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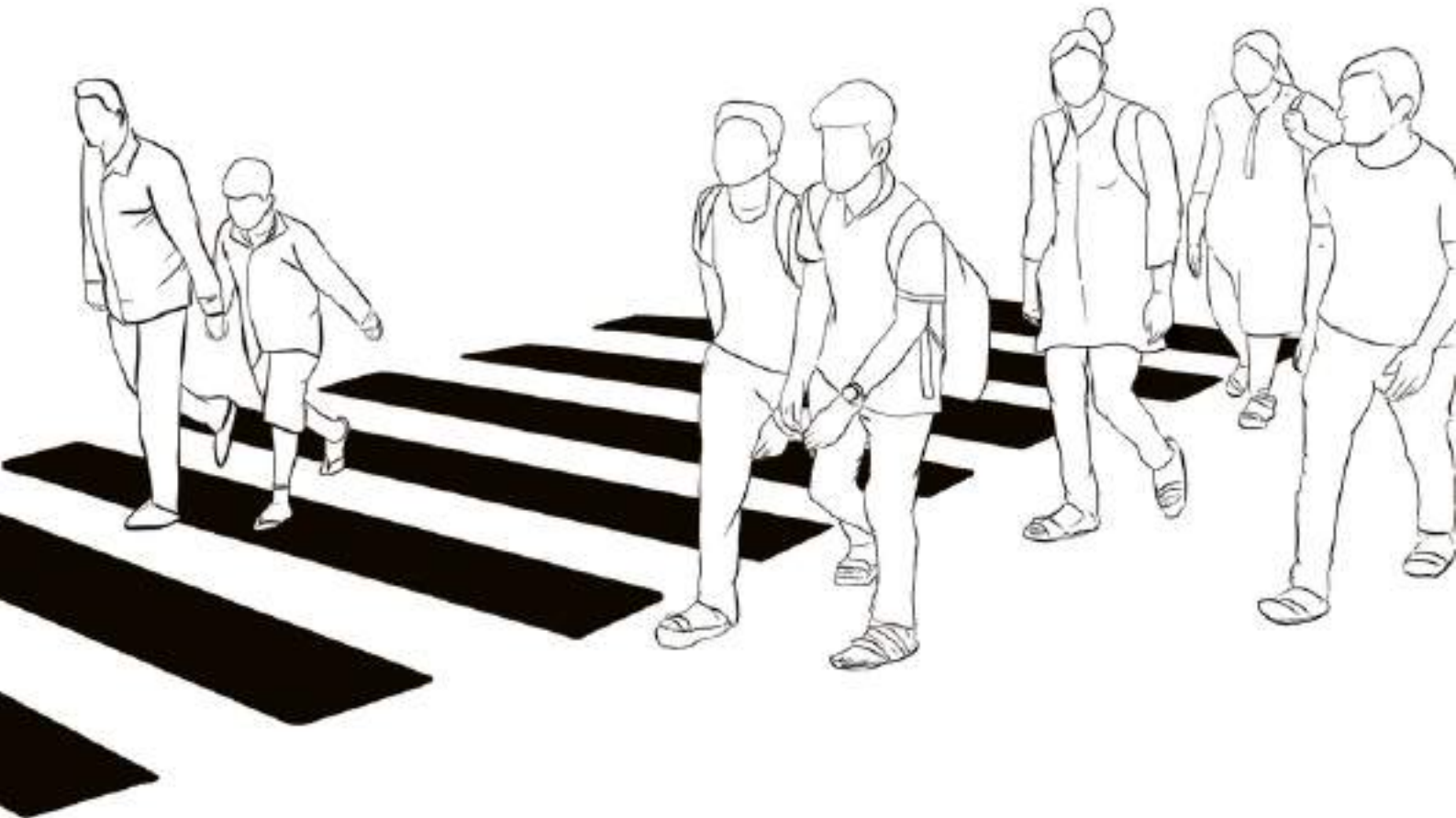TRANSPORTATION RESEARCH AND INJURY PREVENTION CENTRE

ROAD SAFETY IN INDIA
STATUS REPORT 2023

Transportation Research & Injury Prevention Centre

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

Road Safety in India: Status Report 2023

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EXECUTIVE SUMMARY

ROAD TRAFFIC CRASH AND INJURY DATA

- According to official statistics published by the Ministry of Road Transport and Highways (MoRTH), 153,972 persons were killed in road crashes in the year 2021. This corresponds to 11.3 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
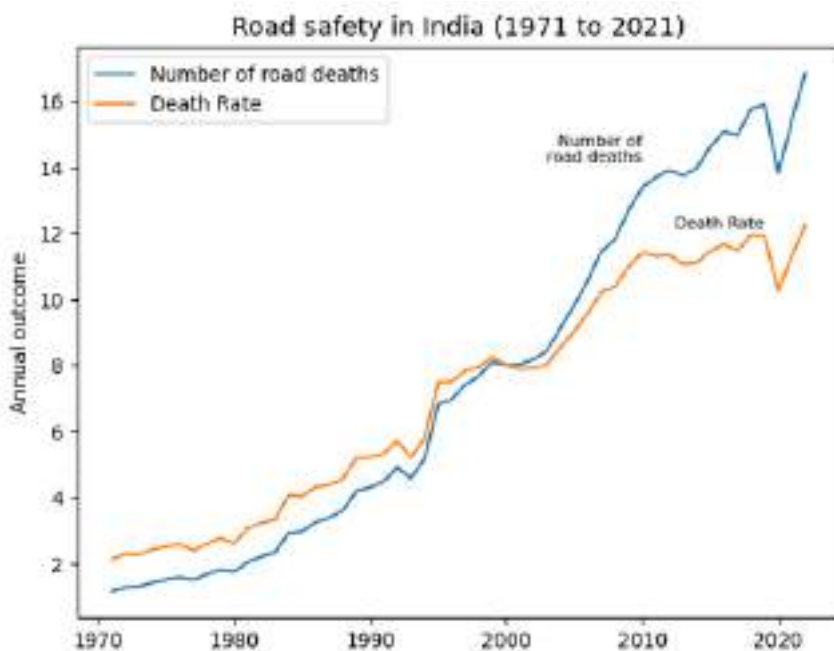

Figure 1 : Number and rate of road deaths in India from 1971 through 2021 (Source: NCRB 2022 & Transport Research Wing 2023).

- The number of cars and motorised two-wheelers (MTW) registered in 2020 was 43.73 and 243.5 million respectively. The official registration data overrepresent 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 registration 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
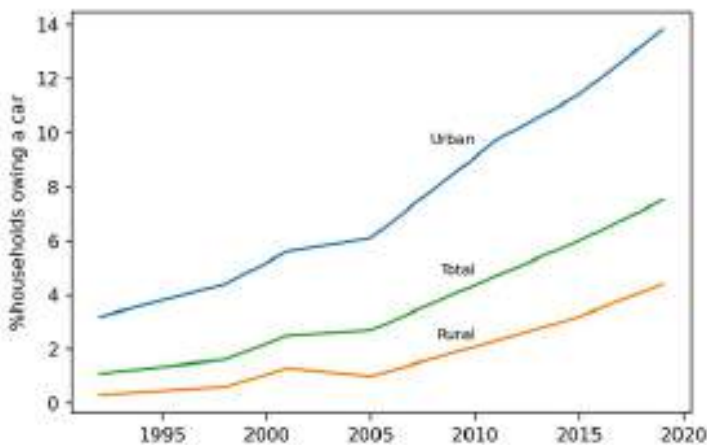

Figure 2 : Car ownership in India

- There is evidence suggesting that number of road deaths in India is underreported, however, its extent is not well understood. 'Global Burden of Diseases, Injuries, and Risk Factors Study' estimated that in 2019, 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 of Healthy Life Lost in India 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

- Annual reports published by Ministry of Road Transport and Highways (MORTH) and National Crime Records Bureau (NCRB) are based on police data. The official estimate of non-fatal RTI in 2021 was 371,884 which probably underestimates injuries requiring hospitalization by a factor of 5 and all injuries by a factor of 20. These data should not be used for studying the epidemiology of non-fatal road traffic injuries (RTI) in the country

- 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, data showing the yearly changes in road deaths in the cities are not reliable

- 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. These are generally noted by the local investigating officer in the police station for purpose of court proceedings

- This situation can only be improved by MoRTH with a complete revamp of the data collection systems in collaboration with the Ministry of Home Affairs and establishment of a professional data and analysis department.

ANALYSIS OF DATA AT NATIONAL LEVEL

- The total number of deaths in 2021 was 13.2 times greater than in 1971 with an average annual compound growth rate of 6%, and the fatality rate in 2021 was 5.3 times greater than that in 1971 with an AACGR of 4%

- 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 (~19% 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

- 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.

- 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 underreporting of road deaths among older adults, as indicated by independent population-level surveys, may explain this inconsistency for older adults

- Among the states with more 10 million population contributing 98% of country's road deaths, during the 5-year period from 2015 to 2019, road death rates have reduced in half the states and have increased in the other half. Significant reductions occurred in Puducherry (39%), Nagaland (35%), Chandigarh (29%), and Mizoram (21%) while significant increases were recorded in Bihar (44%), Tripura (31%) and Chhattisgarh (30%)

- Death rates have increased by more than 20% in Uttar Pradesh, Bihar, Madhya Pradesh, Jharkhand, Assam, Chhattisgarh, Tripura, and Manipur (names in the decreasing order of population). This is a worrying trend as these states cumulatively contribute one in three road deaths in India. 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.

- 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 road infrastructure availability, vehicle modal shares, road design, and enforcement.

URBAN SAFETY

- During the two-year period of 2019 and 2021, the 2-year average fatality rate for all 53 cities with a population of 1 million or more was 10.5 per 100,000 population which is slightly lower than the national average of 11.3 per 100,000

- The five cities with the highest death rates are Asansol, Ludhiana, Vijayawada and Jaipur with the average fatality rate of 21 per 100,000, which is around 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, Pune, Jamshedpur, Bhopal and Surat

DISTRICT - LEVEL SAFETY

- An analysis of road traffic deaths in 27 districts of Chhattisgarh and 11 districts of Haryana (including urban and rural areas) of from 2017 to 2019 shows that the motorcyclists form most of road death victims with a share of 59 and 47 percent respectively. 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 23% (19% and 4%, respectively). In total the share of vulnerable road users (including motorcyclists) is about 87 percent of all deaths. Similarly, in case of Haryana share of of vulnerable road users (including motorcyclists) is about 79 percent of all deaths.

- 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 0.42 deaths per km annually and this fact should be the guiding factor in future design considerations. 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% 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.

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

- Development of street designs and traffic-calming measures that suit mixed traffic with a high proportion of motorcycles and non-motorized modes

- Highway design with adequate and safe facilities for slow traffic

- Pedestrian impact standards for buses and trucks

- Evaluation of policing techniques to minimize cost and maximize effectiveness

- Effectiveness of pre-hospital care measures

- Traffic calming measures for mixed traffic streams including high proportion of motorised two-wheelers

- Establish National Board/Agency for Road Safety

- Establish a special central department for coding and recording all fatal crash data. The data so collected should be anonymised and made available publicly for analysis

- Establish safety departments within operating agencies

- Establish multidisciplinary safety research centres at academic institutions

INTRODUCTION

NATIONAL ROAD TRAFFIC INJURY FATALITY RATE

According to official statistics 155,622 persons were killed and 371,884 injured in road traffic crashes in India in 2021 (NCRB, 2022). This corresponds to a death rate of 11.4 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.

According to official statistics 155,622 persons were killed and 371,884 injured in road traffic crashes in India in 2021. 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.

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 death rate expressed as number of deaths per 100,000 population.

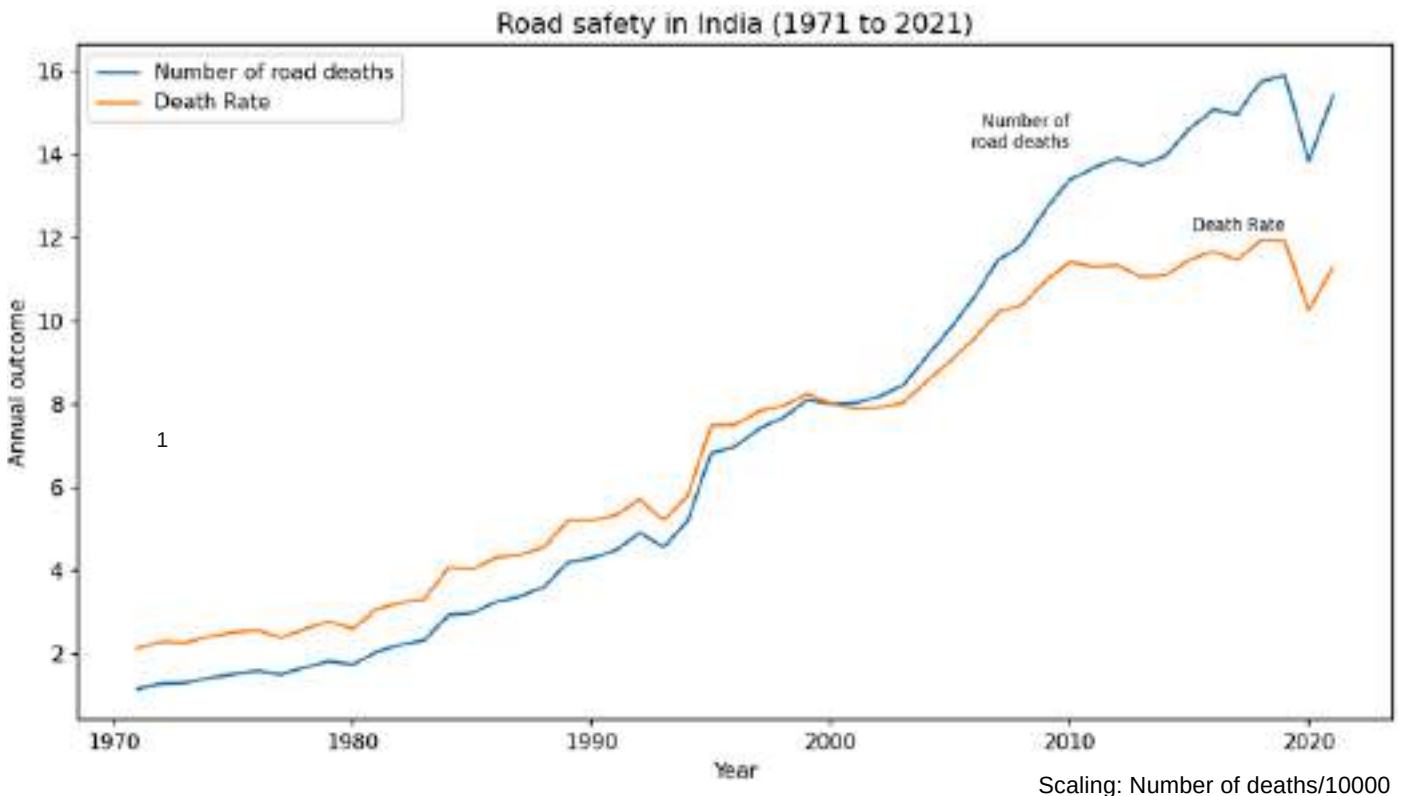Scaling: Number of deaths/10000

Figure 1 : Number of road deaths and death rate per 100,000 persons in India from 1971 through 2021 (Source: NCRB 2022 & Transport Research Wing 2023).

1 For a projected population of 1.36 Billion according to Population projections for INDIA and States 2011 -2036 by National commission on population (Ministry of health and family welfare)

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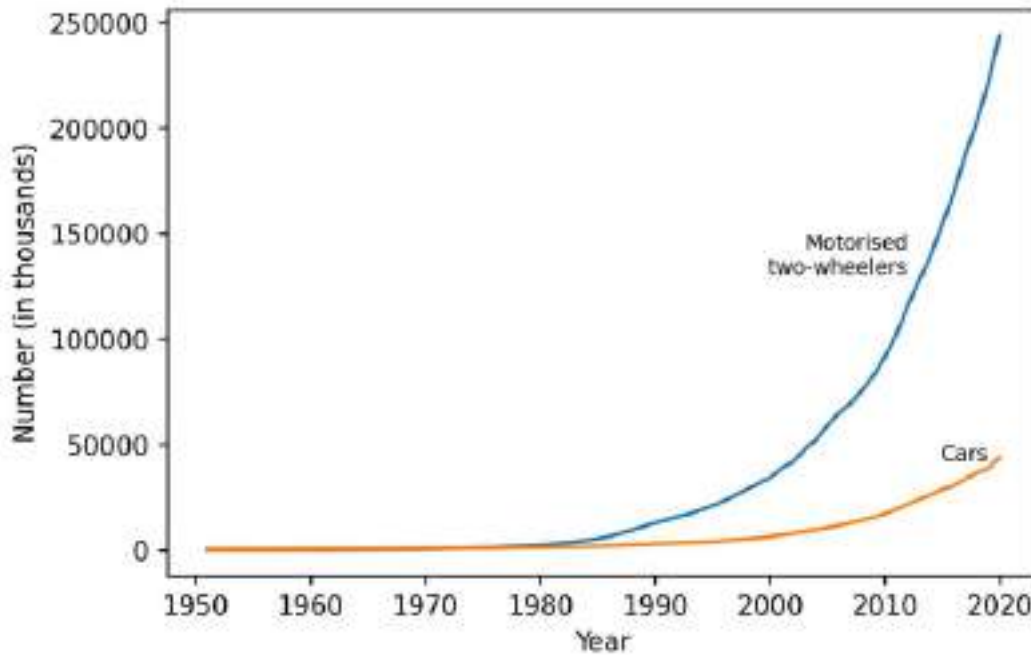
VEHICLE POPULATION

Figure 2 : Cars and motorised two-wheelers (MTW) registered in India by year 1951-2020 (Source : Transport Research Wing, 2022).

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, 2022). The official registration data overrepresent 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 2020 was 43.7 and 243.5 million respectively (TRW, 2022). 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 27 and 146 million respectively, and total personal vehicle ownership (including cars and MTW) estimated at ~13 per 100 persons in 2020.

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.

Figure 3 presents trend of percentage household owning cars and motorised two-wheelers over the 25-year period from 1993 to 2019. This data includes ownership levels reported by National Family Health Surveys (NFHS)[3] for 1993, 1998, 2005, 2015 and 2019.

2 Road transport year book (2017 -2018 and 2018-2019)
3 National Family Health Survey

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	6.0
Chile	45	12.0
Greece	60	7.8
Hungary	32	6.0
Japan	69	4.5
Portugal	56	6.0
Sweden	56	2.7
United Kingdom	54	2.8

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

Next, we compare the two sources of vehicle numbers— vehicle registration and household-level ownership from surveys. We use 2021 India population of 1.36 billion, in-use number of cars and MTWs of 27 and 146 million, respectively, and an average household size of 4.4 (NFHS-5). Using these numbers and assuming each households owns only one MTW or one car, 2021 estimate of household ownership of 8.7% for car and 47% for MTW. These estimates are close to population-survey estimates of 7.5% and 49.7% for 2019 as reported in Figure 3.

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.

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.
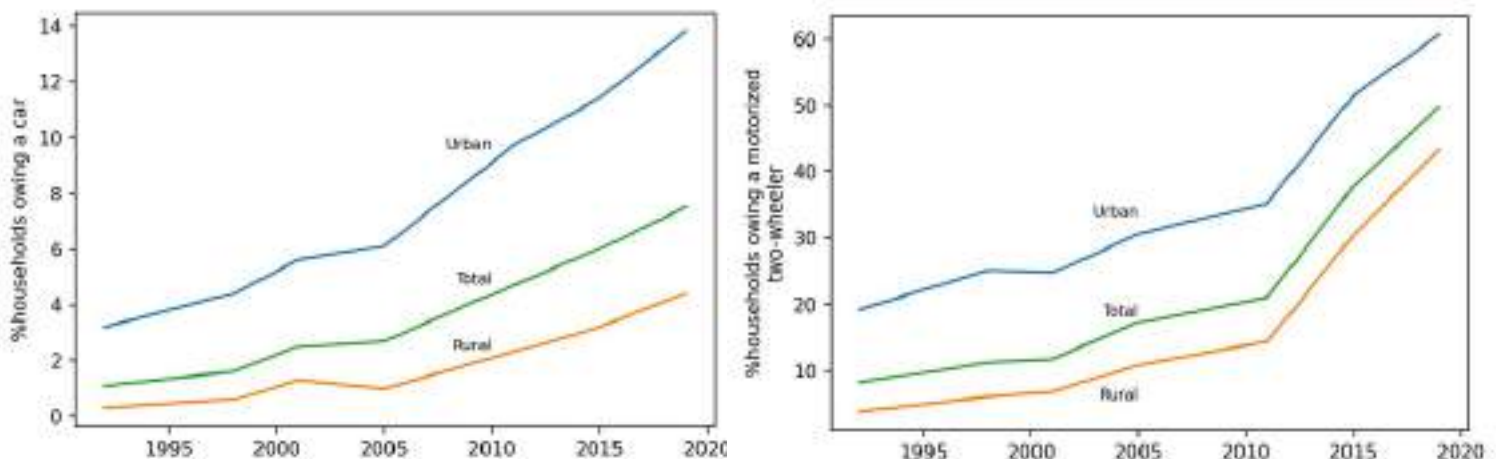

Figure 3: Car and motorcycle ownership in India

ROAD TRAFFIC CRASH AND INJURY DATA IN INDIA

RECORDING OF CRASHES

As in most countries, traffic police is 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, 2022), and the annual publication of the Transport Research Wing of Ministry of Road Transport & Highways (MoRTH) titled Road Accidents in India (MoRTH, 2022). 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.
- CrPC 174. Death caused by a machinery or an accident

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

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

REPORTING OF RTI CRASH DATA

Statistical tables that summarize key information about road traffic injuries are reported by police stations to their district's Crime Records Bureau, from where aggregated statistical tables flow upwards to the state's crime records bureau, and the National Crime Records Bureau (NCRB), which publishes the official statistics for the country (e.g. NCRB 2015). Police-based statistics underreport road traffic deaths and injuries in many countries (Bhalla et al. 2014, W.H.O. 2015, Rosman and Knuiman 1994, Derriks and Mak 2007).

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

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

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.

- 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.
- Under Section 165 of The Motor Vehicles Act 1988 (Ministry of Road Transport and Highways, 1988), all State Governments have been authorised to set up Motor Accident Claims Tribunals for adjudicating upon claims for compensation in respect of road traffic crashes involving death, bodily injury or property damage. Claims can be made by the person who has sustained the injury, by the owner of the damaged property, and by legal representatives of the deceased. Victims or their legal representatives in the case of hit-and-run cases can also make claims. For this reason lawyers look out for such cases in hospitals or police stations and promise legal help to make the claim

- When a RTI victim is admitted to a government hospital and declared as a RTI case, the patients' details are recorded as a 'Medico Legal Case' by a police officer stationed at the hospital. If the victim dies in the hospital, irrespective of the length of stay in the hospital, the body is released only after a mandatory autopsy and the relevant details are provided to a police officer seconded by the relevant police station.

RTI FATALITY ESTIMATES

The extent of underreporting 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. 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.

> *It is possible that the actual number of RTI deaths in India may be more than 40% higher than the official estimate.*

To understand the level of underreporting 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 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 underreporting 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 underreporting.

NON-FATAL INJURY ESTIMATES

While there is uncertainty among experts about the level of underreporting of road traffic deaths, all experts agree that police reports are a poor source of information for non-fatal injury statistics in India. Police databases typically report a small fraction of the non-fatal road traffic injuries that occur in most countries, including most developed countries (Derriks and Mak 2007, International Traffic Safety Data and Analysis Group 2011).

According to a recent IRTAD (2014) report police records alone are usually inadequate to carry out analysis on the nature and consequences of serious injuries because the reported number is underestimated. A report from France also states that under-reporting is inversely and strongly associated with injury severity: there is a clear gradient of decreasing probability of being police-reported with decreasing injury severity, 33-38% for severe injuries and 15% for minor injuries (Amoros et al. 2008, Amoros, Martin, and Laumon 2006).

Studies from India also indicate similar trends. A study done in 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. 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).

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.

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 Center for Statistics and Analysis 2015).Other studies report ratios between deaths:serious-injuries:minor-injuries as 1:13:102 (Martinez 1996) and 1:14:80 (Evans 1991). A more recent report states that in Netherlands the ratio of the estimated number of fatalities and hospitalised persons for the year 2000 was 15.7 (Derriks and Mak 2007).
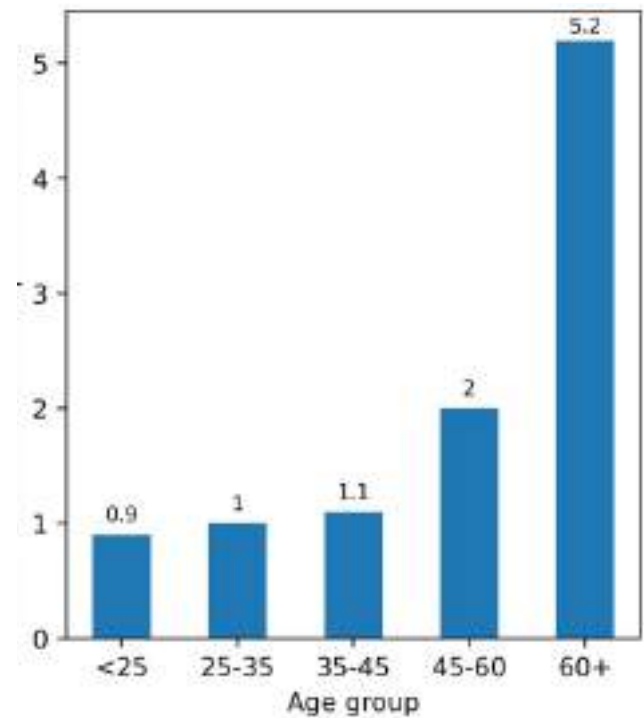

Figure 4: Age-specific comparison of GBD and MoRTH reported road deaths. (Ratio of 1 indicates the two sources of data report equal number of deaths.)

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 2021 is taken as 155,622 then the estimate of serious injuries requiring hospitalization would be 2,334,330 annually, and that for minor injuries 7,781,100. The official estimate of non-fatal RTI in 2021 was 371884 which probably underestimates injuries requiring hospitalisation by a factor of 4 and all injuries by a factor of 20.

The official estimate of non-fatal RTI in 2021 was 371,884 which probably underestimates injuries requiring hospitalisation by a factor of 5 and all injuries by a factor of 20.

The probability that a non-fatal injury gets registered by the police depends on whether there is a need to establish that the injury occurred due to the fault of a particular party, for instance, in order to claim financial compensation. This implies that the probability of a non-fatal crash being included in police reporting varies based on a wide range of factors (e.g. if multiple parties were involved, extent of property damage) that may have little to do with injury severity.

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

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.

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 (ICMR et al., 2017). 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

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).

Both sexes, All ages, DALYs per 100,000

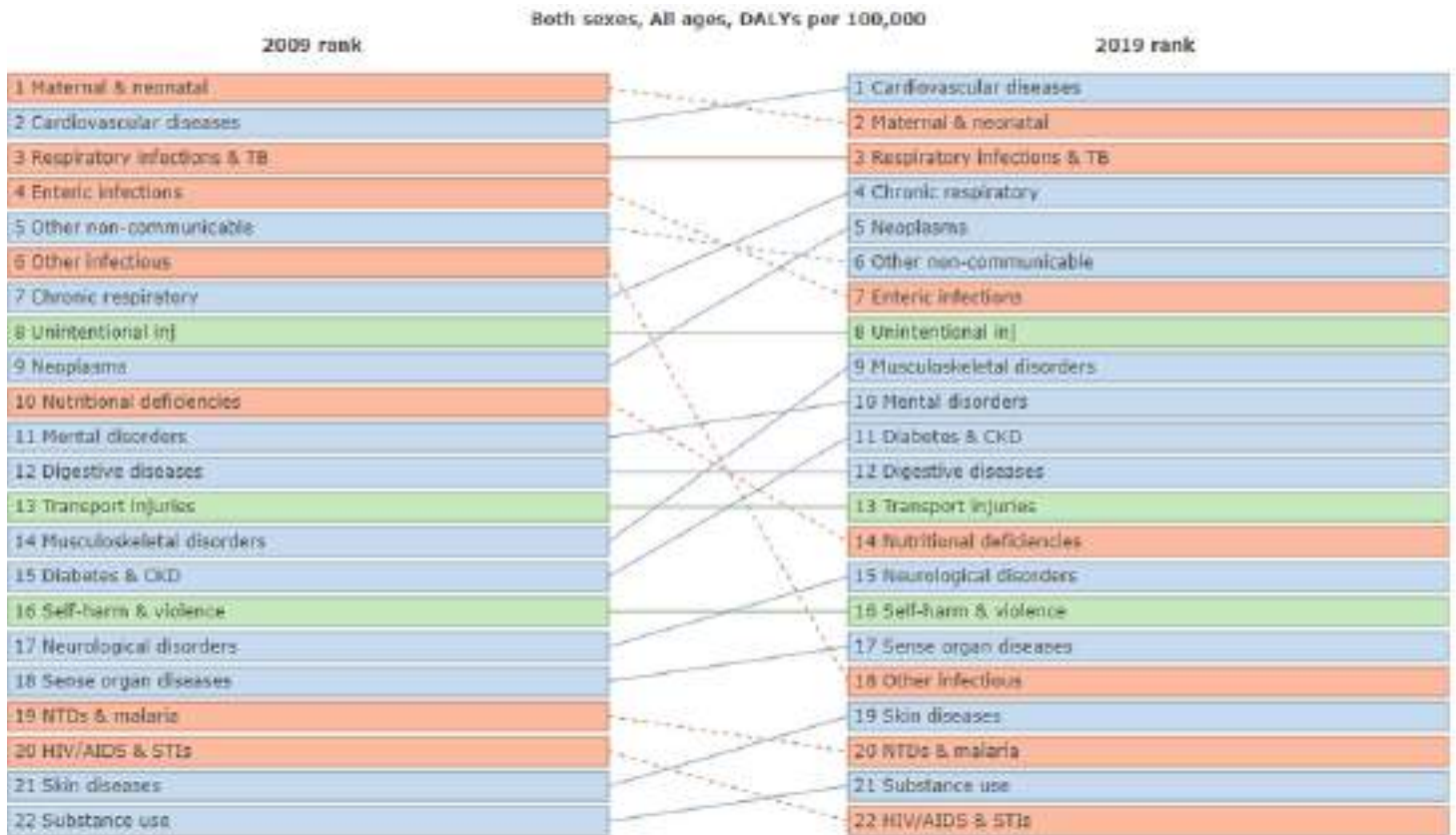| 2009 rank	2019 rank
1 Maternal & neonatal	1 Cardiovascular diseases
2 Cardiovascular diseases	2 Maternal & neonatal
3 Respiratory infections & TB	3 Respiratory infections & TB
4 Enteric infections	4 Chronic respiratory
5 Other non-communicable	5 Neoplasms
6 Other infectious	6 Other non-communicable
7 Chronic respiratory	7 Enteric infections
8 Unintentional inj	8 Unintentional inj
9 Neoplasms	9 Musculoskeletal disorders
10 Nutritional deficiencies	10 Mental disorders
11 Mental disorders	11 Diabetes & CKD
12 Digestive diseases	12 Digestive diseases
13 Transport injuries	13 Transport injuries
14 Musculoskeletal disorders	14 Nutritional deficiencies
15 Diabetes & CKD	15 Neurological disorders
16 Self-harm & violence	16 Self-harm & violence
17 Neurological disorders	17 Sense organ diseases
18 Sense organ diseases	18 Other infectious
19 NTDs & malaria	19 Skin diseases
20 HIV/AIDS & STIs	20 NTDs & malaria
21 Skin diseases	21 Substance use
22 Substance use	22 HIV/AIDS & STIs

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, 2019)

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.

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.

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.
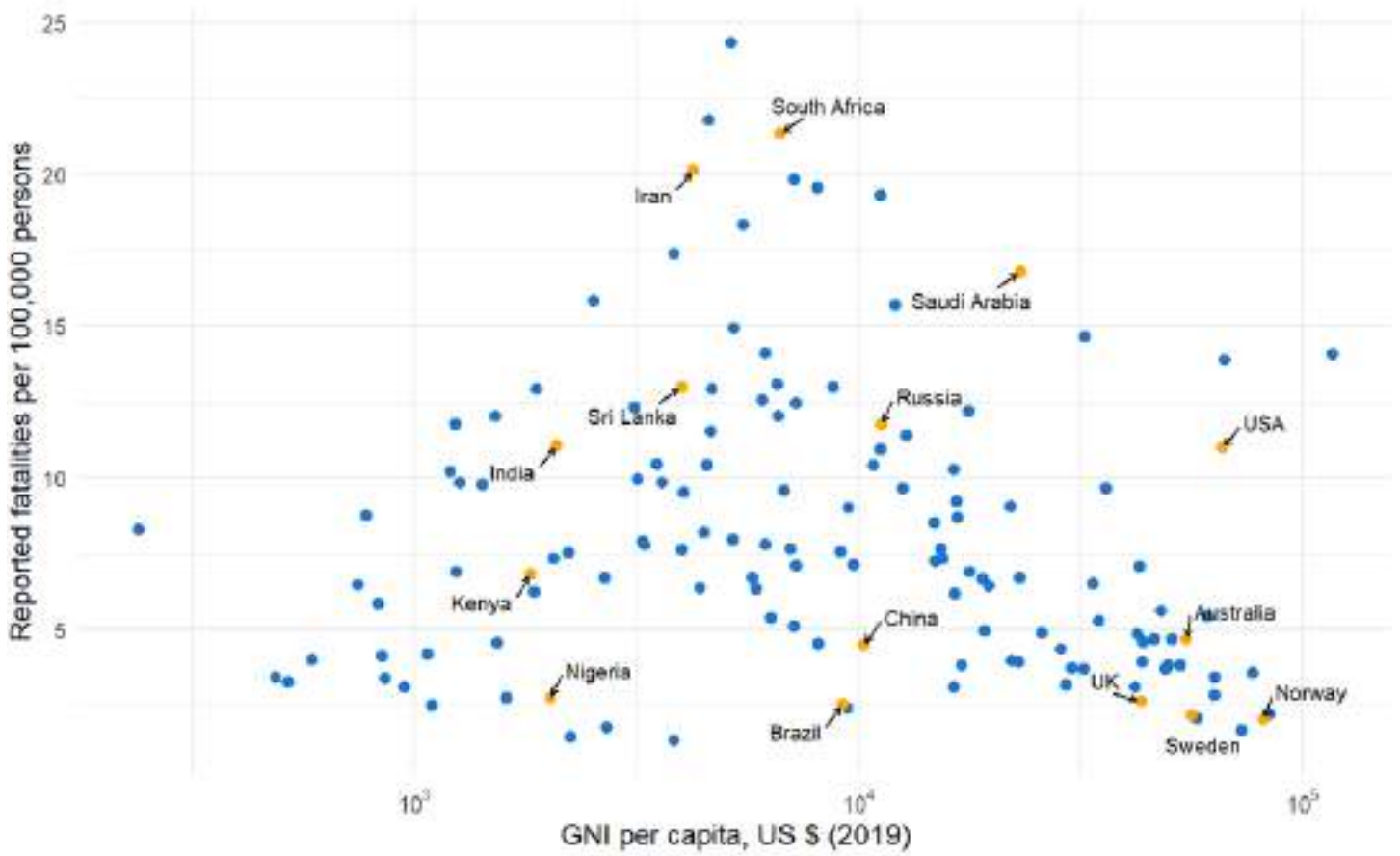
Figure 6. RTI fatality rate per 100,000 persons reported by different countries vs per capita income (Source: WHO and International Road Federation (IRF).
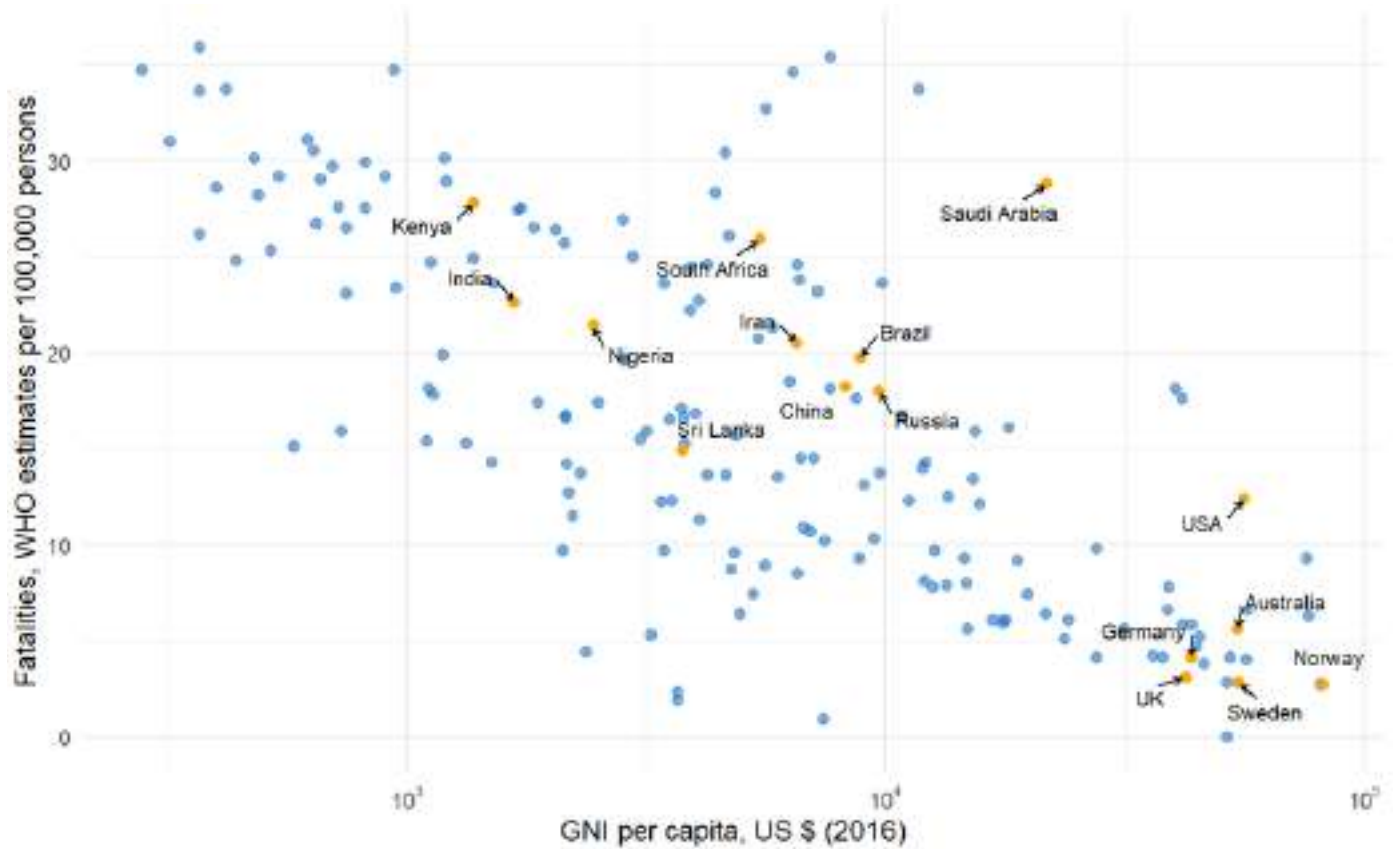

Figure 7. RTI fatality rate per 100,000 persons as estimated by WHO for different countries vs per capita income. (Source: WHO, 2018).

Both the official country data and WHO estimates (Figures 6 and 7) 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.

Lower national income levels cannot be taken as excuse for inefficient data collection systems and it is possible for countries like India to set up professionally managed data collection systems that give a reasonably accurate estimate of RTI fatalities.
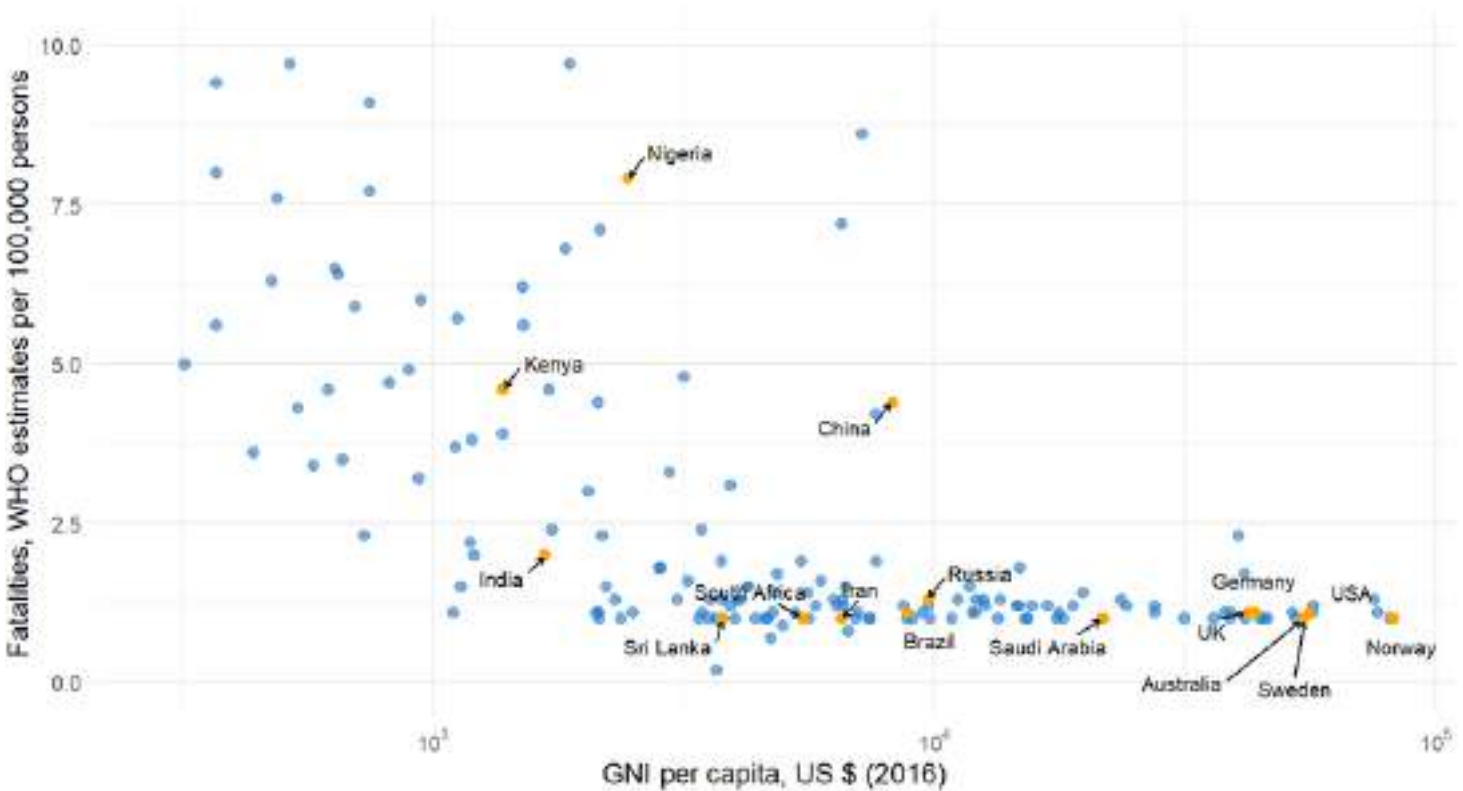

Figure 8. Ratio of WHO estimates and official RTI fatality rate per 100,000 persons for different countries vs per capita income (Source: WHO, 2018)

DATA USED IN THIS REPORT

Injury and fatality data

Table 2 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 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.

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 dies as a result of a road traffic crash	Gives a partial estimate of the magnitude of the road traffic injuries 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 shows 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 shows ratio of fatalities to population	Shows the impact of road traffic crashes on human population as a public heath problem Useful for comparing road 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 year (DALYS)	Measures health 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

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 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).

Data from MoRTH reports

The latest report on RTI in India, Road accidents in India – 2021 (MoRTH, 2022), 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 estimate by GBD 2017 (Dandona et al. 2020) reports that pedestrians accounted for bicycle injuries, night-time crashes, hit and runcases, 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).

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 17 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.

Table 3. Summary of reasons why data from some tables in the Road accidents in India – 2021 (Transport Research Wing, 2022) 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: 1970-2021	Data on person Injured and accidents not reliable	Only fatality data
2	Total Number of Road Accidents in India: 2018 to 2021	Not reliable	No
3	Total Number of Persons Killed in Road Accidents in India: 2018 to 2021	Data by State	Yes
4	Total Number of Persons Injured in Road Accidents in India: 2018 to 2021	Number unreliable	No
5	Total Number of Fatal Road Accidents in States/UTs: 2018 to 2021	Total fatal accident statistics, not number of persons	No
6	Severity of Road Accidents in India (State/UT-wise) : 2018 to 2021	Accidents number unreliable	No
7	Type of Road accidents in States/UTs in 2021	Includes grievous injury, minor and non-Injury accidents - unreliable	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 : 2018 to 2021	Unreliable	No
10	Total Number of Persons Killed in Road Accidents on National Highways : 2018 to 2021	Data by State	Yes
11	Total Number of Persons Injured in Road Accidents on National Highways : 2018 to 2021	Data on persons injured not reliable	No
12	Total Number of Fatal Road Accidents on National Highway : 2018 to 2021	Fatal accident data not used	No
13	Total number of Grevious and Minor Injured Persons in Road Accidents on National Highway during the calendar year 2021	Data on persons injured not reliable	No

Table 3. Summary of reasons why data from some tables in the Road accidents in India – 2021 (Transport Research Wing, 2022) report could not be used in the present analysis. (contd..)

Annexure No	Details	Comment	Data used in this report
14	Total Number of Road Accidents on State Highways : 2018 to 2021	Unreliable	No
15	Total Number of Persons Killed in Road Accidents on State Highways : 2018 to 2021	Fatality statistics used	Yes
16	Total Number of Persons Injured in Road Accidents on State Highways : 2018 to 2021	Injury statistics unreliable	No
17	Total Number of Fatal Road Accidents on State Highways : 2018 to 2021	Accidents numbers not used	No
18	Total Number of Grevious and Minor Injured Persons in Road Accidents on State Highways during the calendar year 2021	Injury number unreliable	No
19	Total Number of Fatal Road Accidents, Total Road Accidents, Persons Killed and Injured on Other Roads during the calendar year 2018 to 2021	By State	Only fatality data used
20	Accidents classified according to Type of Collision during the calendar year 2021	Collision types overlapping, Not clear whether vehicle description is of victim's vehicle, Pedestrian proportion unexpected low, data unreliable	No
21	Accidents classified according to Road Environment during the calendar year 2021	Environment classifications overlapping. Unreliable	No
22	Accidents classified according to Road Features during the calendar year 2021	Road features classifications overlapping . Unreliable	No
23	Accidents classified according to Type of Junctions during the calendar year 2021		No
24	Accidents classified according to Type of Traffic Control during the calendar year 2021		No
25	Accidents classified according to Type of Weather Condition during the calendar year 2021	Weather condition severity not known	No
26	Accidents classified according to type of impacting vehicles/objects 2021	Fatalities due to impacts with pedestrians animals, trees, and other objects are only	No
27	Accidents classified according to Age of Impacting Vehicles during the calendar year 2021	Definition of impacting vehicle unknown.	No
28	Accidents classified according to Load Condition of Involved Vehicles during the calendar year 2021	Loading condition not defined. Overloaded/hanging clubbed together.	No

Table 3. Summary of reasons why data from some tables in the Road accidents in India – 2021 (Transport Research Wing, 2022) report could not be used in the present analysis (contd..)

Annexure No	Details	Comment	Data used in this report
29	Male and Female Persons Killed in Road Accidents in terms of Road User categories in 2021	Pedestrian proportion unexpected low - 20% Data unreliable	No
30	Total number of Persons Killed according to classification of age and sex 2021		Yes
31	Drivers Killed according to classification of age and sex, 2021	See comment for Annexure 33. Data unreliable	Np
32	Passengers Killed according to classification of age and sex, 2021	See comment for Annexure 33. Data unreliable	No
33	Pedestrians Killed according to classification of age and sex, 2021	Pedestrian killed total to 20% of all killed. This is an unrealistic proportion and the data are unreliable. Therefore, statistics by age for all	No
34	Percentage share in Total Registered Motor vehicles in India as on 31st March		No
35	Accidents classified according to Type of Traffic Violations during the calendar year 2021	Variables not mutually exclusive. Data unreliable.	No
36	Accidents classified according to Licence of Drivers during the calendar year 2021	Accidents data unreliable	No
37	Accidents victims classified according to Non-use of safety Device (Non wearing of helmet) during the calendar year 2021	No information on how this was ascertained or whether helmet strapped or not	No
38	Accidents victims classified according to Non-use of safety Device (Non wearing of seat belt) during the calendar year 2021	No information on how this was ascertained or whether helmet strapped or not	No
39	Total number of accidents, number of persons killed and number of persons injured in road accidents in urban and rural areas : 2021	Definitions of urban and rural not mentioned	Yes
40	Fatal road accidents in rural and urban areas during the calendar year 2021		Yes
41	Month-Wise total number of accidents, persons killed and injured during the calendar year 2021	Only fatality data reliable	Yes
42	Road accidents as per the time of occurance 2021	Accident data not reliable	No

Table 3. Summary of reasons why data from some tables in the Road accidents in India – 2021 (Transport Research Wing, 2022) report could not be used in the present analysis (contd..)

Annexure No	Details	Comment	Data used in this report
43	Performance of States/UTs in increasing/decreasing number of road accidents in 2021	Accident data not reliable	No
44	Performance of States/UTs in increasing/decreasing number of persons killed in road accidents in 2021		Yes
45	Accidents classified according to type of weather condition in Million Plus cities during the calendar year 2021		No
46	Accidents classified according to type of impacting vehicles/objects in Million Plus cities during 2021		No
47	Accidents classified according to traffic violations in Million Plus cities during the calendar year 2021		No
48	Accidents classified according to road features in Million Plus cities during the calendar year 2021		No
49	Accidents classified according to type of Junction in Million Plus cities during the calendar year 2021		No
50	Accidents classified according to type of traffic control in Million Plus cities during the calendar year 2021		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, percent						
		Pedestrian	Bicycle	Motorised Two-wheeler	Car	Bus	Truck	Un-known & other
Urban	Mumbai (2008-2012)[1]	58	2	29	4	0	0	7
	Delhi (2013)[2]	47	10	26	3	4	3	7
	Highway (1998)[3]	32	11	24	15	3	14	1
Rural highways	2 lane NH82 (2010-2014)[4]	20	2	42	14	9	13	1
	4 lane NH24 (2010-2014)[4]	27	5	44	8	7	4	4
	6 lane NH1 (2010-2014)[4]	34	3	10	6	5	41	1

Note : (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).

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.

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.

Nevertheless, collecting such data even for a small region or a short period of time can provide valuable insights to researchers and policy makers interested in addressing local road safety issues. The data regarding cause of crashes and persons responsible for crashes as reported in the NCRB and MoRTH reports is also not reliable. As mentioned earlier it is the IPC codes that decide how a police officer assigns blame to one of the participants in a crash (usually one of the drivers). This is an important issue, as the 'cause' of the accident has to be recorded as a 'fault' of a driver under one or more of the 4 or 5 provisions.

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.

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 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.

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 155,622 persons were killed and 371,884 injured in road traffic crashes in India in 2021. 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 2020 was 43.7 and 243.5 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 - 2021 , household vehicle ownership is at least 7.5% for cars and 49.7% for MTW. This ownership has grown rapidly from the 2011 ownership levels of 4.7% and 21%, respectively.

The extent of underreporting 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

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 2021 (NCRB 2022 and MORTH 2022). The total number of deaths in 2021 was 13.2 times greater than in 1971 with an average annual compound growth rate (AACGR) of 6%, and the fatality rate in 2021 was 5.3 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.

The total number of deaths in 2021 was 13.2 times greater than in 1970 with an average annual compound growth rate (AACGR) of 6%, and the fatality rate in 2021 was 5.3 times greater than in 1971 with an AACGR of 4%.

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.

It is known that motor vehicle crash rates have a tendency of decreasing along with a downturn in the national economy (International Traffic Safety Data and Analysis Group 2015):

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

To investigate the link between economy and road traffic deaths, Figure 9 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 and about 70% of diesel is consumed in transport sector (PPAC, 2013).

The reasons for this strong link between diesel consumption and road deaths are discussed in a later chapter.

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.
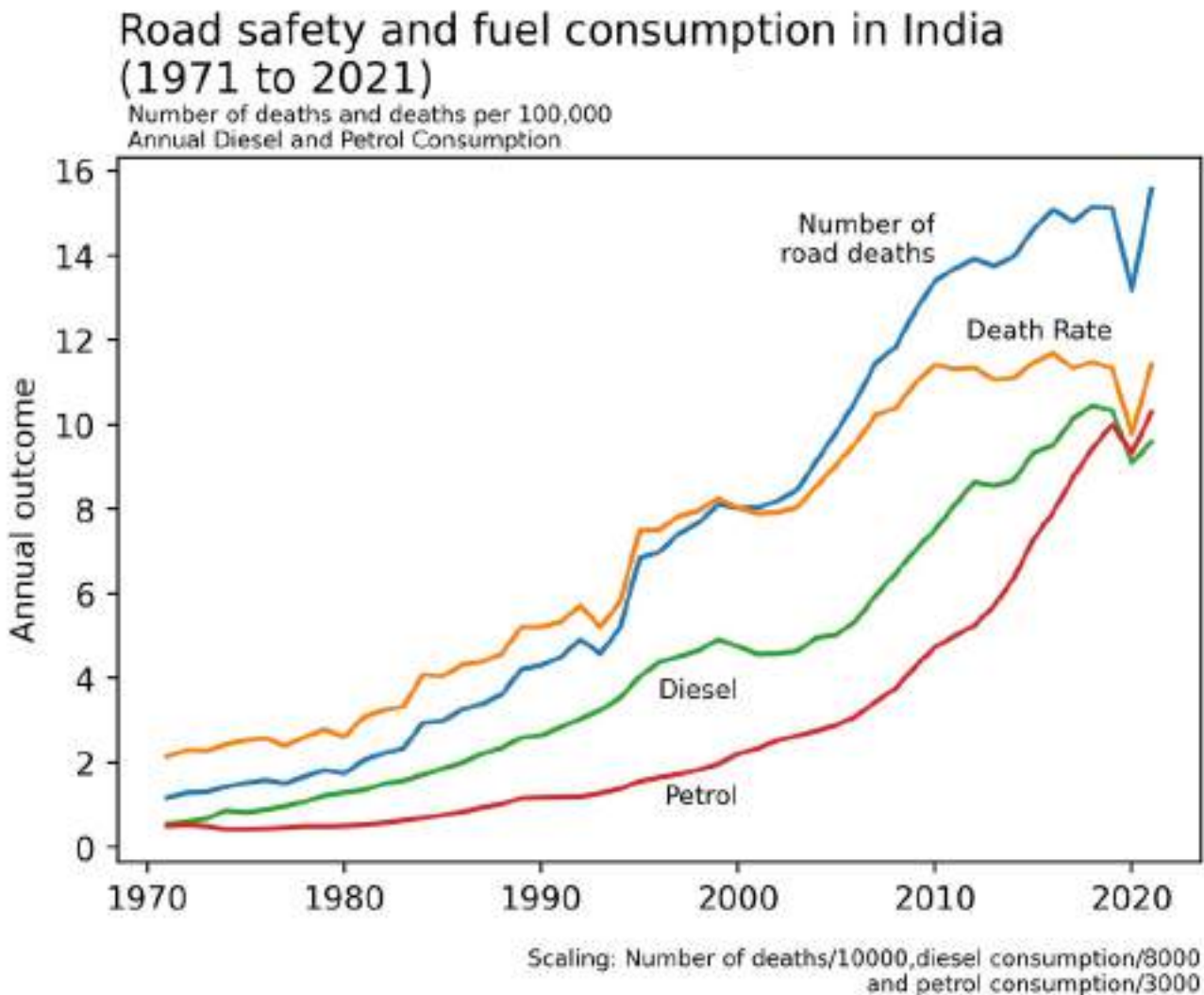

Figure 9. Total number of RTI fatalities and fatalities per 100,000 persons in India (Source: Transport Research Wing 2022, NCRB 2022 and MoPNG 2022).

As a developing economy, it is therefore important for India to decouple this link between economy and traffic safety. The economic growth of a country should not result in more deaths on the roads. In many high-income countries, while short-term changes in economy reflects in the number of road traffic injuries (e.g. during an economic recession year), economic growth in long-term has been decoupled with road traffic injuries (OECD/ITF, 2015).

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, vehicle per unit population and per capita income of 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.

Figure 10 shows estimates of the share of different road user fatalities as reported by MoRTH (Transport Research Wing 2019), estimates made by Hsiao et al. (2013), IIT Delhi, and GBD 2017 (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 and Tagat, 2013, Mohan et al., 2013) and a number of locations on rural roads around the country (Gururaj et al., 2014, Tiwari, 2015, Tiwari et al., 2000, and GBD 2017 estimate is based on several verbal autopsy data sources.

The MoRTH estimates suggest that pedestrian fatalities constitute only 19% of total RTI fatalities in the country. The Hsiao et al. (2013), IIT Delhi and GBD 2017 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 GBD 2017 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.

ESTIMATES OF MODAL SHARE OF RTI FATALITIES IN INDIA

MoRTH (2021) Data

Hsiao, et al. (2013) estimate

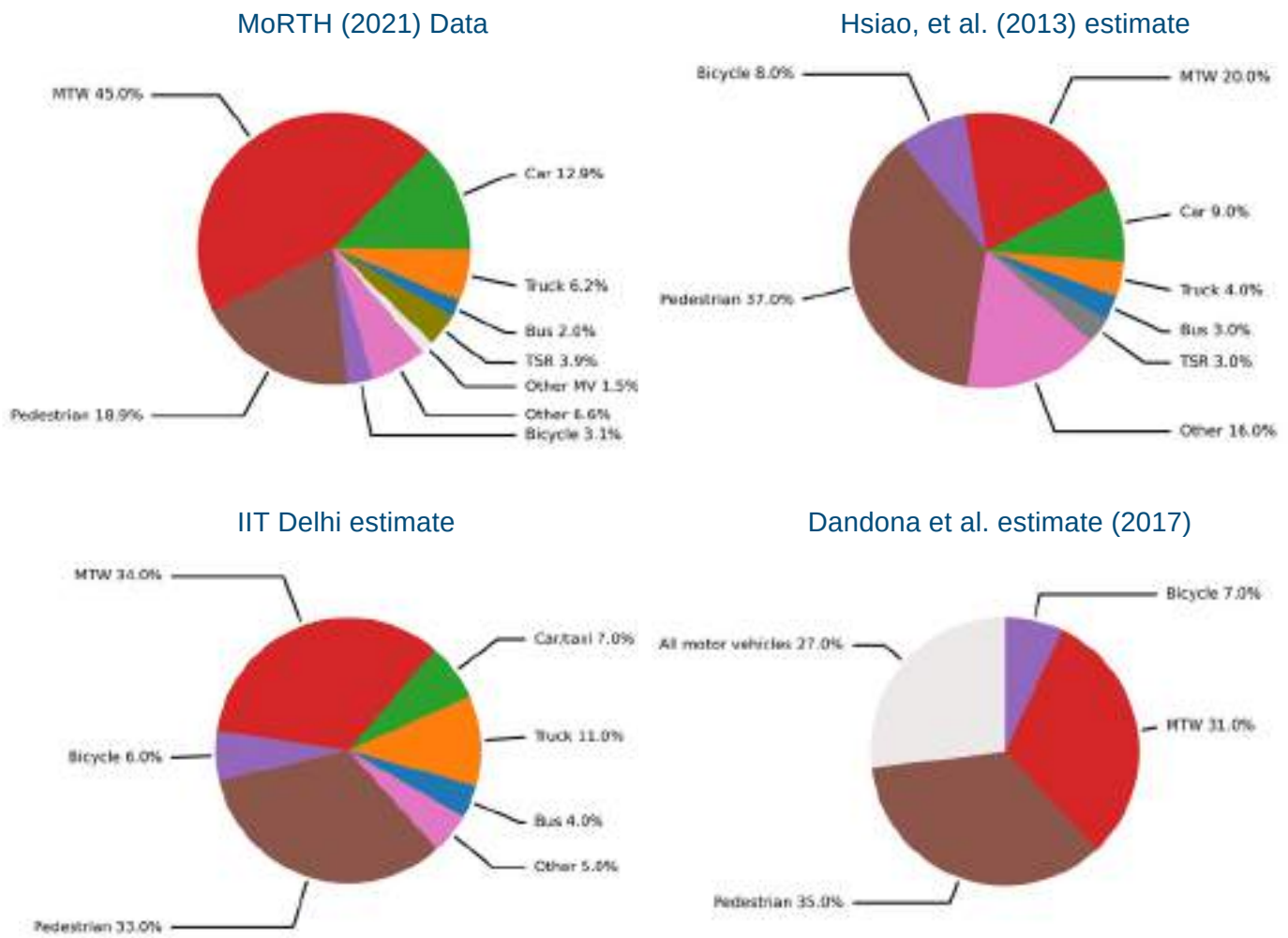IIT Delhi estimate

Dandona et al. estimate (2017)

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).

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 (~19% 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.

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.
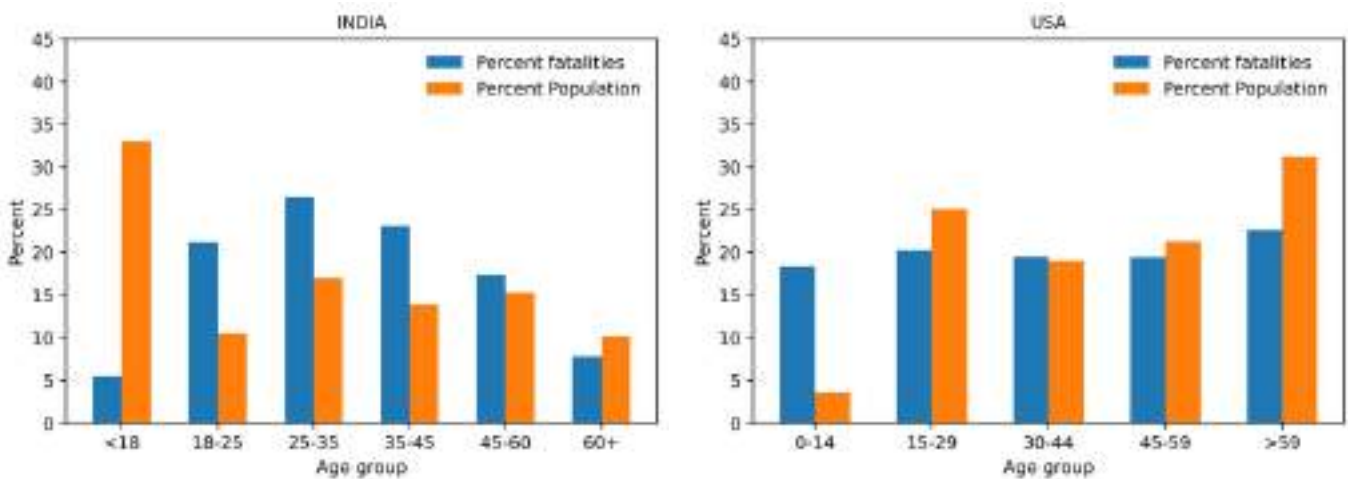
FATALITY DISTRIBUTION BY AGE AND SEX

Figure 11. RTI fatality distribution and population distribution by age in India and USA. (Source: Transport Research Wing 2022 and IHME 2019).

Figure 11 shows the RTI fatalities and population distribution by age in India and USA (Transport Research Wing 2022 and IHME 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 and >59 years. In India, children <15 years have a much lower share (<5%) in RTI fatalities as compared to their share in the population (~20%) but all the other age groups have a slightly higher representation. It is not known why the involve-ment rate of children (<18 years) and the elderly

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

(>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.
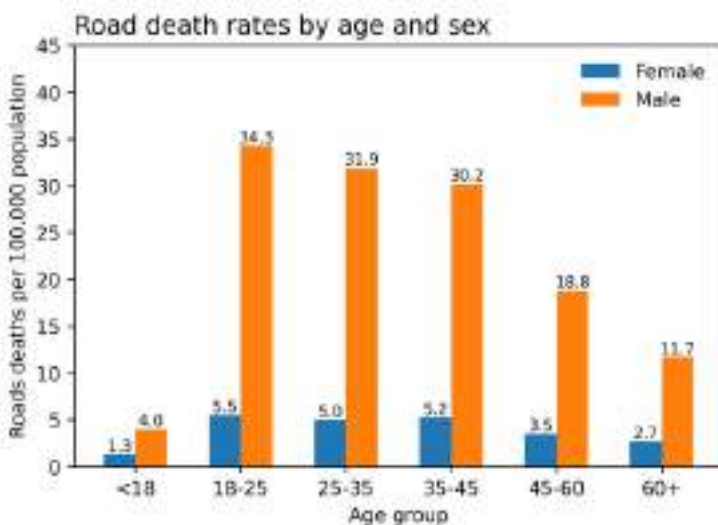

Figure 12. Death per 100,000 population by age and sex

Of those who died, only 14% are females and the rest are males. Globally, females often have a minority share in road deaths (Laiou et al., 2016; IIHS, 2021). 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 license holders are men (MoRTH, 2021). 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.

In the following four states, death rates increased by 23% 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 23% of national road deaths.

However, as discussed above, it is likely that the low death rate of 45 years or older is because of greater underreporting of deaths for these age groups (Dandona et al., 2020). According to GBD (IHME, 2020), 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 also, road death rates often increase with age. Therefore, the inverted U-shape of death rates in India is not expected and may indicate an under-reporting of road deaths for 45 years or older age groups. The reason for differential reporting levels across age groups needs further investigation.

STATE WISE ANALYSIS

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 quarter 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 2015 and 2016 (referred to as 2015/2016) as the base and average of 2019 and 2021 (2019/2021) as the comparator. Since the year 2020 was affected by COVID, death statistics for the year 2020 were not used for calculating comparator average. Use of two years gives a more stable estimate of rates and moderates the effect of an outlying year. For population, we use estimates reported by National Commission on Population.[4]

Among those above-mentioned states, the greatest increase in number of deaths from 2015/2016 to 2019/2021 occurred in the states of Bihar, Tripura and Chhattisgarh, by an average of 25 percent. The greatest reduction of 59% occurred in the state of Nagaland followed by an average of 25% reduction in Mizoram and Goa. Overall, road deaths in India increased by 3.2% over this period.

Next, we present deaths per 100,000 population for the states and UTs with population of more than 10 million. Together, they represent 98% India's population. These death rates for the years 2015/2016 and 2019/2021 are presented in Figure 13 along with the national averages, in the descending order of 2019/2021 death rate.

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4. Report of the Technical Group on Population Projections was published in July 2020 and provides population projections for the period 2011-2036 for India and all states
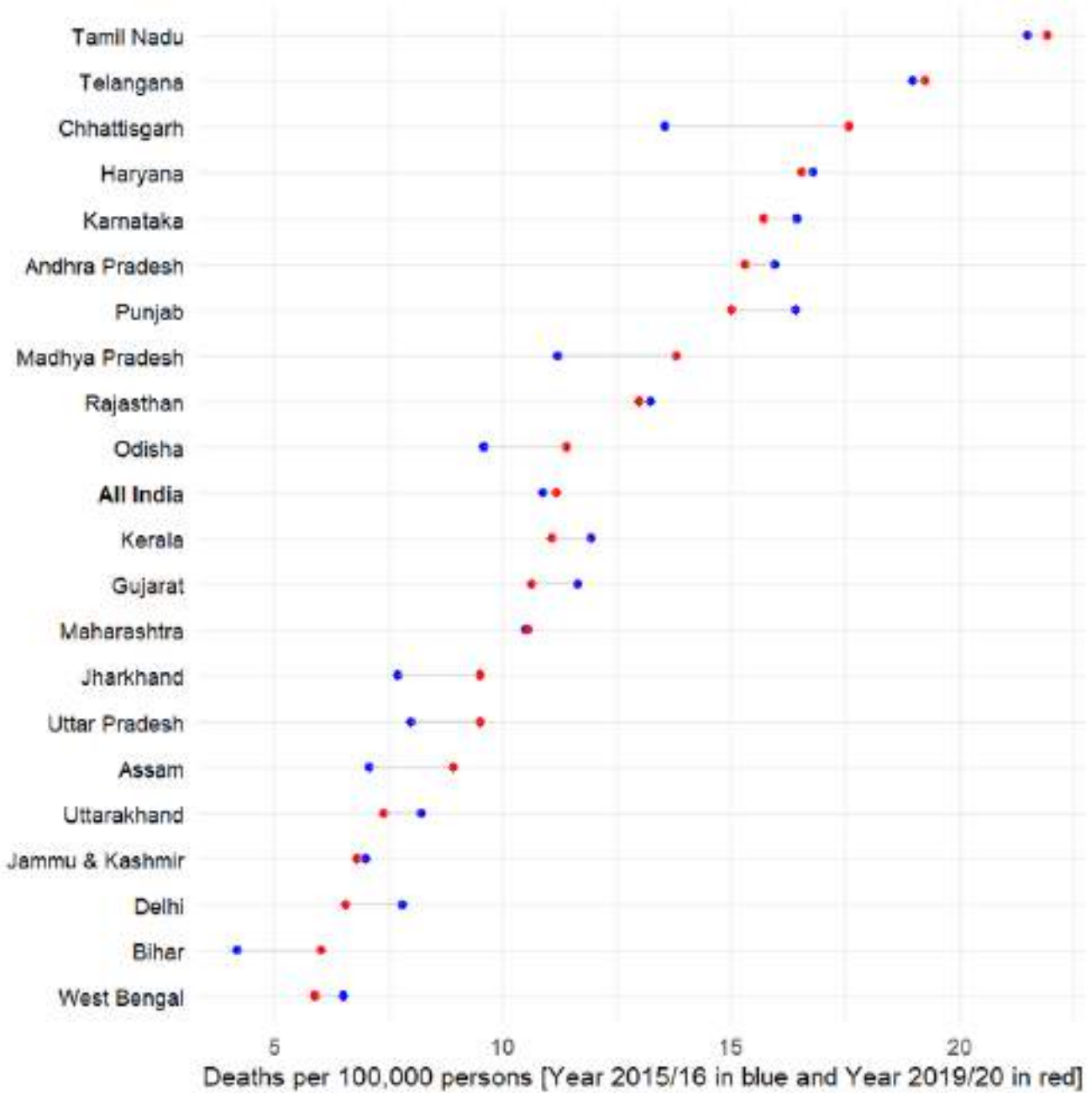
Figure 13. Total number of fatalities per 100,000 population by state in 2015/2016 and 2019/2021 for the states (with population greater than 10 million) and all India.

Tamil Nadu, Telangana and Chhattisgarh are the states with the highest death rate (21.9, 19.2 and 17.6 per 100,000 respectively). 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 2015/2016 to 2019/2021 and the death rate for 2019/2021. 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 five states, death rates increased by 20% or more- Bihar, Tripura, Chhattisgarh, Madhya Pradesh and Assam. Increase in road deaths in these states has a significant implication as these five states contribute around 19% of all road deaths in the country.

Most significant reduction occurred in Puducherry where death rate reduced by 40%. Death rates also reduced by more than 25% in Chandigarh and Mizoram. Delhi and Uttarakhand are the only states with a population of more than 10 million to record a decrease of more than 10% in death rate. It is interesting that rates decreased by 9.5% 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 seat belts), 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.

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 enforcement and infrastructure measures in place for improving safety. The reduction in death rates may be an outcome of those measures.
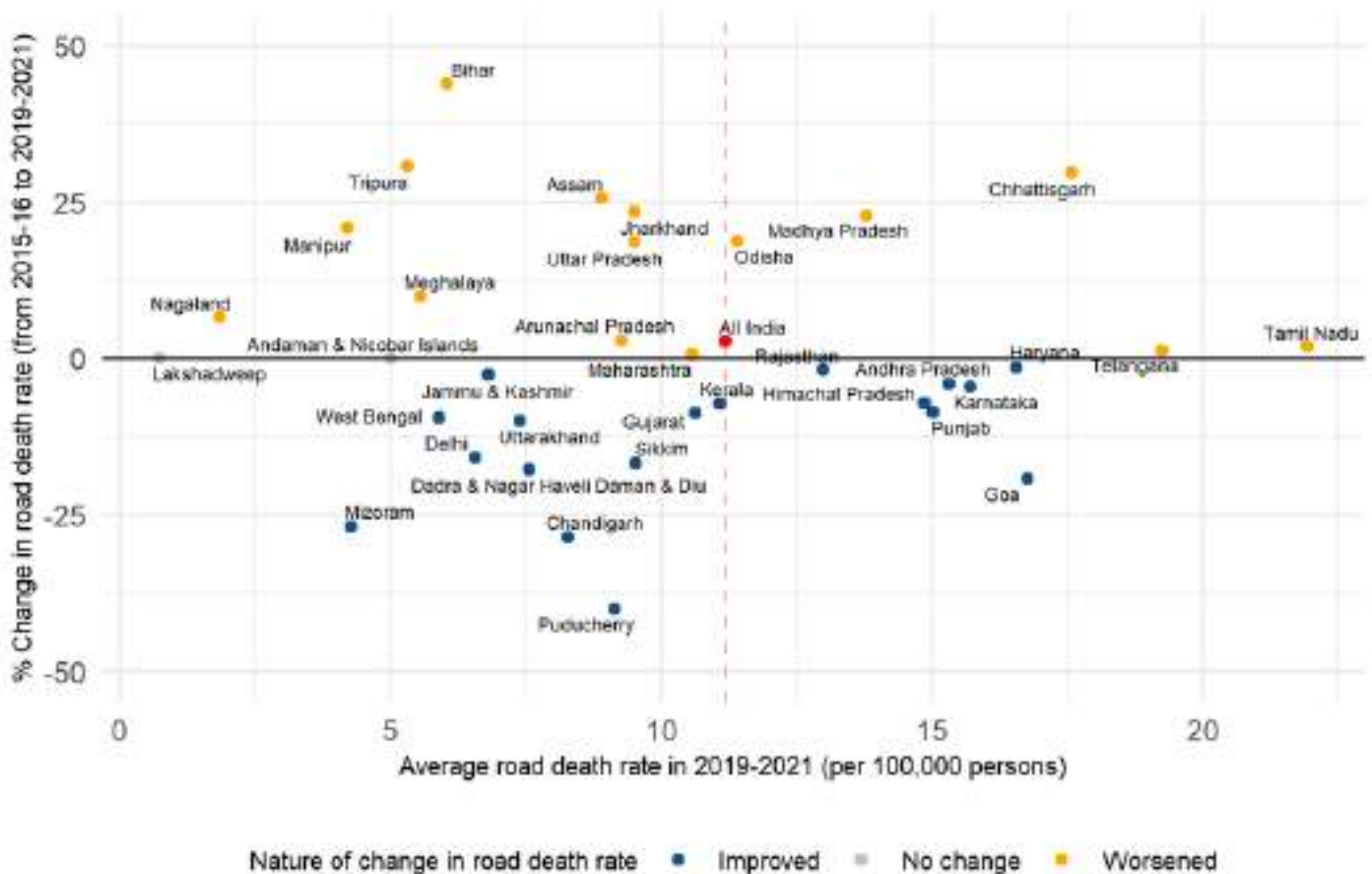

Figure 14. Percentage change in road death rates over the 5-year period from 2015/2016 and 2019/2021 for all states and union territories of India

SUMMARY

- The total number of deaths in 2021 was 13 times greater than in 1971 with an average annual compound growth rate (AACGR) of 6%, and the fatality rate in 2021 was 5.24, which is 4.3 times greater than that in 1971 with an AACGR of 4%

- 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 (~19% 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 under-reporting by police of deaths among older adults may partly explain this

- Telangana and Chhattisgarh have the highest death rate in the country (18.45 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

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

- In Bihar, Chhattisgarh, Madhya Pradesh and Assam, deaths per 100,000 increased by more than 25 percent over the 5-year period from 2015/2016 to 2019/2021. These states together contribute one in five deaths in the country.

- In Nagaland, death rate reduced by 59 percent, which is the largest reduction among all the states in India

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

URBAN SAFETY

CITY DATA

According to the MoRTH report 47,235 (31%) fatalities took place in urban areas and 106,737 (69%) in rural areas in 2021 (MORTH, 2022). These data suggest that the urban RTI fatality share is about the same as the estimated urban population share (34%) in 2018 . The recent trend shows that over time 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 31% in 2021.

For city-level road deaths, we have used NCRB reports for the years 2019 and 2021. These reports consist of data for 53 cities that had a population of 1 million or greater in Census 2011, also referred to as million-plus cities. For 2021, these cities have a total of 13,384 deaths, which is 29% of road deaths in urban areas.

In this chapter, we only use total fatality data for cities from the NCRB report (other data are not reliable) and detailed analysis based on data reported in published research. For population estimates for 2019 and 2021, we used 2011 Census population of the cities and used corresponding district-level population estimates reported by the DHS Program to estimate city populations.

The five cities with the highest death rates are Asansol, Ludhiana, Vijayawada, Allahabad, and Jaipur with an average fatality rate of 21 per 100,000.

Figure 15 shows deaths per 100,000 population for the 53 cities averaged over years 2019 and 2021. During the two-year period of 2019 and 2021 , the average fatality rate for all 53 million-plus cities combined was 10.5 per 100,000 persons which is slightly lower than the national average of 11.4 per 100,000.

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5 Rural population (% of total population) – India. The World Bank.

6 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.
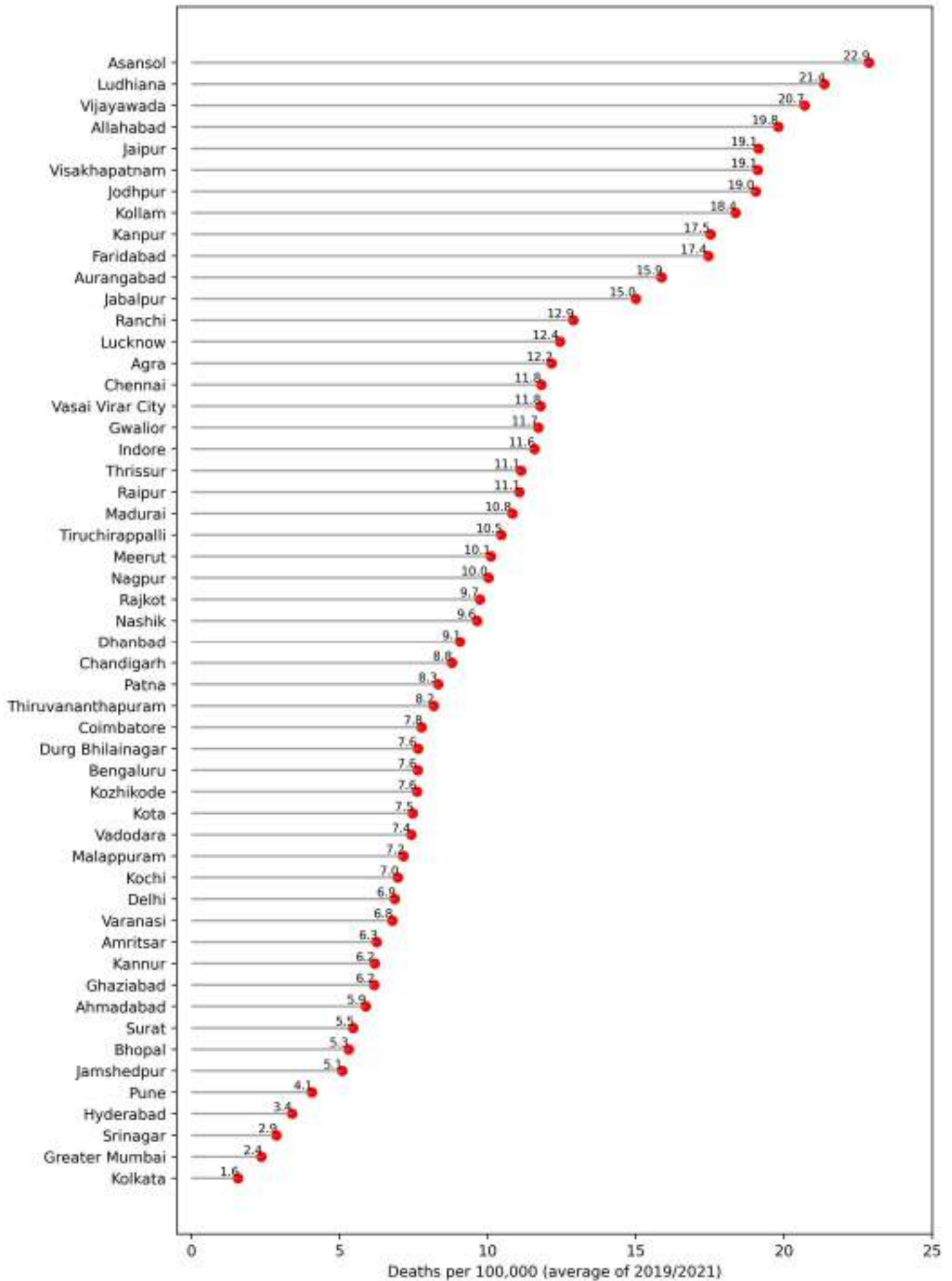
Figure 15. RTI fatality rate per 100,000 persons in million plus cities in India, average of 2019 and 2021 (Source: Transport Research Wing 2022).

Among the 10 largest cities of India, Jaipur has the highest death rate of 19.13 per 100,000 followed by Chennai with a rate of 11.80 per 100,000. Rest of the eight cities have an average rate of 4.7 per 100,000, with the lowest rates among Greater Mumbai (2.4) and Kolkata (1.56).

Among all 53 million-plus cities, five with the highest death rates are Asansol (22.9), Ludhiana, (21.4), Vijayawada (20.7), Allahabad (19.8) and Jaipur (19.1) with an average fatality rate of 21 per 100,000. Among the ten cities with the highest death rates, six are from the northern states of Haryana, Punjab, Rajasthan, and Uttar Pradesh. The five cities with the lowest death rates are Kolkata (1.6), Greater Mumbai (2.4), Srinagar (2.9), Hyderabad (3.4), and Pune (4.1).

It is not possible to explain the differences in city fatality rates as we do not have details of the implementation of safety policies in any of these cities. Since a vast majority of the victims in the cities are vulnerable road users (see next section), one possible cause of low death rates could be because of lower vehicle speeds due to traffic 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).

Inconsistency in the data reported for cities

For the cities, we do not present changes in road fatalities over time. This is because there is inconsistency in the road traffic death numbers reported for the cities. Firstly, for a given year, numbers reported for the cities in the MORTH report are significantly different from those reported in NCRB.

Secondly, for many cities, there was unrealistic reduction or increase in the number of deaths over a short period of time (1-2 years).

Through a preliminary investigation we found that for many cities, the reported number of deaths is for their corresponding districts, which includes both urban and rural areas. For example, for Varanasi city, NCRB reports 255 deaths in 2015 and 76 in 2019. In this case, the 2015 number refers to the whole of Varanasi district, while 2019 number is just for the city, making the comparison over time highly erroneous.

> *It is not possible to explain the differences in city fatality rates as we do not have details of the implementation of safety policies in any of these cities.*

Next, we discuss the changes in death rates over the 5-year period from 2015/2016 to 2019/2021. The percentage changes and average death rates for 2019/2021 are presented in Figure 16. Thrissur and Kannur cities have the highest growth over this period with 83% and 79% increase in the death rate. In one-thirds of the million-plus cities the death rates have increased and other 3/4 million plus cities the death rates have been decreased.

These data show that compared to 2015/2016, the death rate changed significantly in 2019/2021 as follows:

- Increased by more than 25% in 8 cities: Thrissur, Kannur, Dhanbad, Asansol, Malappuram, Faridabad and Jabalpur

- Decreased by more than 25% in 15 cities: Chandigarh, Nashik, Coimbatore, Vadodara, Patna, Lucknow, Hyderabad, Kolkata, Allahabad, Agra, Durg Bhilainagar, Varanasi, Ghaziabad, Pune and Meerut
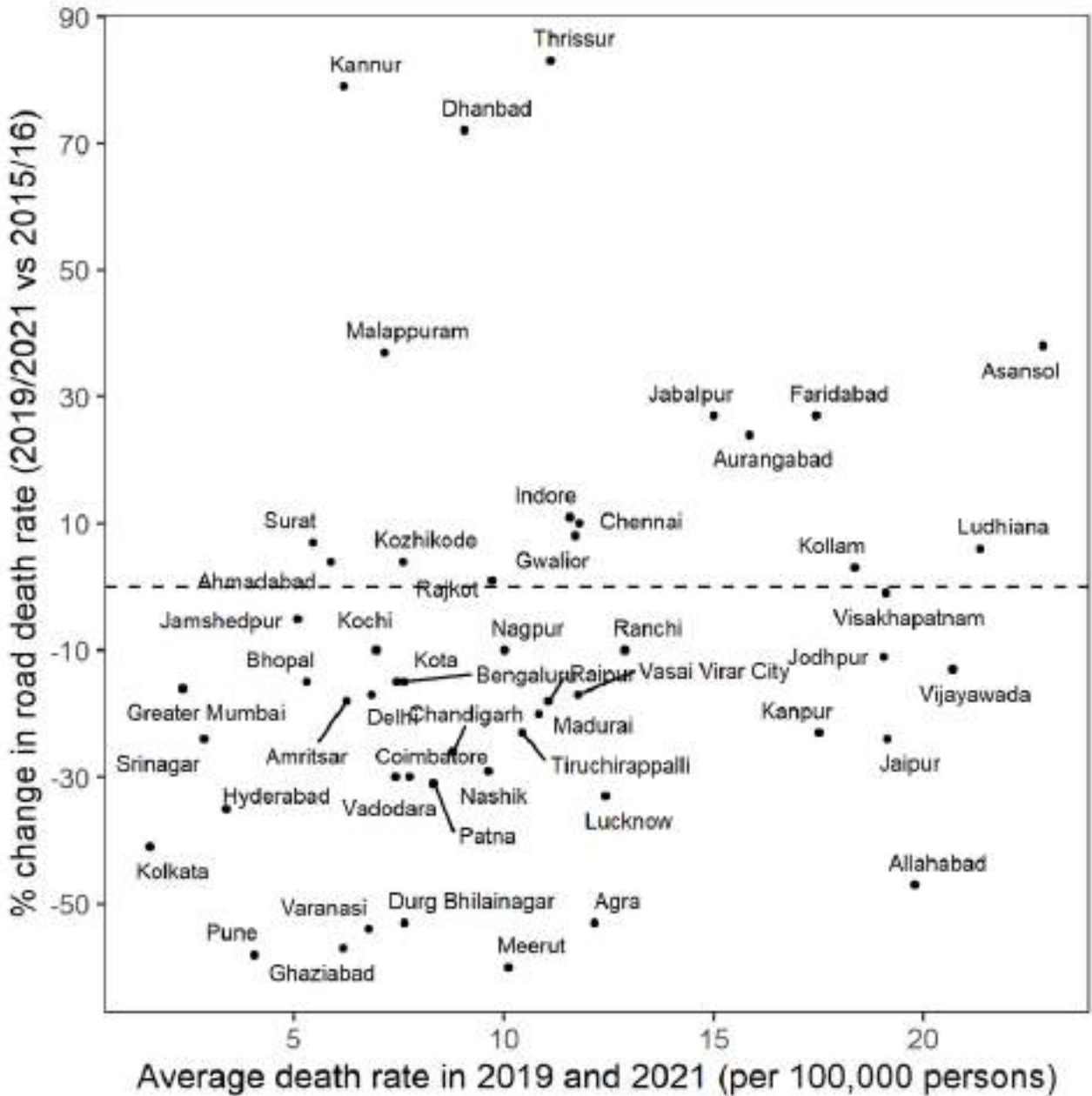
Figure 16: Percent change in road death rates over the 5-year period from 2015/16 to 2019/2021 in million-plus cities of India. X-axis shows the average death rate over 2019/2021. Death rates increased in cities above the dotted line (Source: TRW 2022, NCRB 2022)

It is not possible to explain the differences in city fatality rates per 100,000 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

Table 5 shows the proportion of road traffic fatalities by road user type in seventeen Indian cities. These cities vary in population from 0.28 million to 20 million. The data used here is the case-level road fatality data coded from police FIRs using a crash recording form developed at the TRIP Centre (Banerjee et al., 2023).

The data for the other cities were obtained by analysing FIRs for a period of three years from all the police stations in each city (Mohan, Tiwari, and Mukherjee 2013).

Table 5. Proportion of road traffic fatalities by mode of transport of victim in seventeen Indian cities

City	Population	Pedestrian	Bicycle	Motorised Two-wheeler	Auto-rickshaw	Car & taxi	Bus	Truck	Other
		Percent							
Agra (2013-15)	1,574,542	41	10	37	4	2	4	2	0
Amritsar (2013-15)	1,132,761	27	20	40	5	3	1	3	1
Bhopal (2013-15)	1,795,648	41	5	44	3	2	2	3	0
Ludhiana (2013-15)	1,613,878	35	23	35	3	3	1	0	0
Vadodara (2013-15)	1,666,703	32	12	41	3	4	1	7	0
Visakhapatnam (2013-15)	1,730,320	43	6	35	9	3	1	3	0
Patiala (2015-18)	480,000	22	14	51	3	7	3	0	0
Bulandshahr (2015-18)	280,000	26	7	51	2	5	3	5	2
Sonipat (2017-2019)	327,567	29	6	43	5	13	0	4	1
Panipat (2017-2019)	335,081	34	4	45	5	6	1	5	1
Ambala (2017-2019)	283,628	37	6	35	4	11	1	4	1
Faridabad (2017-2019)	1,600,908	46	7	33	4	6	1	2	1
Gurugram (2017-2019)	1,003,668	41	5	34	6	6	0	7	1
Raipur (2017-2019)	1,298,104	32	5	57	0	3	0	3	-
Bilaspur (2017-2019)	422,373	30	6	47	2	6	2	8	-
Bhilai (2017-2019)	751,611	32	2	56	3	1	1	5	2
Delhi (2019-2021)	20,571,000	45	3	39	3	5	0	2	1

Note: Population estimates for the cities from the year 2015 onward were obtained from the DHS program population projections

The proportion of vulnerable road user (pedestrians, bicyclists and motorised two-wheelers) deaths in the seventeen cities range between 78% and 94%, car occupant fatalities between 1% and 7%, except in Ambala and Sonipat where the proportion is 11% and 13%, and occupants of three-wheeled scooter taxis (TSTs) less than 6% per cent, except in Vishakhapatnam where the proportion for the latter is 8%.

The total of vulnerable road user deaths remains relatively stable across cities of different sizes and the proportion of pedestrian deaths appears to be higher in cities with larger population.

Next, we present the distribution of road traffic fatalities by road user category versus the respective impacting vehicle/objects for the Delhi, Haryana (Ambala, Faridabad, Gurugram, Sonipat, Panipat combined) and Chhattisgarh (Bhilai, Bilaspur, Raipur combined).

Figure 17 shows the distribution of road traffic fatalities by road user category versus the respective impacting vehicles/objects for Delhi, five cities of Haryana and three cities of Chhattisgarh.

Across these cities, the largest proportion of fatalities for all road user categories (especially vulnerable road users) are associated with the impacts with trucks and cars and then buses.

The proportion of pedestrian fatalities associated with the MTW impacts ranges from 13 to 29 percent of the total. The highest proportion was observed in Chhattisgarh. 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.
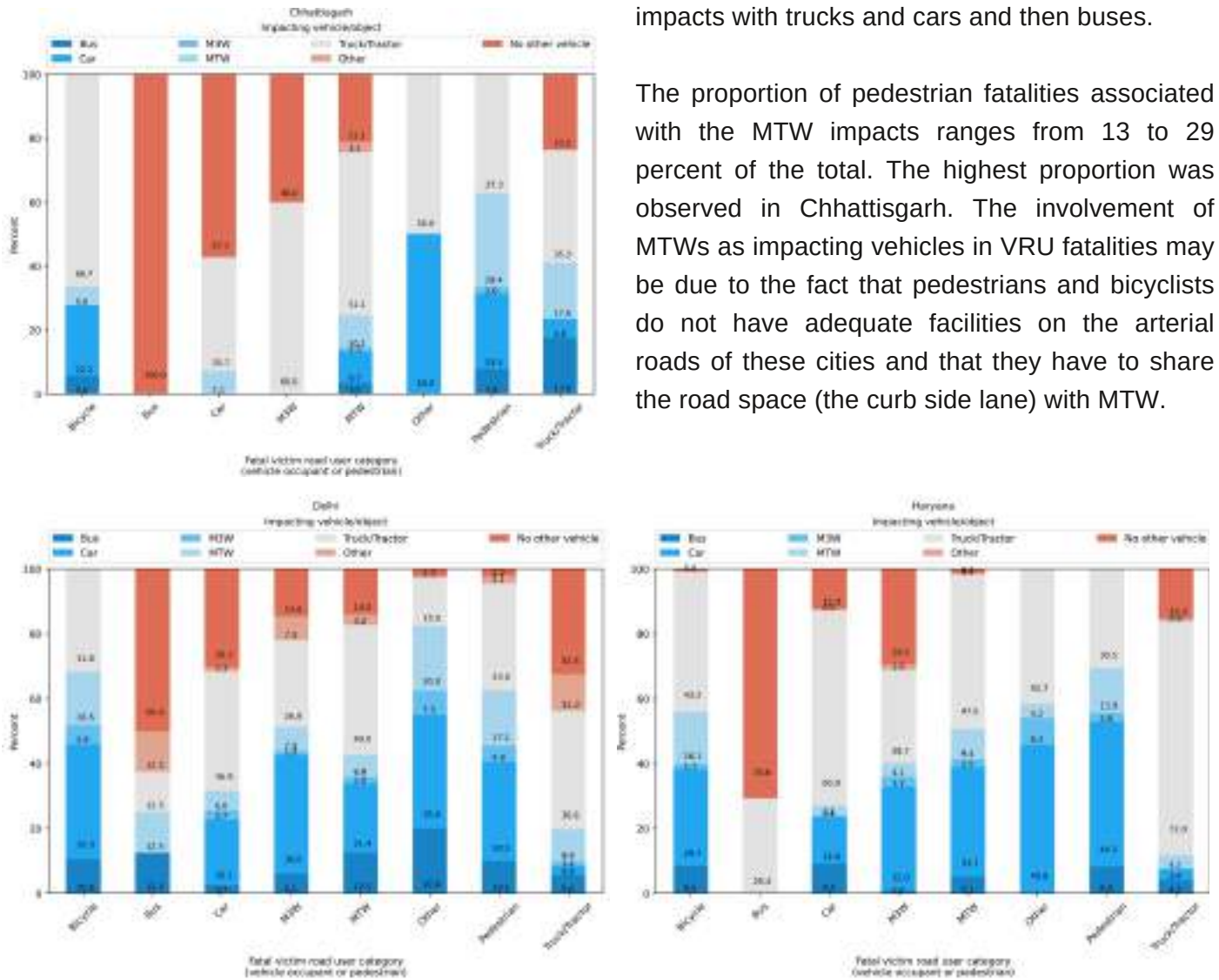

Figure 17. Fatal RTI road user category and impacting vehicles / objects for Delhi and cities in Chhattisgarh and Haryana.

Further, the most interesting fact is that there are more single vehicle crashes in the cities of Chhattisgarh cities as compared to the Delhi and cities of Haryana.

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

SUMMARY

- During the past 5 years (2015/16 to 2019/21), the proportion of total road deaths in India that occurred within urban areas has been decreasing over time—from 39% in 2015 to 31% in 2021. 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 reduced 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 53 cities that have a population of 1 million or greater. In 2021, 29% of all road deaths in urban areas occurred in these million-plus cities. The average fatality rate for these cities combined was 10.5 per 100,000 persons which is slightly lower than the national average of 11.5 per 100,000

- During 2019/2021, five cities with the highest death rate Asansol, Ludhiana , Vijayawada, Allahabad, and Jaipur. Among the 10 largest cities of India, Jaipur has the highest death rate of 19.13 per 100,000 followed by Chennai with a rate of 11.80 per 100,000. The rest of the eight cities have an average rate of 4.7 per 100,000, with the lowest rates among Greater Mumbai (2.4) and Kolkata (1.56)

- There is a large inconsistency in the number of road deaths reported at the city level by NCRB as well as MORTH. It appears that, for many cities, the reported number of deaths is for their corresponding districts. However, for some years (e.g. 2018 and 2019), NCRB reported it for the cities, making the comparison over time erroneous

- The proportion of vulnerable road user (pedestrians, bicyclists and motorised two-wheelers) deaths in the seventeen cities range between 78% and 94%, car occupant fatalities between 1% and 7%, except in Ambala and Sonipat where the proportion is 11% and 13%, and occupants of three-wheeled scooter taxis (TSTs) less than 6% per cent, except in Vishakhapatnam where the proportion for the latter is 8%

INTRODUCTION

We present the analysis of road deaths for all the 27 districts of Chhattisgarh state and 11 districts of Haryana state. Districts consist of both rural and urban areas. First, we present results for Chhattisgarh. We coded FIRs for the years 2017 to 2019, including a total of 11,445 deaths.

The methods are explained in Banerjee et al. (2023) and Banerjee et al. (2024). The average death rate across the 27 districts of Chhattisgarh ranged from 5.6 to 26.2 per 100,000, with a state-wide average of 13.2, which is greater than that of average death rate of the country (11.2).

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

District	Death per 100,000 (2017-2019)	Pedestrian	Bicycle	MTW	M3W	Car & taxi	Bus	Truck/ Tractor	Other
		Percent							
Ambikapur (surguja)	13.5	21	4	55	1	3	2	14	0
Balod	16.1	19	2	61	0	7	1	10	0
Baloda bazaar	13.2	18	4	61	0	2	0	14	0
Balrampur	17.8	15	3	58	2	5	2	15	0
Bastar	16.4	22	7	49	1	9	2	11	0
Bemetara	13.4	20	4	57	0	6	2	11	1
Bijapur	9.9	18	5	51	0	4	4	17	2

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

District	Death per 100,000 (2017-2019)	Pedestrian	Bicycle	MTW	M3W	Car & taxi	Bus	Truck/ Tractor	Other
		Percent							
Bilaspur	12.1	18	4	59	2	4	1	11	0
Dantewada	12.6	17	7	53	2	5	0	16	0
Dhamtari	11.6	19	7	58	0	8	0	7	1
Durg	5.7	24	4	64	1	3	0	4	1
Gariyaband	7.2	11	4	69	0	3	3	9	1
Janjgir champa	12.1	20	5	60	1	4	0	10	0
Jashpur	18.9	16	4	58	1	4	1	16	0
Kabeerdham	10.1	18	1	60	0	2	1	17	0
Kanker	14.9	14	3	66	0	7	0	10	0
Kondagaon	15.6	17	4	56	1	12	2	8	1
Korba	15.5	19	4	59	1	4	1	12	0
Koriya	17.2	17	1	68	1	2	1	10	0
Mahasamund	17.1	15	5	65	0	4	0	10	0
Mungeli	5.6	36	4	47	2	4	1	7	1
Narayanpur	12.3	25	2	60	0	4	0	11	0
Raigarh	14.1	21	4	58	1	3	1	12	0
Raipur	13.7	22	5	61	1	5	1	5	0
Rajnandgaon	13.3	16	6	60	1	4	0	12	0
Sukma	9.9	26	6	41	5	4	0	18	0
Surajpur	26.2	22	4	54	3	5	1	11	0
All districts	13.2	19	4	59	1	4	1	11	0

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

District	No other vehicle	Motorised two-wheeler	M3W	Car & taxi	Bus	Truck/ Tractor	Other
	Percent						
Ambikapur (surguja)	36	16	0	8	3	34	2
Bijapur	52	14	0	10	8	12	4
Balod	28	18	0	10	7	35	3
Baloda bazaar	26	14	0	6	2	47	5
Balrampur	43	14	1	9	4	27	3
Bastar	40	12	2	12	5	28	2
Bemetara	29	22	0	5	4	36	5
Bilaspur	31	17	0	8	2	37	4
Dantewada	35	14	1	14	2	30	5
Dhamtari	25	18	0	10	6	39	1
Durg	26	18	3	10	5	35	4
Gariyaband	32	14	0	12	2	23	17
Jashpur	48	15	0	8	4	24	2
Janjgir champa	23	15	0	8	1	41	11
Kabeerdham	37	14	1	6	4	32	6
Kanker	34	16	0	12	6	26	6
Kondagaon	29	18	1	10	6	32	5
Korba	31	11	0	6	2	46	4
Koriya	39	16	2	11	2	24	7
Mahasamund	29	17	0	10	2	36	5
Mungeli	30	30	3	9	6	21	2
Narayanpur	31	40	0	9	2	11	7
Raigarh	18	18	0	6	2	54	3
Raipur	20	14	0	11	5	46	3
Rajnandgaon	33	22	0	7	3	29	5
Sukma	30	16	1	8	3	32	10
Surajpur	13	24	1	13	4	44	0
All districts	30	17	1	9	4	36	4

Of the total death victims, only 13% are females. The average age of victims was 35 years, with 49% victims younger than 30 years, and 77% victims younger than 45 years. Table 6 describes proportion of road death victims across districts in Chhattisgarh (2017-2019). The data show that motorcyclists are the largest group of road death victims with the share 41% to 69%.

Pedestrians form the second largest group with a share of 11% to 36% of road death victims. Cyclists comprises less than 7%, and car occupants are another 2% to 12% of victims. The three vulnerable road users — pedestrians, bicyclists and motorcyclists — have a combined share of 82%. Among motorcycle victims, 73% were drivers and 27% were pillion riders. The trucks and tractors contributed to 11.5% of road death victims.

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

Road user killed	In crashes with							
	No other vehicle	Motorised two-wheeler	M3W	Car & taxi	Bus	Truck/ Tractor	Other	Unknown
Bicycle	10	134	1	53	19	170	2	85
Bus	54	9	0	3	7	14	6	4
Car	220	7	1	15	9	171	16	57
M3W	46	2	1	7	4	33	4	16
MTW	1681	784	33	490	206	2031	285	1059
Other	8	1	0	3	0	12	1	6
Pedestrian	1	546	14	224	73	591	5	671
Truck/Tractor	729	28	0	14	6	230	62	143
Unknown	11	5	0	1	1	7	0	17

Table 7 presents the distribution of striking vehicles involved in crashes in which another road user was killed. With an average share of 36% across the districts, trucks/tractors are the most frequent striking vehicle. The next largest category is single-vehicle crashes ('no other vehicle'), with an average share of 30 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 19%, respectively).

Table 8 presents distribution of striking vehicles for different road users who died in road crashes for all districts of Chhattisgarh combined. More than 90% of 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 of bicyclists died in crashes with truck/tractor.
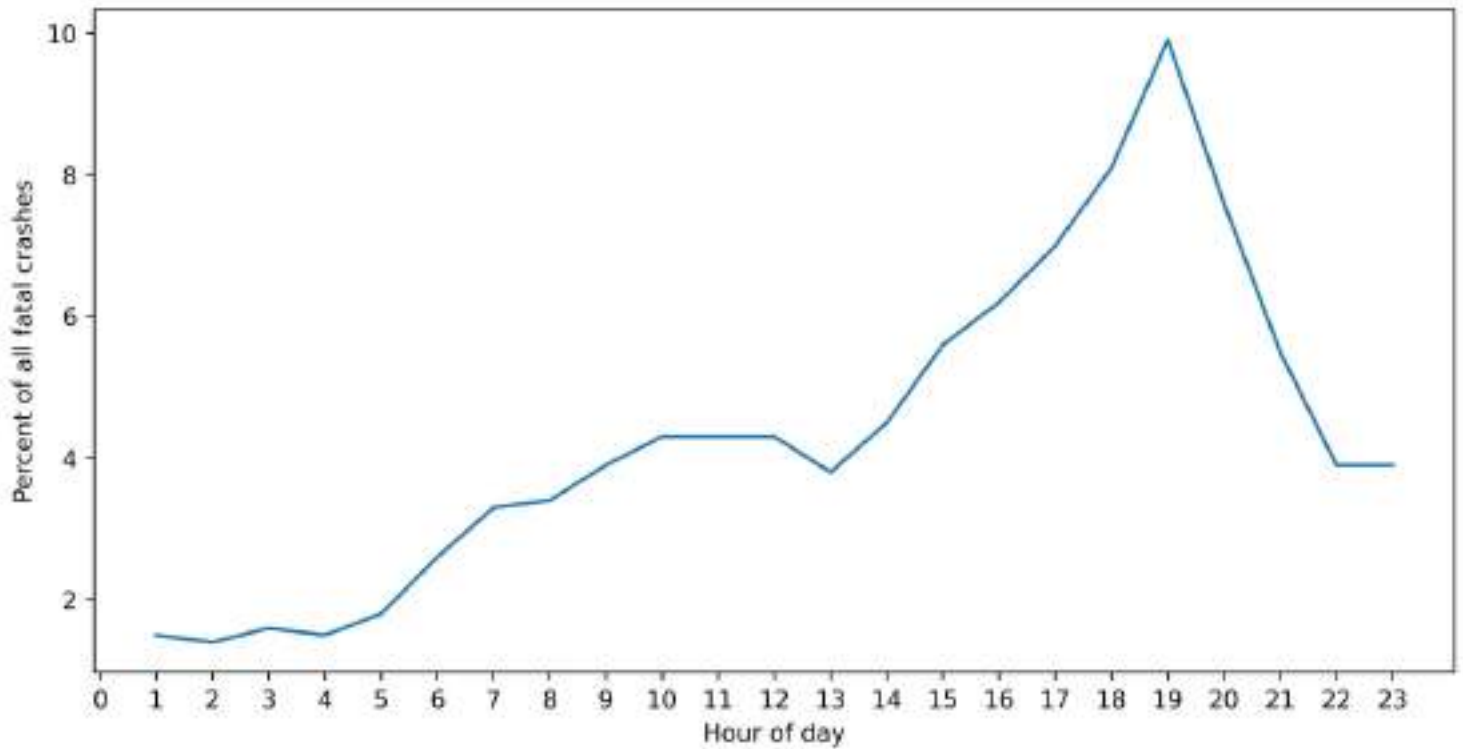
Figure 21. Time of day distribution of road deaths across Chhattisgarh

Crashes with no other vehicle involved have significant contributions in the deaths of motor vehicle users. Up to 68% of all truck/tractor deaths, 50% of car occupant deaths, and 31% of MTW deaths are in single-vehicle crashes. Truck/tractors are also significant contributor in the deaths of MTW and car occupants. Up to 39% of car occupants died in crashes with trucks/tractors.

Figure 21 presents the distribution of road deaths by time of day. More crashes occurred during the night than during the day. Crashes peak between 6 PM to 9 PM. No such peak is present during the morning, indicating that night-time crashes are likely because of poor visibility and a greater proportion of drunk driving. 50% of the fatalities occurred during 33% of the day (i.e., 3pm-10pm).

Next, we present the analysis of FIRs of road crashes for 11 districts of Haryana state for the

years 2017 to 2019 and includes a total of 10771 deaths. The death rates across these eleven districts range from 12.8 to 41.5 deaths per 100,000, with an average of 25.2 across all districts.

Table 9 shows the proportion of road victims for each district and all districts combined. The data shows that motorcyclists are the largest group of road death victims with a share of 34% to 58%. Pedestrians form the second largest group with 21% to 44% of road victims. Cyclists contribute less than 7%.

Table 10 presents the distribution of striking vehicles involved in crashes in which another road user was killed. With an average share of 48% across the districts, trucks/tractors the are most frequent striking vehicles.

Table 9. Proportion of road death victims across districts in Haryana (2017-2019)

District	Death per 100,000 (2017-2019)	Pedestrian	Bicycle	MTW	M3W	Car & taxi	Bus	Truck/ Tractor	Other
		Percent							
Ambala	41.5	24	6	47	3	11	1	5	1
Bhiwani	27.6	25	2	51	5	10	2	5	0
Charkhi Dadri	40.2	21	3	56	1	9	1	7	0
Faridabad	12.8	44	7	34	4	6	1	5	1
Fatehabad	33.8	23	4	58	1	8	1	3	1
Gurugram	26.6	37	3	38	4	8	0	8	1
Jhajjar	25.7	24	3	43	3	15	0	11	0
Jind	13.5	22	5	52	4	10	1	4	1
Kaithal	27.1	22	3	58	3	9	1	4	1
Panipat	22.1	33	3	46	4	7	1	6	1
Sonipat	25.6	31	4	40	4	13	1	7	0
Combined districts	25.2	28	4	47	3	10	1	6	1

Table 10. Proportion of striking vehicles involved in crashes where other road user died (Haryana, 2017-19)

District	No other vehicle	Motorised two-wheeler	M3W	Car & taxi	Bus	Truck/ Tractor	Other
	Percent						
Ambala	3	13	1	35	5	42	1
Bhiwani	6	8	1	27	5	52	1
Charkhi Dadri	2	13	1	16	7	61	0
Faridabad	5	11	3	28	6	47	0
Fatehabad	3	11	0	28	10	47	1
Gurugram	6	8	1	26	6	52	0
Jhajjar	3	6	1	26	5	59	0
Jind	3	9	1	29	7	51	1
Kaithal	2	13	1	34	6	43	2
Panipat	4	9	2	35	5	44	1
Sonipat	4	9	1	35	5	46	1
Combined districts	4	10	1	30	6	48	1

Table 11. Distribution of striking vehicles in the fatal crashes of different road users of Haryana

Road user killed	In crashes with							
	No other vehicle	Motorised two-wheeler	M3W	Car & taxi	Bus	Truck/ Tractor	Other	Unknown
Bicycle	1	50	3	130	26	148	0	78
Bus	51	0	0	0	0	34	7	0
Car	85	17	2	142	74	631	7	74
M3W	79	5	8	76	22	123	6	28
MTW	20	463	54	1371	228	2011	28	876
Other	4	4	2	26	1	31	0	17
Pedestrian	0	305	31	783	146	749	6	986
Truck/Tractor	86	14	0	32	18	419	6	47
Unknown	1	2	0	1	0	10	0	9

The next largest category is cars, with an average share of 30%. Cars have a larger contribution as striking vehicles than motorised two-wheeler (30% and 10%, respectively).

Table 11 presents the distribution of striking vehicles for different road users who died in road crashes for 11 districts of Haryana combined. More than 90% of pedestrians and cyclists died in crashes with three vehicle types— truck/tractors, MTW, and cars. Among crashes in which pedestrians died, car and truck/tractor are equally likely to be involved as striking vehicles. Almost half the cyclists died in crashes with truck/tractor. Crashes with truck/tractor involved have significant contributions in the deaths of different road users that ranges from 37% to 73%. Around 55% of Bus occupants died in the single vehicle crash.

INTERCITY HIGHWAYS

INTRODUCTION

The 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.

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, 2022. The fatality rate per km of road is highest on National Highways with 42.1 deaths per 100 km annually (Figure 23). 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

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.
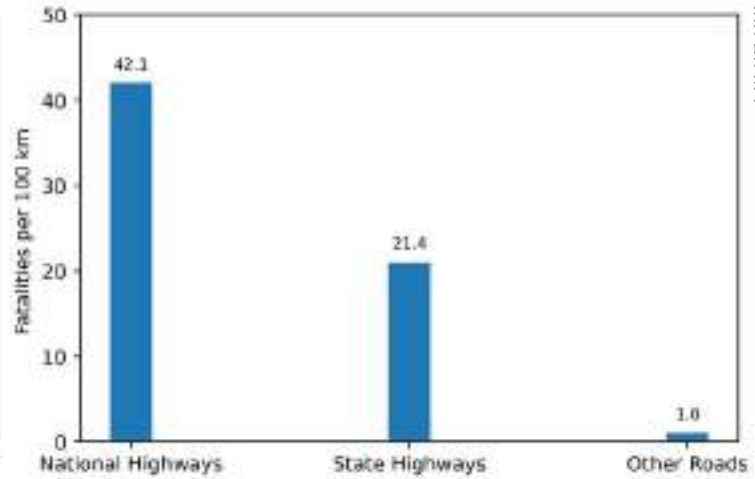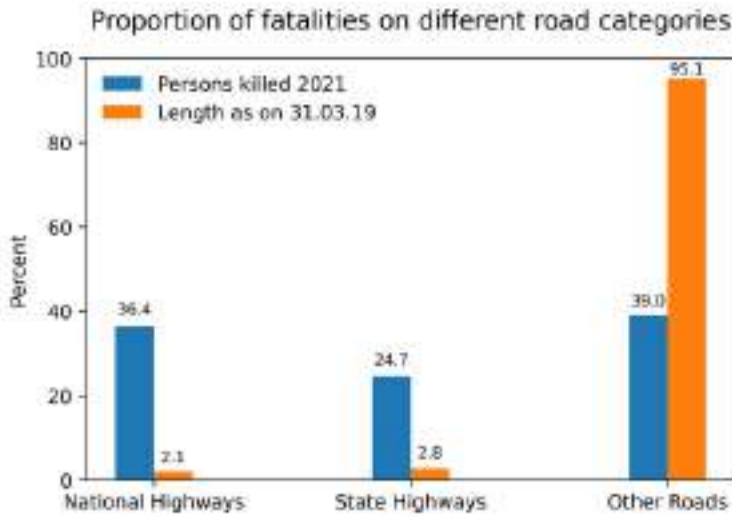
Figure 23. Proportion of RTI fatalities on different categories of roads and the proportion of road length for each category (Source: Transport Research Wing, 2022)

Figure 24. Fatalities per 100 km on different categories of roads in India in 2021 (Source: Transport Research Wing, 2022).

travelled on various categories of highways are not available, it is not possible to make a comparison based on exposure rates.

Recent research studies have reported fatal crash rates (fatalities per km) for three NH (NH-1, NH-8 and NH 24) 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)

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.

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 miss 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, percent						
	Pedestrian	Bicycle	Motorised Two-wheeler	Car	Bus	Truck	Unknown & other
Highway (1998)[1]	32	11	24	15	3	14	1
2 lane NH8 (2010-2014)[2]	20	2	42	14	9	13	1
4 lane NH24 (2010-2014)[2]	27	5	44	8	7	4	4
4 lane NH7 (2016-2018)[3]	24	10	52	8	2	2	1
6 lane NH1 (2010-2014)[2]	34	3	10	6	5	41	1
6 lane NH44 (2016-2018)[4]	40	7	34	8	3	3	6
6 lane Expressway (2012 to 2018)[5]	11	-	28	29	6	13	12

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

Location	Vehicles involved, percent						
	Truck	Bus	Car	TSR	MTW	Other	Total
Highway (1998)[1]	65	16	15	1	3	-	100
2 lane NH8 (2010-2014)[2]	47	5	17	1	5	25	100
4 lane NH24 (2010-2014)[2]	54	8	9	4	3	22	100
4 lane NH7 (2016-2018)[3]	22	9	50	1	3	16	100
6 lane NH1 (2010-2014)[2]	72	3	12	1	2	10	100
6 lane NH44 (2016-2018)[4]	27	10	30	1	7	25	100
6 lane Expressway (2012-2018)[5]	26	6	42	0	11	15	100

Note : (1) Data from locations on 34 national and state highways in India, (Tiwari, Mohan and Gupta 2000); (2) Source (Tiwari 2015); (3) Safety effects of paved shoulder width on a four-lane divided rural highway in India: A matched case-control study (Bisht, L. S., & Tiwari, G. 2022); (4) Assessing the Effect of Paved Shoulder Width on Road Traffic Crash Risk on a Six-Lane Rural Highway in India, (Singh Bisht, L., & Tiwari, G. 2023); (5) Assessment of fatal rear-end crash risk factors of an expressway in India: a random parameter NB modeling approach (Bisht, L. S., & Tiwari, G. 2023).

A more recent study investigated police reports of fatal crashes on selected locations on 2-lane NH8, 4-lane NH24, and 6-lane NH1 (Tiwari 2015) & 4-lane NH7, 6-lane NH 44 and 6 lane Expressway (Singh Bisht, L., & Tiwari, G. 2023), (Bisht, L. S., & Tiwari, G. 2023). 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 percent respectively, whereas the numbers for urban areas were 5%-10% vehicle occupants and the rest were vulnerable road users.

Table 11. Crash types by type of highways 2010-2014 (Tiwari, 2015)

Highway Type	Crash type in percent						
	Overturn	Head-on	Angle	Rear-end	Pedestrian and bicycle	Fixed object	Other
2 lane with paved shoulder undivided (2010-2015) [1]	6	33	6	21	21	-	5
4 lane divided (2010-2015) [1]	0	6	2	54	32	-	1
6 lane divided (2010-2015) [1]	2	10	9	28	45	-	1
2 lane hill road (2010-2015) [1]	77*	4		1	4		13
4 lane NH7 divided (2016-2018) [2]	0	14	7	39	35	0	7
6 lane NH 44 divided (2016-2018) [3]	1	5	9	29	48	3	5
6 lane Expressway (2012-2018) [4]	3	2	4	49	11	18	13

Note : (1) Source (Tiwari 2015); (2) Safety effects of paved shoulder width on a four-lane divided rural highway in India: A matched case-control study (Bisht, L. S., & Tiwari, G. 2022); (3) Assessing the Effect of Paved Shoulder Width on Road Traffic Crash Risk on a Six-Lane Rural Highway in India, (Singh Bisht, L., & Tiwari, G. 2023); (4) Assessment of fatal rear-end crash risk factors of an expressway in India: a random parameter NB modeling approach (Bisht, L. S., & Tiwari, G. 2023).

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 one of the six-lane highways where the proportion of truck victims is higher.

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

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 areas. 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 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.

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*Run off vehicles 76% and 1% overturn

Table 11 shows the distribution of crash types by type of highway and type of crash (Tiwari, G., 2015). The statistics for single lane may not be representative because of the small sample size. It is interesting to note that there are no major differences in the proportion of overturn accidents in 2-lane and 4-lane roads. Similarly, there are no major differences in the proportion of head-on collisions on different types of 2-lane roads. Divided 4-lane roads are justified on the basis that these would eliminate the occurrence of head-on collisions.

The fact that head-on collisions are common on divided roads means that many vehicles are going the wrong way on divided highways. This is probably because tractor and other vehicles travel the wrong way when they exit from roadside businesses and the cut in the median is too far away. This issue needs to be considered seriously and guidelines need to be developed for the placement of cuts in the median or for providing under/overpasses for vehicles at convenient locations.

Table 10 and 11 describe the types of crashes that occurred on different types of highways in 1997-2000 and in the last five years (2010-2014). The types of crashes that occur on hill roads, where run-off crashes dominate, are clearly different from those that occur on other types of highways. Rear-end collisions (including collisions with parked vehicles) are high on all types of highways including 4-lane highways. This shows that even though more space is available on wider roads rear-end crashes do not reduce. This is probably due to poor visibility of vehicles rather than road design itself. Countermeasures would include making vehicles more visible with the provision of reflectors and roadside lighting wherever possible.

Head-on collisions are common on divided roads, which 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.

Impacts with pedestrians and bicycles have a high rate on all roads including 4-lane and six-lane divided highways. The proportion is lower on 2-lane highways with wider (2.5m) paved shoulders. For these types of crashes to be reduced the following countermeasures need to be experimented with: physical segregation of slow and fast traffic, provision of 2.5m paved shoulders with physical separation devices like audible & vibratory pavement markings, provision of frequent and convenient under-passes (at the same level as surrounding land) for pedestrians, bicycles and other non-motorised transport, and traffic calming in semi-urban and habited areas. Collisions with fixed objects are low only on 4-lane divided highways. Provision of adequate run-off area without impediments and design of appropriate medians are obviously very important on highways.

Rear-end collisions (including collisions with parked vehicles) are high on all types of highways including 4- lane 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 the 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 the 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 36.4% of the fatalities. Fatality rate per km of the road is the highest on NH with 0.42 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% 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.

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

RESULTS OF SYSTEMATIC REVIEWS

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.

The effects of campaigns using tangible incentives (rewards) to promote safety-belt usage have been evaluated by means of a meta-analytical approach. The results (weighted mean effect) show a mean short-term increase in use rates of 12.0 percentage points; the mean long-term effect was 9.6 percentage points (Hagenzieker, Bijleveld, and Davidse 1997).

Research first from Australia, later from many European countries, then from Canadian provinces, and finally from some US states clearly shows that the only effective way to get most motorists to use safety belts is with good laws requiring their use. Studies show that driver education may be necessary for beginners to learn the elementary skills for obtaining a license, but compulsory training in schools leads to early licensing.

There is no evidence that driver education in schools result in a reduction in road-crash rates. On the other hand, they may lead to increased road-crash rates (Williams and O'Neill 1974, Vernick et al. 1999, Mayhew and Simpson 1996). While there may be a need to train professional drivers in the use of heavy vehicles, there is no evidence that formal driver education should be compulsory in schools and colleges.

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

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.

Vehicle factors

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

Use of seat belts 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 seat belt use reduced mortality by more than 80% (Kent, Viano, and Crandall 2005, Crinion, Foldvary, and Lane 1975, Parkin, MacKay, and Framton 1993).

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

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.

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.

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.

Driver or pedestrian education programmes by themselves usually are insufficient to reduce crash rates
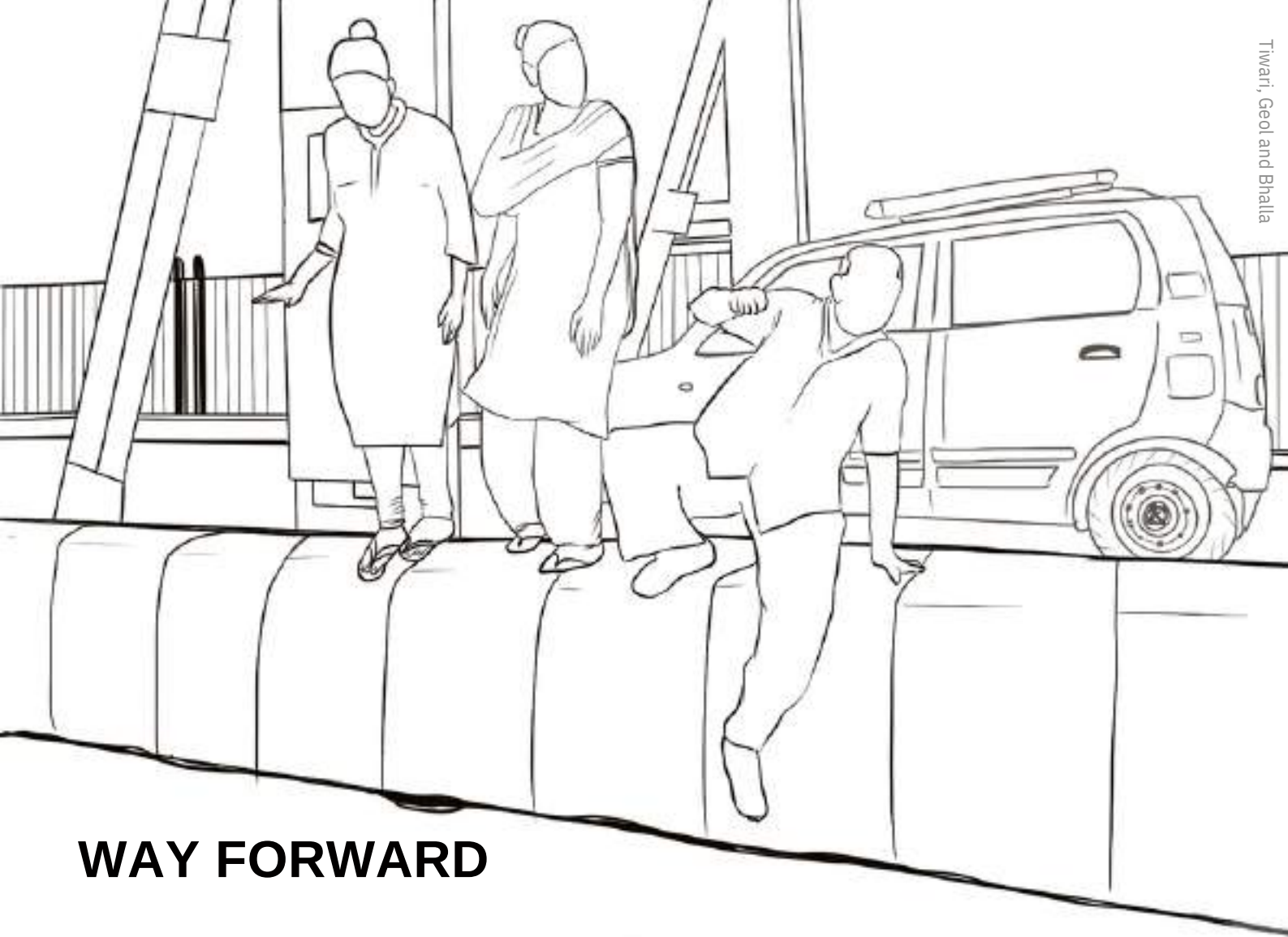
Pre-hospital care

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

- Reserve adequate space for non-motorized modes on all roads where they are present.

- Free left turns must be banned at all signalized junctions. This will give a safe time for pedestrians and bicyclists to cross the road.

- 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.

- 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

- Notification and enforcement of mandatory use of helmet and daytime headlights by two-wheeler riders

- Enforcement of seat belt use laws countrywide.

- Restricting front-seat travel in cars by children and the use of child seats has potential for reducing injuries to child occupants.

- Introduction of alcohol locks.

Road measures

- Traffic calming in urban areas and on rural highways passing through towns and villages.

- Improvement of existing traffic circles by bringing them in accordance with modern roundabout practices and substituting existing signalized junctions with roundabouts.

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

- Mandatory road safety audit for all road building and improvement projects.

- 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.

Enforcement

- 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

- 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.

- Enforcement of seat belt and helmet use.

Pre-hospital care, treatment and rehabilitation

- Modern knowledge regarding pre-hospital care should be made widely available with training of specialists in trauma care in the hospital setting

- Pre-hospital care programmes should be rationalized on evidence-based policies so that scarce resources are not wasted.

Research agenda

- Development of street designs and traffic-calming measures that suit mixed traffic with a high proportion of motorcycles and non-motorized modes

- Highway design with adequate and safe facilities for slow traffic.

- Pedestrian impact standards for buses and trucks.

- Evaluation of policing techniques to minimize cost and maximize effectiveness

- Effectiveness of pre-hospital care measures.

- 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:

- Independent of the respective operational agencies to avoid conflict of interest

- 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

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

- The Board should have an adequate funding mechanism based on the turnover of that sector

- 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:

1. The agency would need to have in-house technical expertise to keep abreast of scientific and technical advancements in road safety knowledge internationally.
2. Since the Board will have the responsibility of establishing safety standards, it is essential that its staff have domain expertise for the same.
3. 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:

- 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.

- 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: List of research studies on road safety in India in 2016

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