Road Safety in India: Status Report 2020

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Executive summary

Road traffic crash and injury data

- According to official statistics, 1,51,417 persons were killed and 469,418 injured in road traffic crashes in India in 2018. However, this is probably an underestimate for injuries, as not all injuries are reported to the police.

- The number of cars and motorised two-wheelers (MTW) registered in 2016 was 30.2 and 168.9 millions 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 are not removed from the records. The actual number of personal vehicles on the road is estimated to be 50%-60% of those mentioned in the records.

- The extent of underreporting of road traffic deaths in India is not well understood. Global Burden of Diseases, Injuries, and Risk Factors Study, estimated that in 2017, 218,876 deaths (95% UI 201,734 to 231,141) due to road injuries occurred in India. A National Burden Estimates study estimates RTI deaths in 2017 in India to be 275,000. These two estimates are 45% and 82% higher than the MoRTH number.

- Police data should not be used for studying the epidemiology of non-fatal road traffic injuries (RTI) in the country. The official estimate of non-fatal RTI in 2018 was 469,418 which probably underestimates injuries requiring hospitalization by a factor of 5 and all injuries by a factor of 20.

- Over the last two decades the burden of road traffic injuries in India has increased, while the number of those affected by infectious diseases has declined. In 1990, road traffic injuries were the 16th leading cause of health loss, and 10th in 2016.

- 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 MoRTH reports are erroneous and cannot be used for any analysis.

- Tables dealing with causes of road traffic crashes should not be used for any analysis or policy making.

- 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.

Analysis of data at national level

- The total number of deaths in 2018 was 10 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%.
• The only way the decline of RTI fatalities can be brought forward in time is to institute evidence based India-specific road safety policies that are more effective.

• The Indian official estimates of pedestrian fatalities are extremely low compared to independent researchers’ estimates (~15% vs ~35%), therefore, official estimates for all other modes will also be wrong.

• 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 the involvement rate of children (<18 years) and the elderly (>59 years) 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.

• Compared with the situation in 2015, the total number of deaths in 2018 decreased by more than 10% in 5 states and union territories, was 10% higher or lower in 16 states, and increased by more than 10% in 11 states.

• Fatality rates per hundred thousand persons in 2018 increased in fifteen states and union territories and reduced in fifteen.

• Since RTI fatality rates in states and union territories do not seem to be influenced strongly by location in the country (culture) 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 an influence on vulnerable road user safety than current practice of focussing on motor vehicles as has been the practice up to now. This will 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.

Urban safety

• In 2018 the average fatality rate for all fifty million plus cities combined was 14.6 per 100,000 persons which is 30% greater than the national average of 11.2. For 33 cities where the data can be compared between 2006 and 2016 only 15 recorded 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 the cities the death rate increased by more than 50% in a period of 10 years.

• Compared to 2015 the number of deaths in 2018 increased by more than 10% in 19 cities, remained about the same in 15 cities, and decreased by more than 10% in 15 cities. Significant reduction in number of deaths was 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 is leading to decreases in vehicle speeds may have contributed to this.

• Eight cities with 50% higher rates than the average for all cities in 2018 (greater than 22 fatalities per 100,000 persons): Agra, Allahabad, Gwalior, Jabalpur, Meerut, Patna, Raipur and Vijaywada.

• Ten cities with 50% lower rates than the average for all cities in 2018 (less than 7 fatalities per 100,000 persons): Ahmedabad, Amritsar, Hyderabad, Kannur, Kochi, Kolkata, Mumbai, Pune, Srinagar and Surat.
• It is not possible to explain the causes of these increases and decreases in the city fatality rates as they do not have any correlation with the size of the cities or their location in India.
• The proportion of vulnerable road user (pedestrians, bicyclists and motorised two-wheelers) deaths in the nine cities range between 84% and 93%, car occupant fatalities between 2% and 7%, and occupants of three-wheeled scooter taxis (TSTs) less than 5% per cent, except in Vishakhapatnam where the proportion for the latter is 8%.
• An 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.
• 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.
• Following countermeasures need to be given priority in cities: Safe pedestrians paths and crossing facilities, speed control by traffic calming measures like raised pedestrian crossings, change of road texture, rumble strips and use of roundabouts.

**Intercity highways**

• 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 NH with 0.67 deaths per km annually and this fact should be the guiding factor in future design considerations.
• 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 majority of those getting killed (68%) on highways in India comprise vulnerable road users.
• Data from three highway segments from 2009-2013 show a similar pattern. Pedestrian and MTW proportions are very high except on six-lane highways 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 that 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 audible & vibratory pavement markings, provision of frequent and convenient underpasses (at the same level as surrounding land) for pedestrians, bicycles and other non-motorized 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.

**Status of research in road safety**

- India despite having the distinction of being the second most populous country contributed only 0.7% published articles on road traffic injuries worldwide.

- When normalized 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.

- Road traffic injury research output is still subcritical in India and not enough original research findings can be used for India specific policy making for the future.

**International knowledge base**

- Imposing stricter penalties (in the form of higher fines or longer prison sentences) will not affect road-user behaviour significantly. In general, the deterrent effect of a law is determined in part by the swiftness and visibility of the penalty for disobeying the law, but a key factor is the perceived likelihood of being apprehended on the road and sanctioned.

- Driver or pedestrian education programmes by themselves usually are insufficient to reduce crash rates. The only effective way to get most motorists to use safety belts and motorcyclists to wear helmets is with good laws requiring their use and strict enforcement.

- Use of seatbelts and airbag-equipped cars can reduce car-occupant fatalities by over 50%.

- Use of daytime running lights on cars shows a reduction in the number of multi-vehicle daytime crashes by about 10–15%. Similar results have been confirmed for the use of daytime running lights by motorcyclists.

- Traffic-calming techniques, use of roundabouts, and the provision of bicycle facilities in urban areas provide significant safety benefits.

- 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.

Way forward

• Reserve adequate space for non-motorized modes on all roads where they are present.
• Notification and enforcement of mandatory use of helmet and daytime headlights by
two-wheeler riders.
• Traffic calming in urban areas and on rural highways passing through towns and villages.
• Construction of service lanes along all 4-lane highways and expressways for use by low-
speed and non-motorised traffic.
• Removal of raised medians on intercity highways and replacement with steel guard rails
or wire rope barriers.
• Modern knowledge regarding pre-hospital care should be made widely available with
training of specialists in trauma care in the hospital setting.
• Research agenda
  o Development of street designs and traffic-calming measures that suit mixed
traffic with a high proportion of motorcycles and non-motorized modes.
  o Highway design with adequate and safe facilities for slow traffic.
  o Pedestrian impact standards for buses and trucks.
  o Evaluation of policing techniques to minimize cost and maximize effectiveness.
  o Effectiveness of pre-hospital care measures.
  o Traffic calming measures for mixed traffic streams including high proportion of
motorised two-wheelers.
• Establish National Board/Agency for Road Safety
• Establish a special central department for coding and recording all fatal crash data. The
data so collected should be anonymised and made available publicly for analysis.
• Establish safety departments within operating agencies.
• Establish multidisciplinary safety research centres at academic institutions.
Introduction

NATIONAL ROAD TRAFFIC INJURY FATALITY RATE

According to official statistics 151,417 persons were killed and 469,418 injured in road traffic crashes in India in 2018 (Transport Research Wing 2019). However, this is probably an underestimate, as not all injuries are reported to the police (Mohan et al. 2009, Gururaj 2006). The actual number of injuries requiring hospital visits may be 2,000,000-3,000,000. In GBD-2010, we estimated that there were 2.2 million injuries in India that warranted hospital admission, and 18 million injuries warranted an emergency room visit (Bhalla et al. 2014). The basis for these estimates is given in a later section. Road traffic injuries (RTI) in India 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 percent 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 2018). 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 are not 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 vehicle when they junk them. The actual number of personal vehicles on the road is estimated to be 50%-55% of those registered in India (Expert Committee on Auto Fuel Policy 2002, Goel et al. 2015, Mohan et al. 2014). The number of cars and motorised two-wheelers (MTW) registered in 2016 was 30.2 and 168.9 million respectively. If we assume that ~60% of them were actually on the road, then the actual number of cars and MTWs present on the roads would be

![Figure 1: Road traffic deaths in India 1970 through 2018 (Source: NCRB 2015 & Transport Research Wing, 2019).](image-url)
According to official statistics 151,417 persons were killed and 469,418 injured in road traffic crashes in India in 2016. This is probably an underestimate, as not all injuries are reported to the police. The actual numbers of injuries requiring hospital visits may be 2,000,000-3,000,000 persons.

Since the actual number of vehicles on the road is much less than that officially registered in India, any RTI fatality rates calculated per vehicle on the basis of official data will give unrealistically low estimates.

Table 1 shows the personal vehicle ownership and official road traffic fatality rates per 100,000 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. These data show that it is not necessary that increases in vehicle ownership rates always result in increases in RTI fatality rates.

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

<table>
<thead>
<tr>
<th>Country</th>
<th>MTW + light 4-wheelers per 100 persons</th>
<th>Official fatality rate per 100,000 population</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>9*</td>
<td>12</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 in India

RECORDING OF CRASHES

As in most countries, traffic police are the source of official government statistics related to 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 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). The details recorded in the FIR are as observed by the person reporting the crash. This sets in motion the process of ‘criminal justice’ 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 determine how a police officer investigates the crash 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 road user 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 RTI CRASH DATA

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 et al. 2014, W.H.O. 2015, Rosman and Knuiman 1994, Derriks and Mak 2007).

It has usually been assumed that in India while many injury cases may be taken to private hospitals and not get recorded by the police, most fatal RTI cases get recorded 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 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 the owner of the 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 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.

RTI FATALITY ESTIMATES

The extent of underreporting of road traffic deaths in India is not well understood. For instance, a record linkage study in

Global Burden of Diseases, Injuries, and Risk Factors Study, estimated the rate of deaths due to road traffic injuries to be 218,876 in 2017.

A National Burden Estimates study estimates RTI deaths in 2017 in India to be 275,000.

Overall, this would imply that it is possible that the actual number of RTI deaths in India may be more than 40% higher than the official estimate.
Bengaluru covering 23 hospitals found that police data only missed 5% of road traffic deaths (Gururaj, G., 2006). Two recent studies have estimated national road traffic deaths using data from the Sample Registration System, Registrar general of India. Dandona et al. (2020) as part of the Global Burden of Diseases, Injuries, and Risk Factors Study, estimated the rate of deaths due to road injuries in each state of India from 1990 to 2017 based on several verbal autopsy data sources. They estimate that in 2017, 218,876 deaths (95% UI 201,734 to 231,141) due to road injuries occurred in India. Their mean estimate is for 2017 is 48% higher than the Government of India figure for the same year. Another study by Menon et al. (2019) creates National Burden Estimates to provide transparent and understandable disease burdens at the national levels and estimates RTI deaths in 2017 in India to be 275,000. The latter figure is 82% higher than the Transport Research Wing estimate for 2017.

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 enter the official statistics, however, some fatal cases in rural areas and those involved in single vehicle crashes may not get reported. 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%. However, this issue cannot be resolved satisfactorily until such time as the recording of traffic crashes is done in a 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 and Mak 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 et al. 2008, Amoros, Martin, and Laumon 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 the 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 and Mohan 1991).

International experience is somewhat similar. In 2013 in U.S.A. police-reported motor vehicle traffic crashes included 30,057 persons killed, 1,591,000 injured, 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 1996) and 1:14:80 (Evans 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 and Mak 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 2016 is taken as 150,785, then the estimate of serious injuries requiring hospitalization would be 2,262,000 annually, and that for minor injuries 7,539,000. The official estimate of non-fatal RTI in 2016 was 494,624 which probably underestimates injuries requiring hospitalisation by a factor of 5 and all injuries by a factor of 20.

The probability that a non-fatal injury gets registered by the police 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.

As non-fatal injury data in India are unreliable and the biases implicit in which cases get recorded not known, police data should not be used for studying the epidemiology of road traffic injuries in the country. Any statistical analysis using injury data would be unreliable and this which would render indices such as accident severity (number of persons killed per 100 accidents) meaningless.

For these reasons, only fatality data have been used for analysis in this report as police data should not be used for studying the epidemiology of non-fatal road traffic injuries in India.
RANKING IN CAUSES OF DEATH AND POPULATION HEALTH

Figure 3 shows the top ten causes of years of life lost (YLLs) in India in 2017 and percent change between 2007-2017 for all ages (Institute for Health Metrics and Evaluation (IHME), 2018). This figure shows that injuries resulting from road traffic crashes impose a substantial burden on the health of the population in India. Road traffic injuries are the 9th leading cause of premature death in India and this exceeds the number of those who succumb to many diseases like malaria and HIV that are acknowledged to be important health issues for the country.

Figure 3. Top ten causes of years of life lost (YLLs) in India in 2017 and percent change between 2007-2017 for all ages (Source: Institute for Health Metrics and Evaluation (IHME, 2018))

Figure 4 shows that over the last two and a half decades the burden of road traffic injuries in India has increased while that due to many infectious diseases has declined. In 1990, road traffic injuries were the 16th leading cause of health loss. However, in 2016 they were ranked 10th due to an increase of 65% in disability adjusted life years (DALYs) attributed to road traffic injuries (Indian Council of Medical Research, Public Health Foundation of India, & Institute for Health Metrics and Evaluation (IHME), 2017).

Figure 4. Change in DALYs number and rate for the leading individual causes in India from 1990 to 2016 (Source: Indian Council of Medical Research, Public Health Foundation of India, & Institute for Health Metrics and Evaluation (IHME), 2017).
Over the last two and a half decades the burden of road traffic injuries in India has increased while that due to many infectious diseases has declined. In 1990, road traffic injuries were the 16th leading cause of health loss, in 2016 it was ranked 10th.

Figure 5. RTI fatality rate per 100,000 persons reported by different countries vs per capita income. (Source: WHO, 2018).

INTERNATIONAL COMPARISON

The 2018 WHO Global Status Report on Road Safety provides two sets of road traffic death statistics for every country (WHO, 2018). These are the official government statistics (usually based on police data) reported by each country to WHO, and estimates produced by WHO through statistical analysis of national health data (including vital registration). Figure 5 shows the official RTI fatality rates for different countries plotted against per capita income of the countries and Figure 6 shows the rates for the same countries as estimated by the WHO (WHO, 2018). These figures show that for 43% of the countries the WHO estimates

Lower national income levels 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.

Figure 6. RTI fatality rate per 100,000 persons as estimated by WHO for different countries vs per capita income. (Source: WHO, 2018).
are 1.5 times greater and for 26% more than 3 times greater than the official rates reported by the countries.

The ratio of WHO estimate and the official rate for different countries is shown in Figure 7. The ratio for India is 2.0 as the official reported rate is 11.4 deaths per 100,000 persons and the WHO estimate 22.6. These data indicate that some countries with similar incomes have lower levels of under-reporting and some with higher income levels have also have higher levels of under-reporting. This suggests that lower national income levels cannot be taken as an 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 WHO estimates (Figures 5 and 6) 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 2 shows the different indicators generally used for assessing RTI issues (Mohan et al. 2006). Out of all these indicators we only use the number of fatalities and fatalities per 100,000 population for most of our analyses. Only fatality statistics from 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 are 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 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 and Narayan 2003, Hupkes 1982, Santos et al. 2011, Transport for London 2011, Zegras 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-time crashes, hit and run cases, and crashes on rural roads (Abay 2015, Amoros, Martin, and Laumon 2006, Rosman and Knuiman 1994, Derriks and Mak 2007).

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

<table>
<thead>
<tr>
<th>Table 2. Examples of commonly used indicators of the road traffic injury problem. Source: Mohan, D. et al., 2006.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Index</strong></td>
</tr>
<tr>
<td>--------------------------------</td>
</tr>
<tr>
<td>Number of injuries</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Number of deaths</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Fatalities per 10,000 vehicles</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Fatalities per 100,000 population</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Fatalities per vehicle-kilometre travelled</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Disability-adjusted life years (DALYS)</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
India and cities are all overestimates (as 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 from place to place (Mohan and Tiwari 2000). The number of fatalities per 10,000 vehicles always decreases as the number of vehicles per capita increase in a society even when no specific safety measures have been put in place (Adams 1987).

Data from MoRTH reports

The latest report on RTI in India, Road accidents in India – 2018 (Transport Research Wing 2019), includes many tables giving details of crashes as reported to the Transport Research Wing (Ministry of Road Transport & Highways, Government of India). Much of the details provided in the official report for RTI in India could not be used in the present analysis as the data do not appear to be reliable. A summary of the reasons why data from various tables in the report could not be used is given in Table 3.

For example, Table 2.6 and Annexure Numbers 27 in the MoRTH report refer to the following details:

Table 2.6: Road accidents, fatalities and injuries by type of collision – 2018.
Annexure 27: Accidents classified according to Nature of Accidents during the calendar year 2016.

In item Table 2.6 the classification is done according to victims by road user categories. If we just take the case of pedestrians in the table, we are informed that a total of 24,861 pedestrians died in 2018 in India (14.96% of the total). The table in Annexure 27 classifies accidents according to ‘nature of accidents’ and records that fatalities due to impacts with pedestrians, animals, trees, and other objects are only 9% of total fatalities. Not only are these two numbers different, but these are very low proportions for pedestrian fatalities in India.

Work done by independent researchers using police reports (same sources as used by MoRTH) from different cities and highway locations show very different results as shown in Table 4 (Mani and Tagat 2013, Delhi Traffic Police 2014, Tiwari, Mohan, and Gupta 2000, Tiwari 2015). 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. A more recent study (Dandona, et al, 2020) reports that pedestrians accounted for 76,729 (35.1%) of all deaths due to road injuries, and motorcyclists accounted for 67,524 (30.9%). These data make it clear that the proportion of pedestrian fatalities in India cannot be as low as 15 or 9 per cent. In all probability, the pedestrian fatalities may comprise around 30-35 percent 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 MoRTH reports are erroneous and cannot be used for any statistical analysis.
Table 3. Summary of reasons why data from some tables in the Road accidents in India – 2018 (Transport Research Wing, 2019) report could not be used in the present analysis.

<table>
<thead>
<tr>
<th>Annexure No</th>
<th>Details</th>
<th>Comment</th>
<th>Data used in this report</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Road Accidents, Persons Killed and Injured: 1970-2018</td>
<td>Data on person injured and accidents not reliable.</td>
<td>Only fatality data</td>
</tr>
<tr>
<td>2</td>
<td>Total Number of Road Accidents in India: 2015 to 2018</td>
<td>Not reliable</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>Total Number of Persons Killed in Road Accidents in India: 2015 to 2018</td>
<td>Data by state</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Total Number of Persons Injured in Road Accidents in India: 2015 to 2018</td>
<td>Numbers unreliable</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>Total Number of Fatal Road Accidents in States/UTs: 2015-2018</td>
<td>Total fatal accident statistics, not number of persons</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>Severity of Road Accidents in India (State/UT-wise): 2015 to 2018</td>
<td>Accident number unreliable</td>
<td>No</td>
</tr>
<tr>
<td>7</td>
<td>Type of Road accidents in States/UTs in 2018</td>
<td>Includes grievous injury, minor and non-Injury accidents - unreliable</td>
<td>No</td>
</tr>
<tr>
<td>8</td>
<td>Total number of Grevious and Minor Injured Persons in Road Accidents on all roads</td>
<td>Unreliable</td>
<td>No</td>
</tr>
<tr>
<td>9</td>
<td>Total Number of Road Accidents on National Highways: 2015 to 2018</td>
<td>Unreliable</td>
<td>No</td>
</tr>
<tr>
<td>10</td>
<td>Total Number of Persons Killed in Road Accidents on National Highways: 2015 to 2018</td>
<td>Data by state</td>
<td>Yes</td>
</tr>
<tr>
<td>11</td>
<td>Total Number of Persons Injured in Road Accidents on National Highways*: 2015 to 2018</td>
<td>Data on persons injured not reliable</td>
<td>No</td>
</tr>
<tr>
<td>12</td>
<td>Total Number of Fatal Road Accidents on National Highways*: 2015-2018</td>
<td>Fatal accident data not used</td>
<td>No</td>
</tr>
<tr>
<td>13</td>
<td>Total number of Grevious and Minor Injured Persons in Road Accidents on National Highways during the calendar year 2018</td>
<td>Data on persons injured not reliable</td>
<td>No</td>
</tr>
<tr>
<td>14</td>
<td>Total Number of Road Accidents on State Highways: 2015 to 2018</td>
<td>Unreliable</td>
<td>No</td>
</tr>
<tr>
<td>15</td>
<td>Total Number of Persons Killed in Road Accidents on State Highways: 2015 to 2018</td>
<td>Fatality statistics used</td>
<td>Yes</td>
</tr>
<tr>
<td>16</td>
<td>Total Number of Persons Injured in Road Accidents on State Highways: 2015 to 2018</td>
<td>Injury statistics unreliable</td>
<td>No</td>
</tr>
<tr>
<td>17</td>
<td>Total Number of Fatal Road Accidents on State Highways: 2015-2018</td>
<td>Accident numbers not used</td>
<td>No</td>
</tr>
<tr>
<td>18</td>
<td>Total number of Grevious and Minor Injured Persons in Road Accidents on State</td>
<td>Injury numbers unreliable</td>
<td>No</td>
</tr>
<tr>
<td>19</td>
<td>Total number of Fatal Road Accidents, Total Road Accidents, Persons Killed and Injured on Other Roads during the calendar years 2016</td>
<td>By state</td>
<td>Only fatality data used</td>
</tr>
<tr>
<td>20</td>
<td>Accidents classified according to Type of Collision during the calendar year 2018</td>
<td>Collision types overlapping. Not clear whether vehicle description is of victim’s vehicle</td>
<td>No</td>
</tr>
<tr>
<td>21</td>
<td>Accidents classified according to Type of Collision during the calendar year 2018</td>
<td>Pedestrian proportion unexpected low. Data unreliable.</td>
<td>No</td>
</tr>
<tr>
<td>22</td>
<td>Accidents classified according to Road Environment during the calendar year 2018</td>
<td>Environment classifications overlapping. Unreliable.</td>
<td>No</td>
</tr>
<tr>
<td>23</td>
<td>Accidents classified according to Road Features during the calendar year 2018</td>
<td>Road features classifications overlapping. Unreliable.</td>
<td>No</td>
</tr>
</tbody>
</table>
### Table 3 continued. Summary of reasons why data from some tables in the Road accidents in India – 2016 (Transport Research Wing 2017) report could not be used in the present analysis.

<table>
<thead>
<tr>
<th>Annexure No</th>
<th>Details</th>
<th>Comment</th>
<th>Data used in this report</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>Accidents Classified according to Type of Junctions during the calendar year 2018</td>
<td>Total fatalities at junctions amounts to 137,317. This is 91% of total fatalities. Highly unlikely. Unreliable.</td>
<td>No</td>
</tr>
<tr>
<td>25</td>
<td>Accidents Classified according to Type of Traffic Control during the calendar year 2018</td>
<td>Total fatalities at junctions amounts to 333,220. This is more than double total fatalities. Unreliable data.</td>
<td>No</td>
</tr>
<tr>
<td>26</td>
<td>Accidents Classified according to Type of Weather Condition during the calendar year 2018</td>
<td>Weather condition severity not known.</td>
<td>No</td>
</tr>
<tr>
<td>27</td>
<td>Accidents classified according to type of impacting vehicles / objects : 2018</td>
<td>Fatalities due to impacts with pedestrians, animals, trees, and other objects are only 9% of total fatalities. All data unreliable.</td>
<td>No</td>
</tr>
<tr>
<td>28</td>
<td>Accidents Classified according to Age of impacting Vehicles during the calendar year 2018</td>
<td>Definition of impacting vehicle unknown.</td>
<td>No</td>
</tr>
<tr>
<td>29</td>
<td>Accidents classified according to Load Condition of Involved Vehicle during the calendar year 2018</td>
<td>Loading condition not defined. Overloaded/landing clubbed together.</td>
<td>No</td>
</tr>
<tr>
<td>30</td>
<td>Male and Female Persons Killed in Road Accidents in terms of Road User categories in 2018</td>
<td>Pedestrian proportion unexpected low - 15%. Data unreliable.</td>
<td>No</td>
</tr>
<tr>
<td>31</td>
<td>Total number of Persons Killed according to classification of age and sex 2018</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Drivers Killed according to classification of age and sex, 2018</td>
<td>See comment for Annexure 35. Data unreliable.</td>
<td>No</td>
</tr>
<tr>
<td>33</td>
<td>Passengers Killed according to classification of age and sex, 2018</td>
<td>See comment for Annexure 35. Data unreliable.</td>
<td>No</td>
</tr>
<tr>
<td>34</td>
<td>Cyclist Killed according to classification of age and sex, 2018</td>
<td>See comment for Annexure 35. Data unreliable.</td>
<td>No</td>
</tr>
<tr>
<td>35</td>
<td>Pedestrians killed according to classification of age and sex, 2018</td>
<td>Pedestrians killed total to 15% of all killed. This is an unrealistic proportion and the data are unreliable. Therefore, statistics by age for all</td>
<td>No</td>
</tr>
<tr>
<td>36</td>
<td>Accidents Classified according to Type of Traffic Violations during the calendar year 2018</td>
<td>Variables not mutually exclusive. Data unreliable.</td>
<td>No</td>
</tr>
<tr>
<td>37</td>
<td>Accidents classified according to Licence of Drivers during the calendar year 2018</td>
<td>Accident data unreliable.</td>
<td>No</td>
</tr>
<tr>
<td>38</td>
<td>Accidents Victims Classified according to Non-Use of Safety Device (Non Wearing of Helmet) during the calendar year 2018</td>
<td>No information on how this was ascertained or whether helmet strapped or not.</td>
<td>No</td>
</tr>
<tr>
<td>39</td>
<td>Accidents Classified according to Non-Use of Safety Device ( Non-Wearing of Seat Belt) by Victims during the calendar year 2018</td>
<td>No information on how this was ascertained or whether belt buckled or not.</td>
<td>No</td>
</tr>
<tr>
<td>40</td>
<td>Total Number of Accidents, Number of Persons Killed and Number of Persons Injured in Road Accidents in Urban &amp; Rural Areas:</td>
<td>Definitions of urban and rural not mentioned</td>
<td>No</td>
</tr>
<tr>
<td>41</td>
<td>Fatal Road Accidents in Rural and Urban Areas during the calendar year 2018</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Month-Wise total number of accidents, persons killed and injured during the calendar year 2018</td>
<td>Only fatality data reliable</td>
<td>Yes</td>
</tr>
<tr>
<td>43</td>
<td>Road Accidents as per time of occurrence 2018</td>
<td>Accident data not reliable</td>
<td>No</td>
</tr>
<tr>
<td>44</td>
<td>Performance of States/UTs in Reducing Number of Road Accidents in 2018</td>
<td>Accident data not reliable</td>
<td>No</td>
</tr>
<tr>
<td>45</td>
<td>Performance of States/UTs in Reducing Number of Persons Killed in Road Accidents in 2018</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Percentage share in Total Registered Motor Vehicles in India as on 31st March</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>
Although it is clear that NCRB and MoRTH reports do not provide valid statistical tabulations on types of road users killed and other 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 relevant information. Clearly this cannot be done over a large region as researchers have 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 type of road user killed, cause of crashes and persons responsible for crashes as reported in the NCRB and MoRTH reports are not reliable.

If one of the risk factors is underestimated by a large margin then the estimates for all the other ‘causes’ or other factors becomes unreliable. Therefore, tables dealing with various causes of road traffic crashes should not be used for any analysis or policymaking.

Although it is clear that NCRB and MoRTH reports do not provide valid statistical tabulations on types of road users killed and other 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 relevant information. Clearly this cannot be done over a large region as researchers have 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 MoRTH report (Annexure 36) attributes ‘Drunken driving/consumption of alcohol and drugs’ as contributing to 4,188 deaths which amounts to only 3% of the total. Independent studies estimate alcohol and drugs as a contributing factor in more than 20-30 percent of the crashes India (Arora, Chanana, and Tejpal 2013, Das et al. 2012, Esser et al. 2015, Gururaj 2006, Mishra, Banerji, and Mohan 1984). If one of the risk factors is underestimated by a large margin then the estimates for all the other ‘causes’ or

**Table 4 : 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></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mumbai (2008-2012)</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>Delhi (2013)</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>highways</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>Rural</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2lane 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>4lane 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>6lane 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) Average of data 2008-2012, adapted from (Mani and Tagat 2013); (2) Source: (Delhi Traffic Police 2014); (3) Data from locations on 34 national and state highways in India, (Tiwari, Mohan, and Gupta 2000); (4) Source (Tiwari 2015).
other factors becomes unreliable. Therefore, tables dealing with various causes of road traffic crashes should not be used for any analysis or policymaking.

The summary of data usability in Table 3 suggests that at present MoRTH reports can only be relied upon to provide information like date, place, location and time of fatal crashes. This situation can be improved by MoRTH only with a complete revamp of the data collection systems in collaboration with the Ministry of Home Affairs and the establishment of a professional data and analysis department (National Transport Development Policy Committee 2014a).

SUMMARY

- According to official statistics 151,417 persons were killed and 469,418 injured in road traffic crashes in India in 2018. However, this is probably an underestimate for injuries, as not all injuries are reported to the police.

- The number of cars and motorised two-wheelers (MTW) registered in 2016 was 30.2 and 168.9 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 are not removed from the records. The actual number of personal vehicles on the road is estimated to be 50%-60% of those mentioned in the records.

- The extent of underreporting of road traffic deaths in India is not well understood. The ICMR, PHFI and IHME study for 2017 estimates that there were 218,876 deaths (95% UI 201,734 to 231,141) due to road injuries in India. Their mean estimate is for 2017 is 45% higher than the Government of India figure for 2018. 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 2016 was 469,418 which probably underestimates injuries requiring hospitalization by a factor of 5 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, the health burden of road traffic injuries was ranked 16th, however, in 2016 they were ranked 10th.

- Lower national income levels 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 causes of road traffic crashes should not be used for any analysis or policy making.

- 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.
Analysis of data at national level

NATIONAL FATALITY RATES

Figure 8 shows the official estimates for total number of RTI fatalities and fatalities per 100,000 persons in India from 1970 to 2018 (Transport Research Wing 2019). The total number of deaths in 2018 was 10 times greater than in 1970 with an average annual compound growth rate (AACGR) of 6%, and the fatality rate in 2018 was 4.3 times greater than in 1970 with an AACGR of 4%. There are indications that the rate of growth of fatalities in India has decreased after 2010. There have been a few periods when the absolute growth in RTI fatalities has decreased briefly, 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 (International Traffic Safety Data and Analysis Group 2015):

*Economic downturns are associated with less growth in traffic or a decline in traffic volumes. They 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

![Figure 8. Total number of RTI fatalities and fatalities per 100,000 persons in India (Source: Transport Research Wing 2019).](image-url)
predict the time period over which we might expect fatality rates to decline in different countries (Koornstra 2007, Kopits and Cropper 2005).

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 and Elvik (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 at time is to institute evidence based India specific road safety policies that are more effective.

ESTIMATES OF MODAL SHARE OF RTI FATALITIES IN INDIA

Figure 9 shows estimates of the share of different road user fatalities as reported by MoRTH (Transport Research Wing 2019), estimates made by Hsiao, M. et al. (2013), IIT Delhi, and Dandonia et al. (2020). 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, IIT Delhi 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
The MoRTH estimates suggest that pedestrian fatalities constitute only 15% of total RTI fatalities in the country. The Hsiao et al. (2013), IIT Delhi and Dandona et al. (2020) estimates for share of pedestrian fatalities are 37%, 33% and 35% respectively. This is a very large gap between the official and researchers’ estimates. Since Hsiao et al. and Dandona et al. have estimated the fatalities from verbal autopsies with a statistically representative sample of households in India (a part of the Sample Registration System of the Registrar General of India), it is likely that their numbers are closer to the truth. The IIT Delhi estimate is made from detailed analysis of police reports from various parts of the country, and therefore, may be considered as being based on official data, though from a smaller sample in the country. Since these latter estimates for pedestrian fatalities are similar, it is quite
It is not known why the involvement rate of children (<15 years) and the elderly (>59 years) 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.

In India the ratio of female : male fatalities in 2016 was 1:6.1 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 could be a lower participation rate in formal employment in India.

It is certain that these estimates are more reliable than those in MoRTH reports. The error in the official reports probably arises from wrong coding of the victims’ status and the procedure needs to be reviewed carefully and revised. The Indian official estimates of pedestrian fatalities are extremely low compared to independent researchers’ estimates (~15% vs ~35%), therefore, official estimates for all other modes will also be wrong. For the time being we will have to use research estimates for modal share of road traffic fatalities and not the official number.

FATALITY DISTRIBUTION BY AGE AND SEX

Figure 10 shows the RTI fatalities and population distribution by age in India and USA (National Center for Statistics and Analysis 2015, Central Bureau of Health Intelligence 2019, Transport Research Wing 2019). In India, the proportion of fatalities for the age group 18-59 is greater than their representation in the population and less for the age groups 0-18 years (1:5 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.

In India the ratio of female : male fatalities in 2016 was 1:6.1 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 could be a lower participation rate in formal employment in India.

Figure 10. RTI fatality distribution and population distribution by age in India and USA. (Source: Transport Research Wing 2019 and National Center for Statistics and Analysis 2015).
It is not known why the involvement rate of children (<18 years) and the elderly (>59 years) in India is lower than that in the USA when a large number of children walk, cycle and travel in 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 a greater focus on policies for ensuring safety of older persons on the roads.

In India the ratio of female: male fatalities in 2018 was 1:6.1 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 could be a lower 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 11 shows the total number of fatalities by state and union territory in 2015 and 2018 (Transport Research Wing 2019). According to the reported statistics the total number of deaths in 2018 decreased by more than 10% in 5 states and union territories (Mizoram-38%, Chandigarh-24%, Tamilnadu-22%, Andaman & Nicobar Islands-17%, Goa-16%), was 10% higher or lower in 16 states (Andhra Pradesh, West Bengal, Telangana, Puducherry, Manipur, Punjab, Rajasthan, Gujarat, Meghalaya, Maharashtra, Karnataka, Kerala, Delhi, Haryana, Jammu & Kashmir, Himachal Pradesh), and increased by more than 10% in 11 states (Chhattisgarh, Uttarakhand, Madhya Pradesh, Jharkhand, Odisha, Assam, Bihar, Uttar Pradesh, Nagaland, Tripura, Arunachal Pradesh). No studies are available that can explain the reason for these changes.

Figure 12 shows the fatalities per 100,000 population for states and union territories in 2015 and 2018. The six highest fatality rates (greater than 15 per 100,000 population) in 2018 were recorded in Chhattisgarh (17.3), Haryana (18.4), Himachal Pradesh (16.8), Karnataka (17.3), Punjab (16) and Tamil Nadu (17.4). It is important to note that large states with high number of RTI fatalities are not necessarily the ones which have high rates per hundred thousand persons. Large states (with more than 1,000 deaths in 2018) with the six lowest rates per hundred thousand persons were West Bengal (6.1), Bihar (6.3), Andhra Pradesh (8.4), Assam (8.9), Uttarakhand (9.6) and Uttar Pradesh (9.9).

Compared with fatality rates in 2015 the fatality rates per hundred thousand persons in 2018 increased in fifteen states and union territories and reduced in fifteen. The large states with more than 10% increase in rates were Uttar Pradesh (21%), Odisha (20%), Bihar (19%), Assam (19%) Jharkhand (18%) and Madhya Pradesh (11%). The large states with more than 10% decrease were West Bengal (10%), Andhra Pradesh (12%), and Tamil Nadu (23%).

The reasons for differences in fatality rates among states are not known. These data indicate that the higher income states tend to have higher RTI fatality rates but there is a wide scatter in the data. It is possible that the richer states have higher motor vehicle ownership and also a greater proportion of 4-6 lane divided highways without adequate attention to safe design.
Figure 1. Total number of fatalities by state and territory in 2015 and 2018 (Source: Transport Research Wing 2019).
Figure 12. Total number of fatalities per 100,000 population by state and territory in 1996 2015 and 2018 (Source: Transport Research Wing 2019).

Note: Population for Telangana is not available and it is included in Andhra Pradesh Population
However, since there is no reliable information available regarding use of safety equipment (like helmets and seatbelts), enforcement of speed regulations and implementation of safer road design features in different states it is impossible assign any scientific reasons for these differences. However, it is surprising that the number of fatalities in Bihar in 2018 was greater by 24% as compared to that in 2015 even though alcohol was banned in the state from 1 April 2016. Similarly, it is not possible to find out why the fatality rates have decreased in West Bengal, Andhra Pradesh, and Tamil Nadu as no data are available on what safety policies were responsible for these changes.

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 or state income, it suggests that state RTI fatality rates may be more influenced by quality and design of infrastructure, 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 2018 was 10 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%.
- The only way the decline of RTI fatalities can be brought forward in time is to institute evidence based India-specific road safety policies that are more effective.
- The Indian official estimates of pedestrian fatalities are extremely low compared to independent researchers’ estimates (~15% vs ~35%), therefore, official estimates for all other modes will also be wrong.
- 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 the involvement rate of children (<18 years) and the elderly (>59 years) 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.

- Compared with the situation in 2015, the total number of deaths in 2018 decreased by more than 10% in 5 states and union territories, was 10% higher or lower in 16 states, and increased by more than 10% in 11 states.
- Fatality rates per hundred thousand persons in 2018 increased in fifteen states and union territories and reduced in fifteen.
- Since RTI fatality rates in states and union territories do not seem to be influenced strongly by location in the country (culture) 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 an influence on vulnerable road user safety than current practice of focussing on motor vehicles as has been the practice up to now. This will 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.
Urban safety

CITY DATA

According to the MoRTH report 51,379 (34%) fatalities took place in urban areas and 100,038 (66%) in rural areas (Transport Research Wing, 2019). These data suggest that the urban RTI fatality share is about the same as the estimated urban population share (34%) in 2018. 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 17,709 fatalities (34% of all urban RTI deaths). In this chapter, we only use total fatality data for cities from the MoRTH report (other data are not reliable) and detailed analysis based on data reported in published research reports.

Data for 50 cities are included (population greater than 1 million) in the MoRTH report published in 2019. Figure 13 shows deaths reported in these cities for the years 2015 and 2018. Data for cities that did not have populations greater than 1 million in 2011 are not available. These data show that compared to 2015 the number of deaths in 2018 changed as follows:

- Increased by more than 10% in 19 cities: Agra, Allahabad, Asansol Durgapur, Bhopal, Chennai, Dhanbad, Faridabad, Ghaziabad, Gwalior, Jaipur, Kollam, Ludhiana, Meerut, Patna, Rajkot, Surat, Thiruvanthapuram, Thrissur and Varanasi.
- Remained about the same in 15 cities (increase or decrease of 10%): Ahmedabad, Aurangabad, Bengaluru, Delhi, Jabalpur, Jamshedpur, Kannur, Kanpur, Khozikode, Lucknow, Mallapuram, Nagpur, Nashik, Raipur, Vijaywada.
- Decreased by more than 10% in 15 cities: Amritsar, Chandigarh, Coimbatore, Hyderabad, Indore, Jodhpur, Kochi, Kolkata, Kota, Madurai, Mumbai, Pune, Srinagar, Tiruchirapalli, Vadodra and Visakhapatnam.

The cities of Thrissur, Patna and Dhanbad show increases of 98%, 129% and 425% respectively over the period 2015-2018. These increases are much larger than all the other cities, the closest in percentage increase being Jaipur with 45%. Such large increases are not usual over a period of three years and it is possible that there may be a misreporting of data. The increase in fatalities in Chennai over the same period was 42%, whereas the state of Tamil Nadu recorded a decrease of 22%. It is curious why the fatalities in Chennai did not decrease when they showed a significant decrease in the state.

It is not possible to explain the causes of these increases and decreases in the city fatality rates as they do not have any correlation with the size of the cities or their location in India.

Figure 14 shows the RTI deaths rates per 100,000 population in million plus cities for 2015 and 2018. Population numbers for these for these cities are not available for the years 2015 and 2018 from the Office of the Registrar General & Census Commissioner, India. Population for each city in 2015 and 2018 was estimated using 2011 official figures.

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Figure 13. Annual RTI deaths in million plus cities 2015 and 2018 (Source: Transport Research Wing 2019).
Figure 14. RTI fatality rate per 100,000 persons in million plus cities in India, 20015 and 2018 (Source: Transport Research Wing 2017).

Note: Population of cities for 2015 and 2018 estimated from the base population in 2011, details in text.
The Office of the Registrar General of India has published estimates for total population by sex as on 1st March for all states and union territories of India for every year 2001 to 2026. The ratios of populations in each state for the years 2015 and 2018 as compared to 2011 were obtained from this publication. The population for each city in 2011 is available from the Census of India 2011. The populations for all cities in 2015 and 2018 were estimated by using the ratios obtained for their respective states.

In 2018 the average fatality rate for all fifty million plus cities combined was 14.6 per 100,000 persons which is 30% greater than the national average of 11.2. Cities that recorded fifty percent higher or lower rates than the average were:

- Eight cities with 50% higher rates than the average for all cities in 2018 (greater than 22 fatalities per 100,000 persons): Agra, Allahabad, Gwalior, Jabalpur, Meerut, Patna, Raipur and Vijaywada.
- Ten cities with 50% lower rates than the average for all cities in 2018 (less than 7 fatalities per 100,000 persons): Ahmedabad, Amritsar, Hyderabad, Kannur, Kochi, Kolkata, Mumbai, Pune, Srinagar and Surat.

It is not possible to explain the causes of these increases and decreases in the city fatality rates as they do not have any correlation with the size of the cities or their location in India.

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Table 5. Proportion of road traffic fatalities by road user type in nine Indian cities (Source: see text)

<table>
<thead>
<tr>
<th>City</th>
<th>Population</th>
<th>Pedestrian</th>
<th>Bicycle</th>
<th>Motorised two-wheeler</th>
<th>Auto-ricksha</th>
<th>Car &amp; taxi</th>
<th>Bus</th>
<th>Truck</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delhi (2018)</td>
<td>1,99,58,118</td>
<td>46</td>
<td>3</td>
<td>34</td>
<td>-</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Agra (2013-15)</td>
<td>15,74,542</td>
<td>41</td>
<td>10</td>
<td>37</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Amritsar (2013-15)</td>
<td>11,32,761</td>
<td>27</td>
<td>20</td>
<td>40</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Bhopal (2013-15)</td>
<td>17,95,648</td>
<td>41</td>
<td>5</td>
<td>44</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Ludhiana (2013-15)</td>
<td>16,13,878</td>
<td>35</td>
<td>23</td>
<td>35</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vadodara (2013-15)</td>
<td>16,66,703</td>
<td>32</td>
<td>12</td>
<td>41</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Visakhapatnam (2013-15)</td>
<td>17,30,320</td>
<td>43</td>
<td>6</td>
<td>35</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Patiala (2015-2018)</td>
<td>4,80,000</td>
<td>22</td>
<td>14</td>
<td>51</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bulandshahr (2015-2018)</td>
<td>2,80,000</td>
<td>26</td>
<td>7</td>
<td>51</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

RTI DETAILS FOR SELECTED CITIES

Table 5 shows the proportion of road traffic fatalities by road user type in nine Indian cities. These cities vary in population from 280 thousand to twenty million. The data for Delhi was obtained from the Delhi Police and for all other cities by analysing First Information Reports (FIR) obtained for a period of three years from all the police stations in each city (Mohan, Tiwari, and Mukherjee 2013).

The proportion of vulnerable road user (pedestrians, bicyclists and motorised two-wheelers) deaths in the nine cities range between 84% and 93%, car occupant fatalities between 2% and 7%, and occupants of three-wheeled scooter taxis (TSTs) less than 5% per cent, except in Vishakhapatnam where the proportion for the latter is 8%. The total of vulnerable road user deaths remains relatively stable across cities of different sizes and the proportion of pedestrian deaths appears to be higher in cities with larger population.

RTI victims and impacting vehicles

Figure 15 shows the data for the distribution of road traffic fatalities by road user category versus the respective impacting vehicles/objects for two of the nine cities, Vishakhapatnam and Bhopal. These two cities are representative of the patterns in all the cities studied 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 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 the arterial roads of these cities and that they have to share the road space (the curb side lane) with MTW riders.

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

Figure 16 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 as their 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 work 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 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.

**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 17 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 that 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 (Mohan and Roy 2003, Wilbur Smith Associates 2008, Chanchani and Rajkotia 2012). The results of these calculations are shown in Figure 18. 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 Vishakhapatnam are much higher than the other three cities. The reasons for this
Owing 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 may be the cause of high crash rates at night.

A MTW rider is 3-6 times more at risk than a car occupant and it is very important to focus on their safety (helmet use and daytime running lights).

Figure 18. Occupant fatality rates per 10 million trips.

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 19 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

Figure 19. All fatalities associated with each vehicle category per 100,000 vehicle km (estimated).
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 medium sized 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 was not enforced in any of the smaller 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) is 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 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 percent of the total. The involvement of MTWs as impacting vehicles in VRU fatalities maybe due to the fact that pedestrians and bicyclists do not have adequate facilities on the 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 and need to be studied. Relative risk of occupants of MTW is the highest but not as high as in 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 three-wheeled scooter taxis. Further research is necessary to determine the veracity of these findings.
SUMMARY

- In 2018 the average fatality rate for all fifty million plus cities combined was 14.6 per 100,000 persons which is 30% greater than the national average of 11.2. For 33 cities where the data can be compared between 2006 and 2016 only 15 recorded 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 the cities the death rate increased by more than 50% in a period of 10 years.
- Compared to 2015 the number of deaths in 2018 increased by more than 10% in 19 cities, remained about the same in 15 cities, and decreased by more than 10% in 15 cities. Significant reduction in number of deaths was 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 is leading to decreases in vehicle speeds may have contributed to this.
- Eight cities with 50% higher rates than the average for all cities in 2018 (greater than 22 fatalities per 100,000 persons): Agra, Allahabad, Gwalior, Jabalpur, Meerut, Patna, Raipur and Vijaywada.
- Ten cities with 50% lower rates than the average for all cities in 2018 (less than 7 fatalities per 100,000 persons): Ahmedabad, Amritsar, Hyderabad, Kannur, Kochi, Kolkata, Mumbai, Pune, Srinagar and Surat.
- It is not possible to explain the causes of these increases and decreases in the city fatality rates as they do not have any correlation with the size of the cities or their location in India.
- The proportion of vulnerable road user (pedestrians, bicyclists and motorised two-wheelers) deaths in the nine cities range between 84% and 93%, car occupant fatalities between 2% and 7%, and occupants of three-wheeled scooter taxis (TSTs) less than 5% per cent, except in Vishakhapatnam where the proportion for the latter is 8%.
- An 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.
- 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.
- Following countermeasures need to be given priority in cities: Safe pedestrians paths and crossing facilities, speed control by traffic calming measures like raised pedestrian crossings, change of road texture, rumble strips and use of roundabouts.
**Interchange 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 up gradation has been improving inter-city and interstate connectivity through capacity enhancement as well as improving highway safety.

**Traffic crashes on Indian Highways**

Figure 20 shows the proportion of RTI fatalities on different categories of roads and the proportion of road length for each category (Transport Research Wing, 2019). Fatality rate per km of road is the highest on National Highways with 47.3 deaths per 100 km annually (Figure 21). The relatively high death rate on NH could be because they carry a significant proportion of passenger and freight traffic. 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.

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 and Tiwari 2015).

![Proportion of fatalities on different road categories](image-url)

Figure 20. the proportion of RTI fatalities on different categories of roads and the proportion of road length for each category (Source: Transport Research Wing, 2019)
Recent studies show 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.

A 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.

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.

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.

![Figure 21. Fatalities per 100 km on different categories of roads in India in 2018 (Source: Transport Research Wing, 2019).](image)

**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, Mohan, and Gupta 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:

a. The data available from the police records misses out many minor injury and single vehicle accidents.

b. 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 she 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, 4lane NH24, and 6lane NH1 (Tiwari 2015). The results for modal shares of those killed on these locations are given in Table 6. 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. 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 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 victims is higher.

Table 7 shows the involvement of different impacting vehicles in fatal crashes on highways. This shows that as far as vehicle involvement is concerned the patterns are similar in urban and rural area. 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 at many locations there is high-density habitation along the highways, and this may result in the use of many sections of the highway as urban arterial arterials. 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 8 shows the distribution of crash types by type of highway and type of crash (Tiwari, Mohan, and Gupta 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.

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 developed for the placement of cuts in the median or for providing under/overpasses for vehicles at convenient locations.

Table 7 and 8 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. For these types 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 audible & vibratory pavement markings, 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 and Patel (2002) and Shrinivas (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, Venkatramayya, and Kashinath (2004) have done a study of crashes on the 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 and Patel 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, Mohammed, and Rajeevan (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. The 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 collisions due to them going the wrong way on divided highways by provision of safe road crossings at convenient distances. Solutions for many of these issues are not readily available and research studies are necessary for evolution of new designs.

SUMMARY

• National Highways comprise only 2% of the total length of roads in India but account for 36% of the fatalities. Fatality rate per km of the road is the highest on NH with 0.67 deaths per km annually and this fact should be the guiding factor in future design considerations
• A majority (68%) of those getting killed on highways in India comprise vulnerable road users
• Data from three highway segments from 2009-2013 show a similar pattern. Pedestrian and MTW proportions are very high except on six-lane highways 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 audible & vibratory pavement markings, provision of frequent and convenient underpasses (at the same level as surrounding land) for pedestrians, bicycles and other non-motorized 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.
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 11 and the output normalised for population (2011) shown in Table 12 (National Transport Development Policy Committee 2014b). These tables show that not only does India fare poorly in terms of total output, but that 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 13) 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. 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

Table 11. Number of academic articles published originating in India, China, and Brazil in the period 2006-2010. (Source: Scopus™).

<table>
<thead>
<tr>
<th>Area</th>
<th>India</th>
<th>China</th>
<th>Brazil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Safety</td>
<td>120</td>
<td>911</td>
<td>118</td>
</tr>
<tr>
<td>Railways</td>
<td>121</td>
<td>2,167</td>
<td>28</td>
</tr>
<tr>
<td>Emissions</td>
<td>15</td>
<td>60</td>
<td>51</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>151</td>
<td>1,234</td>
<td>19</td>
</tr>
<tr>
<td>Air Transport</td>
<td>33</td>
<td>323</td>
<td>29</td>
</tr>
<tr>
<td>Marine Transport</td>
<td>12</td>
<td>97</td>
<td>1</td>
</tr>
<tr>
<td>Transport Planning</td>
<td>18</td>
<td>129</td>
<td>13</td>
</tr>
</tbody>
</table>
productivity, the research output in India 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.

**INDIAN RESEARCH OUTPUT**

A literature 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, Google Scholar and Scopus. 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. The papers were reviewed for analysis regarding the following issues:

- Prevalence of different modes/factors on accident rates in different environment.
- Exposure of RTA’s on different road users.

### Table 12. 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 13. 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>China/India</td>
<td></td>
<td></td>
</tr>
<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>

When normalized 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.
- 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 and Hyder 2009).

Table 13 shows the number of papers by year of publication. The papers had the following characteristics:
- On urban themes about a third of the studies had statistical analysis involving modelling.
- On highway themes about a third of studies had statistical analysis involving modelling.
- On public transportation themes about a quarter of the studies had statistical analysis involving modelling.
- In national trends 25% studies had statistical analysis involving modelling.
- The number of papers published that dealt with road safety in India increased to 68 in 2016. However, almost half of these papers were hospital based and only recorded the type of injuries sustained in road traffic crashes. These studies do not include any epidemiological details of risk factors for different road users. Less than 10% of the papers published included any detailed epidemiological analysis of road traffic crashes in India. A list of the papers published 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 worldwide.
- When normalized 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, research output in India 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.
- Road traffic injury research output is still subcritical in India and not enough original research findings can be used for India specific policy making for the future.
International knowledge base

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 and Elvik 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 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 2001).

In general, the deterrent effect of a law is determined in part by the swiftness and visibility of the penalty for disobeying the law, 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 (Sweedler et al. 2004, Elder et al. 2004, Koornstra 2007).

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 2001, OECD 1986). Most highway safety educational programmes do not work. They do not reduce motor-vehicle crash deaths and injuries (Robertson et al. 1974, Robertson 1980, 1983). Only a few programmes have ever been shown to work, and contrary to the view that education cannot do any harm, some programmes have been shown to make matters worse (Robertson 1980, Sandels 1975).

Driver or pedestrian education programmes by themselves usually are insufficient to reduce crash rates (Elvik and Vaa 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, Roberts, and Bunn 2003, Roberts and Kwan 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, Bijleveld, and Davidse 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 driver education in schools result in a reduction in road-crash rates. On the other hand, they may lead to increased road-crash rates (Williams and O’Neill 1974, Vernick et al. 1999, Mayhew and Simpson 1996). 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.

Compulsory helmet use reduces bicycle-related head and facial injuries for bicyclists of all ages involved in all types of crashes,

**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% (Kent, Viano, and Crandall 2005, Crinion, Foldvary, and Lane 1975, Parkin, MacKay, and Framton 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 1993). Similar results have been confirmed for the use of daytime running lights by motorcyclists (Radin Umar, Mackay, and Hills 1996, Radin Umar 2006, Yuan 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 (Koornstra 2007, Elvik and Vaa 2004, Noland 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 and Schermers 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 1995, 2001, Hyden and Varhelyi 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 2003, O’Neill and Krychchenko 2006).

Road designs that control speeds seem to be the most effective crash control measure (Aarts and van Schagen 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**

Cochrane Reviews have concluded that (Bunn et al. 2001, Sethi et al. 2004, Kwan, Bunn, and Roberts 2004b, a):
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 and Moscati 2001). While it is desirable that we save 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 et al. 2003).

Since the evidence shows that advanced pre-hospital interventions do not necessarily improve outcomes, pre-hospital care should focus primarily on transporting victims safely to a hospital facility where they can receive definitive medical care.

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

SUMMARY

Imposing stricter penalties (in the form of higher fines or longer prison sentences) will not affect road-user behaviour significantly. In general, the deterrent effect of a law is determined in part by the swiftness and visibility of the penalty for disobeying the law, but a key factor is the perceived likelihood of being detected and sanctioned.

Driver or pedestrian education programmes by themselves usually are insufficient to reduce crash rates. Only effective way to get most motorists to use safety belts and motorcyclists to wear helmets is with good laws requiring their use and enforcement.
• Use of seatbelts and airbag-equipped cars can reduce car-occupant fatalities by over 50%.
• Use of daytime running lights on cars shows reduction in the number of multi-vehicle daytime crashes by about 10–15%. Similar results have been confirmed for the use of daytime running lights by motorcyclists.
• Traffic-calming techniques, use of roundabouts, and provision of bicycle facilities in urban areas provide significant safety benefits.
• 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.
Way forward

PRACTICE POINTS

Some of the policy options are outlined below.

**Pedestrian and bicyclist safety**

1. Reserve 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 40-50 km/h on arterial roads need to be enforced by road design and police monitoring. Maximum speeds of 30 km/h in residential areas need to be enforced by judicious use of speed-breakers 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 and enforcement of mandatory use of helmet and daytime headlights by two-wheeler riders.
2. Enforcement of seatbelt use laws countrywide.
3. Restricting front-seat travel in cars by children and the use of child seats has potential for reducing injuries to child occupants.
4. Introduction of alcohol locks.

**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. Pedestrian impact standards for buses and trucks.
4. Evaluation of policing techniques to minimize cost and maximize effectiveness.
5. Effectiveness of pre-hospital care measures.
6. 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 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.”

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.

**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.

At present the road traffic crash data as reported by the MoRTH is not detailed enough or reliable for epidemiological analysis and policy making. This can only be done if data are reported and recorded in systematic manner by a specialised central agency. The first step in this direction would be for the Ministry of Home Affairs to establish a special central department for coding and recording all fatal crash data in a systematic manner:
1. This Centre would be responsible for coding and recording details of all fatal traffic crashes based on case files of each crash. The State Crime Record Bureau of each state would have to send copies of completed fatal road accident case files every week to the national centre. The Centre will have to staffed by specially trained data coders to transfer relevant details from the case files to a fatal accident recording data base. The data so collected should be anonymised and made available publicly for analysis.

2. Centres of excellence have to be established at selected IITs/NITs which can contribute to continuous data analysis at regional and national level.

The national safety agency can then use these data for statistical analysis for different policy making purposes. 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 Organization, National Crime Record Bureau, Central Bureau of Health Intelligence, etc.
- 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 from 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.

Establish 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 is 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. The national safety agency should establish procedures for issuing calls 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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Appendix 1. List of research studies on road safety in India in 2016


Naveen Kumar, C., M. Parida, and S. S. Jain. 2016. "Recognising Risk Factors Associated with Crash Frequency on Rural Four Lane Highways.".


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