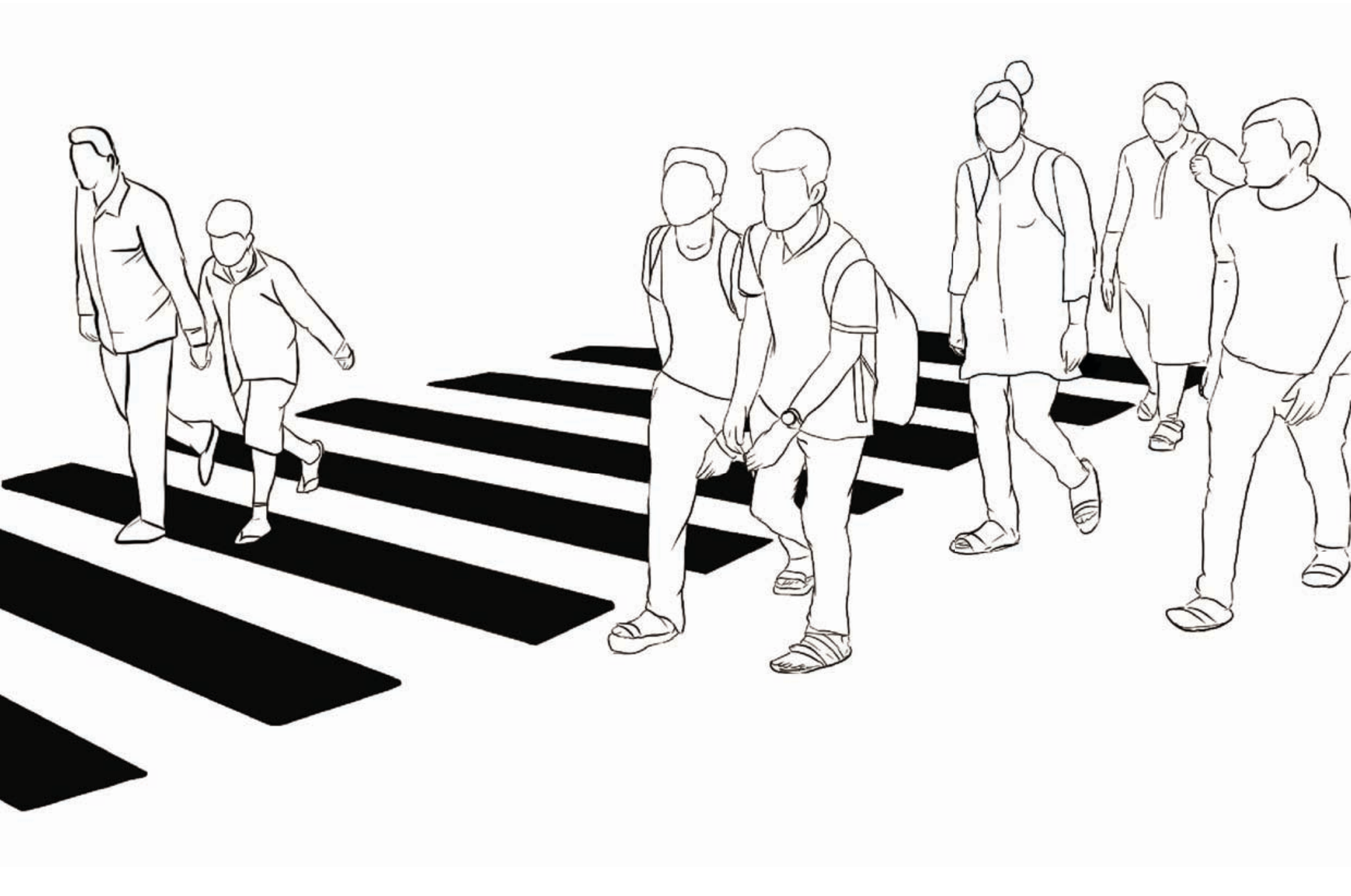
ROAD SAFETY IN INDIA: STATUS REPORT 2021



Transportation Research & Injury Prevention Centre

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

Geetam Tiwari
Rahul Goel
Kavi Bhalla

Road Safety in India: Status Report 2021

Transportation Research & Injury Prevention Centre
Indian Institute of Technology Delhi

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Acknowledgement

Road Safety in India Status report was conceptualised by Prof Dinesh Mohan who led the writing of these annual reports since 2015. He passed away in May 2021. This is the first volume of this report since his passing.

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Cover page shows the percentage distribution of road deaths among different modes of transport.

CONTENTS

EXECUTIVE SUMMARY

ROAD TRAFFIC CRASH AND INJURY DATA

• According to official statistics 151,113 persons were killed, which corresponds to 11.6 deaths per 100,000 population.

• Of those who died, only 14% are females and the rest are males. Internationally, females always have a minority share in road deaths. However, in India, their share is among the lowest in the world. This may be because of much lower exposure of females to traffic risk. Share of women in total number of motor vehicle license holder is about 6 percent, while the rest of the license holders are men.

• Over the last decade (2009-2019) road traffic crashes have been 13th largest contributor to health burden (deaths and disabilities) in India. For the working age population (15-49 years), they are the sixth largest contributor.

• The number of cars and motorised two-wheelers (MTW) registered in 2019 was 36.5 and 221.2 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.

• Censuses and population-level sample surveys indicate that percentage of households owning a car as well as those owning a MTW have more than doubled in the past decade (2008-2017). Over this period, about 1.5 million cars and 10 million motorcycles were registered every year—equivalent to 0.6% new households owning a car and 4% owning a motorcycle every year. In 2017, seven percent households owned at least one car and 45% owned at least one motorcycle. Cycle ownership, on the other hand, has stabilised between 40-45 percent.

• There is evidence suggesting that number of road deaths in India is under-reported, however, its extent is not well understood. 'Global Burden of Diseases, Injuries, and Risk Factors Study' estimated that in 2019, 211,975 deaths (95% confidence interval: 159,343 - 250,315) due to road injuries occurred in India.
This estimate is 40% greater than government-reported number of deaths. A National Burden Estimates study, using Sample Registration System (SRS) estimates of deaths by different causes, reported 275,000 road deaths in 2017. This estimate is 82% higher than the government-reported number (150,785) for the corresponding year.

• 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 2019 was 451,361 which probably underestimates injuries requiring hospitalization by a factor of 5 and all injuries by a factor of 20.

• Annual reports published by Ministry of Road Transport and Highways (MORTH) and National Crime Records Bureau (NCRB) have erroneously reported district-level deaths for million-plus cities. In some years, they have reported correctly for the cities. Because of this inconsistency, the yearly changes in road deaths in the cities are not reliable.

• 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.

• The numbers and proportions of different road users killed and injured as mentioned in Ministry of Road Transport and Highways (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.

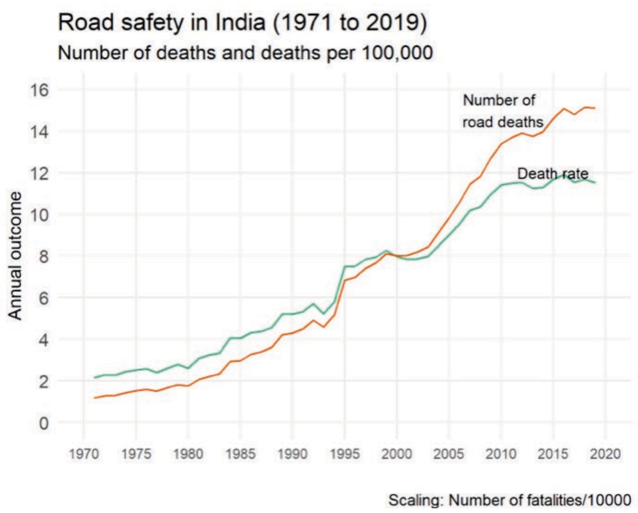


Figure 1 : Number and rate of road deaths and annual fuel consumption in India from 1971 through 2019 (Source:NCRR 2015 and transport research wing 2020. (Ref page 16)

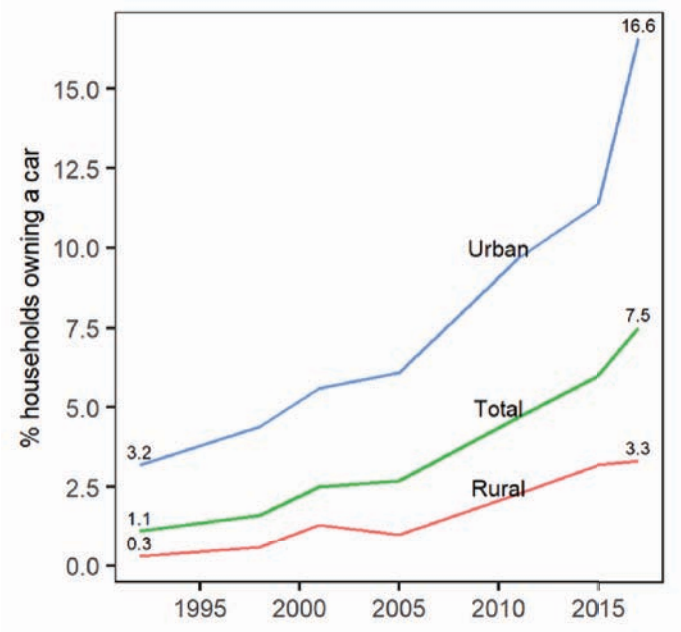
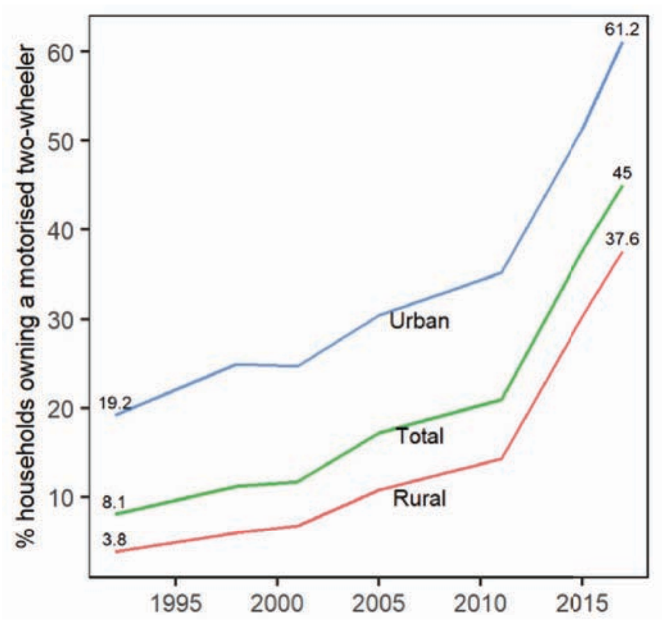


Figure 3 Car and motorcycle ownership in India (Ref page 19)



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ANALYSIS OF DATA AT NATIONAL LEVEL

• The total number of deaths in 2019 was 13 times greater than in 1971 with an average annual compound growth rate (AACGR) of 5.4%, and the fatality rate in 2019 was 5.4 times greater than in 1971 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 official estimates of share of pedestrian among all road deaths 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 be 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. Higher level of under-reporting of road deaths among older adults, as indicated by independent population-level surveys, may explain this inconsistency for older adults.

• Among the 18 largest states contributing 96% of country's road deaths, during the 5-year period from 2015 to 2019, road death rates have reduced in half the states, while they have increased in the other half. Significant reductions occurred in Tamil Nadu, Gujarat, Telangana, and West Bengal while significant increase in Assam, Bihar, Jharkhand, Odisha, Madhya Pradesh, and Uttar Pradesh.

• Tamil Nadu witnessed the greatest reduction in road death rate over the 5-year period, where the rate reduced from 25 to 15 per 100,000 persons. An in-depth understanding of how this was achieved would be useful for developing effective road safety policies across the country.

• In the states of Bihar, Uttar Pradesh, Jharkhand, and Odisha, death rates have increased by 25% or more. This is a worrying trend as these four states contribute one in four road deaths in the country.

• The impact of Motor Vehicles (Amendment) Act that was passed in August 2019 cannot be evaluated without monthly data and a greater understanding of the extent of its implementation across the states. Due to COVID restrictions in 2020 and 2021, it may be few years before a robust analysis could be done to understand its effectiveness.

• Since road death 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. 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.

• During the two-year period of 2018 and 2019, the average fatality rate for all 53 cities with a population of 1 million or more was 11.2 per 100,000 population which is slightly lower than the national average of 11.6 per 100,000.

• The five cities with the highest death rates are Allahabad, Vijayawada, Asansol, Kollam and Jaipur with an average death rate of 22 per 100,000, which is twice the national average. Cities with death rates lower than half the national average are the following (in ascending order of death rates)—Kolkata, Greater Mumbai, Srinagar, Hyderabad, Kannur, Pune and Ahmedabad.

• A detailed study of police reports of road deaths was conducted in nine Tier-I and Tier-II studies for the 2008-2011 period. The proportion of vulnerable road users (pedestrians, bicyclists, and motorised two-wheelers) among all road deaths in these cities range between 84% and 93%. Car occupants constituted between 2% and 7% of all road deaths, and occupants of three-wheeled scooter taxis less than 5 percent.

• 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 8 PM to 11 PM 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.

• 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.

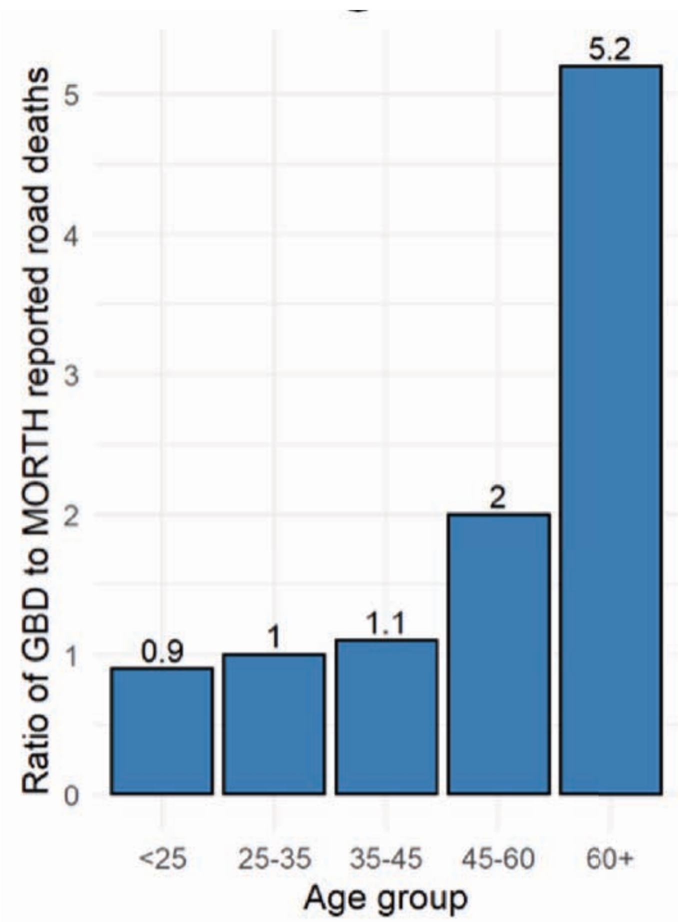


Figure 4 Age-specific comparison of GBD and MORTH reported road deaths.

Ratio of 1 indicates the two sources of data report equal number of deaths.

DISTRICT - LEVEL SAFETY

• An analysis of road traffic deaths in six districts (including urban and rural areas) of Chhattisgarh state from 2017 to 2019 shows that the motorcyclists form most of road death victims with a share of 60 percent. This share of motorcycle in road deaths is much greater than those reported in the past across multiple locations in India. This may be because of rapidly increasing ownership of motorcycles in India that is resulting in equally rapid changes in traffic injury patterns.

• Pedestrians and cyclists form the second largest group of road users among road death victims, with a total share of 25% (21% and 4%, respectively). In total the share of vulnerable road users (including motorcyclists) is about 85 percent of all deaths.

• One in four motorcycle deaths resulted from single-vehicle crashes i.e. skidding or hitting a fixed object on the road. Another 40% resulted from crashes with trucks or tractors. Up to 75% of pedestrian and cyclist deaths occurred in crashes with trucks/tractors or motorcycles.

• To contain the large burden of deaths due to motorcycle use, there needs be strict enforcement of motorcycle helmets for riders as well as passengers. The enforcement should ensure that helmets are of standard quality, correct size and are strapped properly. The enforcement should not be limited to cities or towns but should be extended to rural roads.

INTERCITY HIGHWAYS

• National Highways (including expressways) 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. 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 pedestrians, cyclists and motorcyclists. Pedestrian and MTW proportions are very high except on six-lane highways where the proportion of truck victims is much higher. The high level of involvement of vulnerable road users on highways is highly unexpected in many high-income countries.

• 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.

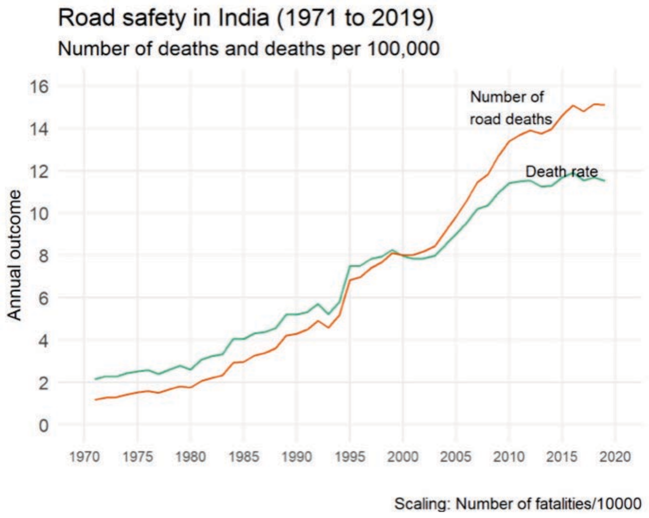
• On 4-lane divided roads head-on collisions comprise 19% of the crashes. Divided 4-lane roads are justified on the basis that these would eliminate the occurrence of head-on collisions. The fact that this is not occurring means that many vehicles are going the wrong way on divided highways. This is 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 under-passes (at the same level as surrounding land) for pedestrians, bicycles and other non-motorized transport, and traffic calming in semi-urban and habited areas.

• Analysis of road deaths on an access-controlled expressway shows that 22% of road death victims are pedestrians. This share of pedestrian even on access-controlled roads highlights that there may be large population who access these highways to either go across or to access public transportation. In any case, provisions need to be made so that either of these functions can be safely served by the expressways.

• 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.



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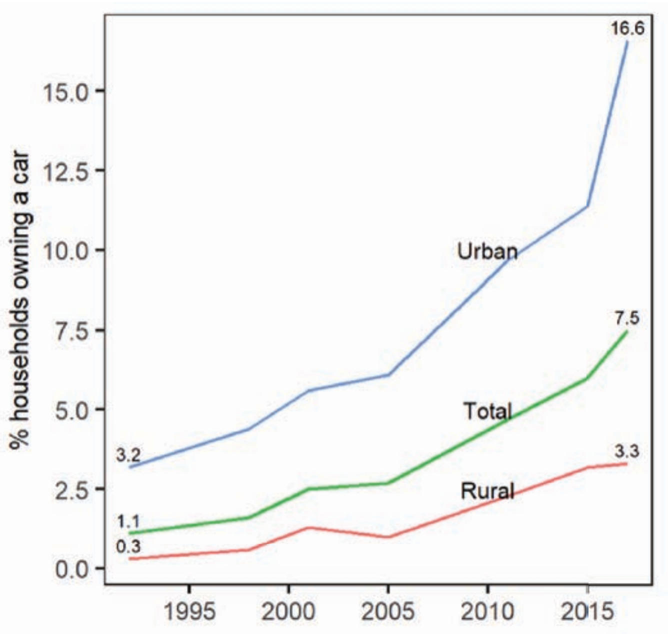

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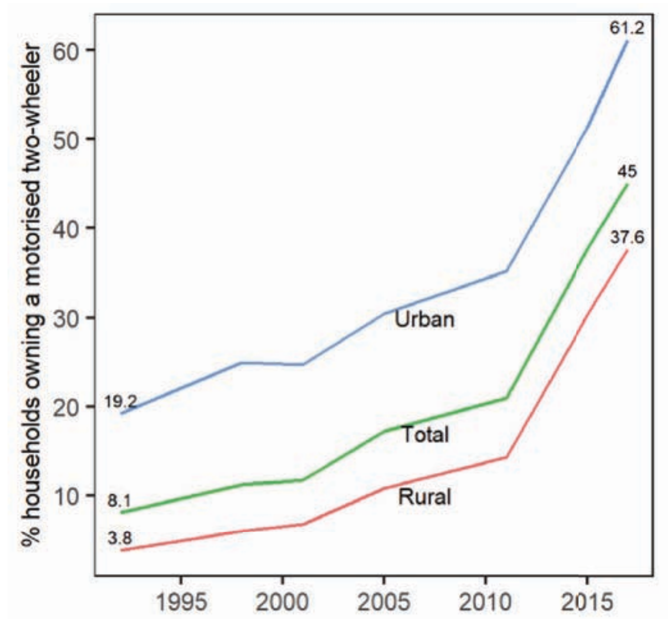

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STATUS OF RESEARCH IN ROAD SAFETY

• 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 sub-critical 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

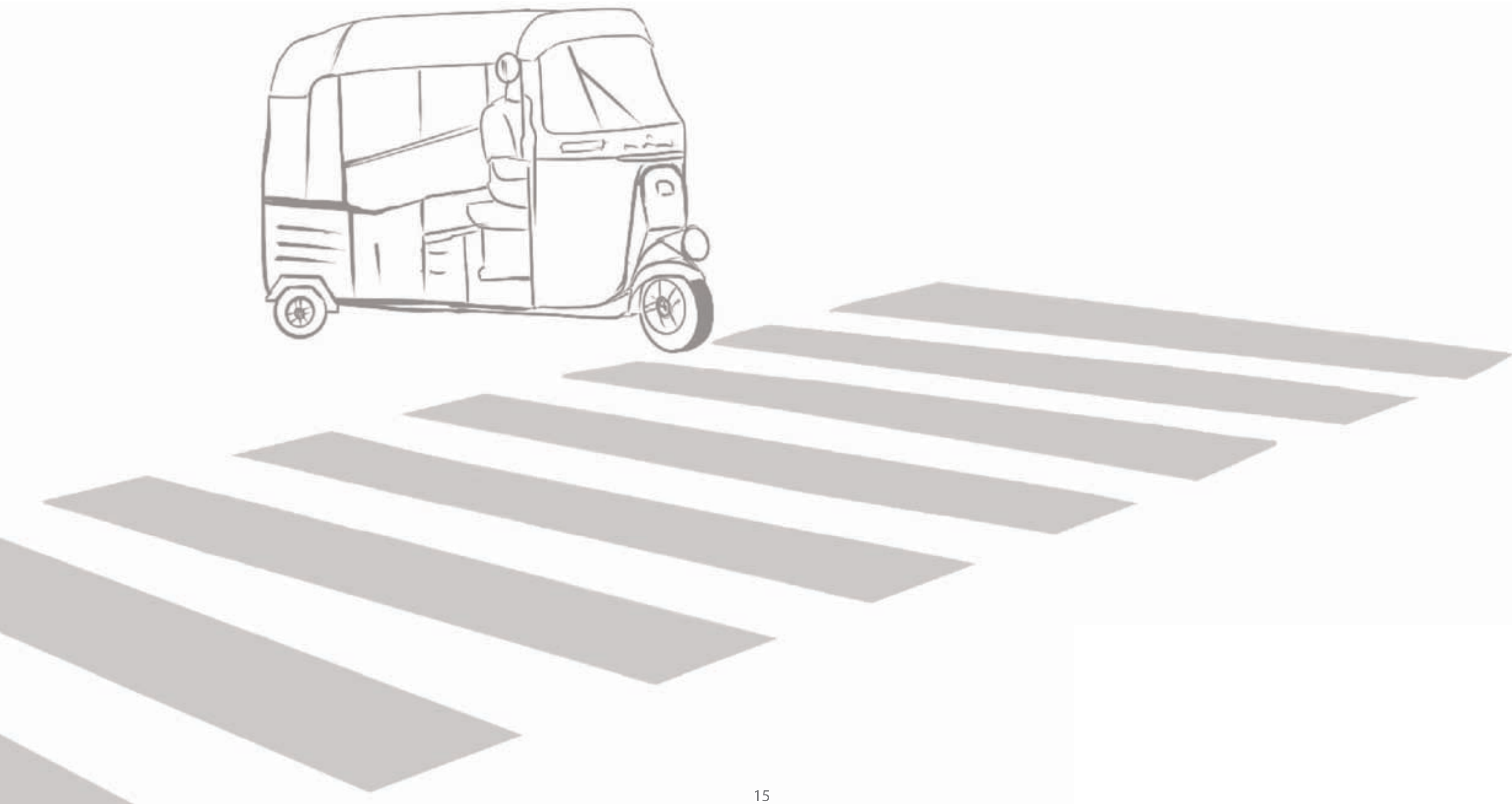
  o Development of street designs and traffic-calming measures that suit mixed traffic with a high proportion of motorcycles and non-motorized modes.
  o Highway design with adequate and safe facilities for slow traffic.
  o Pedestrian impact standards for buses & trucks.
  o Evaluation of policing techniques 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

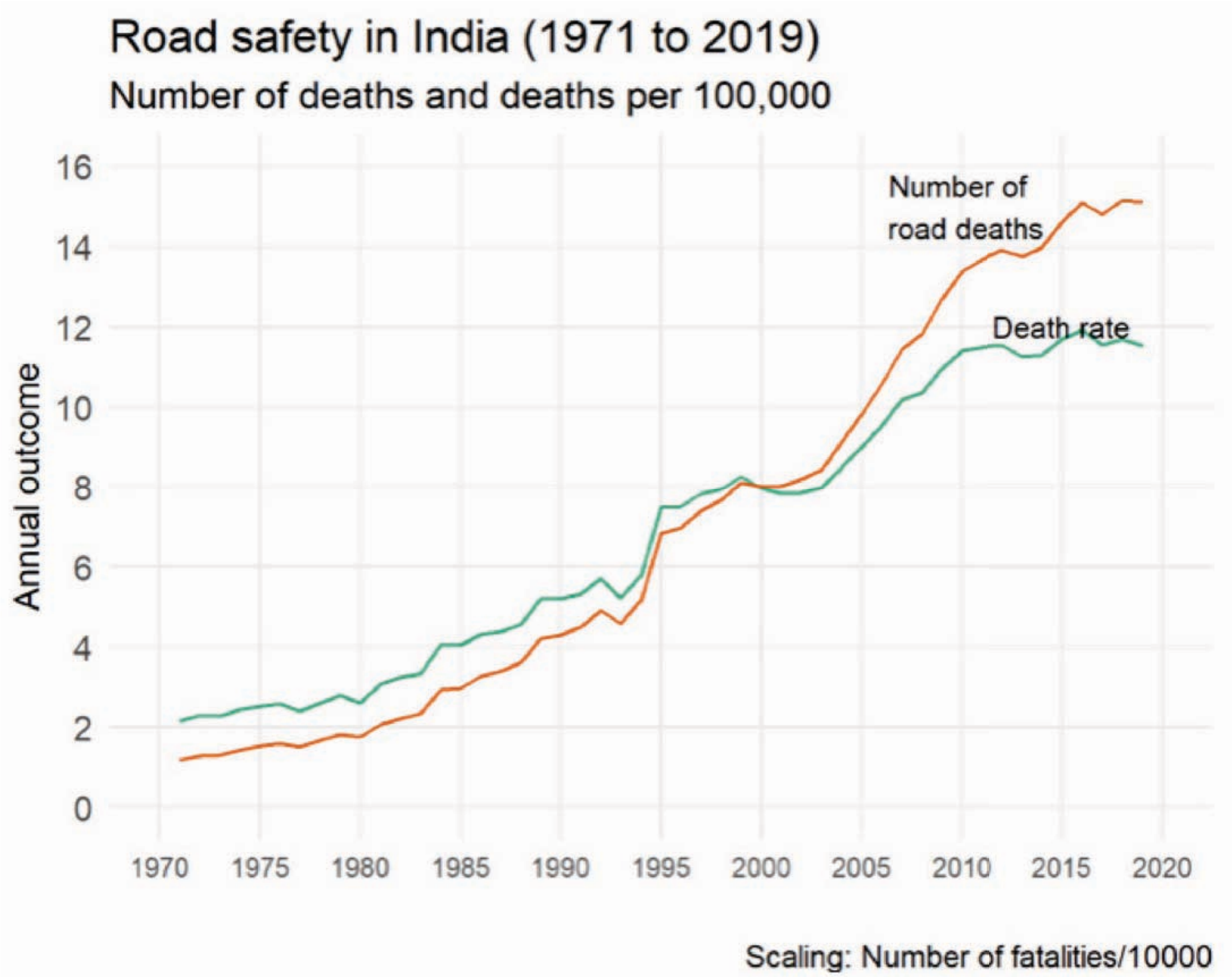


Figure 1 : Number and rate of road deaths and annual fuel consumption in India from 1971 through 2019 (Source:N-CRR 2015 and transport research wing 2020.

According to official statistics 151,113 persons were killed and 451,361 injured in road traffic crashes in India in 2019 (MORTH, 2020). This corresponds to a death rate of 11.5 per 100,000 population. However, the number of injuries is probably an underestimate, as not all such cases 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 though the rate of increase has been varying (Figure 1). Number of road deaths increased rapidly from years 2004 through 2011 at a rate of 6.8% every year. Since 2012, road deaths have been increasing at a much lower rate of 0.8% every year. Figure 1 shows number of road deaths and number of deaths per 100,000 population. During the 8-year period from 2012 to 2019, the death rate has been stable at around 11.5 deaths per 100,000 persons.

For a projected population of 1.31 Billion

VEHICLE POPULATION

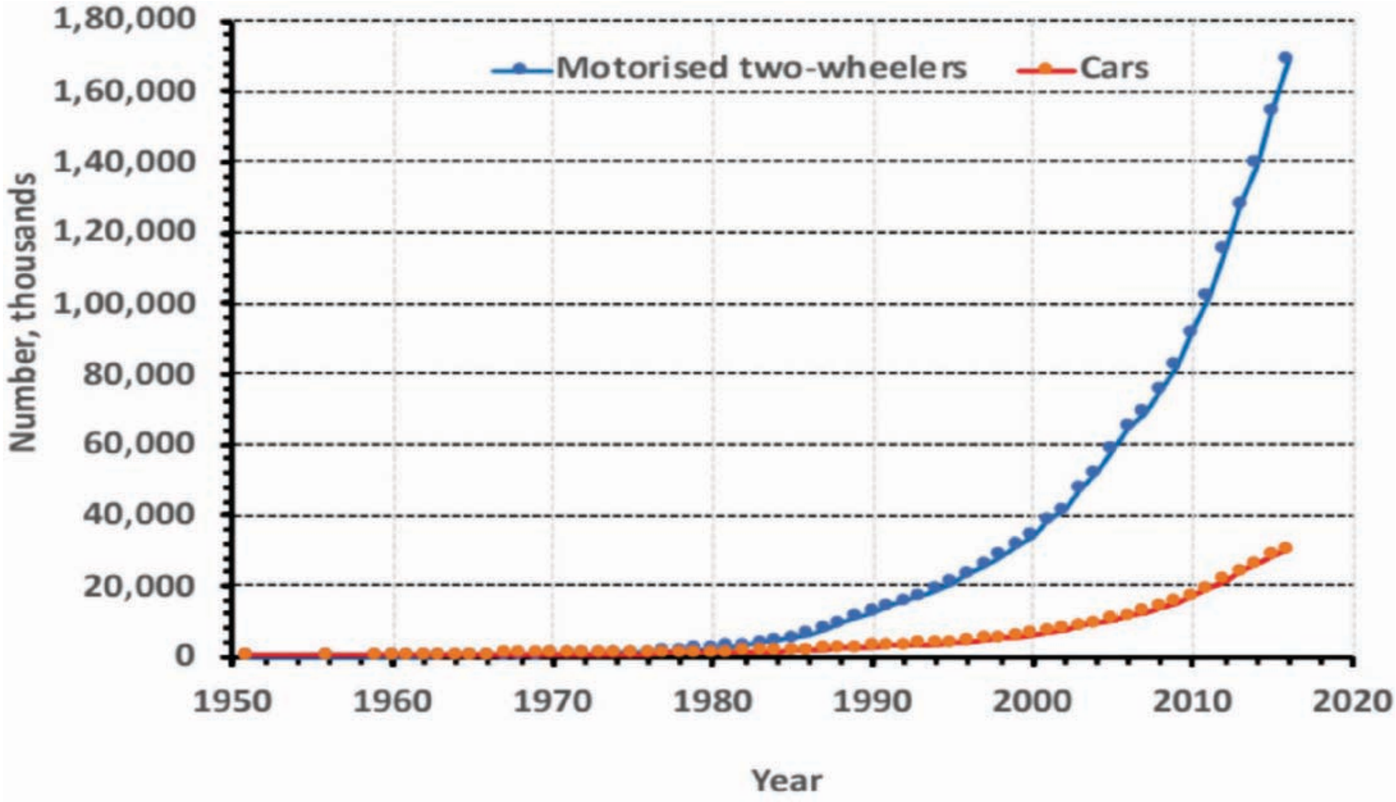


Figure 2 : Cars and motorized two-(MTW) registered in India by year 1950-2016. (Source : Transport Research Wing, 2018).

Note: Actual numbers on the road would be considerably less, see text.

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 2019 was 38.4 and 221.3 million respectively (TRW, 2021). 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 approximately 23 and 133 million respectively, and total personal vehicle ownership (including cars and MTW) estimated at ~12 per 100 persons in 2019. 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.

According to official statistics 151,113 persons were killed and 451,361 injured in road traffic crashes in India in 2019. 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.

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

Country	MTW + light 4-wheelers per 100 persons	Official fatality rate per 100,000 population
India	12*	11.6
Australia	71	5.1
Canada	61	6
Chile	45	12
Greece	60	7.8
Hungary	32	6
Japan	69	4.5
Portugal	56	6
Sweden	56	2.7
United Kingdom	54	2.8

***Vehicle ownership rate adjusted for number of actual vehicles on road. See text.**

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 (WHO, 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.

1 https://morth.nic.in/sites/default/files/RTYB-2017-18-2018-19.pdf

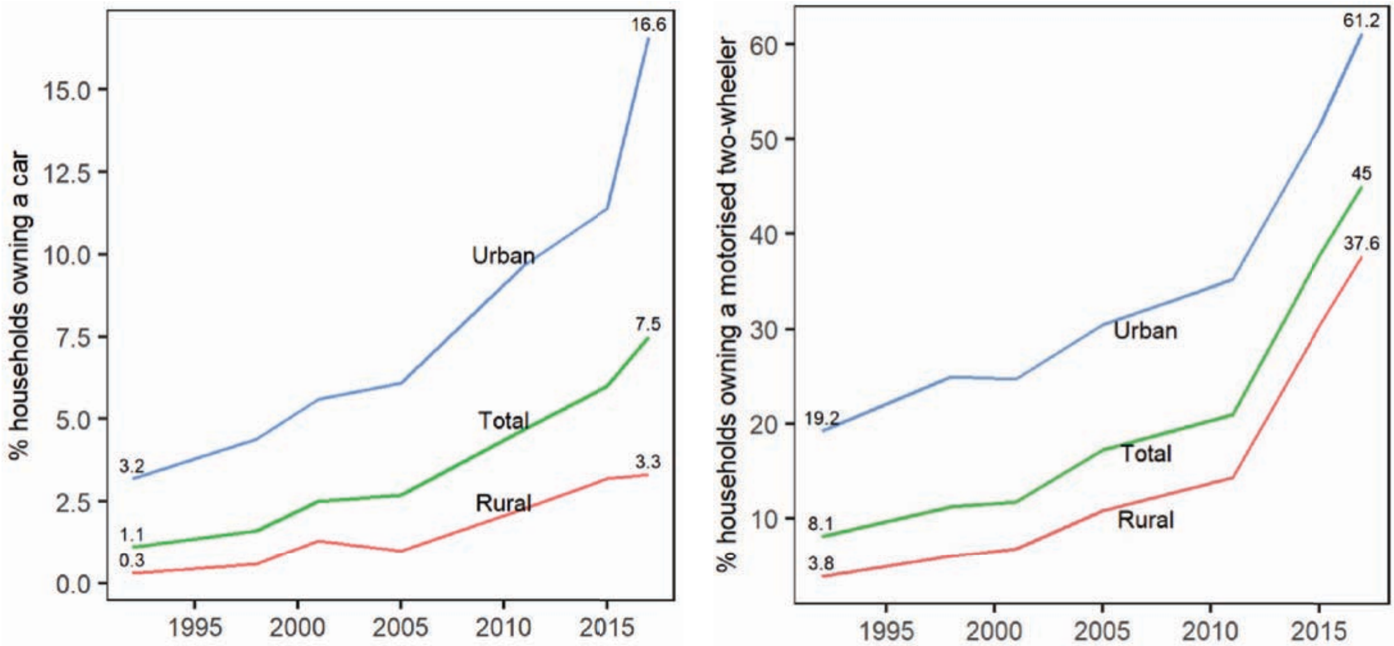


Figure 3 Car and motorcycle ownership in India

Figure 3 presents trend of percentage household owning cars and motorised two-wheelers over the 25-year period from 1993 to 2017. This data includes ownership levels reported by National Family Health Surveys (NFHS) for 1993, 1998, 2005, and 2015 (IIPS, 2021), those reported by Census in 2001 and 2011 (Chandramouli, 2012) and Longitudinal Ageing Study of India (LASI) for 2017 (IIPS et al., 2020). Both NFHS and LASI are population-representative sample surveys. For motorcycles, from 2011 to 2017, there are three data points lying on a linear trend. The sudden jump of car ownership from 2015 to 2017 could be an overestimate, as LASI survey for 2017 included only those households that have at least one member of age 45 years or older. This condition could result in overestimation of car ownership.

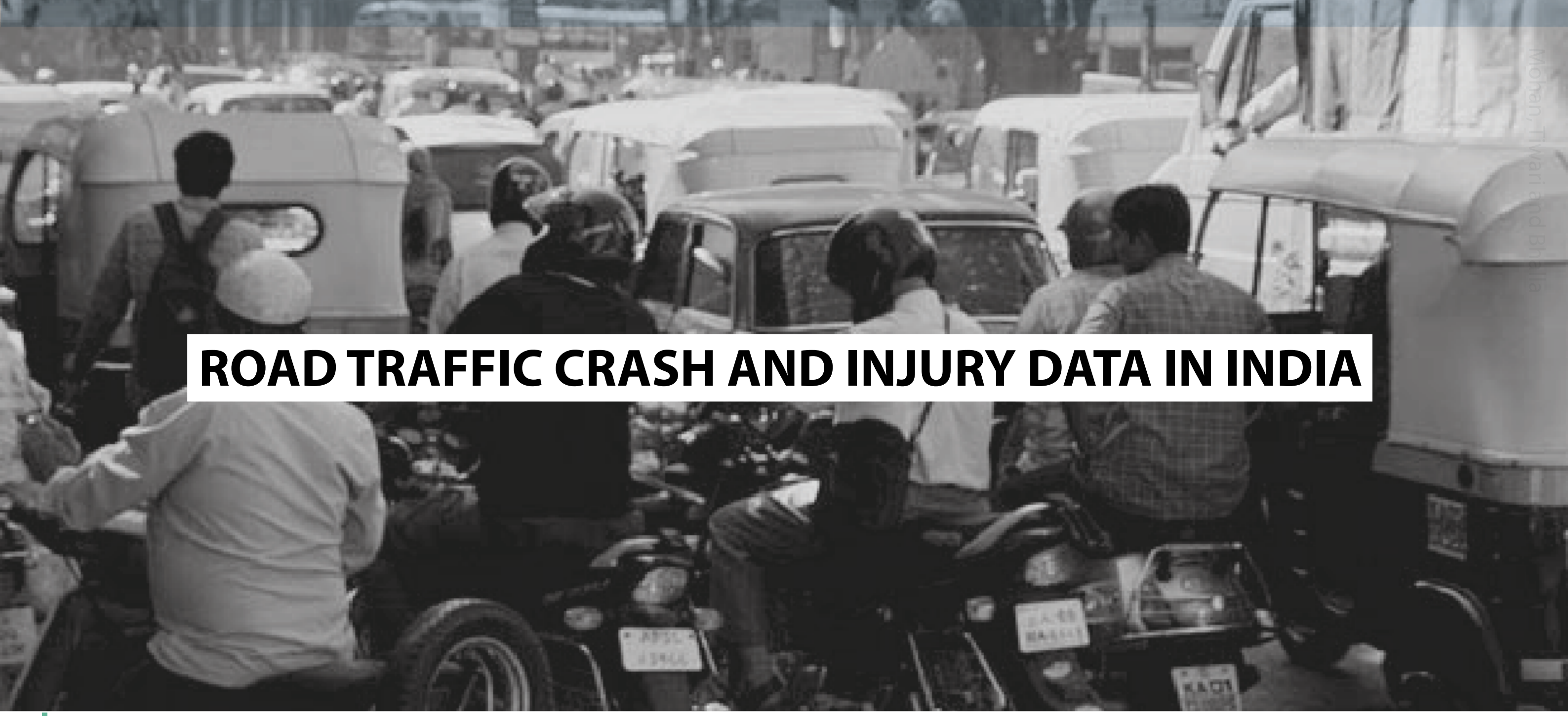
Next, we compare the two sources of vehicle numbers— vehicle registration and household-level ownership from surveys.

We use 2019 India population of 1.31 billion, in-use number of cars and MTWs of 23 and 133 million, respectively, and an average household size of 4.8. Using these numbers and assuming each households owns only one MTW or one car, 2019 estimate of household ownership of 8.4% for cars and 49% for MTW. These estimates are close to population-survey estimates of 7.5% and 45% for 2017 as reported in Figure 3 above. Note that there is a gap of 2 years between the two estimates.

The time trend indicates a rapidly increasing ownership of vehicles. For motorcycles, the rate of growth in urban and rural areas is almost the same. However, car ownership trend shows it is increasing at a much faster rate in urban areas than in rural areas. Motorcycle and car ownership has doubled in the decade from 2008 to 2017. This rapid rate of vehicle ownership is troubling from road safety's perspective if policies continue to lag.

2 http://rchiips.org/nfhs/

3 https://www.iipsindia.ac.in/sites/default/files/LASI_India_Report_2020_compressed.pdf



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) titled Accidental deaths and Suicides in India (NCRB, 2020), and the annual publication of the Transport Research Wing of Ministry of Road Transport & Highways (MoRTH) titled Road Accidents in India (MORTH, 2020). 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 under-report road traffic deaths and injuries in many countries (Bhalla et al. 2014, W.H.O. 2015, Rosman and Knuiman 1994, Derriks and Mak 2007).

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.

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.

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

• 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.

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.

• 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 under-reporting of road traffic deaths in India is not well understood. For instance, a record linkage study in Bengaluru covering 23 hospitals found that police data only missed 5% of road traffic deaths (Gururaj, 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 (GBD), 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 there were 211,975 (95% confidence interval: 159,343 - 250,315) deaths in India in 2019 (IHME, 2020). The mid-point estimate is 40% higher than government-reported number of 151,113 deaths for the same year. Interestingly, the two estimates are much closer than they were in 2016, when GBD estimate was 68% higher. Another study by Menon et al. (2019) reports 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 86% higher than the Transport Research Wing estimate of 147,913 for 2017 (MORTH, 2020).

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 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 under-reporting to be around 50% of rural deaths. Overall, this would imply that the under-reporting 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.

To understand the level of under-reporting by different age groups, Figure 4 presents ratios of number of road deaths reported by GBD to the number reported by MoRTH for the five age groups for year 2019.

A ratio of one indicates that the two sources of data are in complete agreement with each other. The disagreement between GBD and MoRTH reported is the greatest in the age groups 45 years or older.

For 45-60 years, GBD-estimated road deaths are about twice as many as MoRTH-reported number. For 60+ age group, GBD-estimates number is more than five times as high. The reasons for this variation in the level of under-reporting by age is not yet clear.

Since proportion of all deaths in 60+ age group is small, high-level of underestimation for this age group does not translate to equally high levels of overall under-reporting.

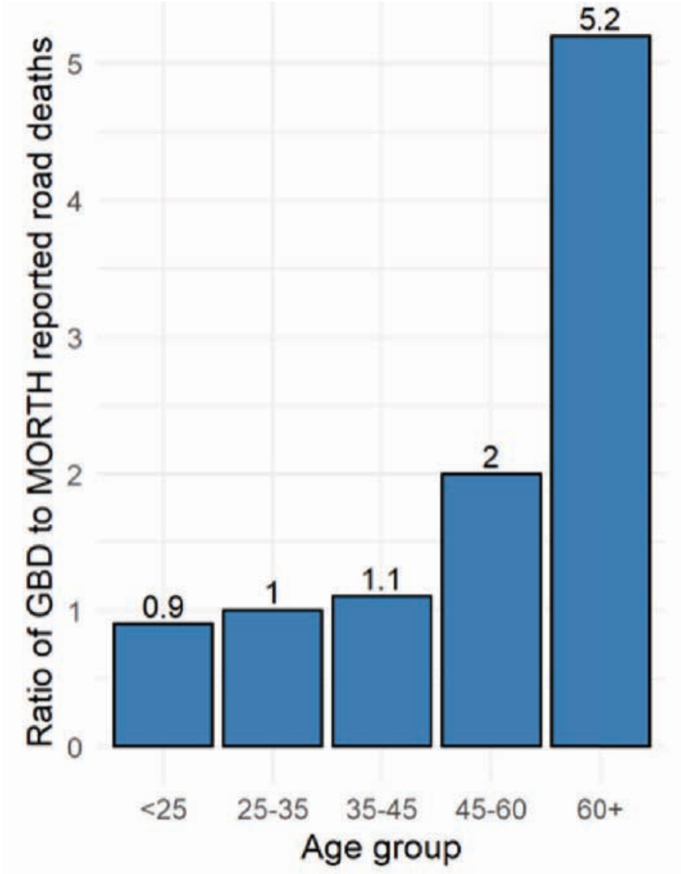


Figure 4 : Age - Specific comparison of GBD and MORTH reported road deaths.

Ratio of 1 indicates the two sources of data report equal number of deaths.

NON-FATAL INJURY ESTIMATES

While there is uncertainty among experts about the level of under-reporting 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 (now Bengaluru) 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, 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.

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.

The official estimate of non-fatal RTI in 2019 was 451,361 which probably underestimates injuries requiring hospitalisation by a factor of 5 and all injuries by a factor of 20.

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.

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.

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.

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 the US 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 Centre 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 2019 is taken as 151,113, then the estimate of serious injuries requiring hospitalization would be 2,267,000 annually, and that for minor injuries 7,555,000. The official estimate of non-fatal RTI in 2019 was 451,361 which probably underestimates injuries requiring hospitalisation by a factor of 4 and all injuries by a factor of 20.

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.

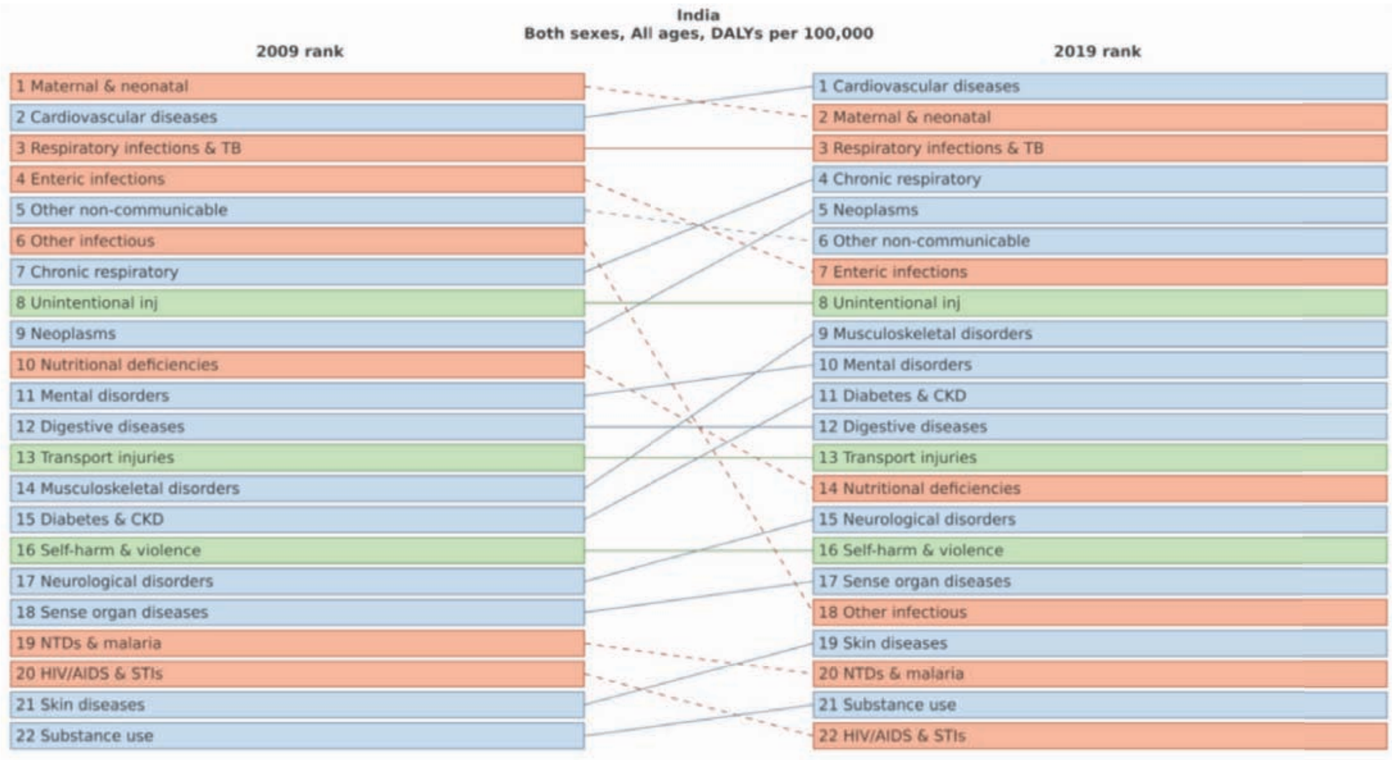


Figure 5 : Ranking of the cause of health burden (DALYs) in India in 2009 and 2019 for all ages (Source : Institute for Health Metrics and Evaluation (IHME, 2018)

RANKING IN CAUSES OF DEATH AND POPULATION HEALTH

Figure 5 shows the diseases ranked by their contribution to overall health burden for all age and sex groups combined for years 2009 and 2019. (Institute for Health Metrics and Evaluation (IHME). 2018). The burden reported here is expressed as Disability-adjusted Life Years (DALYs) which includes burden due to deaths as well as disabilities.

Road traffic injuries have been the 13th leading cause of premature death in India over the last decade. The burden due to injuries 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.

INTERNATIONAL COMPARISON

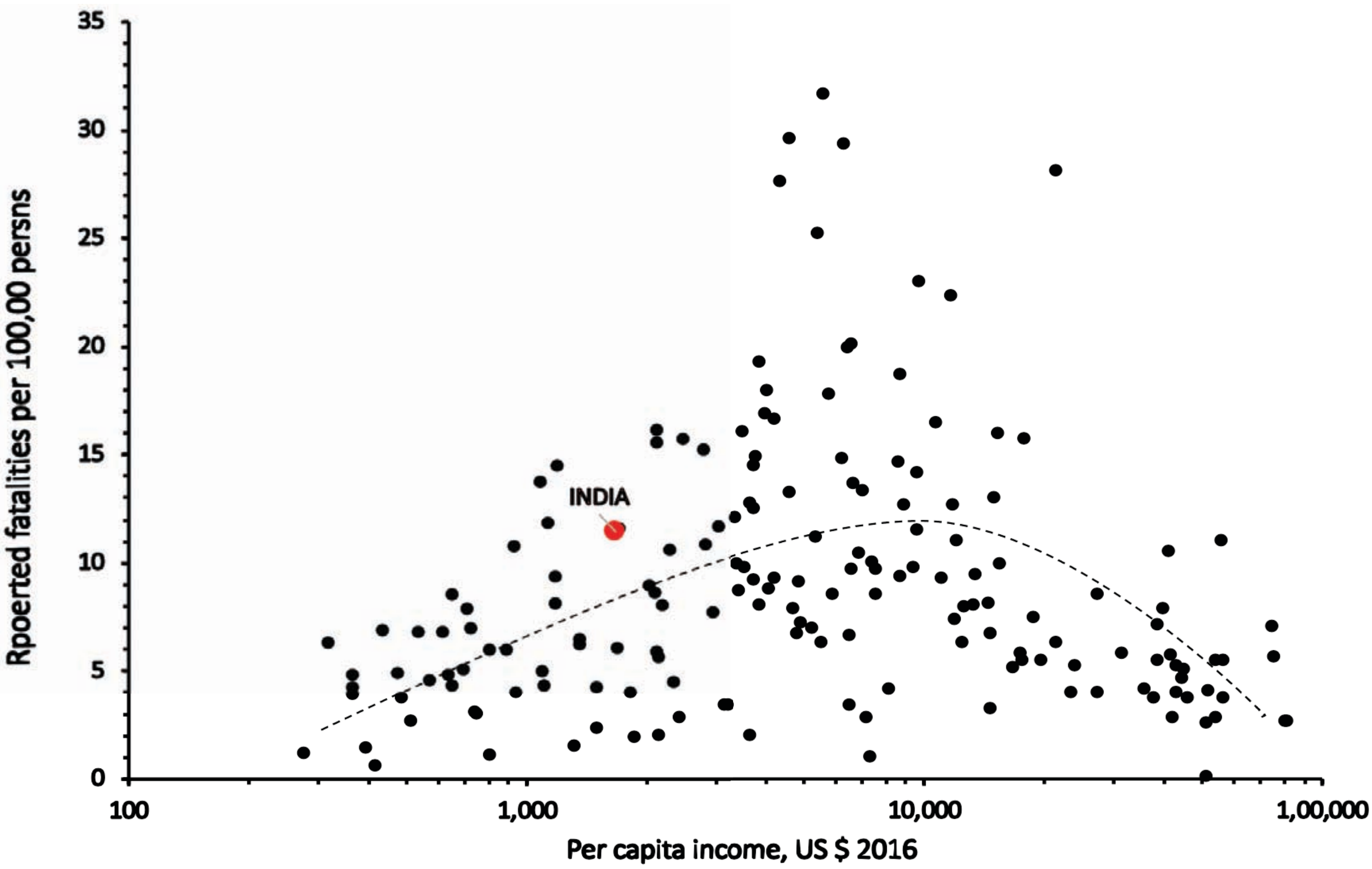


Figure 6. RTI fatality rate per 100,000 persons reported by different countries vs per capita income. (Source: WHO, 2018).

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 6 shows the official RTI fatality rates for different countries plotted against per capita income of the countries and Figure 7 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 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 8. 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.

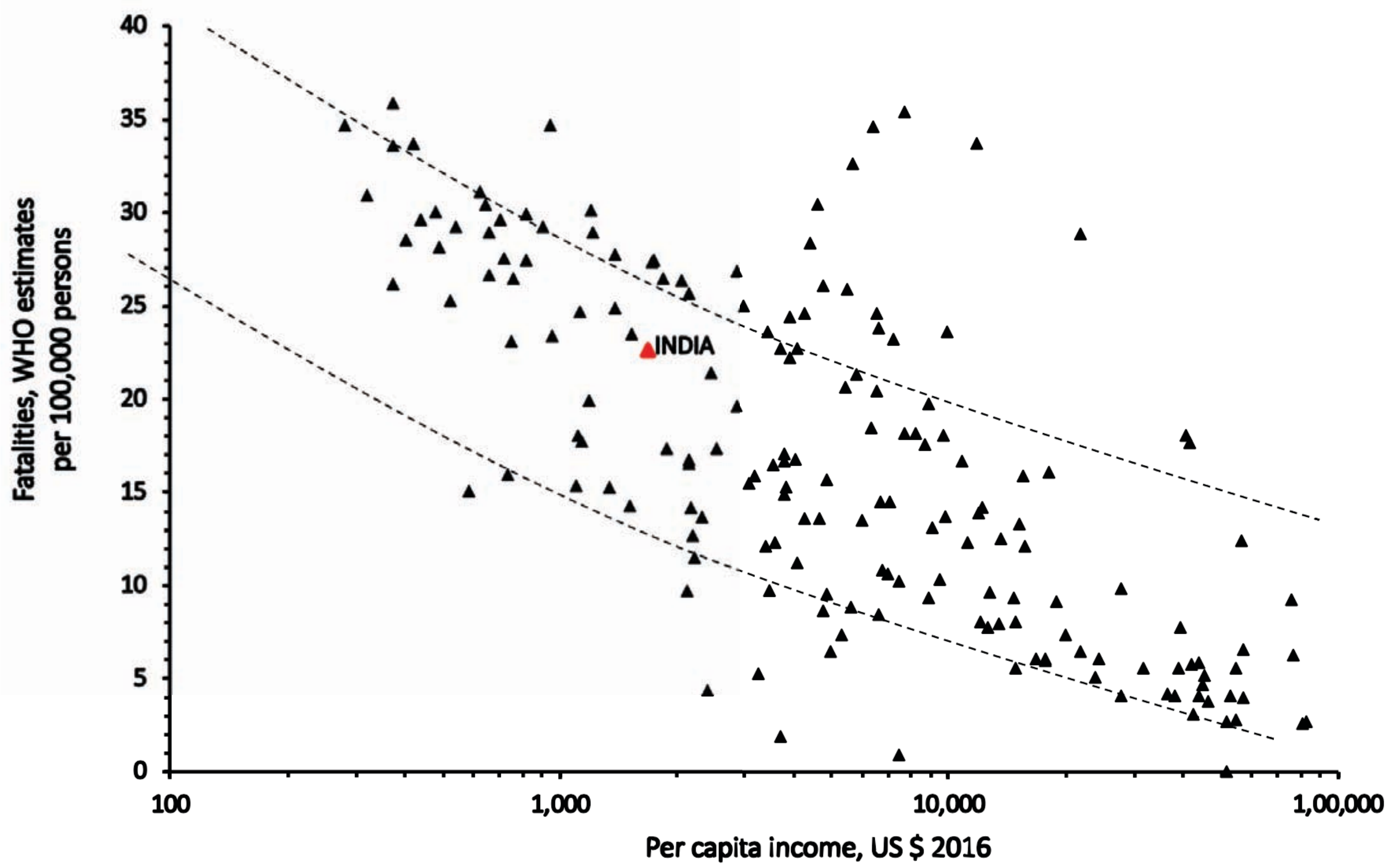


Figure 7. RTI fatality rate per 100,000 persons as estimated by WHO for different countries vs per capita income. (Source: WHO, 2018).

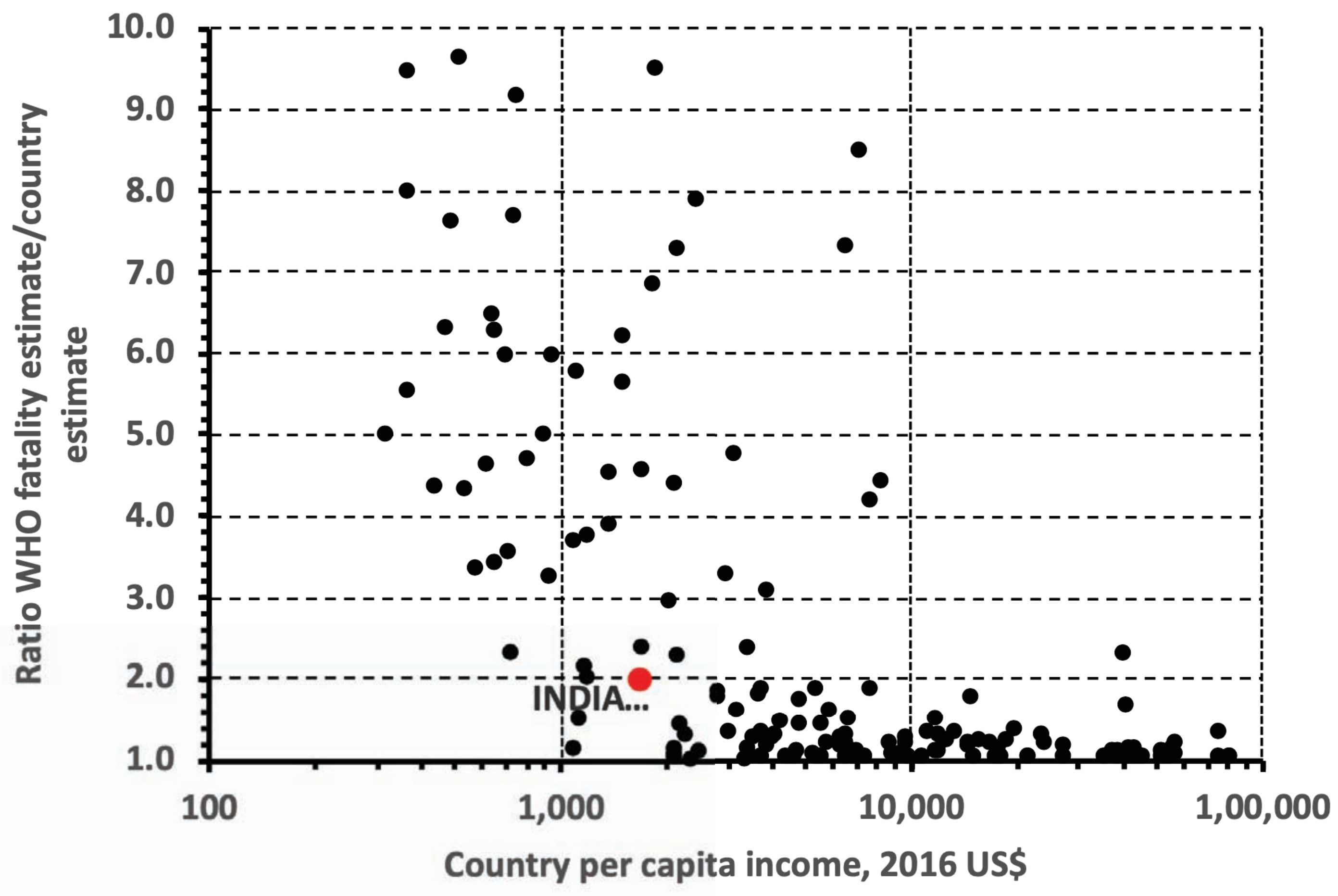


Figure 8. Ratio of WHO estimates and official RTI fatality rate per 100,000 persons for different countries vs per capita income (Source: WHO, 2018)

DATA USED IN THIS REPORT

Injury and fatality data

Table 2. Examples of commonly used indicators of the road traffic injury problem. Source: Mohan, D. et al., 2006.

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

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 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 – 2019 (Transport Research Wing 2020), 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.

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.

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.

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.

Annexure No	Details	Comment	Data used in this report
1	Road Accidents, Persons Killed and Injured: 1970-2018	Data on person Injured and accidents not reliable.	Only fatality data
2	Total Number of Road Accidents in India: 2015 to 2018	Not reliable	No
3	Total Number of Persons Killed in Road Accidents in India: 2015 to 2018	Data by state	Yes
4	Total Number of Persons Injured in Road Accidents in India: 2015 to 2018	Numbers unreliable	No
5	Total Number of Fatal Road Accidents in States/UTs: 2015-2018	Total fatal accident statitics, not number of persons	No
6	Severity of Road Accidents in India (State/UT-wise): 2015 to 2018	Accident number unreliable	No
7	Type of Road accidents in States/ UTs in 2018	Includes grievous injury, minor and non-Injury accidents - unrelaible	No
8	Total number of Grevious and Minor Injured Persons in Road Accidents on all roads	Unreliable	No
9	Total Number of Road Accidents on National Highways: 2015 to 2018	Unreliable	No
10	Total Number of Persons Killed in Road Accidents on National Highways: 2015 to 2018	Data by state	Yes
11	Total Number of Persons Injured in Road Accidents on National Highways*: 2015 to 2018	Data on persons injured not reliable	No
12	Total Number of Fatal Road Accidents on National Highways*: 2015-2018	Fatal accident data not used	No
13	Total number of Grevious and Minor Injured Persons in Road Accidents on National Highways during the calendar year 2018	Data on persons injured not reliable	No
14	Total Number of Road Accidents on State Highways: 2015 to 2018	Unreliable	No
15	Total Number of Persons Killed in Road Accidents on State Highways: 2015 to 2018	Fatality statistics used	Yes
16	Total Number of Persons Injured in Road Accidents on State Highways: 2015 to 2018	Injury statitics unreliable	No
17	Total Number of Fatal Road Accidents on State Highways: 2015-2018	Accident numbers not used	No
18	Total number of Grevious and Minor Injured Persons in Road Accidents on State	Injury numbers unreliable	No
19	Total number of Fatal Road Accidents, Total Road Accidents, Persons Killed and Injured on Other Roads during the calendar years 2016	By state	Only fatality data used

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.

Annexure No	Details	Comment	Data used in this report
20	Accidents classified according to Type of Collision during the calendar year 2018	Collision types overlapping. Not clear whether vehicle description is of victim's vehicle	No
21	Accidents classified according to Type of Collision during the calendar year 2018	Pedestrian proprtion unexepected low. Data unrelaible.	No
22	Accidents classified according to Road Environment during the calendar year 2018	Environment classifications overlapping. Unreliable.	No
23	Accidents classified according to Road Features during the calendar year 2018	Road features classifications overlapping. Unreliable.	No
24	Accidents Classified according to Type of Junctions during the calendar year 2018	Total fatalities at junctions amounts to 137,317. This is 91% of total fatalities. Highly unlikley. Unreliable.	No
25	Accidents Classified according to Type of Traffic Control during the calendar year 2018	Total fatalities at junctions amounts to 333,220. This is more than double total fatalities. Unreliable data.	No
26	Accidents Classified according to Type of Weather Condition during the calendar year 2018	Weather condition severity not known.	No
27	Accidents classified according to type of impacting vehicles/ objects : 2018	Fatalities due to impacts with pedestrians, animals, trees, and other objects are only 9% of total fatalities. All data unreliable.	No
28	Accidents Classified according to Age of impacting Vehicles during the calendar year 2018	Definition of impacting vehicle unknown.	No
29	Accidents classified according to Load Condition of Involved Vehicle during the calendar year 2018	Loading condition not defined. Overloaded/hnaging clubbed together.	No
30	Male and Female Persons Killed in Road Accidents in terms of Road User categories in 2018	Pedestrian proprtion unexepected low - 15%. Data unrelaible.	No
31	Total number of Persons Killed according to classification of age and sex 2018		Yes
32	Drivers Killed according to classification of age and sex, 2018	See comment for Annexure 35. Data unreliable.	No
33	Passengers Killed according to classification of age and sex, 2018	See comment for Annexure 35. Data unreliable.	No
34	Cyclist Killed according to classification of age and sex, 2018	See comment for Annexure 35. Data unreliable.	No
35	Pedestrians killed according to classification of age and sex, 2018	Pedestrians killed total to 15% of all killed. This is an unrealistic proportion and the data are unreliable. Therefore, statistics by age for all	No
36	Accidents Classified according to Type of Traffic Violations during the calendar year 2018	Variables not mutually exclusive. Data unrelaible.	No
37	Accidents classified according to Licence of Drivers during the calendar year 2018	Accident' data unreliable.	No

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.

Annexure No	Details	Comment	Data used in this report
38	Accidents Victims Classified according to Non-Use of Safety Device (Non Wearing of Helmet) during the calendar year 2018	No information on how this was asccertained or whether helmet strapped or not.	No
39	Accidents Classified according to Non-Use of Safety Device (Non-Wearing of Seat Belt) by Victims during the calendar year 2018	No information on how this was asccertained or whether belt buckled or not.	No
40	Total Number of Accidents, Number of Persons Killed and Number of Persons Injured in Road Accidents in Urban & Rural Areas:	Defibnitions of urban and rurla not mentioned	Yes
41	Fatal Road Accidents in Rural and Urban Areas during the calendar year 2018		Yes
42	Month-Wise total number of accidents, persons killed and injured during the calendar year 2018	Only fatality data reliable	Yes
43	Road Accidents as per time of occurance 2018	Accident data not reliable	No
44	Performance of States/UTs in Reducing Number of Road Accidents in 2018	Accident data not reliable	No
45	Performance of States/UTs in Reducing Number of Persons Killed in Road Accidents in 2018		Yes
46	Percentage share in Total Registered Motor Vehicles in India as on 31st March		No

Table 4. Modal share of road traffic fatalities in Mumbai, Delhi and four rural highway locations in India.

Location		Fatalities by type of road user, per cent						
		Pedestrian	Bicycle	Motorised two-wheeler	Car	Bus	Truck	Unknown & other
Urban	Mumbai (2008-2012)[1]	58	2	29	4	0	0	7
	Delhi (2013)[2]	47	10	26	3	4	3	7
Rural highways	Highways (1998)[3]	32	11	24	15	3	14	1
	2lane NH8 2 (2010-2014)[4]	20	2	42	14	9	13	1
	4lane NH24 (2010-2014)[4]	27	5	44	8	7	4	4
	6lane NH1 (2010=2014)[4]	34	3	10	6	5	41	1

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).

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.

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.

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 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 151,113 persons were killed and 451,361 injured in road traffic crashes in India in 2019. 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 2019 was 36.5 and 221.2 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.

• In 2019, household vehicle ownership is at least 7.4% for cars and 45% for MTW. This ownership has grown rapidly from the 2011 ownership levels of 4.7% and 21%, respectively.

• The extent of under-reporting of road traffic deaths in India is not well understood. Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) estimated that in 2019, 211,975 deaths (95% confidence interval: 159,343 - 250,315) due to road injuries occurred in India. This estimate is 40% greater than government-reported number of deaths. A National Burden Estimates study estimates road deaths in 2017 in India to be 275,000. This estimate is 86% higher than the MoRTH number (147,913) for the corresponding year. 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 2019 was 451,361 which probably underestimates injuries requiring hospitalization by a factor of 5 and all injuries by a factor of 20.

• Over the last decade (2009-2019) road traffic crashes have been 13th largest contributor to health burden (deaths and disabilities) in India. Among working age population (15-49 years), they are the sixth largest contributor to health burden.

• 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 9 shows the official estimates for total number of RTI fatalities and fatalities per 100,000 persons in India from 1971 to 2019 (Transport Research Wing 2019). The total number of deaths in 2019 was 13 times greater than in 1971 with an average annual compound growth rate (AACGR) of 6%, and the fatality rate in 2019 was 5.4 times greater than in 1971 with an AACGR of 4%. Over this 50-year period, road fatalities have grown at a varying rate. There have been periods when road fatality trend flattened or when absolute number of fatalities reduced, or the period when fatalities grew at a fast rate. 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):

> *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%.*

" 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. "

> *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.*

To investigate the link between economy and road traffic deaths, Figure 8 presents annual consumption of diesel and petrol as reported by Ministry of Petroleum and Natural Gas (MoPNG). Both diesel and petrol consumption follow a long-term trend similar to that of number of road deaths. However, diesel consumption has a much stronger correlation with its short-term changes coinciding with similar changes in road deaths. Diesel being used by goods traffic is a strong indicator of economy.

> *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.*

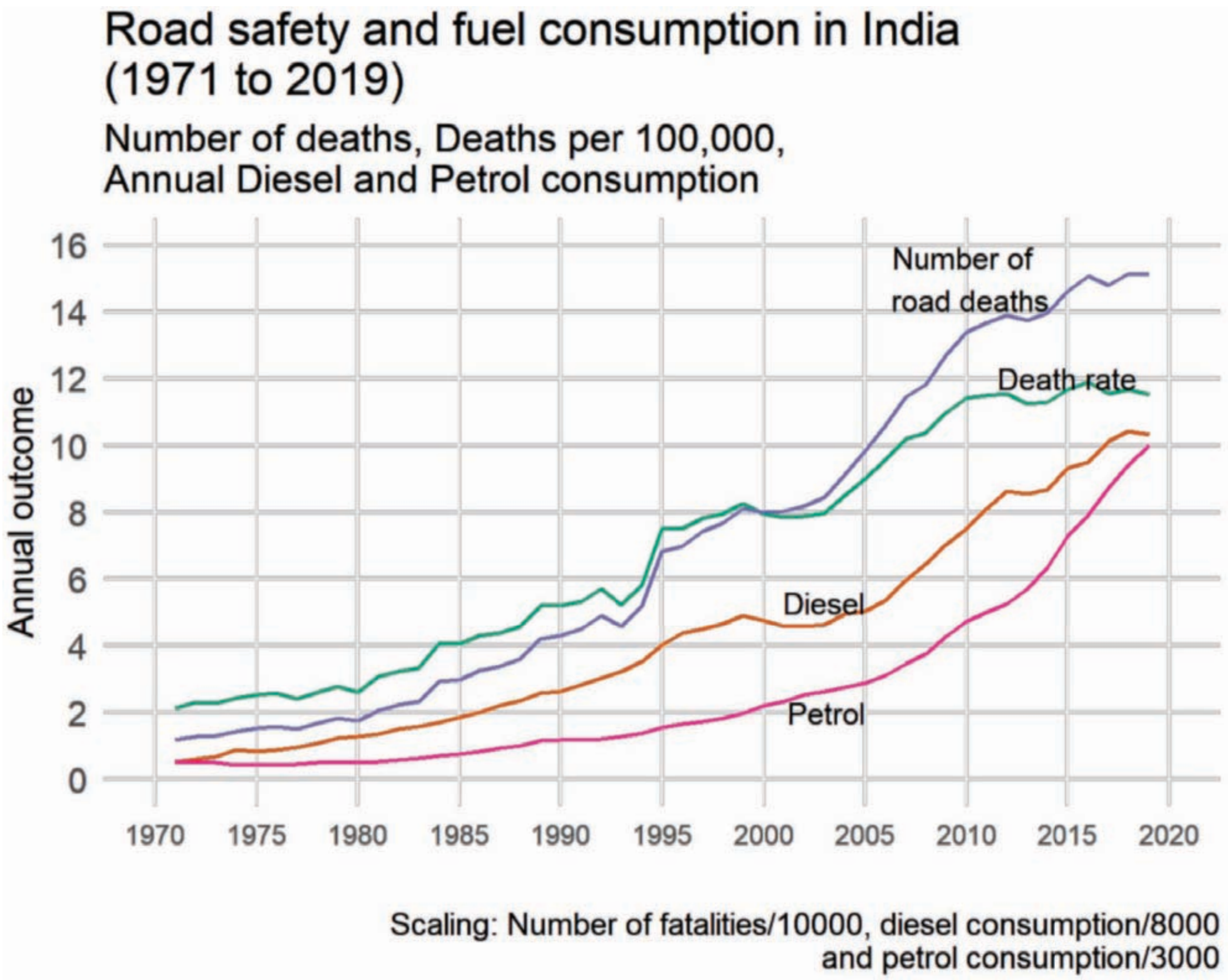


Figure 9. Total number of RTI fatalities and fatalities per 100,000 persons in India (Source: Transport Research Wing 2019).

The slowdown in the growth rate of fatalities since 2012 coincides with the similar slowdown in diesel consumption during this period. Similarly, the flattening of number of fatalities in early 2000s coincides with the flattening of diesel consumption during that period. This shows that road safety in India is strongly linked to the economy. In other words, if the economy grows at a high rate in the near future, road deaths are also likely to grow at the same rate.

Two modelling exercises have attempted to 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

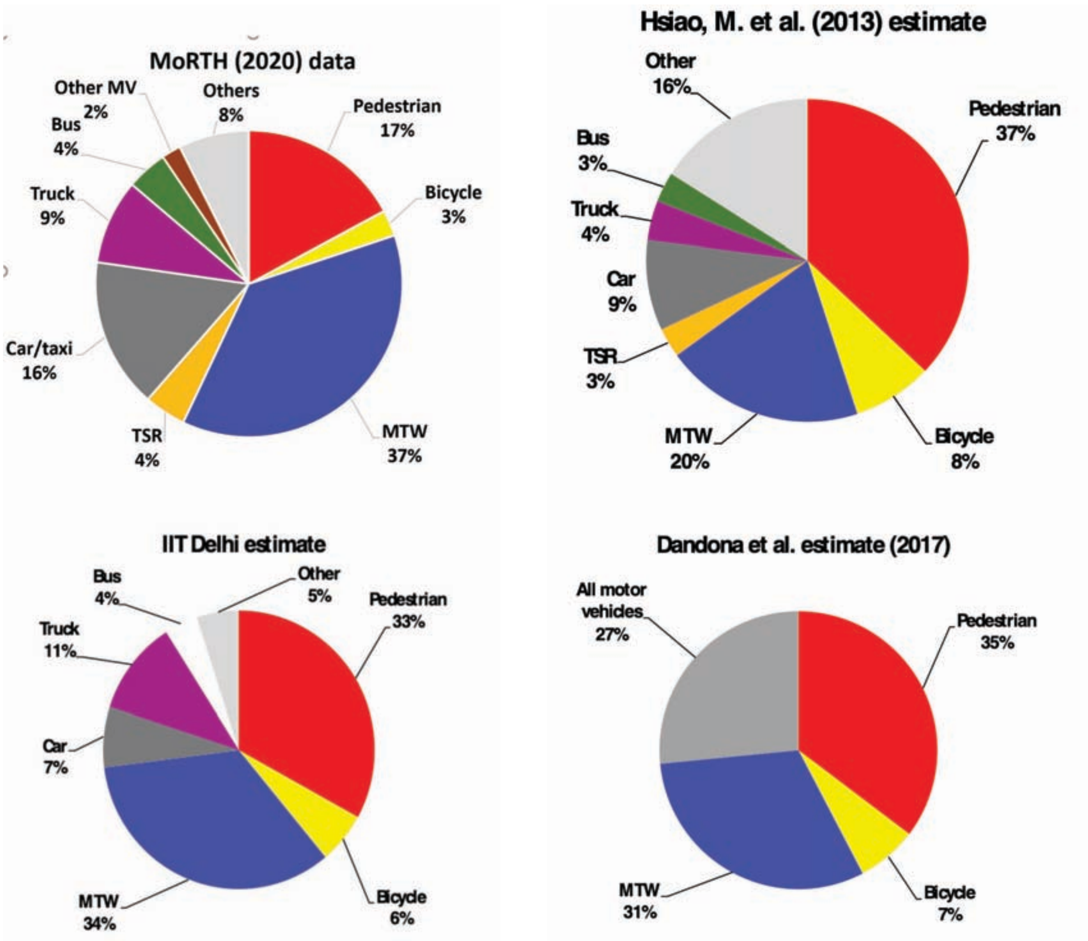


Figure 10. Estimates of the share of different road user fatalities in India (Source: Transport Research Wing 2019, Hsiao, M. et al. 2013, GBD: Institute for Health Metrics and Evaluation (IHME), IIT Delhi estimate: authors of the present report).

Figure 10 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 Dandona 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 al., 2000, and Dandona et al. (2020) estimate is based on several verbal autopsy data sources.

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 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

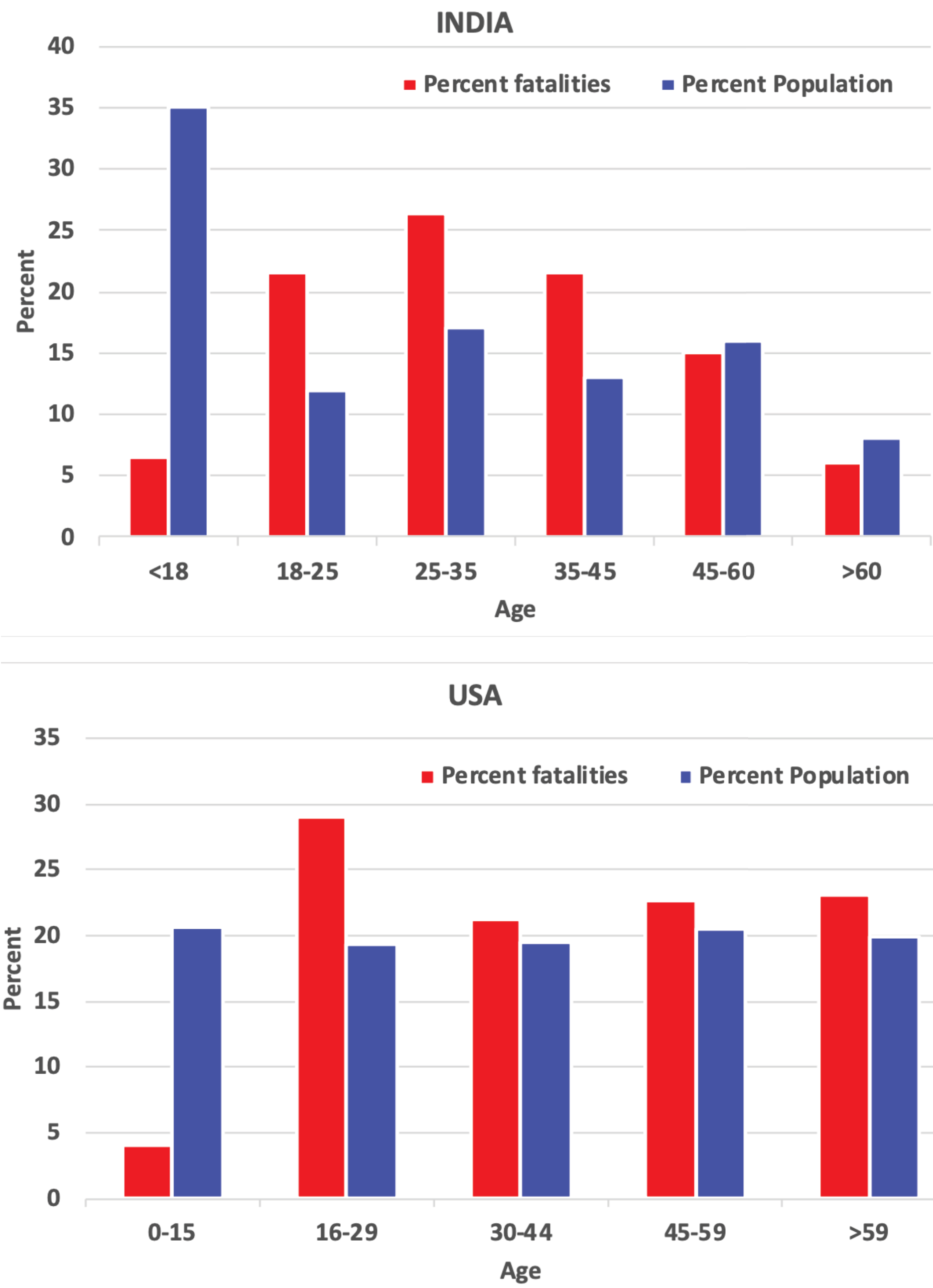


Figure 11. RTI fatality distribution and population distribution by age in India and USA. (Source: Transport Research Wing 2019 and National Centre for Statistics and Analysis 2015).

Figure 11 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.

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.

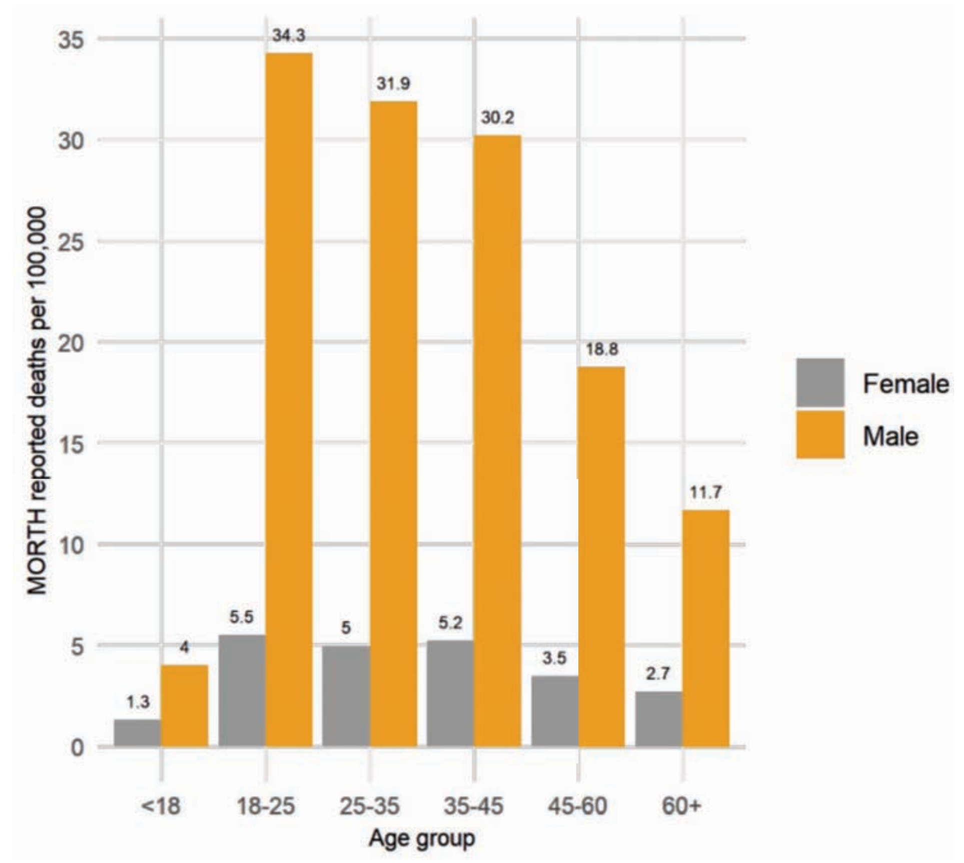


Figure 12. Death per 100,000 population by age and sex

Of those who died, only 14% are females and the rest are males. Globally, females often have a 4 minority share in road deaths. However, in India, their share is among the lowest in the world. This may be because of much lower exposure of females to traffic risk. Share of women in total number of motor vehicle license holders in India is about 6 percent, while the rest of the 5 license holders are men.

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.

Another possible reason is lower participation rate of women in formal employment in India compared to men (World Bank 2015a), and this gender gap is one of the highest in the world. Figure 12 presents number of deaths per 100,000 population by age groups and sex.

There is a wide gap in the death rate of females and males. For both sex groups, death rates are the highest from 18 to 45 years.
However, as discussed above, it is likely that the low death rate of 45 years or older is because of greater under-reporting of deaths for these age groups (Dandona et al., 2020). According to GBD6, death rate of 70+ age group in India is more than twice the death rate of 15-49 years. Similarly, Million Death Study for year 2005 also reported that death rates increased with age (Hsiao et al., 2013). Globally, road death rates often increase with age. Therefore, the U-shape of death rates in India may be an underestimate for 45 years or older age groups.

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

4 EU https://ec.europa.eu/transport/road_safety/sites/default/files/pdf/statistics/dacota/bfs2018_gender.pdf
US https://www.iihs.org/topics/fatality-statistics/detail/males-and-females
5 License https://morth.nic.in/sites/default/files/RTYB-2017-18-2018-19.pdf
6 https://vizhub.healthdata.org/gbd-compare/india

STATE WISE ANALYSIS

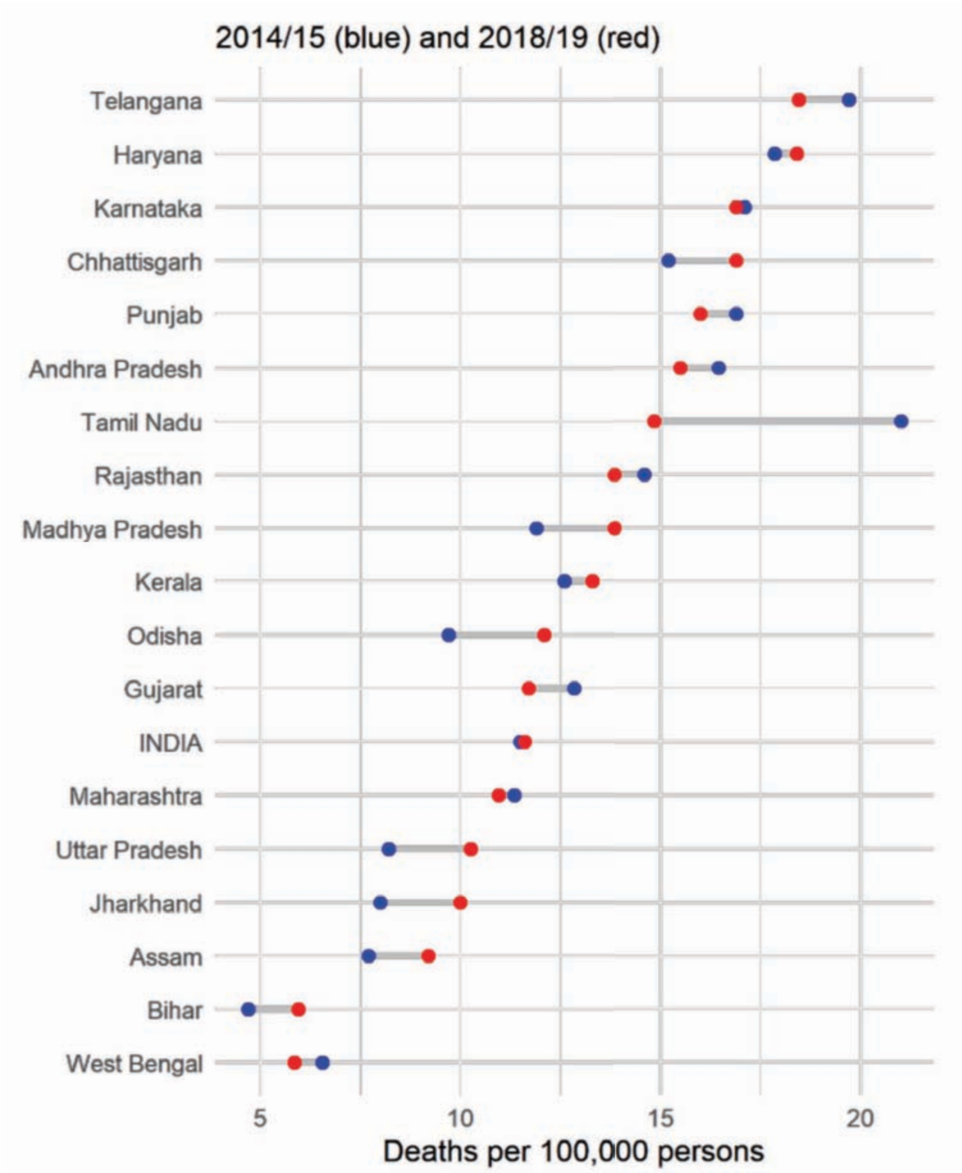


Figure 13. Total number of fatalities per 100,000 population by state and territory in 2014/15 and 2018/19 for the 18 largest states and all India.

There are 36 states and union territories in India. Up to half of the country's road deaths are contributed by the following six states—Uttar Pradesh, Maharashtra, Madhya Pradesh, Karnataka, Rajasthan, and Tamil Nadu. Another 25% are contributed by the following five states—Andhra Pradesh, Gujarat, Bihar, Telangana, and West Bengal.

To compare road death statistics over 5-year period, we used average of 2014 and 2015 (referred to as 2014/15) as the base and average of 2018 and 2019 (2018/19) as the comparator. Use of two years gives a more stable estimate of rates and moderates the effect of an outlying year.

Among those above-mentioned states, the greatest increase in number of deaths from 2014/15 to 2018/19 occurred in the states of Uttar Pradesh, Madhya Pradesh, and Bihar, by an average of 30 percent. The greatest reduction of 26% occured in the state of Tamil Nadu followed by an average of 5% reduction in Andhra Pradesh, Gujarat, and Telangana. Overall, road deaths in India increased by 6% over this period. Next, we present deaths per 100,000 population for the 18 largest states that represent 96% of India's population. (7)

7 The deaths are reported by Ministry of Road Transport and Highways and population estimates are reported by the Spatial Data Repository of The DHS Program.

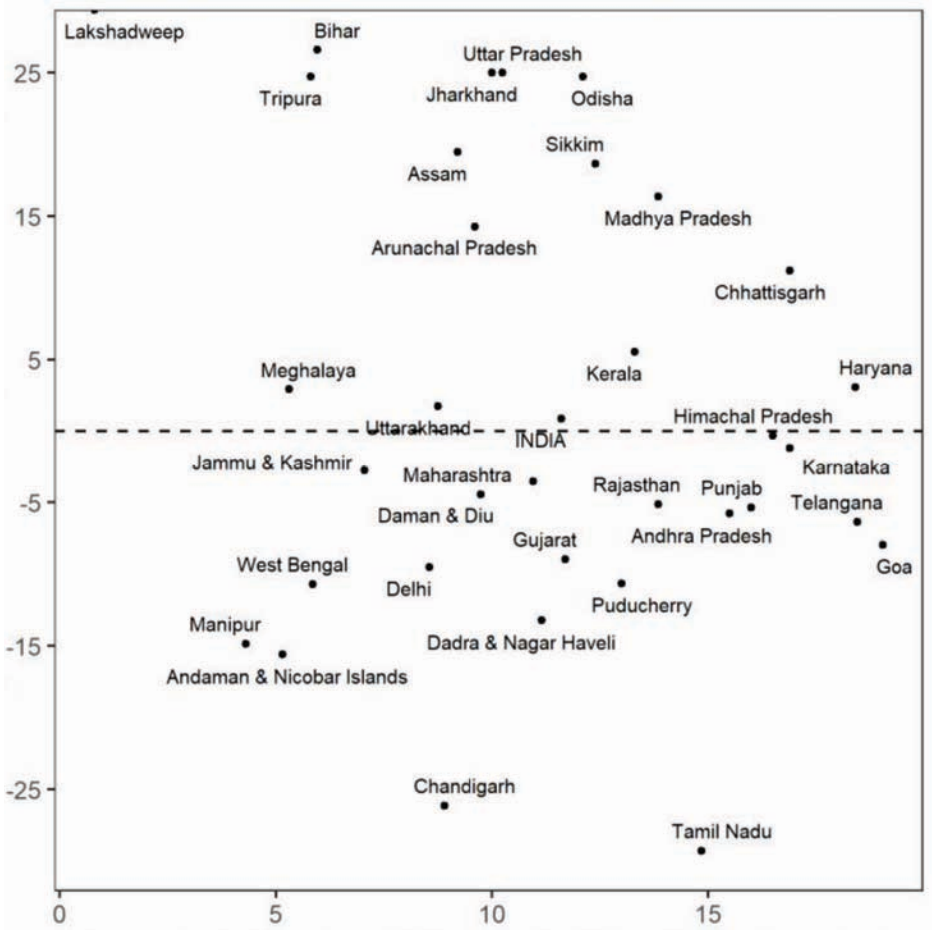


Figure 14. Percentage change in death rates over the 5-year period from 2014/15 to 2018/19 for all states and union territories of India.

These death rates for the years 2014/15 and 2018/19 are presented in Figure 13 along with the national averages, in the descending order of 2018/19 death rate. Telangana and Haryana are the states with the highest death rate (18.5 per 100,000), which is about 60% greater than the national average (11.6 per 100,000). On the other extreme, West Bengal and Bihar have the lowest rate (5.9 per 100,000), which is about half the national average. In general, all the southern states have higher death rate than the national average.

Figure 14 shows the percentage change in death rate from 2014/15 to 2018/19 and the death rate for 2018/19. The figure includes all the 36 states and union territories. The states above X-axis are those where death rates have increased over the 5-year period, and the states below are those where rates have decreased. In the following four states, death rates increased by 25% or more—Bihar, Uttar Pradesh, Jharkhand and Odisha. Increase in road deaths in these states has a significant implication as these four states contribute more than 25% of national road deaths. Five years ago, all these states had the lowest death rates. Other large states with a significant increase in death rates are Assam, Madhya Pradesh and Chhattisgarh. Note that many of the states which witnessed increase in death rates are in north and east of India.

Most significant reduction occurred in Tamil Nadu where death rate reduced by 30 percent. This state had the highest death rate five years ago and contributed 10% of all road deaths. Over the 5-year period from 2014/15 to 2018/19, its death rate has reduced from 21 to 15 per 100,000. There are now 8 more states that have higher death rates than this state.

Death rates also reduced in West Bengal, Gujarat, Andhra Pradesh and Rajasthan. It is interesting that rates decreased in West Bengal even though it already had one of the lowest rates among the large states in India.

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 to assign any scientific reasons for these changes over time. 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.

Up to 50% of the country's road deaths are contributed by the following six states— Uttar Pradesh, Maharashtra, Madhya Pradesh, Karnataka, Rajasthan, and Tamil Nadu.

In the following four states, death rates increased by 25% or more—Bihar, Uttar Pradesh, Jharkhand and Odisha. Increase in road deaths in these states has a significant implication as these four states contribute more than 25% of national road deaths.

The states in India seem to be going through a transition. Though there are exceptions, many states that had low levels of death rates five years ago have recently witnessed significant rise in death rates. While others that had high levels of death rate are becoming safer. One likely explanation is that many states that had low levels of death rates were also among the poorest in India (e.g. Uttar Pradesh, Bihar and Jharkhand). In these states, vehicle ownership may be increasing at a much greater rate while road safety policies are not in place to control traffic injuries. On the other hand, the states that had high levels of death rates may have put in place enforcement and infrastructure measures for improving safety. The reduction in death rates may be an outcome of those measures.

Most significant reduction of 30% occurred in Tamil Nadu. This state had the highest death rate five years ago and contributed 10% of all road deaths. Over the 5-year period from 2014/15 to 2018/19, its death rate has reduced from 21 to 15 per 100,000.

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SUMMARY

- The total number of deaths in 2019 was 13 times greater than in 1971 with an average annual compound growth rate (AACGR) of 6%, and the fatality rate in 2019 was 4.33 times greater than in 1971 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. Though higher level of underreporting by police of deaths among older adults may partly explain this.

- Telangana and Haryana have the highest death rate in the country (18.5 per 100,000), and West Bengal and Bihar have the lowest rate (5.9 per 100,000). This, there is a large variation in the levels of road safety within the country. In general, all the southern states in India have greater death rate than national average.

- In Bihar, Uttar Pradesh, Jharkhand and Odisha, deaths per 100,000 increased by more than 25 percent over the 5-year period from 2014/15 to 2018/19. These states combined also contribute one in four deaths in the country.

- In Tamil Nadu, death rate reduced by 30 percent, which is the largest reduction among all the states in India. Interestingly, Tamil Nadu had the highest death rate in the country 5 years ago and now there are eight more states that have greater death rate than this state.

- Data suggests that the road deaths have increased significantly in those states that had low death rates 5 years ago (e.g. Bihar, Uttar Pradesh, Jharkhand). On the other hand, deaths have reduced in the states that had high death rates earlier (Tamil Nadu, Telangana, Punjab, Andhra Pradesh). The states that had low death rates are also among the poorest in the country and may be witnessing a much greater rate of increase in vehicle ownership. This may also explain why number of deaths nationally have stabilised.

- 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.

CITY DATA

According to the MoRTH report, 49715 (33%) fatalities took place in urban areas and 101398 (67%) in rural areas in 2019 (Transport Research Wing, 2020). These data suggest that the urban RTI fatality share is about the same as the estimated urban population share (34%) in 2018 (8). The recenttrend shows that every year the percentage of all road deaths that occurred in rural areas has been increasing. In 2015, 39% of all road deaths occurred in urban areas compared to 33% in 2019.

Over the 5-year period from 2014/15 to 2018/19, deaths per 100,000 increased by 25% in 13 out of 50 million-plus cities, and decreased by 25% in 11 cities.

Within urban areas, details of fatalities and vehicles registered are reported only for cities with populations greater than one million. The latest report for 2019 includes details for 50 million-plus cities recording a total of 17,202 fatalities (35% of all urban road 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.

The five cities with the highest death rates are Allahabad, Raipur, Jodhpur, Agra and Jabalpur, with an average fatality rate of 34.3 per 100,000.

Data for 50 cities are included (population greater than 1 million) in the MoRTH report published in 2019. Figure 15 shows deaths per 100,000 population for the 50 cities averaged over years 2018 and 2019. Data for cities that did not have populations greater than 1 million in 2011 are not available. During the two-year period of 2018 and 2019, the average fatality rate for all 50 million-plus cities combined was 14.5 per 100,000 persons which is 25% higher than the national average of 11.6 per 100,000 (9).

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.

8 Rural population (% of total population) – India. The World Bank. https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?locations=IN
9 We used 2011 Census population of the million-plus cities and used district-level population estimates reported by The DHS Program to estimate city populations from 2014 through 2019.

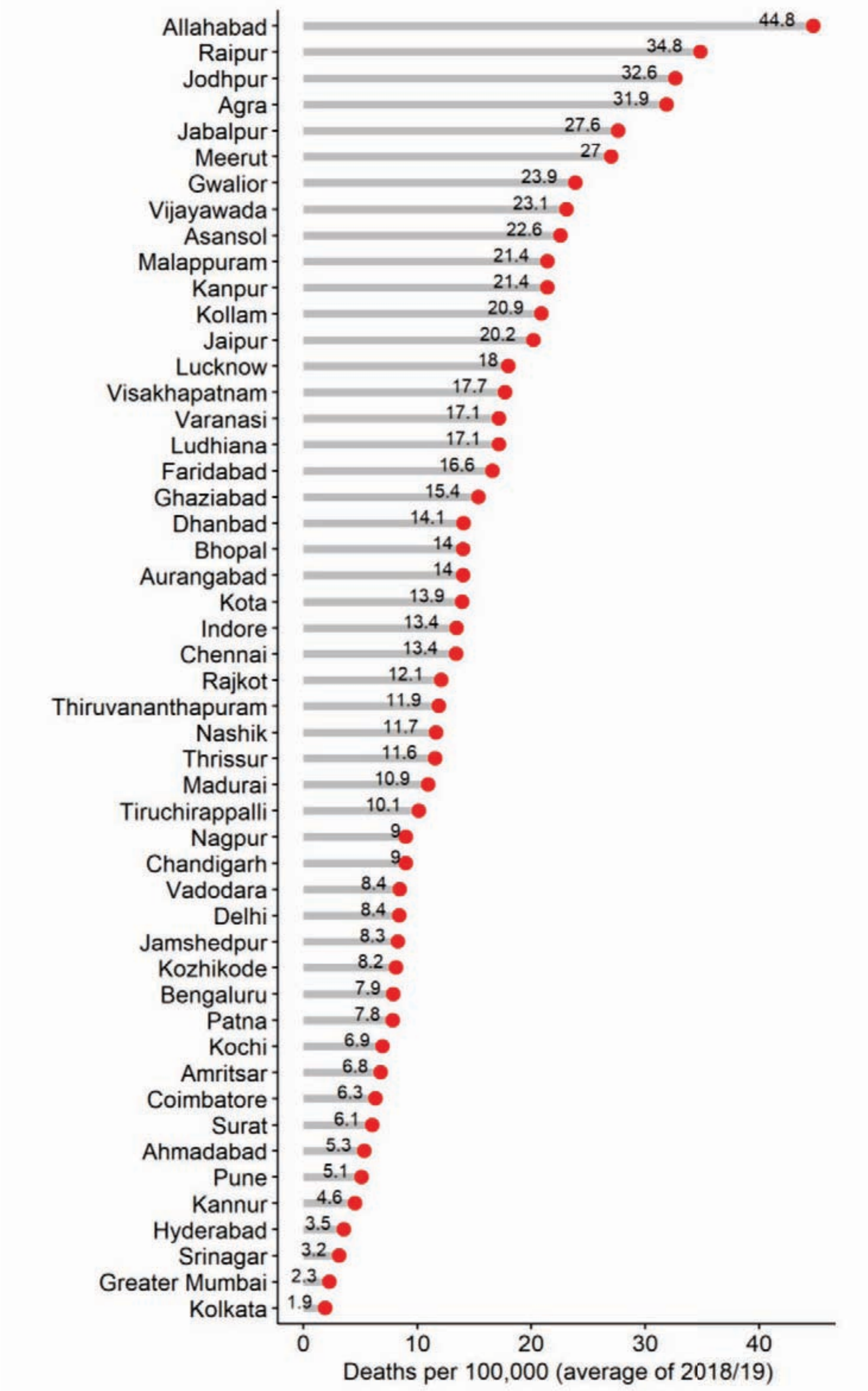

Figure 15. RTI fatality rate per 100,000 persons in million plus cities in India, average of 2018 and 2019 (Source: Transport Research Wing 2020).

Among the 10 largest cities of India, Jaipur has the highest death rate of 20.2 per 100,000 followed by Chennai with a rate of 13.4 per 100,000. Rest of the eight cities have an average rate of 8 per 100,000. The five cities with the highest death rates are Allahabad, Raipur, Jodhpur, Agra and Jabalpur, with an average fatality rate of 34.3 per 100,000. Among the ten cities with the highest death rates, eight are from the northern states of Uttar Pradesh, Madhya Pradesh, and Rajasthan. The five cities with the lowest death rates are Kolkata, Greater Mumbai, Srinagar, Hyderabad, and Kannur.

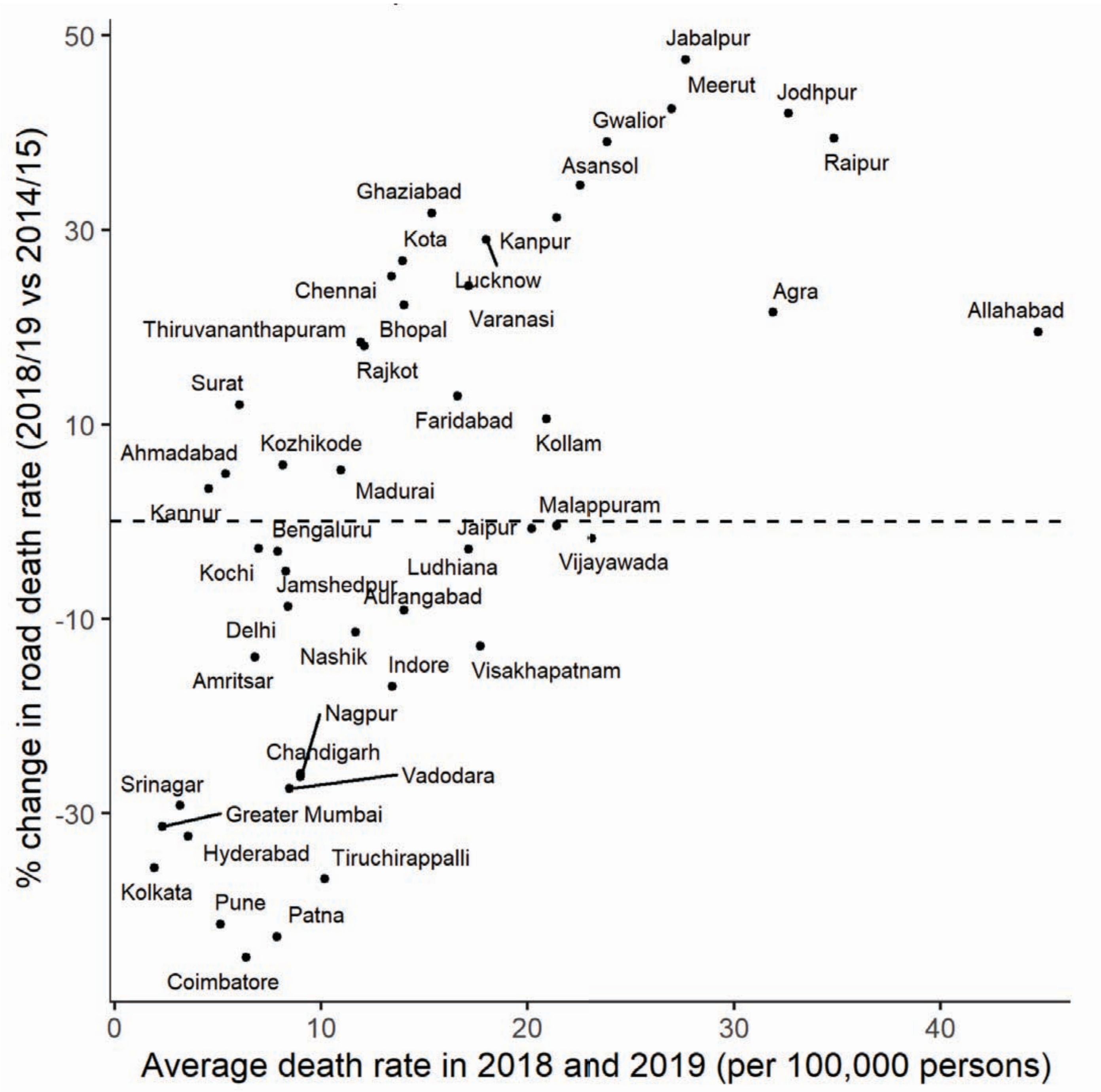

Figure 16. Percent change in road death rates over the 5-year period from 2014/15 to 2018/19 in million-plus cities of India. X-axis shows the average death rate over 2018/2019. Death rates increased in cities above X-axis (Source: Transport Research Wing 2020)

Next, we discuss the changes in death rates over the 5-year period from 2014/15 to 2018/19. The percentage changes and average death rates for 2018/19 are presented in Figure 16. Dhanbad and Thrissur cities have the highest growth over this period with 219% and 99% increase in death rates. In both these cities, a step change occurred from low to high numbers, and there is a possibility that their death numbers may have been misreported. These two cities have not been shown in Figure 16. In half the cities, death rates increased and in the other half they either reduced or remained the same.

These data show that compared to 2014/15, death rates changed significantly in 2018/19 as follows:

- Increased by more than 25% in 13 cities: Dhanbad, Thrissur, Jabalpur, Meerut, Jodhpur, Raipur, Gwalior, Asansol, Ghaziabad, Kanpur, Lucknow, Kota, and Chennai.

- Decreased by more than 25% in 11 cities: Coimbatore, Patna, Pune, Tiruchirappalli, Kolkata, Hyderabad, Greater Mumbai, Srinagar, Vadodara, Nagpur, and Chandigarh.

A large majority of cities where deaths rates increased significantly are in the northern states of the country, and a large majority where road deaths have reduced are in the western and southern states. The increase in death rate in Chennai over the same period was 25%, whereas the state of Tamil Nadu recorded a decrease of 30%. 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.

It is not possible to explain the differences in city fatality rates per hundred thousand persons as we do not have details of the implementation of safety policies in any of these cities. It is interesting to note that none of the high rate cities include cities with populations greater than three million, whereas the low rate cities include five with population greater than five million.

Since a vast majority of the victims in the cities are vulnerable road users (see next section), one possible cause of low death rates in low rate cities (populations greater than 5 million) could be reduction of vehicle speeds due to congestion. The probability of pedestrian death is estimated at less than 10% at impact speeds of 30 km/h and greater than 80% at 50 km/h, and the relationship increase in fatalities and increase in impact velocities is governed by a power of four (Leaf and Preusser 1999, Koornstra 2007).

RTI DETAILS FOR SELECTED CITIES

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

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

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 proportions of pedestrian fatalities reported in detailed research reports are very much greater than those reported by the MoRTH. The MoRTH estimates for RTI modal shares suffer from erroneous coding and should not be used.

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%.

Largest proportion of fatalities for all road user categories (especially vulnerable road users) are associated with impacts with buses and trucks and then cars.

The 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.

An interesting feature emerging from this analysis is the involvement of MTW as impacting vehicles for pedestrian, bicyclist and MTW fatalities in cities.

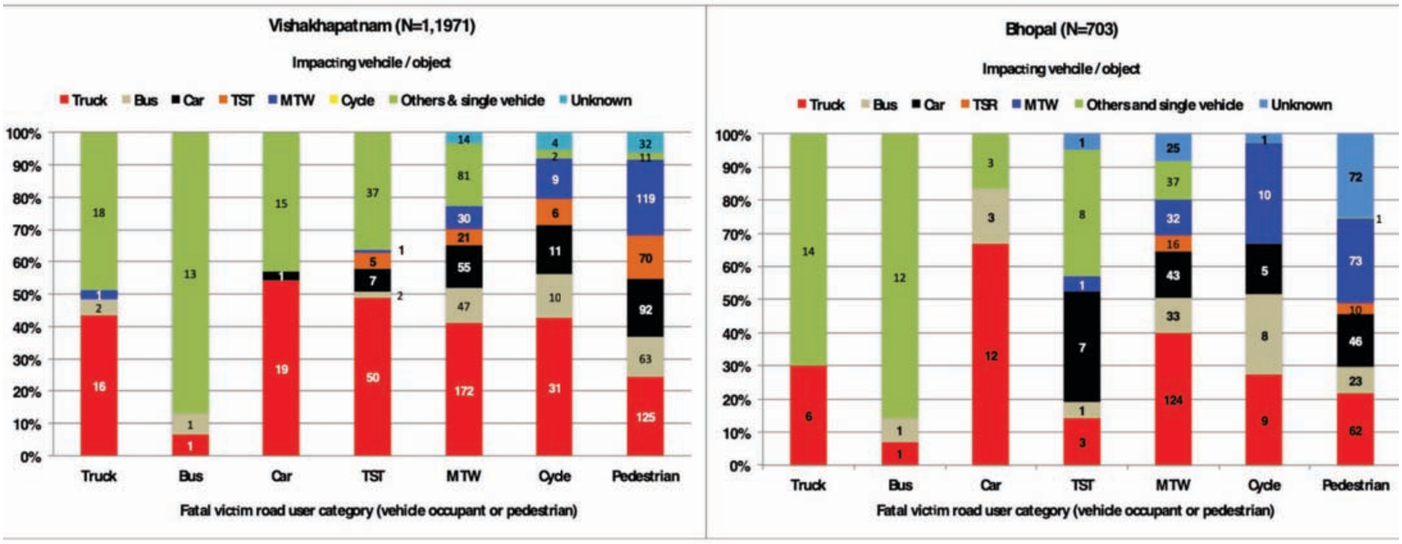

Figure 17. Fatal RTI road user category and impacting vehicles / objects in Vishakhapatnam and Bhopal (Numbers in bars represent number of cases; TST: three-wheeled scooter taxis).

RTI victims and impacting vehicles

Figure 17 shows the data for the distribution of road traffic fatalities by road user category versus the respective impacting vehicles/objects for two of the 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.

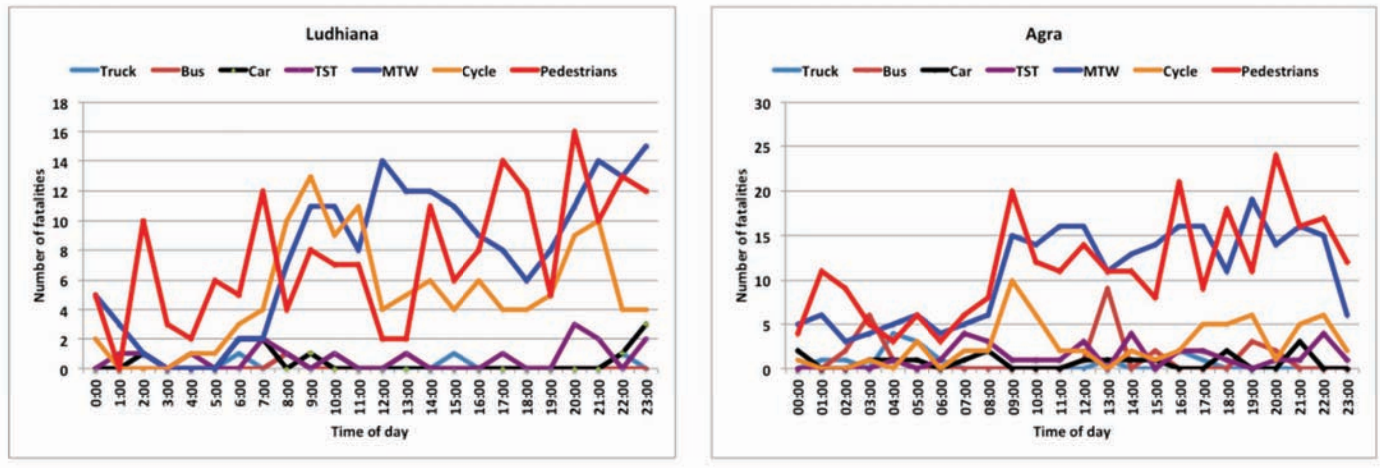

Figure 19. Fatalities by road user category and time of day in Ludhiana and Agra

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

Figure 19 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.

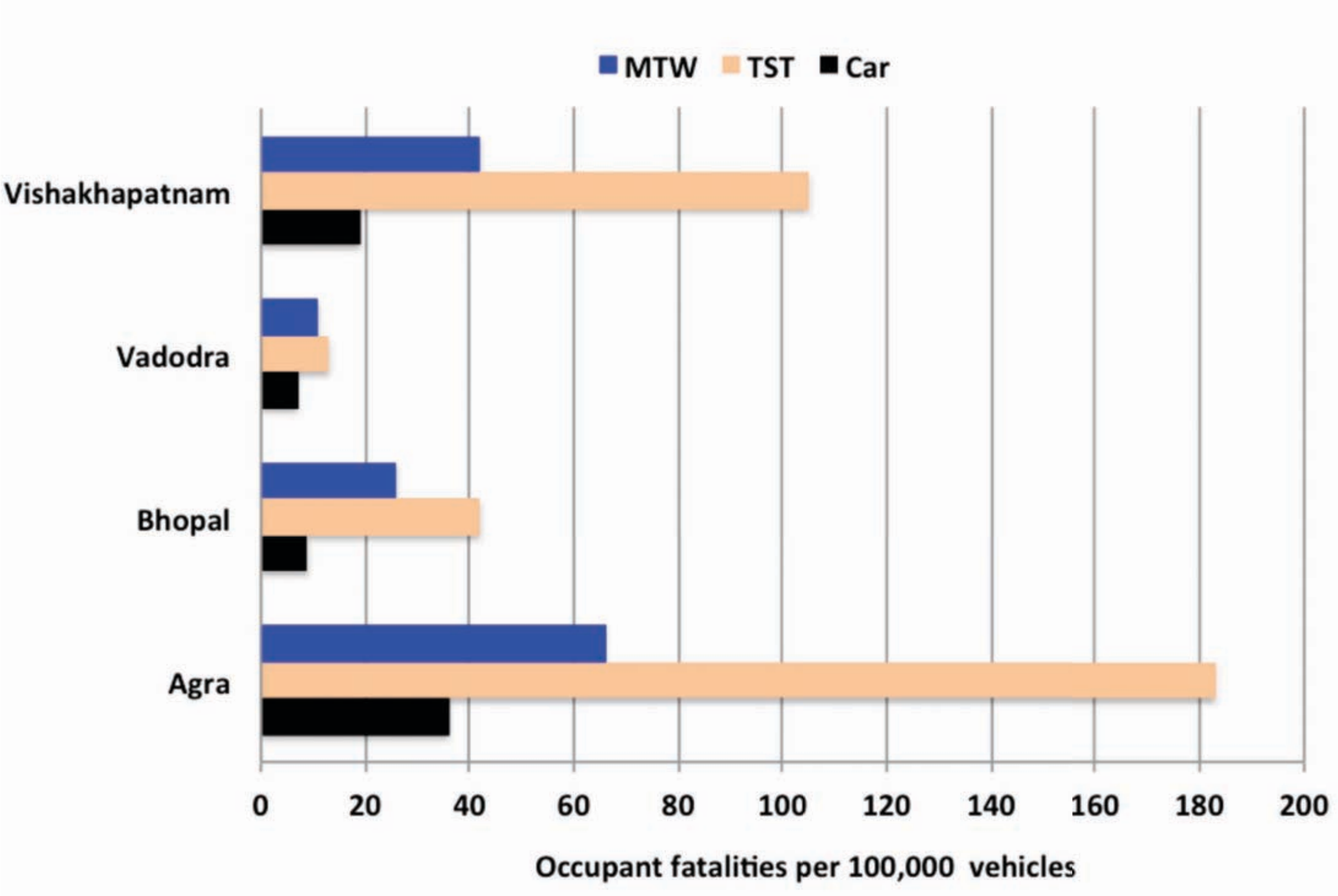

Figure 18. Motor vehicle occupant fatalities per 100,000 vehicles.

Occupant risk per hundred thousand vehicles

Figure 18 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).

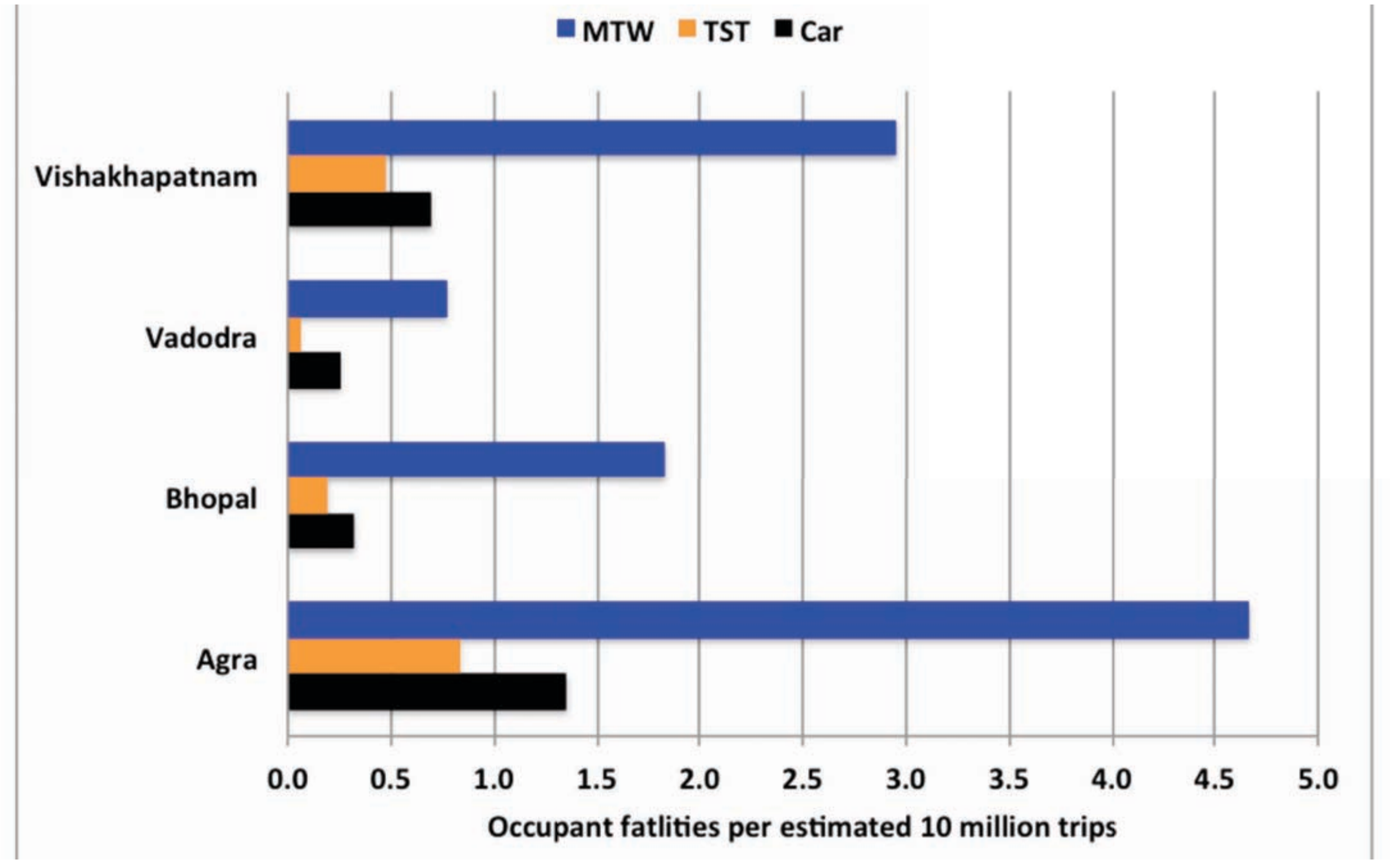

Figure 20. Occupant fatality rates per 10 million trips.

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 20. It is clear that given the present trip lengths for each vehicle type, the MTW rider is 3-6 times more at risk than a car occupant.

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.

The MTW fatality rates per trip in Agra and Vishakhapatnam are much higher than the other three cities. The reasons for this are not known at present. At a personal level, risk per trip seems to be lowest for TST occupants in all the cities for the assumed occupancy rates and number of trips per day.

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).

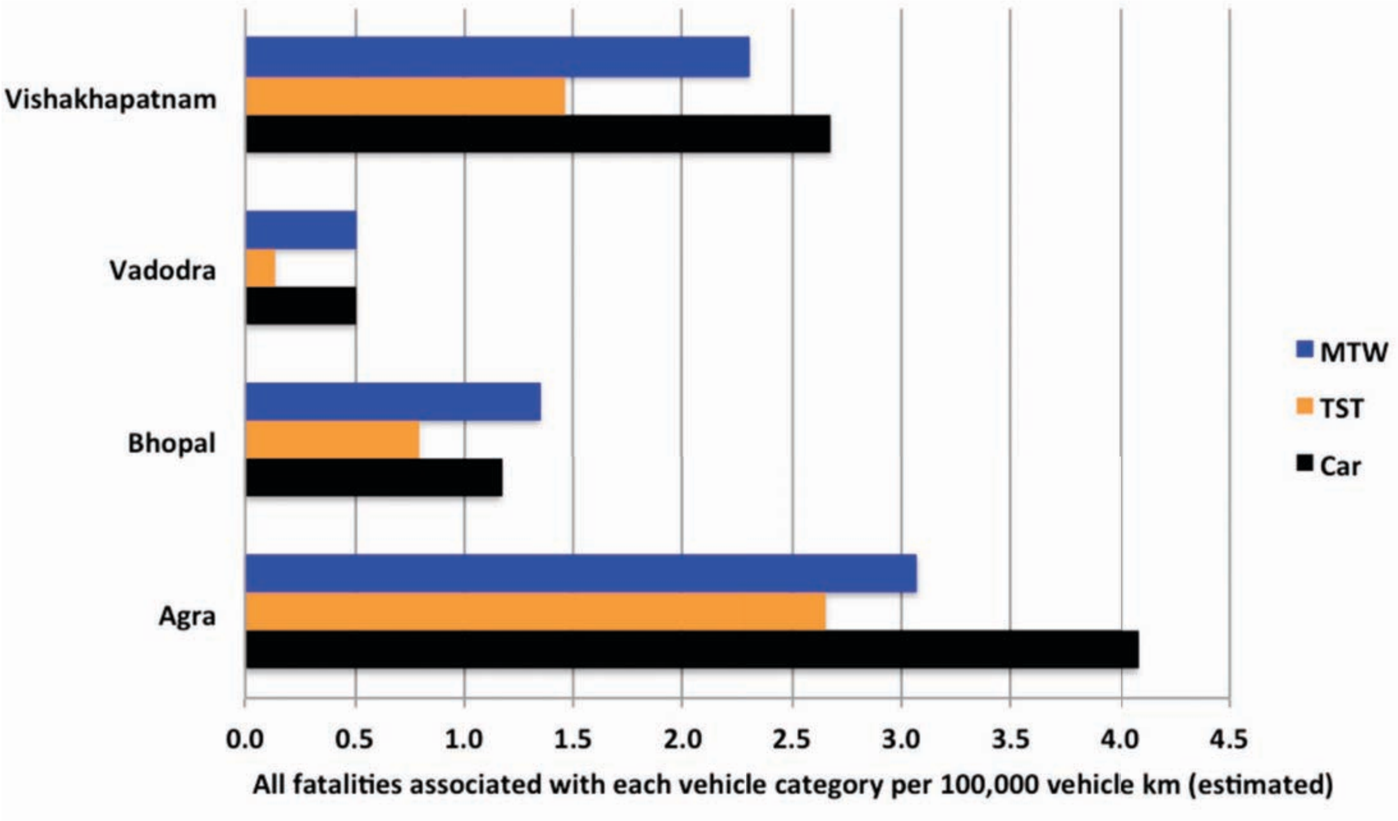

Figure 21. All fatalities associated with each vehicle category per 100,000 vehicle km (estimated).

Fatalities associated with each vehicle type accounting for exposure

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

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

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

Conclusions from detailed city studies

The total number of vulnerable road user deaths in the six 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

- During the past 5 years (2014/15 to 2018/19), the proportion of total road deaths in India that occurred within urban areas has been decreasing every year—from 39% in 2015 to 33% in 2019. The possible reasons can be widening of national highways and development of new expressways leading to greater number of fatalities in rural areas. In urban areas, increasing congestion could be resulting in reducing incidence of road deaths. Traffic enforcement such as motorcycle helmets and seatbelt are also limited to urban areas.

- Government data reports road death statistics for 50 cities that have a population of 1 million or greater. In 2019, 35% of all urban deaths occurred in 50 million-plus cities. The average fatality rate for these cities combined was 14.5 per 100,000 persons which is 25% greater than the national average of 11.6 per 100,000.

- During 2018/19, five cities with the highest death rates are Allahabad, Raipur, Jodhpur, Agra, and Jabalpur with an average rate of 34.3 per 100,000. Among the 10 largest cities in India, Jaipur has the highest death rate of 20.2 per 100,000 and Kolkata has the lowest rate of 1.9 per 100,000.

- The regional pattern in the changes in road deaths is also reflected in the cities. There are 13 cities in which death rates have increased by 25 percent, out of which 9 are in northern states. There are 11 cities in which death rates have reduced by 25% and majority of those are in the southern states.

- 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.

DISTRICT LEVEL SAFETY

INTRODUCTION

We present analysis of road deaths for the six districts of Chhattisgarh state. Unlike data for cities that represent only urban areas and for highways that represent only rural areas, districts consist of both rural and urban areas, and are representative of road death statistics at the state level. The six districts are Balod, Bemetara, Durg, Gariaband, Kondagaon, and Raipur. These districts represent central and southern part of the state. We collected FIRs of road crashes for these districts for the years 2017 to 2019 and includes a total of 2544 deaths. The death rates across these six districts range from 11.1 to 20.3 deaths per 100,000, with an average of 15.7 across all districts. In general, these death rates are greater than the country average. Of the total death victims, 13% are females and the rest are males. Average age of victims is 37 years, with 30% of them younger than 25 years and 75% younger than 45 years.

District	Deaths per 100,000 (2017-2019)	Pedestrian	Bicycle	Motorised two-wheeler	Car & taxi	Bus	Truck/ Tractor	Other
		Percent						
Balod	18.8	19	2	61	7	1	10	0
Bemetara	15.9	20	4	57	6	2	10	1
Durg	11.1	25	4	64	3	0	4	2
Gariaband	12.2	12	4	68	3	3	9	1
Kondagaon	20.3	17	4	56	12	2	8	2
Raipur	18.3	22	5	61	5	1	5	1
All districts	15.7	20	4	61	6	1	7	1

Table 6. Proportion of road death victims across districts in Chhattisgarh (2017-2019)

Table 6 shows for each district and all districts combined the percentage of road death victims. The data shows that motorcyclists are the largest group of road death victims with a share of 56 to 68 percent. Pedestrians form the second largest group with 12 to 25 percent of the road death victims. Cyclists contribute less than 5% and car occupants are another 3% to 12% of victims. The three vulnerable road users—pedestrians, bicyclists and motorcyclists— have a combined share of 85 percent. Among the motorcycle victims, 73% were drivers and 27% were pillion riders. Among the car occupants who died, 33% were drivers and 67% were passengers.

District	No other vehicle	Motorised two-wheeler	Car & taxi	Bus	Truck/ Tractor	Other
	Percent					
Balod	28	18	10	7	35	3
Bemetara	29	23	6	3	33	6
Durg	29	17	10	4	34	5
Gariaband	34	14	10	3	22	17
Kondagaon	29	14	8	6	37	5
Raipur	22	14	11	5	43	4
All districts	27	16	10	5	37	5

Table 7. Proportion of striking vehicles involved in crashes where other road user died across districts in Chhattisgarh (2017-2019)

Table 7 presents distribution of striking vehicles involved in crashes in which another road user was killed. With an average share of 37% across the districts, trucks/tractors are the most frequent striking vehicle. The next largest category is 'no other vehicle', with an average share of 27 percent. This is a significantly large share given that in these crashes a road user was killed with no other road user involved. This may result from vehicles skidding, tripping or colliding into a fixed object such a tree or median. Truck, tractor, and no-other-vehicle are involved in two-thirds of fatal cases. Motorised two-wheelers have a larger contribution as striking vehicles than cars (16% and 10%, respectively).

Road user killed	In crashes with					
	No other vehicle	Motorised two-wheeler	Car & taxi	Bus	Truck/ Tractor	Other
	Percent					
Pedestrian	0	36	15	6	40	3
Cycle	0	27	19	5	47	1
Motorised two-wheeler	26	14	10	5	38	7
Car	42	1	5	3	48	2
Truck/Tractor	59	7	1	3	29	1

Table 8: Distribution of striking vehicles in the fatal crashes of different road users

Table 8 presents proportion of striking vehicles for different road users who died in road crashes for all six districts combined. More than 90% pedestrians and cyclists died in crashes with three vehicle types—truck/tractors, MTW or cars. Among crashes in which pedestrians died, MTW and truck/tractor are equally likely to be involved as striking vehicles. Almost half the cyclists died in crashes with truck/tractor. Crashes with no other vehicle involved have significant contributions in the deaths of motor vehicle users. Up to 60% of all truck/tractor deaths, 42% of car occupant deaths, and 26% of MTW deaths are in single-vehicle crashes. Truck/tractors are also significant contributor in the deaths of MTW and car occupants. Up to half of car occupants died in crashes with trucks/tractors.

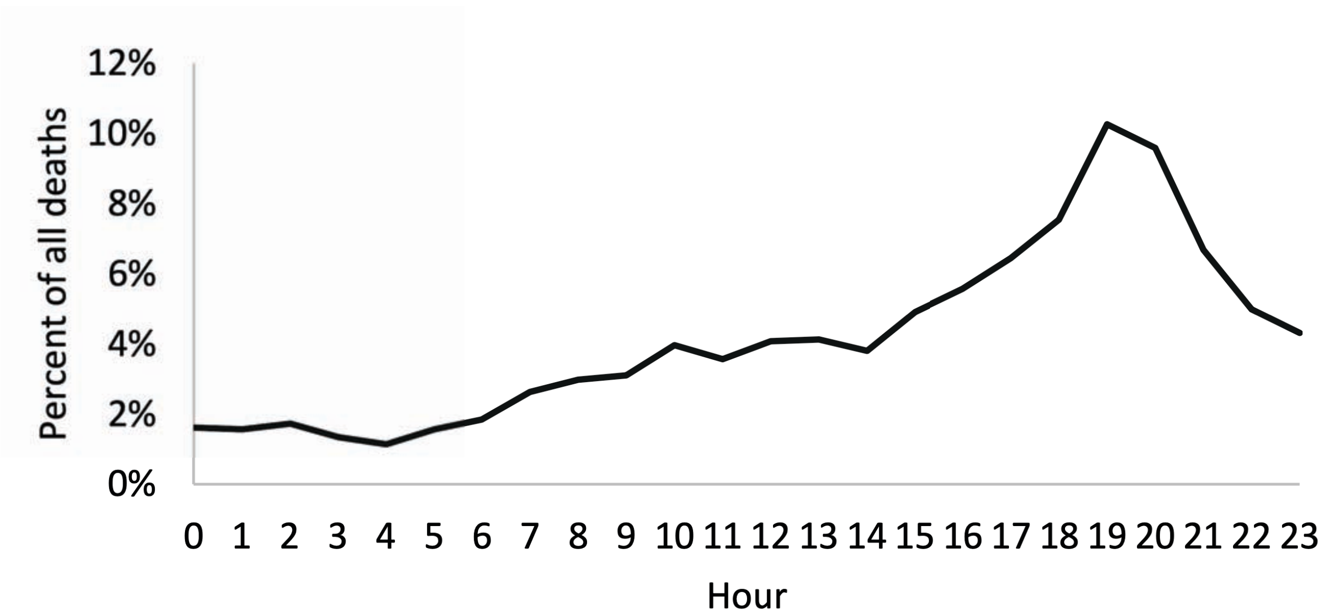

Figure 22. Time of day distribution of road deaths across six districts of Chhattisgarh

Figure 22 presents time-of-day distribution of road deaths. Greater number of crashes occurred during night than during the day. The crashes peak between 7 PM to 9 PM. No such peak is present during the morning, indicating that night-time crashes are likely because of poor visibility and greater proportion of drunk driving.

INTERCITY HIGHWAYS

INTRODUCTION

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

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.

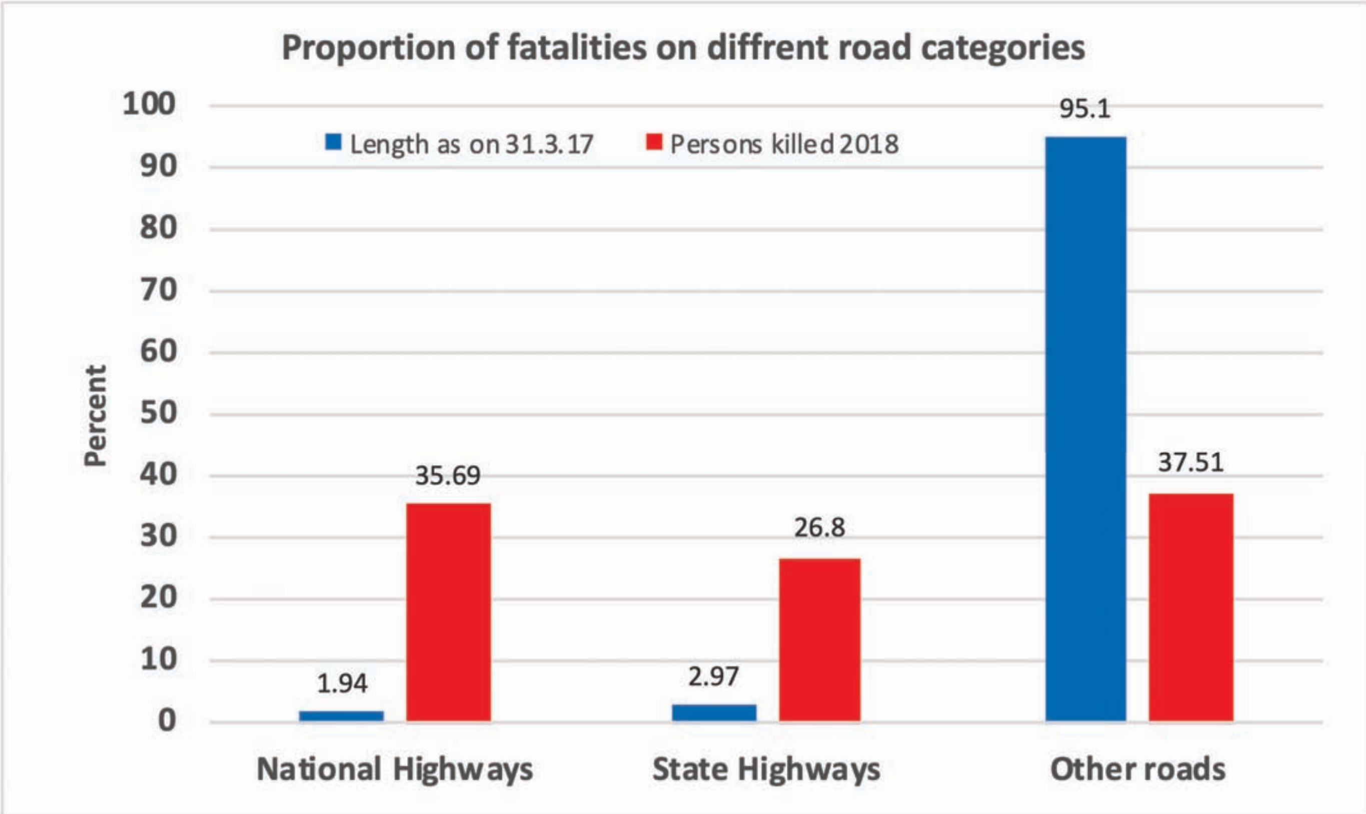

Figure 23. Proportion of RTI fatalities on different categories of roads and the proportion of road length for each category (Source: Transport Research Wing, 2019)

Traffic crashes on Indian Highways

Figure 23 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 24). 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-8and 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).

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.

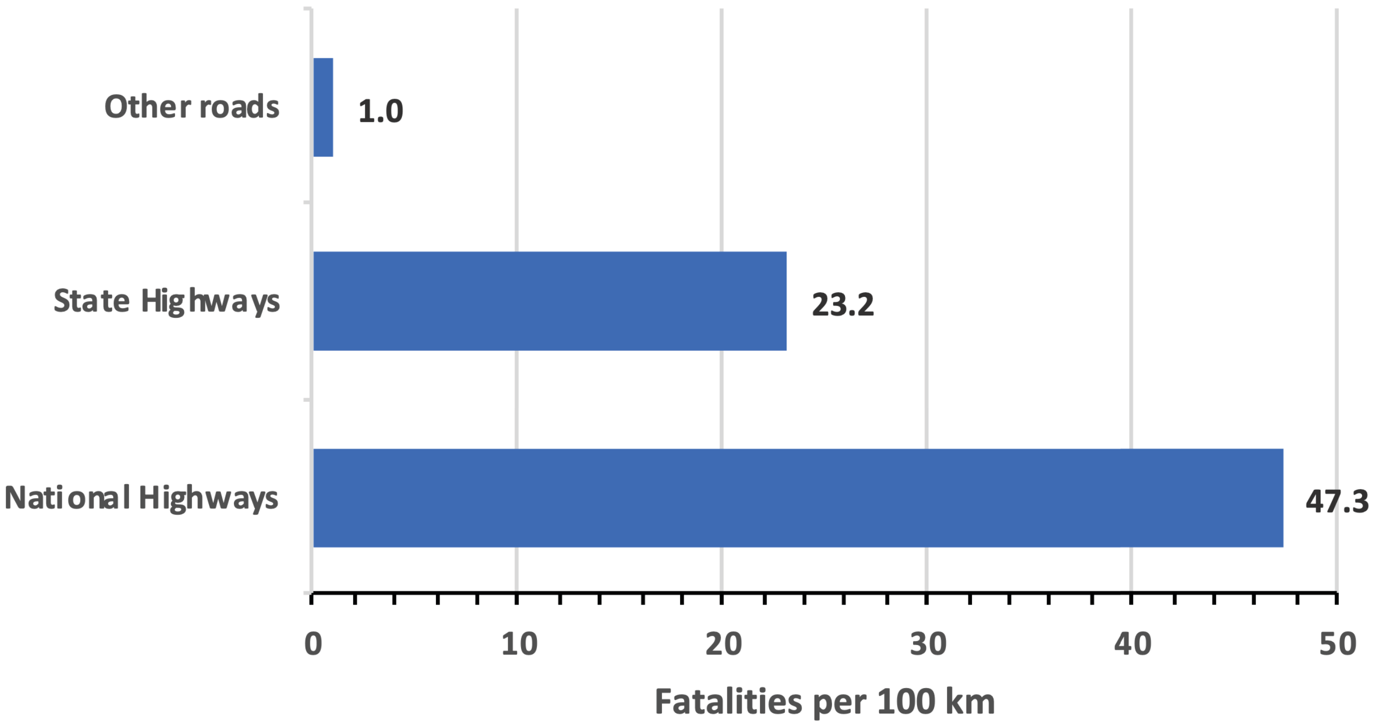

Figure 24. Fatalities per 100 km on different categories of roads in India in 2018 (Source: Transport Research Wing, 2019).

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.

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

Location	Fatalities by type of road user, per cent						
	Pedestrian	Bicycle	Motorised two-wheeler	Car	Bus	Truck	Unknown & other
Highways (1998)[1]	32	11	24	15	3	14	1
2lane NH8 (2010-2014)[2]	20	2	42	14	9	13	1
4lane NH24 (2010-2014)[2]	27	5	44	8	7	4	4
6lane NH1 (2010=2014)[2]	34	3	10	6	5	41	1

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

Table 10. Proportion of impacting vehicle type in fatal crashes on selected highway locations.

Location	Vehicles involved, percent						
	Truck	Bus	Car	TSR	MTW	Others	Total
Highways (1998)[1]	65	16	15	1	3	-	100
2lane NH8 (2010-2014)[2]	47	5	17	1	5	25	100
4lane NH24 (2010-2014)[2]	54	8	9	4	3	22	100
6lane NH1 (2010=2014)[2]	72	3	12	1	2	10	100

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

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 9. In the 1998 study of highways the proportions of motor vehicle occupants and vulnerable road users were 32 and 68 per cent respectively, whereas the numbers for urban areas were 5%-10% vehicle occupants and the rest were vulnerable road users. 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 10 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.

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 arterialsz *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 arterialsz*

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.

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 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.

Rear-end collisions (including collisions with parked vehicles) are high on all types of highways including 4- lane highways.

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 crashes 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 under-passes (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.

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.

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 programs 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.

Imposing stricter penalties (in the form of higher fines or longer prison sentences) will not affect road-user behaviour significantly.

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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.

Use of seatbelts and airbag-equipped cars can reduce car-occupant fatalities by over 50% (provided car user is seat belted)

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.

Driver or pedestrian education programmes by themselves usually are insufficient to reduce crash rates

Compulsory helmet use reduces bicycle-related head and facial injuries for bicyclists of all ages involved in all types of crashes, including those involving motor vehicles (Thompson, Rivara, and Thompson 2003). Similar results have been confirmed for motorcyclists (Mohan et al. 1984, McKnight and McKnight 1995, National Highway Traffic Safety 1996, American College of 2001, Bledsoe et al. 2002, Brandt et al. 2002, Liu et al. 2003)

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.

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 50% (provided the car user is seat belted). 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 Kyrychenko 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.

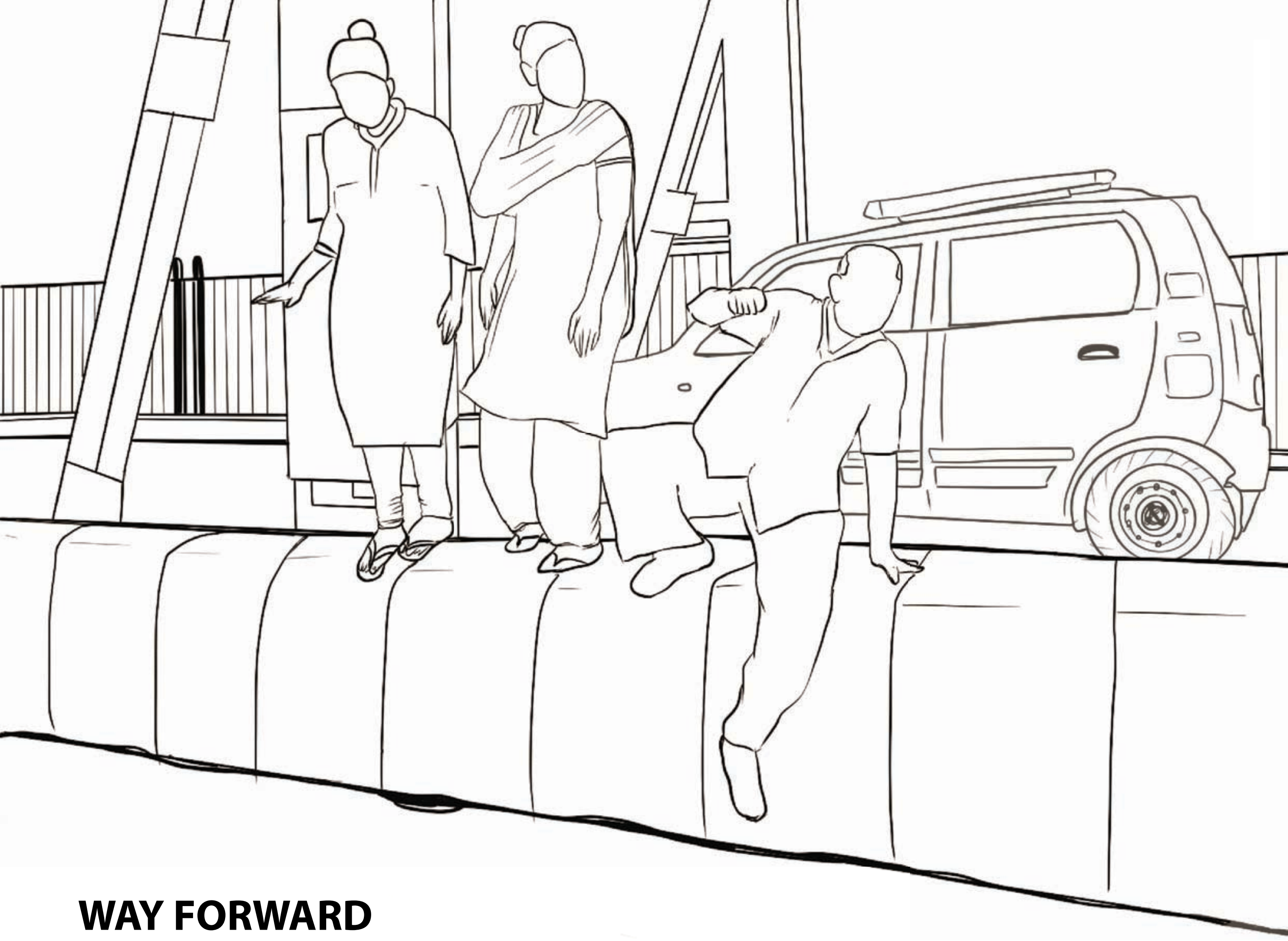
- Driver or pedestrian education programmes by themselves usually are insufficient to reduce crash rates. Only effective way to get most motorists to use safety belts and motorcyclists to wear helmets is with good laws requiring their use and enforcement.

- Use of seatbelts and airbag-equipped cars can reduce car-occupant fatalities by over 50% (provided the car user is seat belted).

- 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.

3. Provision of segregated bicycle lanes and disabled-friendly pedestrian paths.

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

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

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Transportation Research and Injury Prevention Centre
Indian Institute of Technology Delhi

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