, but this does not seem to result in a reduction in crash rates (Duperrex, O. et al., 2003, Roberts, I. et al., 2003). There is, however, no reason to waste money on general campaigns. Campaigns should be used to put important questions on the agenda, and campaigns aimed at changing road-user behaviour should be focused on clearly defined behaviours and should by preference fortify other measures such as new legislation and/or police enforcement.

The effects of campaigns using tangible incentives (rewards) to promote safety-belt usage have been evaluated by means of a meta-analytical approach. The results (weighted mean effect) show a mean short-term increase in use rates of 12.0 percentage points; the mean long-term effect was 9.6 percentage points (Hagenzieker, M. P. et al., 1997). Research first from Australia, later from many European countries, then from Canadian provinces, and finally from some US states clearly shows that the only effective way to get most motorists to use safety belts is with good laws requiring their use.

Studies show that driver education may be necessary for beginners to learn the elementary skills for obtaining a license, but compulsory training in schools leads to early licensing. There is no evidence that such schemes result in a reduction in road-crash rates. On the other hand they may lead to increased road-crash rates (Mayhew, D. R. and Simpson, H. M., 1996, Vernick et al., 1999, Williams, A. F. and O’neill, B., 1974). While there may be a need to train professional drivers in the use of heavy vehicles, there is no evidence that formal driver education should be compulsory in schools and colleges.

**Vehicle factors**

Vehicles conforming to EU or USA crashworthiness standards provide significant safety benefits to occupants, and the effectiveness of the following measures have been evaluated.

Use of seatbelts and airbag-equipped cars can reduce car-occupant fatalities by over 30%. It is estimated that air-bag deployment reduced mortality by 63%, while lap–shoulder-belt use reduced mortality by 72%, and combined air-bag and seatbelt use reduced mortality by more than 80% (Crinion, J. D. et al., 1975, Kent, R. et al., 2005, Parkin, S. et al., 1993).

High-mounted rear brake lights reduce the incidence of rear-end crashes (Etsc, 1993).

A meta-analysis of 17 studies that have evaluated the effects on traffic safety of using daytime running lights on cars shows that their use reduces the number of multi-vehicle daytime crashes by about 10–15% for (Elvik, R., 1993). Similar results have been confirmed for the use of daytime running lights by motorcyclists (Radin Umar, R., 2006, Radin Umar, R. S. et al., 1996, Yuan, W., 2000).

Improvements in vehicle crashworthiness and restraint use have contributed to a major reduction in occupant fatality rates and are estimated to be more than 40% in most reviews (Elvik, R. and Vaa, T., 2004, Koornstra, M., 2007, Noland, R. B., 2003).

However, not enough work has been done to make vehicles safer in impacts with vulnerable road users, or on vehicles specific to Indian conditions.

**Environmental and infrastructure factors**

The road environment and infrastructure must be adapted to the limitations of the road user (Van Vliet, P. and Schermers, G., 2000).

Traffic-calming techniques, use of roundabouts, and provision of bicycle facilities in urban areas provide significant safety benefits and limited-access highways with appropriate shoulder and median designs provide significant safety benefits on long-distance through roads (Elvik, R., 1995, Elvik, R., 2001, Hyden, C. and Varhelyi, A., 2000).

Though improvements in road design seem to have some beneficial effects on crash rates, increases in speed and exposure can offset some of these benefits (Noland, R. B., 2003, O’neill, B. and Kyrychenko, S., 2006). Road designs that control speeds seem to be the most effective crash control measure (Aarts, L. and Van Schagen, I., 2006).

A great deal of additional work needs to be done on rural and urban road and infrastructure design suitable for mixed traffic to make the environment safer for vulnerable road users. This would require special guidelines and standards for design of, (a) roundabouts, (b) service lanes along all intercity highways, and (c) traffic calming on urban roads and highways passing through settlements.

**Pre-hospital care**

Recent Cochrane Reviews have concluded that (Bunn, F. et al., 2001, Kwan, I. et al., 2004a, Kwan, I. et al., 2004b, Sethi, D. et al., 2004):
There is no evidence from randomized controlled trials to support the use of early or large-volume intravenous fluid administration in uncontrolled haemorrhage. There is uncertainty about the effectiveness of fluid resuscitation in patients with bleeding.

The effect of pre-hospital spinal immobilization on mortality, neurological injury, spinal stability, and adverse effects in trauma patients therefore remains uncertain. Because airway obstruction is a major cause of preventable death in trauma patients, and spinal immobilization – particularly of the cervical spine – can contribute to airway compromise, the possibility that immobilization may increase mortality and morbidity cannot be excluded.

In the absence of evidence of the effectiveness of advanced life support training for ambulance crews, a strong argument could be made that it should not be promoted outside the context of a properly concealed and otherwise rigorously conducted randomized controlled trial.

A recent study by Lerner and Moscati shows that no scientific evidence is available for supporting the concept of the ‘golden hour’ (Lerner, E. B. and Moscati, R. M., 2001). While it is desirable that we possible time, it is equally important that ambulances do not endanger the life of others while doing so, and do not waste scarce resources in promoting systems of dubious benefit (Becker, L. R. et al., 2003).

Before we import expensive pre-hospital care systems from high income countries, it is necessary that their effectiveness be established.

THE WAY FORWARD

Practice points

Some of the policy options are outlined below.

Pedestrian and bicyclist safety
1. Reserving adequate space for non-motorized modes on all roads where they are present.
2. Free left turns must be banned at all signalized junctions. This will give a safe time for pedestrians and bicyclists to cross the road.
3. Speed control in urban areas: maximum speed limits of 50 km/h on arterial roads need to be enforced by road design and police monitoring, and 30 km/h in residential areas and by judicious use of speed-breakers, dead-end streets and mini roundabouts.
4. Increasing the conspicuousness of bicycles by fixing reflectors on all sides and wheels and painting them yellow, white or orange.

Motorcyclist and motor vehicle safety
1. Notification of mandatory use of helmet and daytime headlights by two-wheeler riders.
2. All cars to conform to latest international crashworthiness regulations.
3. Pedestrian safety regulations for cars to be notified.
4. Enforcement of seatbelt use laws countrywide.
5. Restricting front-seat travel in cars by children and the use of child seats has potential for reducing injuries to child occupants.

Road measures
1. Traffic calming in urban areas and on rural highways passing through towns and villages.
2. Improvement of existing traffic circles by bringing them in accordance with modern roundabout practices and substituting existing signalized junctions with roundabouts.
4. Mandatory road safety audit for all road building and improvement projects.
5. Construction of service lanes along all 4-lane highways and expressways for use by low-speed and non motorised traffic.
6. Removal of raised medians on intercity highways and replacement with steel guard rails or wire rope barriers.

Enforcement
1. The most important enforcement issue in India is speed control. Without this it will be difficult to lower crash rates as a majority of the victims are vulnerable road users.
2. The second most important measure to be taken seriously is driving under the influence of alcohol. 30%–40% of fatal crashes in India may have alcohol involvement.
3. Enforcement of seatbelt and helmet use.

Pre-hospital care, treatment and rehabilitation
1. Modern knowledge regarding pre-hospital care should be made widely available with training of specialists in trauma care in the hospital setting.
2. Pre-hospital care programmes should be rationalized on evidence-based policies so that scarce resources are not wasted.

Research agenda
1. Development of street designs and traffic-calming measures that suit mixed traffic with a high proportion of motorcycles and non-motorized modes.
2. Highway design with adequate and safe facilities for slow traffic.
3. Design of lighter helmets with ventilation.
4. Pedestrian impact standards for small cars, buses and trucks.
5. Evaluation of policing techniques to minimize cost and maximize effectiveness.
6. Effectiveness of pre-hospital care measures.
7. Traffic calming measures for mixed traffic streams including high proportion of motorised two-wheelers.

Institutional arrangements
International experience suggests that unless a country establishes an independent national road traffic safety agency it is almost impossible to promote safety in a comprehensive and scientific manner. This was stated powerfully in a report *Reducing Traffic Injury: A Global Challenge* almost 22 years ago (Trinca, G. W. et al., 1988):
“Each country should create (where one does not exist) a separate traffic safety agency with sufficient executive power and funding to enable meaningful choices between strategy and program options. Such an agency would ideally report directly to the main legislative/political forum or to the head of government.”


- Make road safety a political priority.
- Appoint a lead agency for road safety, give it adequate resources, and make it publicly accountable.
- Develop a multidisciplinary approach to road safety.
- Set appropriate road safety targets and establish national road safety plans to achieve them.
- Create budgets for road safety and increase investment in demonstrably effective road safety activities.”

The following suggestions made by the National Transport Development Committee (National Transport Development Policy Committee, 2014b) should be considered for implementation.

**Establish National Board/Agency for Road Safety.**

This Board must be:

(a) Independent of the respective operational agencies to avoid conflict of interest

(b) The CEO of the Board should be of a rank of Secretary to the Government of India and report directly to the Minister of the concerned ministry

(c) The Board should be staffed by professionals who have career opportunities and working conditions similar to professionals working in IITs/CSIR laboratories

(d) The Board should have an adequate funding mechanism based on the turnover of that sector

(e) The terms of reference can incorporate the recommendations similar to those included in the reports submitted by the Committee on Roads Safety and Traffic Management (Committee, 2007).

The Committee also recommended that the Board be given power to not only set standards but also monitor their adoption and implementation. For this purpose, the Board would empanel auditors to do spot checks and audits of highways under design, construction or operation to ensure that safety standards are adhered to. If standards are not adhered to, the Board would have powers to issue suitable directions with regard to corrective measures. The Board would have similar powers to ensure that mechanically propelled vehicles conform to safety standards set by the Board. In addition, the Board would have powers to seek information and reports and access records and documents. Where the standards set or directions issued by the Board have not been adhered to the Board should have the power to levy penalties.
The Committee recommended that a minimum of one per cent of the total proceeds of the cess on diesel and petrol should be available to the Road Safety Fund of Centre and the States as road safety is a matter of concern not only on national highways but also on the state roads, village roads and railway level crossings. Also, at least 50 per cent of the amount retained by the Government of India by way of the share of the national highways and the Railways should be allocated to accident-prone urban conglomerations and States in addition to their entitlement. Assistance to the States from the National Road Safety Fund should be released to support road safety activities provided that the States enter into agreements with the Government of India in respect of these activities and faithfully implement the agreements.

**Manpower requirements**

International experience suggests that the proposed National Road Safety and Traffic Management Board at maturity would need at least 250-350 professionals to man the eleven departments envisioned in the report of the Committee. Almost all of these professionals would have to be at the post-graduate level in the different areas of expertise needed for road safety. This is essential for the following reasons: (a) the agency would need to have in-house technical expertise to keep abreast of scientific and technical advancements in road safety knowledge internationally. (b) Since the Board will have the responsibility of establishing safety standards, it is essential that its staff have domain expertise for the same. (c) The Board will be sponsoring research in various areas of road safety. For establishment of research priorities and monitoring of projects the Board would need to have professionals whose expertise is similar to those working in academic and research institutions.

The role of a national agency such as the one proposed above was highlighted in the *World Report on Road Traffic Injury Prevention* (Peden, M. et al., 2004). Without the existence of such an agency, accountable road safety leadership at country, state, provincial and city does not get established. In the absence of such leadership it is almost impossible to evolve sustainable policies and establish mechanisms for their implementation. The national agency will have to focus on the following objectives in the immediate future (Bliss, T. and Breen, J., 2009):

1. Set project objectives
2. Determine scale of project investment
3. Identify project partnerships
4. Specify project components
5. Confirm project management arrangements
6. Specify project monitoring and evaluation procedures
7. Prepare detailed project design
8. Highlight project implementation priorities

Bliss and Breen (2009) have proposed a set of questions that can be asked to evaluate the strengths and weaknesses of a national safety agency (Box 3). The project implementation and research priorities will have to be developed on an urgent basis and measureable targets established for each five-year plan period. An illustrative list is given in Box 4. The measures and principles outlined for the national road safety agency can be modified appropriate for national agencies for other sectors.
National Data Base and Statistical Analysis Systems

At present very little epidemiological information is available in India for deaths and injuries associated with transport. For evolution of evidence based safety policies and strategies based on the systems approach, it is necessary to set up reliable data collection and analysis procedures for traffic accidents in consonance with international practices at different levels. This needs a special input for establishing special agencies in all sectors of transport.

The national safety agency must include a special department for data collection and statistical analysis. International experience suggests that such departments need to employ about 50-100 statistical and epidemiology experts who design surveys, data collection methods, perform statistical analyses and publish reports. It is equally important that all such data be available in the public domain so that independent researchers outside the official agency can also perform independent analyses and studies.

The functions of these Departments could include:

- Collating relevant data from existing surveillance systems: Census Bureau, National Sample Survey Organisation, National Crime Record Bureau, Central Bureau of Health Intelligence, etc.
- Establishing systems for scientific data collection by the police department
- National surveillance systems for all fatal accidents
- Sample surveys for specially identified problems
- Sample surveillance systems in identified hospitals
- Establishment of multidisciplinary accident investigation units in academic and research institutions
- Coordinating with relevant ministries and departments at the central, state and city level for collating data collected by the respective agencies

Establish safety departments within operating agencies

MoRTH should have an internal safety department (at different levels) for ensuring day to day compliance with safety standards, studying effectiveness of existing policies and standards, conducting safety audits, collecting relevant data, and liaison with the National Safety Agency, etc. These departments must employ 30-60 professional with expertise in the relevant area of safety, with 30-40 per cent of the staff on deputation form the field.

Agencies operating under the Ministry (e.g. National Highway Authority of India) should also establish their own departments of safety with domain specialists. The functions of these departments would include field audits, before and after studies, data collection from the field, and liaison with the relevant ministry and the national safety agency.

Fund establishment of multidisciplinary safety research centres at academic institutions.

The national safety agencies in each of the transport ministries should establish multidisciplinary safety research centres in independent academic and research institutions. These centres would ideally
include three or more disciplines of research, and for each area of work should be at pursued in three or more centres. This would promote competition among centres and likely to result in more innovation. Safety research involves the following disciplines: relevant engineering sciences, statistics and epidemiology, trauma and medical care, sociology, psychology, jurisprudence, and computer science. For these centres to be productive, each centre should have a minimum of 8-10 professionals. It is also possible that one academic institution has more than one of these safety research centres. It is recommended that 15 such centres be established by 2020 and another 15 by 2025.

The funding for each of these centres should include:

- Endowment for three or more professorial chairs
- Endowment grant for at least two postgraduate scholarships per endowed chair
- Establishment funds for critical laboratories
- Funds for supporting visiting professionals
- Support for surveys, software, travel

For these centres to function effectively the minimum grant per centre per year would be in the range of Rs. 30-40 million annually including endowment funds. Each national safety agency should establish procedures for issuing call for proposals and for evaluating the same under open completion. A procedure should also be established for an academic peer evaluation of each centre every two years.
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