

Ahmedabad Urban Road Accident Study 2016

Comprehensive analysis of 156 accidents examined between January to December 2016

Submitted by:

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Ahmedabad City Road Accident Study

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Acknowledgements

We express our sincere thanks to Mr. R. M. Jadav, IAS, Commissioner of Transport, Mr. Kamal Kumar Dayani, IAS, Former Principal Secretary, Commissioner of Transport and Mr. J. P. Gupta, IAS, Commissioner of Health, Medical Services & Medical Education for giving us the opportunity to conduct this study.

We would also like to extend our thanks to Mr. A. K. Singh, IPS, Commissioner of Police, Ahmedabad City; Mr. Shivanand Jha, IPS, Former Commissioner of Police, Ahmedabad City; Dr. Sudhir Kumar Desai, IPS, Additional Commissioner of Police (Traffic), Ahmedabad City; Mr. H .G. Patel, IPS, Former Additional Commissioner of Police (Traffic), Ahmedabad City; Mr. Subhash Trivedi, IPS, Former Additional Commissioner of Police (Traffic). Mr. Narendrasinh Gohil, GVK-EMRI 108 Ambulance Service; Mr. Nitin Dossa, Executive Chairman, Western Indian Automobile Association for their co-operation and assistance during the project and, we sincerely thank all the officials, present and past, who have supported this study.

Our sincere appreciation and gratitude to all the officers of Gujarat State Police for their support and co-operation. We hope that the government would soon recognize their importance and train them in Road accident management and, provide them with better protection, equipment, and facilities so that they can do their jobs more effectively and, in turn, help in saving more lives. We are grateful to the GVK-EMRI 108 Ambulance Service personnel who work 24/7 to save lives of people and provide us with details of the accidents.

This study is being conducted under the Road Accident Sampling System – India (RASSI) project, which is an initiative financially and technically supported by the following consortium members:



RASSI Consortium Members

We thank the RASSI consortium members not only for their financial support but also for their belief in safer road travel for India, which ultimately has made this project possible. We also take this opportunity to express our deepest sense of gratitude to all the researchers and employees of JP Research India, and JP Research, Inc., whose untiring efforts, dedication and passion have made all this possible.

We think this is a pioneering attempt in India towards data-driven road safety strategies that have proven to be highly effective in mitigating fatalities, injuries and accidents around the world. We hope that the data collected and analyzed from this study is useful to all the stake holders of Ahmedabad roads (including all road users) in making our journeys safer.

Our study is dedicated to all the people whose lives have been affected, directly or indirectly, by road accidents on Ahmedabad city roads.

1 INTRODUCTION

Ahmedabad city is the administrative headquarters of the Ahmedabad district and is the seat of the Gujarat High Court. It is the sixth-largest city and seventh-largest metropolitan area of India. Ahmedabad has emerged as an important economic and industrial hub in India. Residential areas are densely populated and hence the roads of Ahmedabad see a lot of motorized 2-wheelers (M2Ws) and motorized 3-wheelers (M3Ws) plying on them.

The study area of this road accident study covers about 2000+ kilometers of important roads and highways that falls under the city limit of Ahmedabad. This report presents the results of the study of accidents that occurred on the public roads of Ahmedabad city (Figure 1) that were examined by JP Research India (JPRI) between 1st January and 31st December 2016.

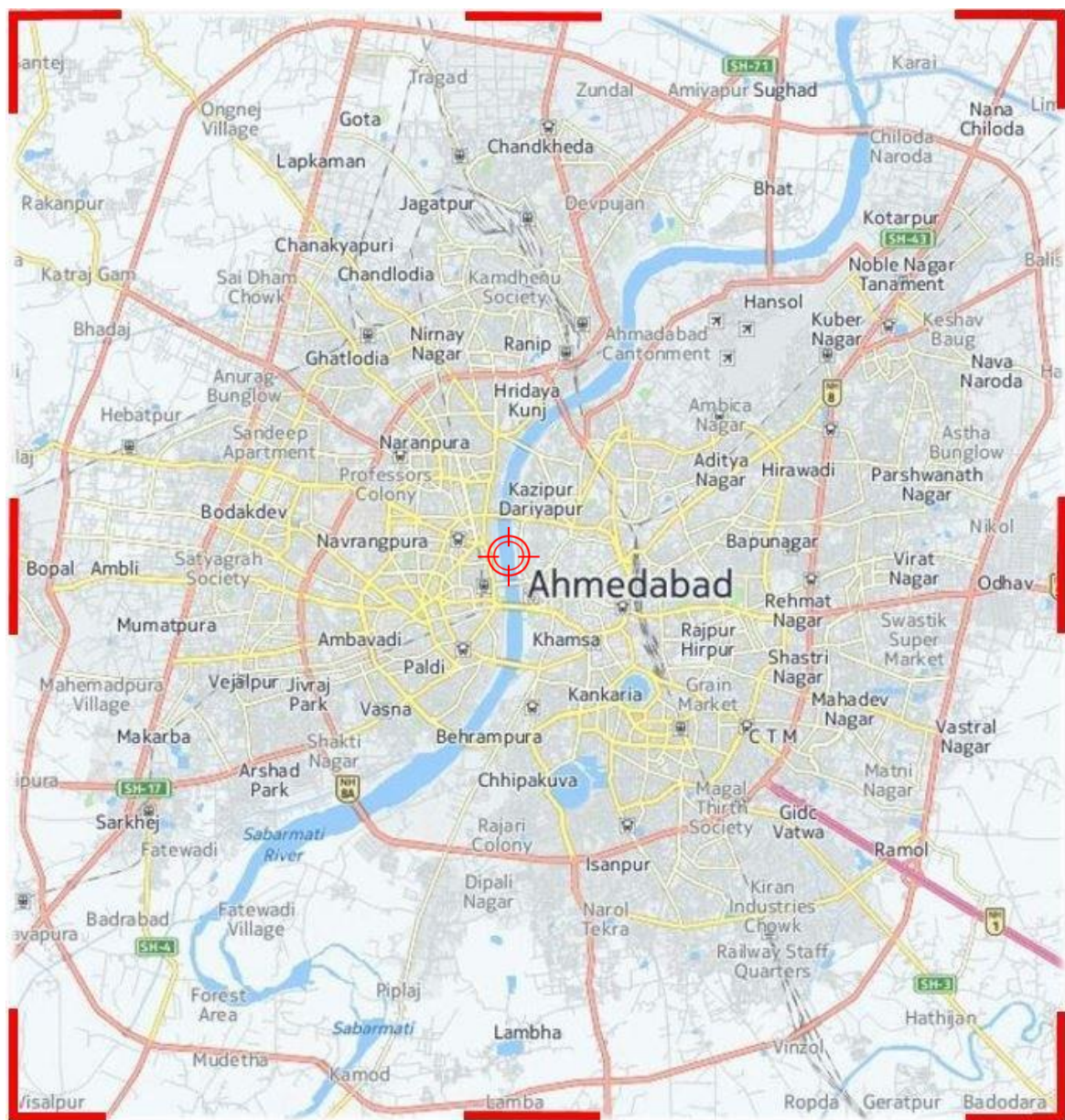


FIGURE 1: REPRESENTS OUR AREA OF STUDY IN AHMEDABAD
(COURTESY: HERE MAPS)

BACKGROUND

How did this study begin?

In November 2013, JPRI approached the Transport Department of Gujarat with a proposal to conduct on-site crash investigation and accident data collection on selected roads of Ahmedabad and Gandhinagar districts. The proposal was accepted, and since 7 February 2014, JPRI researchers have been examining accidents on-site as soon as they are informed of a crash. We started in 2014, with a small study area and the team focusing on accidents notified to GVK EMRI 108 in the western parts of the Ahmedabad city. From 1st November 2015, with the approval of Commissioner of Police, Ahmedabad city, JPRI expanded its study area and started covering the entire city focusing on all the fatal accidents reported to the police, and serious injury and minor injury accidents notified by GVK EMRI 108. Now we operate and investigate road accidents throughout the city limits of Ahmedabad.

How does JPRI conduct this study for free for the government?

This study is being conducted at NO COST to the government. JPRI respects and is grateful for the co-operation provided by the police and other government agencies for conducting these in-depth crash investigation studies. In return, JPRI provides reports that give scientific, detailed and unbiased insights regarding road safety issues in India.

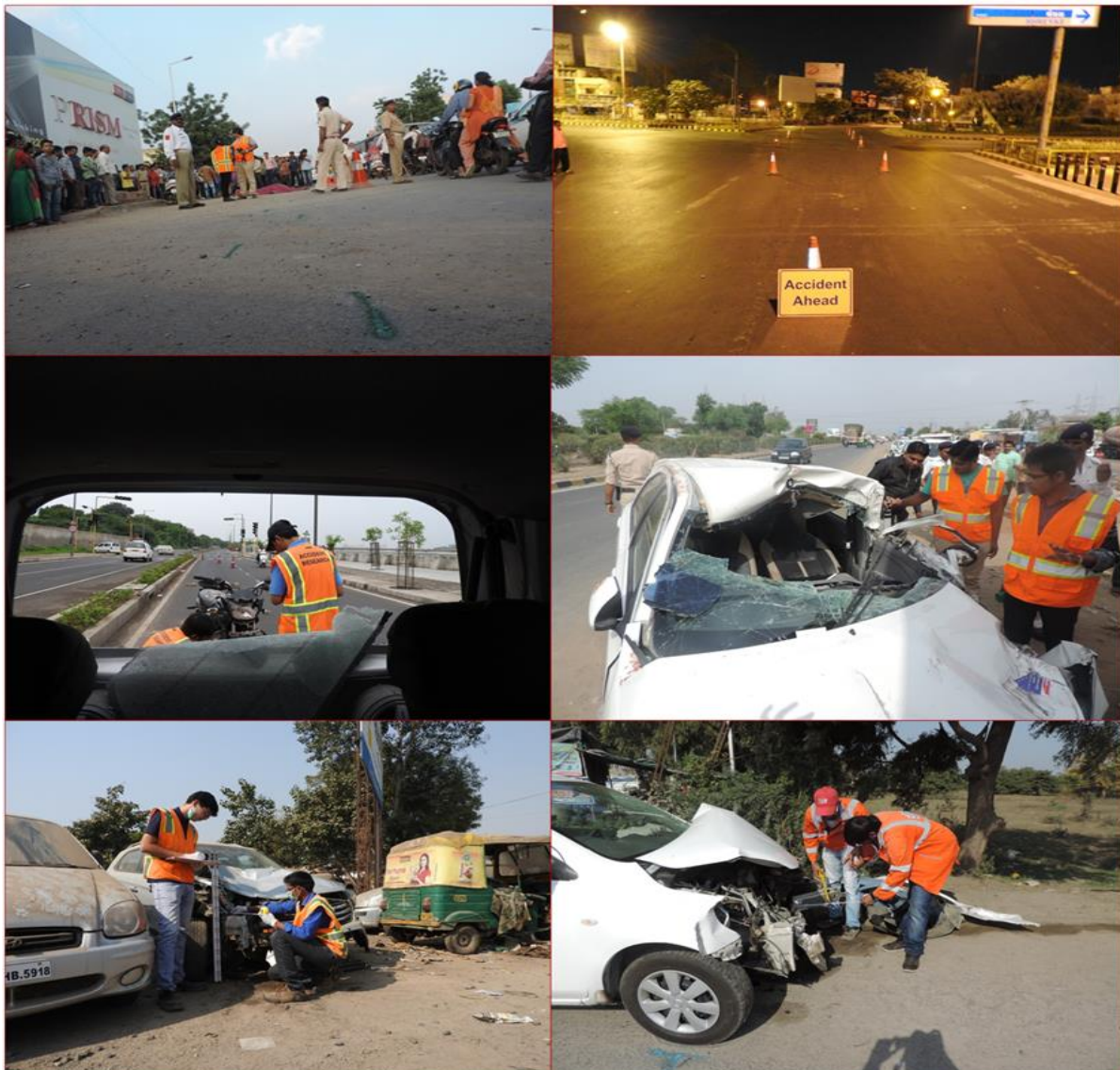




FIGURE 2: JPRI ACCIDENT RESEARCHERS PERFORMING ON-SCENE CRASH INVESTIGATIONS

JPRI accident research teams spend a considerable amount of time examining road crashes. In-depth crash investigations are conducted in a scientific manner involving detailed examination of the crash scene and crash vehicles and detailed coding of the injuries sustained by the accident victims (Figure 2). In most occasions, our researchers also interview the accident victims to understand the accident sequences better. The data collected is stored in a database in a format which allows for detailed analysis of accidents.

Numerous measurements, observations and notes are taken on accident data forms, which are used to build a scientific database called “Road Accident Sampling System – India” (RASSI). This database is shared by a consortium of automotive manufacturers who use it for improving vehicle design and developing India-specific automotive safety technologies. This scientific research consortium provides financial and technical support to JPRI under the RASSI initiative for obtaining this data. (More details in the following sections).

Does this study affect my privacy?

This study is purely scientific, and personal information such as victim names, contact numbers, vehicle registration numbers, etc. are NOT stored in the analytical database.

JPRI crash investigation processes are designed keeping in mind that the entire purpose is not to investigate accidents to find fault, but to make an unbiased scientific examination of each accident to determine the various contributing factors in order to better understand what could be done to prevent reoccurrences of such accidents. Since personal information is not needed for analysis, JPRI researchers, after completing an accident examination, anonymize all the details that go into the scientific database.

What is the objective of this report?

Over the period of 1st January 2016 through 31st December 2016, JPRI researchers examined 231 accidents that occurred in the study area, of which researchers were able to study 156 accidents comprehensively to determine the reasons for the occurrence of the accidents and resulting injuries.

This report provides an in-depth analysis of these 156 accidents and provides information of the various factors influencing accidents and the resultant injuries on the roads of Ahmedabad city. The report not only identifies these “contributing factors” but also ranks them based on the number of accidents these factors have influenced. This ranking is to help policy makers, decision makers and road safety stakeholders in planning cost-effective road safety investments using data-driven road safety strategies.

ABOUT JP RESEARCH INDIA

JP Research India Pvt. Ltd. (JPRI) is a private research firm dedicated to the business of automotive crash data collection and analysis. The company, a fully owned subsidiary of JP Research, Inc., is a forerunner in road safety research and has undertaken pioneering on-scene accident investigation and in-depth data collection projects aimed at scientifically understanding and mitigating road accident fatalities in India.

Accident research has proven to be the best way to understand the characteristics of real-world road traffic crashes. Countries such as USA, UK, Germany and Japan routinely use the results of such research to significantly reduce the number of road traffic fatalities in their countries. The fact that India has been losing approximately 1,50,000 lives on its roads every year makes it imperative that we too conduct this kind of research to identify and then take swift steps to address the key factors influencing the high traffic injury and mortality rate in our country.

JPRI is experienced in using accident research methodologies developed in other nations and customizing these to suit India’s unique traffic conditions. After conducting numerous studies and on-site crash research projects on Indian roads, JPRI has developed its own India-specific crash data collection forms, a methodology for conducting site and vehicle crash investigations in the inimitable Indian traffic environment, and a searchable database of in-depth accident data. In addition, the company’s experts offer training in all of these areas, for those who would prefer to perform their own data collection and analysis. In other words, at JPRI, our overriding objective is to understand Indian roads, traffic and road users in ways that can be used to save lives: ours and yours.

ABOUT ROAD ACCIDENT SAMPLING SYSTEM – INDIA (RASSI)

India is currently ranked highest in the world for road traffic fatalities; thus, there is a critical need to reduce the number of road traffic-related fatalities across the country. While the economic and social benefits of implementing standardized accident reporting and crash data collection systems to improve road and automotive safety and reduce fatalities have been demonstrated in Europe and the USA for some time, there has been no comparable system in India.

The absence of systematically collected, nationwide in-depth traffic crash data is seriously impeding scientific research and analysis of road traffic accidents in India. To address root causes of real crashes and injuries across India, it is necessary to fully understand the traffic accidents taking place throughout the country. Only real world accident data, properly defined, can reliably identify the key factors that contribute to traffic crashes, both in terms of their frequency and severity. Further, since cultural and socio-economic conditions, as well as the roads themselves, affect driving conditions and crash outcomes, the data must be specific to a particular region. An automotive accident data collection system – based on the models used in Europe/US, but modified to suit Indian road scenario – has been initiated by a consortium of automobile original equipment manufacturing (OEM) companies. This initiative is called RASSI.

The genesis of the RASSI project began with a passenger car crash analysis study undertaken in Chennai. This led to short-term accident studies on National Highways in the districts of Kanchipuram and Coimbatore, with the cooperation of the Tamil Nadu state police.

Based on the experience from these initial studies, a robust methodology was developed to perform an in-depth accident data collection and research that applied generically to all Indian roads. A relational database was also developed to record the scientific data obtained from each accident investigated by the researchers. Based on the early success of RASSI, a number of OEMs came forward to provide financial support for the continuation of the study on a yearly basis. In 2011 in JPRI's Coimbatore Data Centre, the RASSI Consortium officially came into being, and members were granted interactive access to the database.

Crashes are continually being investigated comprehensively by JPRI teams in Coimbatore, Pune, Ahmedabad, Kolkata and Jaipur, and the program logs a wide array of data, as well as vehicle and crash site photographs. The teams collect and assess detailed evidence—such as skid marks, broken glass, debris, impacted objects, measurements of crash damage to the vehicle—and identify interior vehicle locations contacted by occupants during the crash event. They then follow up on-site investigations by linking medical record contents to document the nature and severity of injury from a crash.

The long-term goal of the RASSI Consortium is to extend RASSI to create an integrated network of data centers across India with the support of other automotive and transportation-related companies and of the government. This would result in a common set of automotive crash data for research and analysis to better identify the root causes behind India's road traffic issues.

Contact information for JPRI and RASSI is provided in Appendix A.

2 METHODOLOGY

ACCIDENT DATA SAMPLE

Of the 231 accidents examined between 1st January 2016 and 31st December 2016, JPRI researchers were able to collect comprehensive data for 156 accidents. These 156 accidents involve 301 road users that resulted in 129 fatalities and 53 seriously injured victims.

How were these accidents found?

JPRI researchers identified 6 GVK-EMRI 108 ambulances who respond to road accidents occurring inside JPRI's study area in Ahmedabad city. The GVK-EMRI 108 Control Room was requested to provide text notifications of all road accidents which are attended by these 6 ambulances. On receiving the text message, JPRI researchers would travel to the crash scene and examine the road accident. We are also notified by Ahmedabad city traffic police stations and control room about all the fatal accidents happening in Ahmedabad City Police's Jurisdiction.

Out of the 156 accidents, 25 accidents were notified to JPRI researchers through text messages of GVK-EMRI Control Room, 121 accidents were notified by Police and remaining 10 accidents were notified through other sources such as newspaper, researchers seeing an accident while travelling to another accident location etc.

As shown in figure 3, Most of the accidents examined are reported to the police. Non-reported accidents were usually minor or no injury, but occasionally involved serious injuries. Such non-reported accidents are still important for accident analysis.

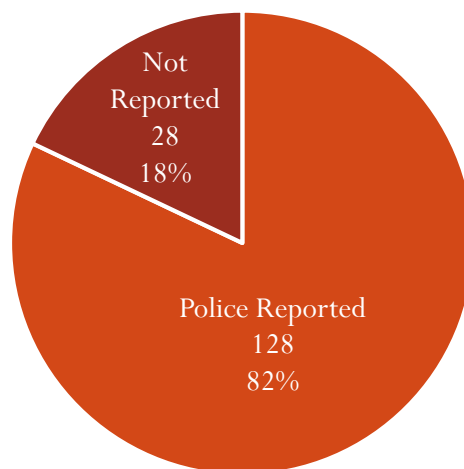


FIGURE 3: DISTRIBUTION OF 156 ACCIDENTS BASED ON REPORTING OF ACCIDENTS TO POLICE

Why are “Non-Police Reported” accidents important?

Having access to all road traffic accidents is important because this:

1. Gives a more realistic indication of the total number accidents actually occurring on the streets of Ahmedabad city.
2. Allows analysis of common contributing factors leading to injuries in all fatal and serious injury accidents.
3. Allows analysts to determine which safety systems work well, and which does not in preventing an accident or mitigating injuries.

Distribution of total accidents as per police jurisdiction

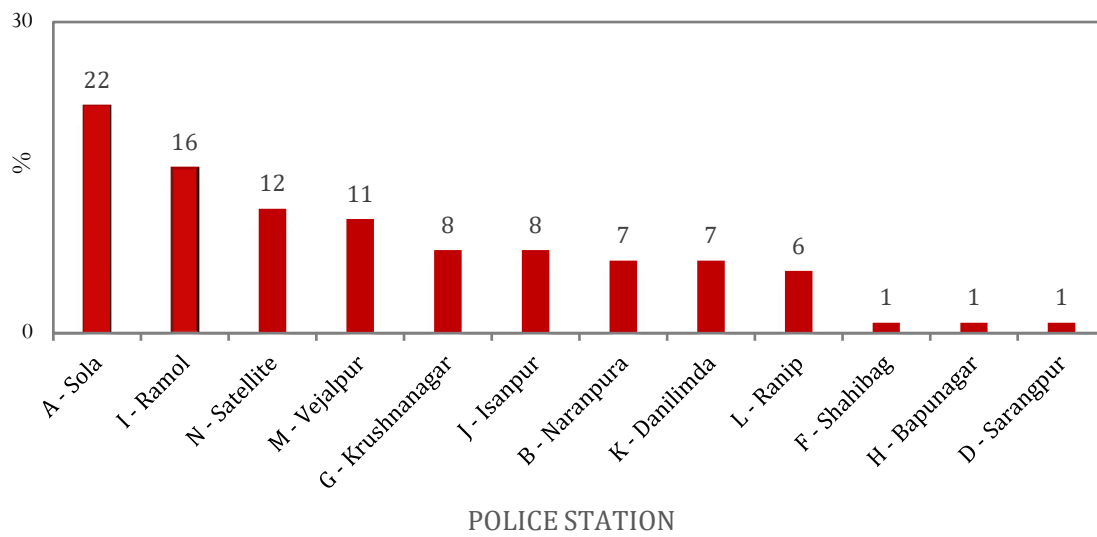


FIGURE 4: REPRESENTATION OF THE TOTAL ACCIDENTS BY POLICE JURISDICTIONS

As can be seen from figure 4, maximum accident cases were reported in A – Division (Sola) which is 22 % of the total accidents.

Ahmedabad city police jurisdiction area is divided into 14 Traffic divisions. The 156 accidents investigated in the Ahmedabad city were distributed among these police stations as shown in figure 4.

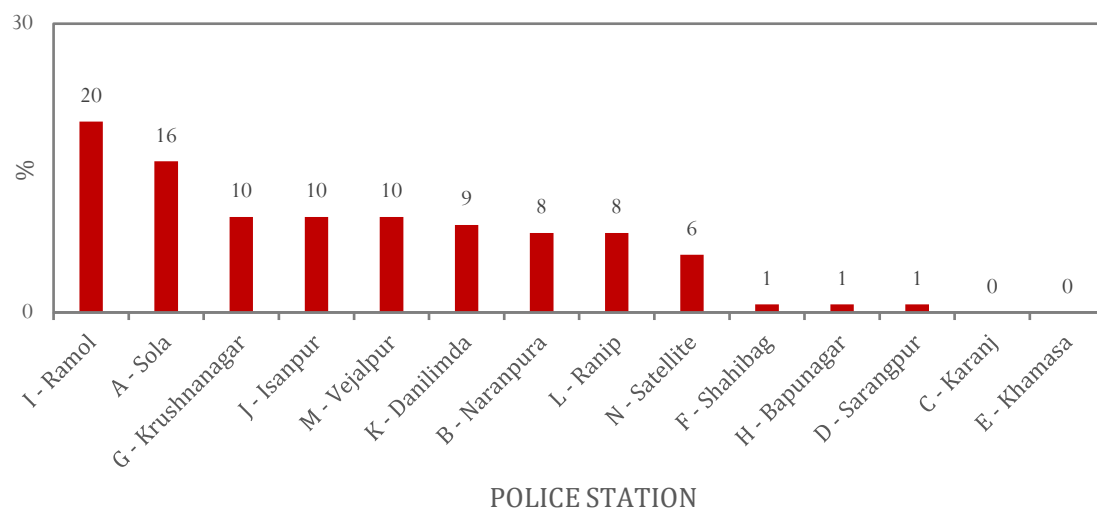


FIGURE 5: REPRESENTATION OF FATAL ACCIDENTS BY TRAFFIC DIVISIONS

As can be seen from figure 5, I – division (Ramol) reported maximum fatal accidents (20%) followed by A – Division (Sola) with 16% of the total 121 fatal accidents.

CONTRIBUTING FACTORS – A PRIMER

Road traffic accidents are primarily influenced by three main factors:

- Human (drivers, riders, vehicle occupants, pedestrians, tri-cyclists and bicyclists)
- Vehicle (vehicle design/structure, mass, equipment such as seatbelts or tires, etc.)
- Infrastructure/Environment (hereinafter called “infrastructure” which includes road design, signage, weather, conditions affecting visibility, etc.)

Conventionally, accidents are analyzed for each of the above factors, and the accident causation factor is finalized as a result of a problem with only *one* of these factors. This type of analysis results in an overrepresentation of human failures and tends to identify driver errors as the main contributors to road traffic accidents. Thus, the commonly repeated wisdom— “Driver error is the cause of over 90% of accidents”.

The problem with this type of analysis is the assumption that the driver initiated the accident and hence all responsibility lies with him/her. Influencing factors which are vehicle-related and infrastructure-related are often not accounted for, even though they are an inseparable part of the whole accident.

THE JPRI APPROACH TO STUDYING AN ACCIDENT

When JPRI researchers examine an accident, they try to determine all the possible contributing factors that can influence an accident independently or as a combination. This kind of analysis gives a broader perspective and can help identify vehicle related and infrastructure related solutions that can prevent accidents and mitigate injuries in spite of human errors.

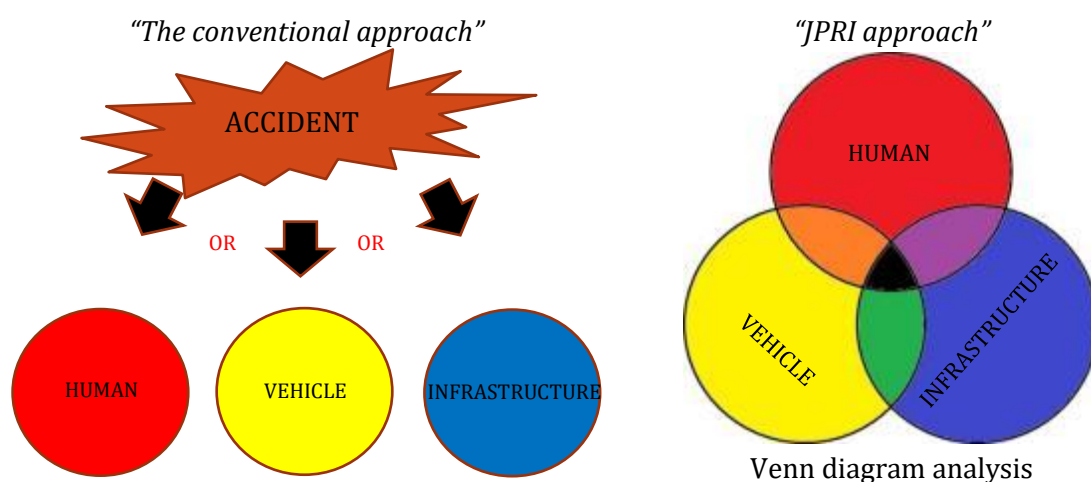


FIGURE 6: APPROACHES FOR ANALYZING ACCIDENT CAUSES.

Of course, not all accidents result in serious or fatal injuries, and even for accidents occurring in similar circumstances, the type and severities of injuries are often not the same. JPRI researchers have found an accident (with contributing factors leading to the crash) that can have very different injury outcomes based on the contributing factors that influence injuries. ***This necessitates that accident occurrence be understood separately from the occurrence of resulting injuries.*** Although injuries are the outcome of an accident, the causal factors for an accident need not be the same as those for the injuries sustained.

Hence, just as an accident is analyzed for human, vehicle and infrastructure factors that contributed to its occurrence, the resulting injuries are similarly analyzed for human, vehicle and infrastructure factors that influenced their occurrence and severity.

Figure 7 is a representation of the JPRI approach to analyzing the factors influencing the occurrence of an accident as related to, but separate from, the factors influencing the occurrence of an injury. Note that while this approach can be used even when injuries are slight to none, in the case of this study, the focus was on serious/fatal injuries only.

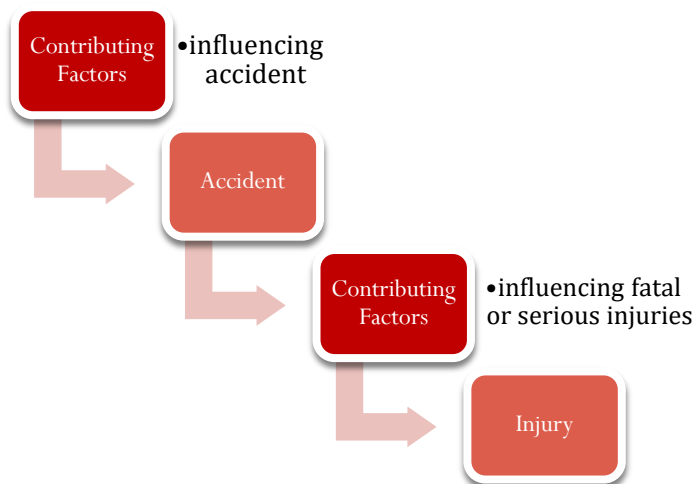


FIGURE 7: A REPRESENTATION OF THE CONTRIBUTING FACTORS ANALYSIS, SEPARATING INFLUENCES ON ACCIDENTS AND INJURIES

Below is a case study of an accident that demonstrates the above methodology.

Case Study:-

Accident Summary: Bus was travelling on a straight road towards south, a Motorized two wheeler (M2W) with two occupants intended to cross the road from left to right with respect to bus’s travel direction in order to access a gap in median. The rider of M2W misjudged the speed of the bus and entered the roadway. The driver of the bus who was over-speeding for the conditions was unable to react on time and had a Front-Side collision. The rider of M2W sustained minor injuries while the Pillion sustained fatal injuries. The occupants of the bus were unhurt.

Vehicle body type	M2W	Bus
Vehicle Photos - Damage sustained by the vehicles		

Contributing human factors - Lead to the accident	Driver's Inattention/Misjudgment	Speeding - Excessive speed for conditions
Contributing Vehicle factors - Lead to the accident	None	None
Contributing Infrastructure factors - Lead to the accident	Intersection Design	None

Contributing factors that lead to injuries sustained by motorcycle riders


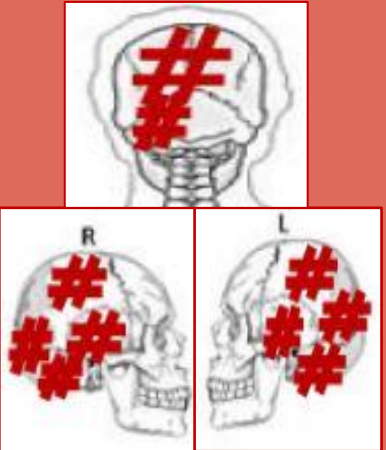
Occupant role	Rider	Pillion rider
Injury Severity	Minor	Fatal
Occupant impact/ contact area	Front fascia of the bus and the ground	Front fascia of the bus and the ground
Contributing factors - Lead to the Injury	Knock down to ground	Knock down to ground Helmet not used
Impact forces were taken by		
Result	Destroyed helmet	Fractured skull

FIGURE 8: DEMONSTRATING JPRI APPROACH ON FACTORS CONTRIBUTING ACCIDENT AND INJURY

In the above case, both the rider and the pillion rider of the motorcycle contacted the front fascia of the bus at almost the same speed but the injury outcomes were totally different. The rider sustained minor injuries like superficial skin abrasions and contusions, whereas the pillion rider succumbed to his injuries.

Although, the injury causation conditions were same for the riders of the motorcycle, the sole factor that made a substantial difference in the injury outcome was the usage of helmet by the rider of the motorcycle. The helmet absorbed all the impact forces directed to the head of the motorcycle rider and shielded it completely. The pillion rider whose head was unprotected died due to head injuries.

3 DATA ANALYSIS

The 156 road accidents examined on-scene by JPRI researchers were analyzed to determine the key characteristics of these accidents.

DISTRIBUTION OF ACCIDENTS BY HIGHEST INJURY SEVERITY

The distribution of the 156 road accidents by injury severity (based on the most severe injury sustained by any human involved in each accident) is shown in Figure 9. As can be seen, about 78% of the accidents examined during this study resulted in at least 1 fatality of an occupant or pedestrian involved in an accident. Out of these 156 accidents, 137 accidents (88%) resulted in fatal or serious injury to at least one vehicle occupant or pedestrian.

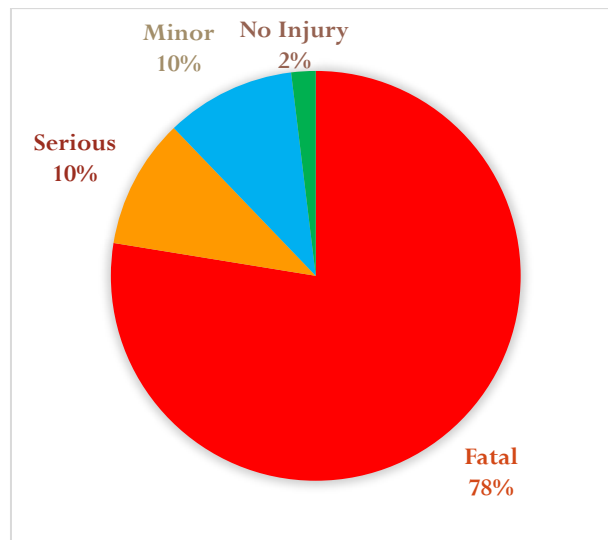


FIGURE 9: DISTRIBUTION OF THE 156 ACCIDENTS BY HIGHEST INJURY SEVERITY

Injury Severity Definitions

The following are the definitions used to classify road traffic accidents.

Fatal Injury: An accident involving at least one fatality. Any victim who dies within 30 days of the accident as a result of the injuries due to the accident is counted as a fatality.

Serious Injury: An accident with no fatalities, but with at least one or more victims hospitalized for more than 24 hours.

Minor Injury: An accident in which victims suffer minor injuries which are treated on-scene (first aid) or in a hospital as an outpatient.

No Injury: An accident in which no injuries are sustained by any of the involved persons. Usually only vehicle damage occurs as a result of the accident.

DISTRIBUTION OF 156 ACCIDENTS BASED ON THEIR LOCATION AND HIGHEST INJURY SEVERITY.

The map below represents the accident location and highest injury severity of all 156 road accidents.

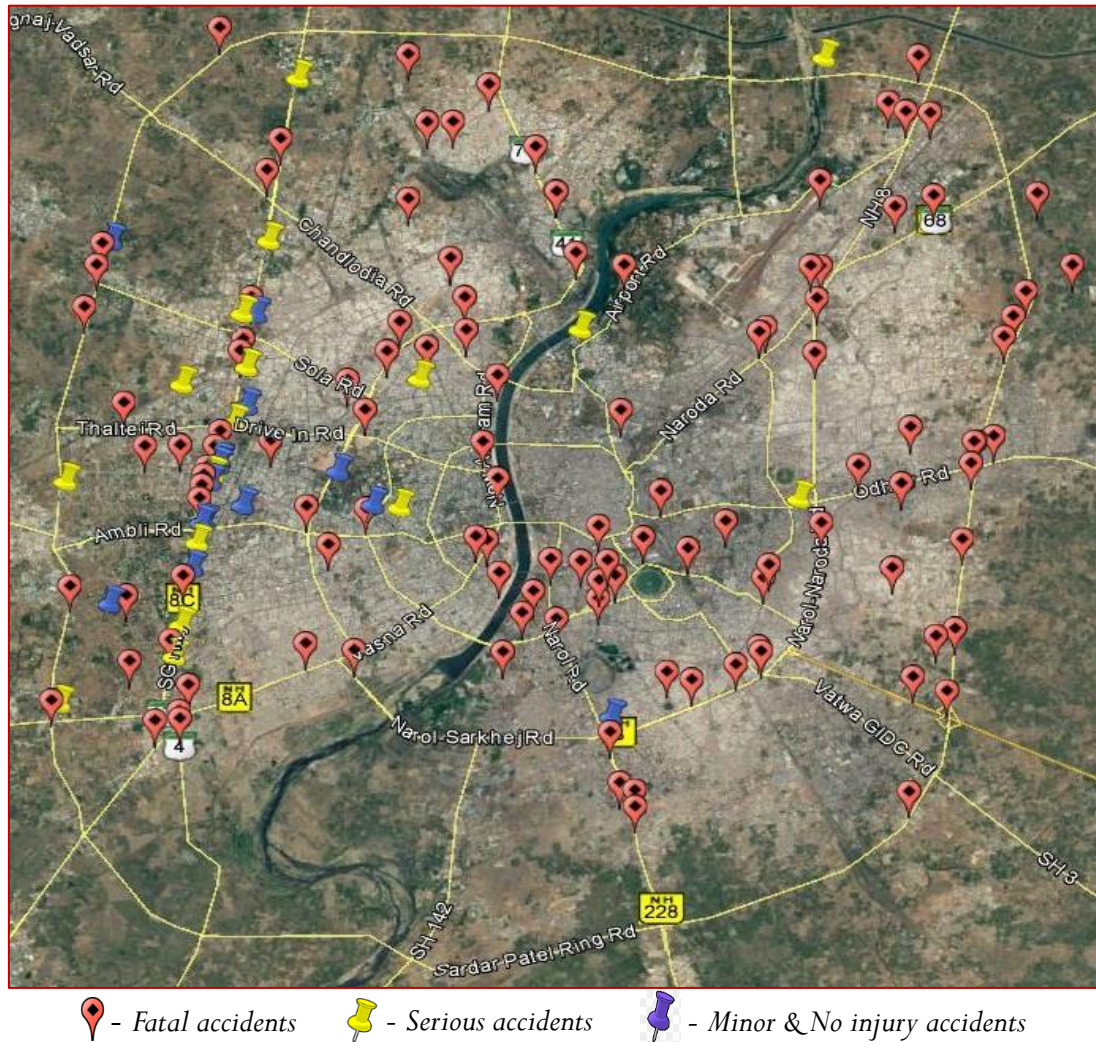


FIGURE 10: DISTRIBUTION OF ALL ACCIDENTS BASED ON LOCATIONS AND HIGHEST INJURY SEVERITY

As can be seen from the above distribution, both western and eastern parts of Ahmedabad city saw equal distribution of the 121 fatal accidents examined by JPRI i.e., 50% respectively spread across either side of the Sabarmati River. Majority of the serious and minor accidents examined fall under the western section of Ahmedabad city.

DISTRIBUTION OF ALL ACCIDENT VICTIMS BASED ON THEIR GENDER AND AGE.

The total number of occupants and pedestrians involved in these 156 accidents were 472. This includes 384 males, 84 females and 4 unknowns. They are distributed according to their sex as follows:

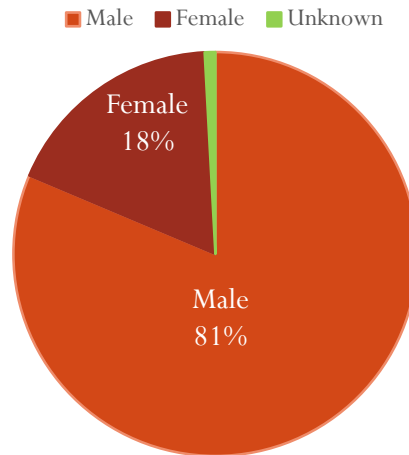


FIGURE 11: PERCENTAGE DISTRIBUTION OF TOTAL OCCUPANTS ACCORDING TO SEX

As can be seen from the above chart (Figure 11), 81% of the victims involved in the accidents were male.

Distribution of the male victims based on their age and injury severity

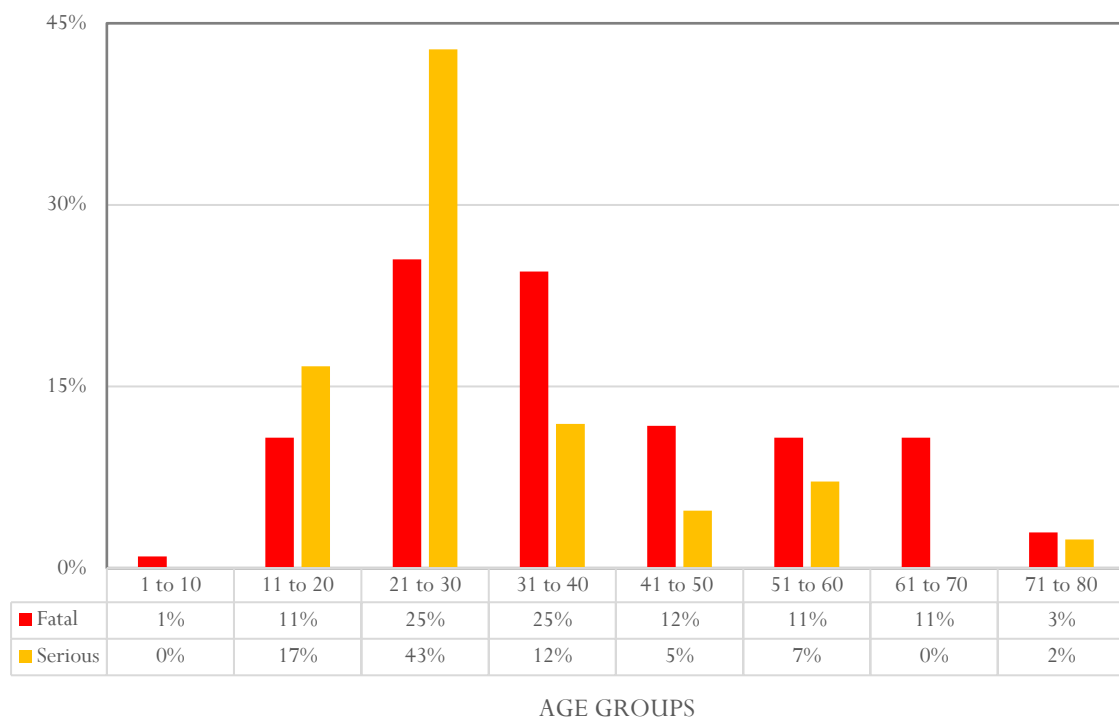


FIGURE 12: DISTRIBUTION OF THE TOTAL MALE VICTIMS (384) INVOLVED IN THE ACCIDENTS BASED ON THEIR AGE AND INJURY SEVERITY.

As can be seen from figure 12, the male victims belonging to the age group of 21 to 30 years were the most affected out of all the age groups. This age group also records the highest number of fatalities (25%) and serious injuries (43%) amongst all the age groups. The age group between 31 and 40 years also tops the list recording 25% of total fatalities. There were 102 fatal and 42 serious male occupants which are considered for this analysis. Age of 2% fatal and 14% serious male occupants is not known.

As can be seen, the age group between 21 and 40 whom we generally consider as the most potential age group contributing towards the growth and development of their families and the nation are the most affected, recording over 50% of total fatalities and serious injuries.

Distribution of the female victims based on their age and injury severity

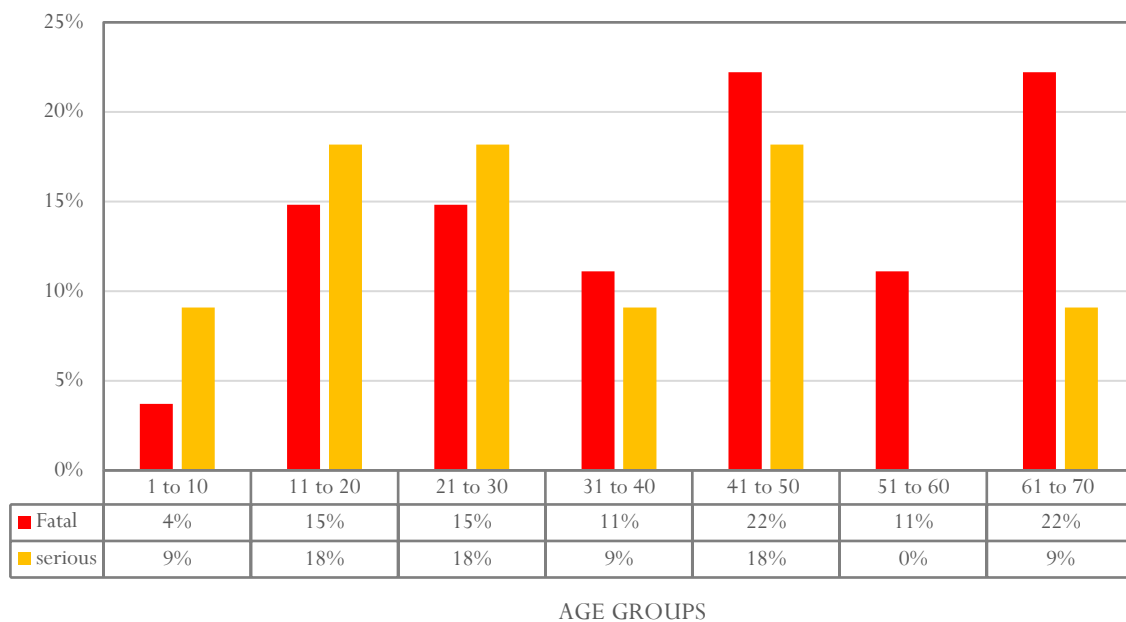


FIGURE 13: DISTRIBUTION OF THE TOTAL FEMALE OCCUPANTS (84) INVOLVED IN THE ACCIDENTS BASED ON THEIR AGE GROUP AND INJURY SEVERITY.

As can be seen from Figure 13, Female victims falling under the age groups of 41-50 and 61-70 recorded the highest number of fatalities (22% each) amongst all age groups and, female victims falling under the age groups of 11-20, 21-30 and 41-50 recorded the highest number of seriously injured victims (18% in each group). Age of 18% serious female occupants is not known.

DISTRIBUTION OF ACCIDENTS BY DAY AND TIME OF OCCURRENCE

Distribution of Accidents by day of Occurrence

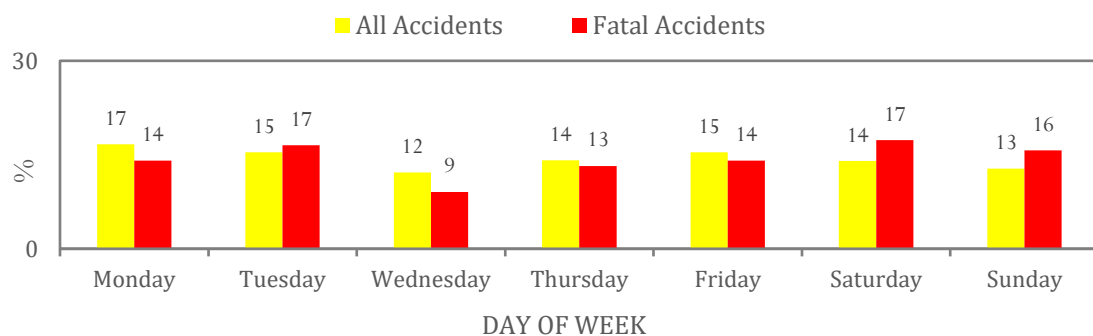


FIGURE 14: PERCENTAGE DISTRIBUTION OF 156 ACCIDENTS BY DAY OF OCCURRENCE

The distribution of total number of accidents and fatal accidents based on the day of occurrence is represented in the Figure 14. The distribution shows that the accidents (156 accidents) are distributed almost equally throughout the days of the week although Mondays records a slight spike and Wednesdays records a slight dip in the occurrence of total accidents. Similarly, fatal accidents (121 accidents) are also distributed evenly throughout the week and again Wednesdays record the least number of fatal accidents in a week. This shows that the accident trend for both total and fatal accidents remains un-changed be it a week day or a week off.

Distribution of Accidents by Time of Occurrence

The 156 accidents were plotted against a time durations of 3 hours (Figure 15) to identify times of occurrence of accident. The data shows lowest percentage of accidents (14%) occurred during time period of 00:00 to 05:59 hours. The lowest percentage of fatal and serious injury accidents (14%) occurred in daytime periods i.e. between 00:00 to 05:59 hours.

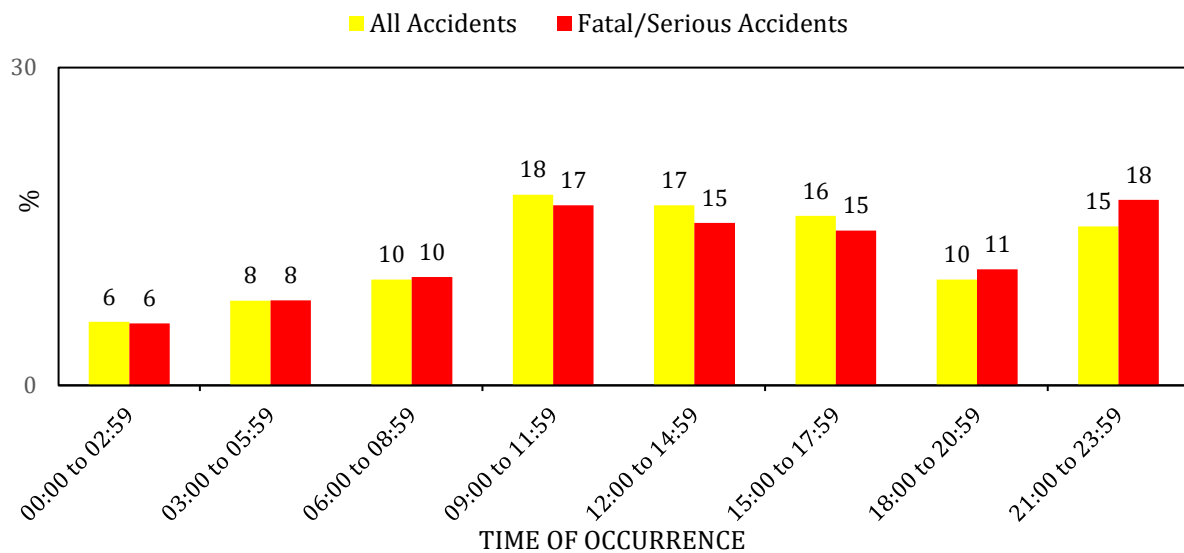


FIGURE 15: PERCENTAGE DISTRIBUTION OF 156 ACCIDENTS BY TIME OF OCCURRENCE

Please note that in the above figure, "Fatal/Serious Accidents" refers to accident counts and not the numbers of injury victims or vehicles involved.

VEHICLES/ROAD USERS INVOLVED

A total of 301 road users (includes vehicles of all body types and pedestrians) were involved in the 156 road traffic accidents examined. These 301 road users includes 262 vehicles and 39 pedestrians. Figure 16 shows the percentage distribution of the types of vehicles/road users involved in these 156 accidents.

Please note that the figure is based on a count of the vehicles and pedestrians involved in the 156 accidents analyzed and not the number of occupants or accidents. In the case of pedestrians, each pedestrian is a single count.

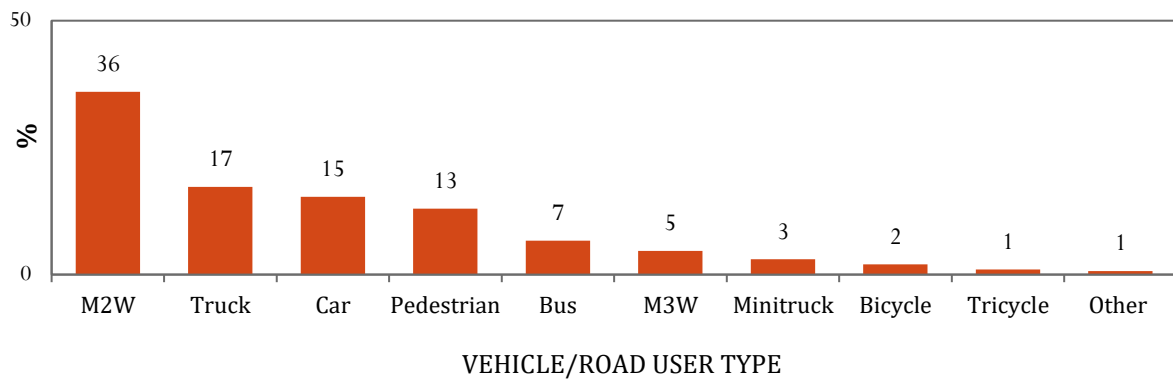


FIGURE 16: PERCENTAGE DISTRIBUTION OF VEHICLE/ROAD USER TYPE INVOLVED (N=301)

As can be seen from figure 16, Motorized two wheelers (M2Ws) were the most frequently involved road user type, recording 36% involvement in the total number of vehicles involved in the accidents. This is followed by trucks (17%) and cars (15%). The most vulnerable road user type i.e., M2W, pedestrians, bicycles and tri-cycles together saw an involvement of about 52%.

For purposes of this report, all persons injured outside of a vehicle are considered pedestrians (refer “accident type” classification; see Appendix B).

ROAD USERS AFFECTED IN CRASHES WITH FATAL OR SERIOUS INJURY

Figure 17 shows the percentage distribution of road users (all vehicles and pedestrians) directly associated with a fatality or a serious injury due to the crash. Please note that percentages given for M2Ws, M3Ws, cars, trucks, and buses reflect a count of vehicles with at least one fatal victim or serious injury victim. Only in the case of pedestrians does the percentage reflect the number of persons counted. Also, note that the below distribution is based on the highest injury severity suffered per vehicle / pedestrian in the accidents i.e. a motorized two-wheeler involved in an accident consisting of a fatal and seriously injured victim will only be considered in fatal distribution in the below figure (Figure 17).

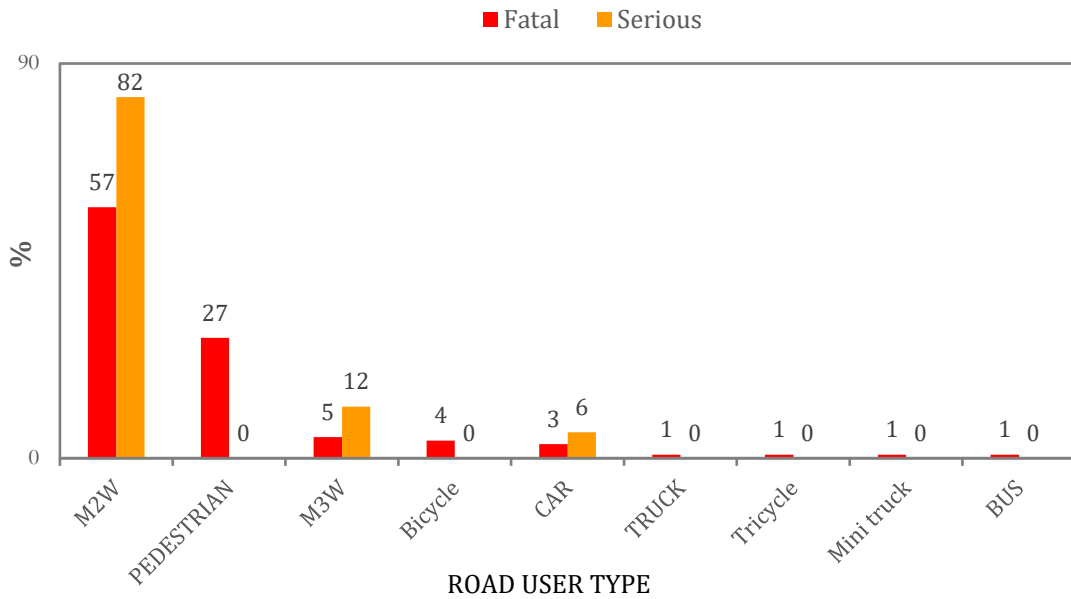


FIGURE 17: PERCENTAGE DISTRIBUTION OF VEHICLE/ROAD USER TYPES IN CRASHES WITH AT LEAST ONE FATALITY OR SERIOUS INJURY VICTIM.

As can be seen from Figure 17, Motorized Two wheelers (M2Ws) is the most affected vehicle type recording 57% of total fatalities amongst the 124 road users (includes all types of vehicles and pedestrian) which had at least 1 fatality, followed by pedestrians recording 27% of total fatalities amongst the 124 road users.

Again Motorized Two wheelers saw the highest number of seriously injured victims recording 82% of serious injuries amongst the 17 road users (includes all types of vehicles and pedestrian) where at least one road user suffered serious injury (and no fatality).

ROAD TRAFFIC ACCIDENT TYPES

Figure 18 shows the distribution of the total 156 accidents and the distribution of 137 serious and fatal accidents based on the type of accident. The twelve accident types used in coding for this study are listed below and defined in detail in Appendix B.

1. Collision with another vehicle which starts, stops or is stationary.
2. Collision with another vehicle moving ahead or waiting.
3. Collision with another vehicle moving laterally in the same direction.
4. Collision with another oncoming vehicle.
5. Collision with another vehicle which turns into or crosses a road.
6. Collision between vehicle and pedestrian.
7. Collision with an obstacle in the carriageway.
8. Run-off-road to the right.
9. Run-off-road to the left.
10. Motorised two wheeler rider /Bicyclist self-fall
11. Rollover
12. Accident of another kind.

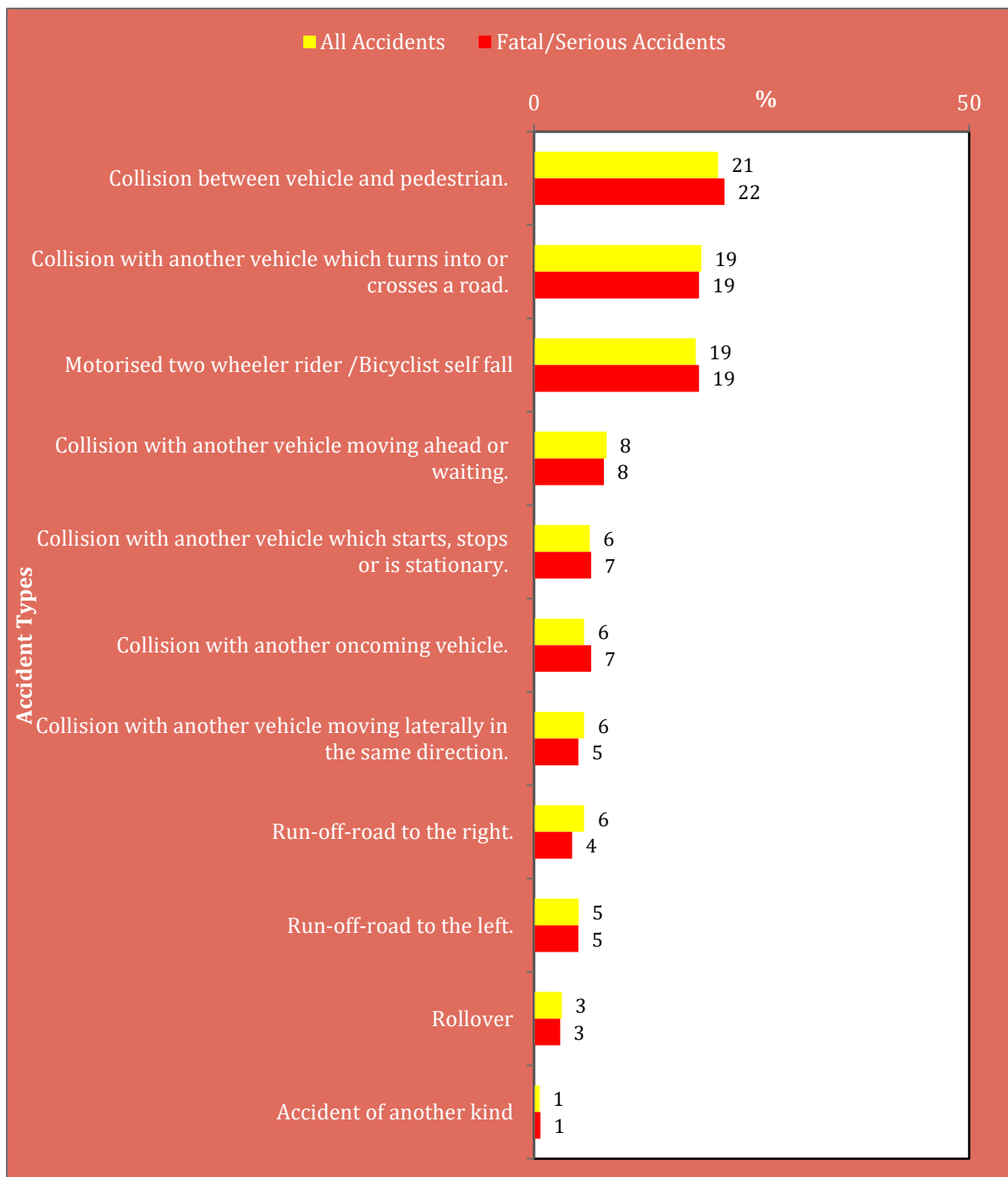


FIGURE 18: PERCENTAGE DISTRIBUTION OF ACCIDENTS BY ACCIDENT TYPE

As can be seen from Figure 18, “Collision between vehicle and pedestrian”, which contributed to 21% of all accidents and 22% of fatal or serious injury accidents. Followed by “M2W rider/ bicyclist self-fall” and “Collision between turning and crossing vehicles”, both contributed 19% of all accidents and 19% of fatal or serious injury accidents.

SAFETY SYSTEM USAGE

Distribution of helmet usage

The 156 accidents considered for this study includes 110 motorized two wheelers (M2Ws) and 6 Non-motorized two wheelers (Bicycles) where helmet usage is applicable. These 116 M2Ws and bicycles includes 177 riders and pillions in total.

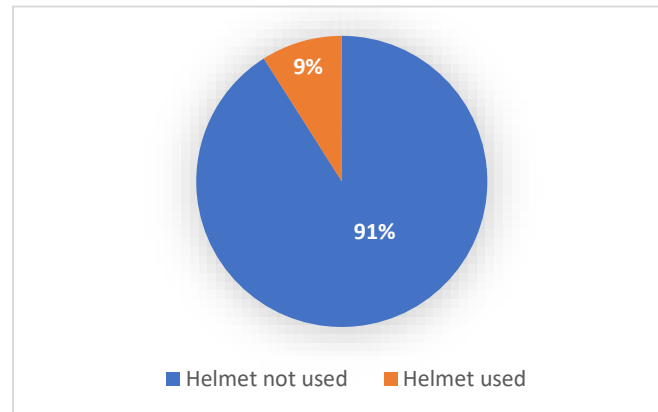


FIGURE 19: DISTRIBUTION OF HELMET USAGE IN MOTORIZED AND NON-MOTORIZED TWO WHEELERS (177 RIDERS AND PILLIONS IN TOTAL)

As can be seen from figure 19, Non-usage of helmets is recorded in 91% of total M2W and bicycle occupants (Riders and pillions) involved in an accident.

4 CONTRIBUTING FACTORS ANALYSIS

To determine the contributing factors influencing the occurrence of each accident, 156 road traffic accidents were analyzed in detail. In addition, the contributing factors influencing the occurrence of serious or fatal injury in 137 of these road accidents were also analyzed in detail.

ANALYZING ACCIDENT AND INJURY CAUSATION

Factors Influencing Occurrence of Accidents (156 accidents)

A distribution by contributing factors (human/vehicle/infrastructure) for the 156 accidents analyzed over a period of one year is represented in the Venn diagram (Figure 20).

The diagram (Figure 20) shows that human factors solely had an influence of 46% on the occurrence of accidents, followed by the combination of human and infrastructure factors which had an influence of 41% on the occurrence of accidents.

The influences of each factor in the occurrence of accidents were found to be:

Factor	All Combinations	Alone
Human	92%	46%
Vehicle	8%	2%
Infrastructure	46%	3%

As can be seen from the table above, Human related factors solely or in combination had an influence of 92% in the accident occurrence and Infrastructure related factors solely or in combination had an influence of 46% in the accident occurrence.

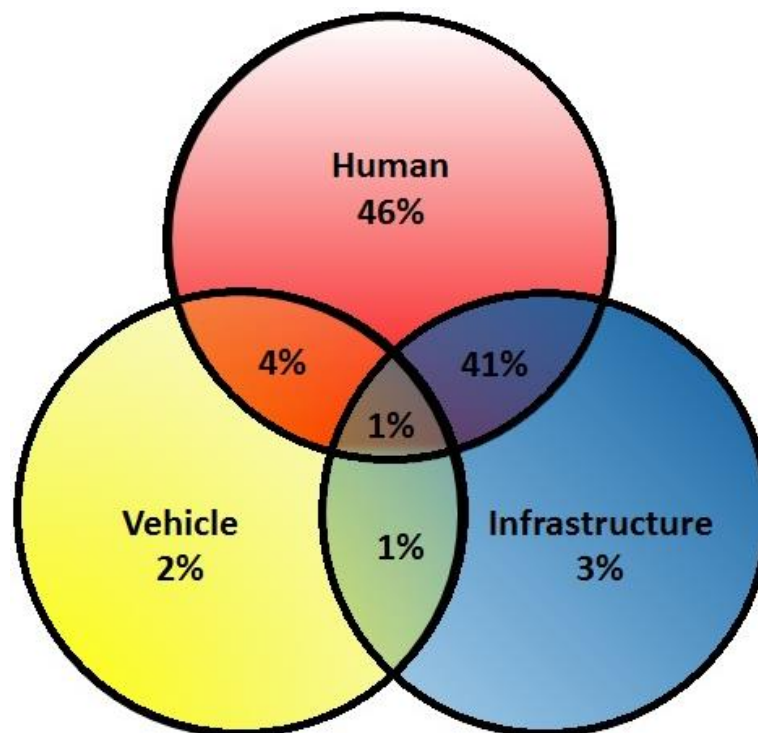


FIGURE 20: DISTRIBUTION OF 156 ACCIDENTS BY CONTRIBUTING FACTORS INFLUENCING THE OCCURRENCE OF ACCIDENTS

HUMAN FACTORS INFLUENCING ACCIDENT OCCURRENCE

For the 156 accidents considered for this study, the following are the contributing human factors determined to have influenced the occurrence of an accident and its influence per road user. *Please note that more than one factor can influence an accident; hence, the sum of percentage influence will not be equal to sum of human factors influencing accidents (92%). Also factors with negligible counts have not been included in the table for analysis.*

Contributing Human Factors (Accident occurrence)	No. of Accidents	% Influenced
<i>Driver and rider behaviour related</i>	91	58%
Improper lane change/lane usage (8 M2Ws, 6 Trucks, 2 Cars, 2 Buses, 1 M3W, 1 Mini truck)	20	13%
Illegal road usage (includes travelling in the wrong direction) (9 M2Ws, 4 Cars, 2 Buses, 2 M3Ws, 1 Truck, 1 Bicycle)	19	12%
Sudden steering / braking / both) (12 M2Ws, 2 Cars, 2 M3Ws)	16	10%
Following too closely (6 M2Ws, 1 Crane, 1 Truck, 1 Bus,)	9	6%
Driving under influence of alcohol (3 M2Ws, 2 Cars)	5	3%
Overtaking on undivided road (2 Buses, 2 M2Ws)	4	2%
Overtaking on left side of vehicle (2 M2Ws, 1 Car, 1 Mini truck)	4	2%
Turning suddenly or without indication (1 M3W, 1 M2W, 1 Truck, 1 Tricycle)	4	2%
Disobeyed traffic signal (4 M2Ws)	4	2%
Improper backing / reversing (3 Trucks)	3	2%
Parked vehicle on the road (Full or Partial) (1 Car, 1 Truck)	2	1%
Violation of right of way (1 Bus)	1	<1%
<i>Vehicle speeding related</i>	52	33%
Speeding - excessive speed for conditions (10 Cars, 10 M2Ws, 1M3W, 5 Trucks, 1 Bus)	27	17%
Speeding - exceeding speed limit (5 M2Ws, 9 Cars, 1 Truck)	15	10%
Speeding - speed limit unknown (4 Cars, 1 M2W, 1 Mini truck)	6	4%
Slowed down or stopped for non-traffic conditions (1 M2W, 1 Truck, 1 Bus)	3	2%
Stopped due to traffic (1 M2W)	1	<1%
<i>Driver and rider inattention/distraction related</i>	39	25%
Driver inattention/Misjudgement (18 M2Ws, 6 Cars, 3 M3Ws, 5 Trucks, 1 Mini Truck, 1 Tricycle, 1 Bicycle)	35	22%
Driver distraction inside vehicle (1 Mini truck, 2 Car)	3	2%
Driver distraction outside vehicle (1 M2W)	1	<1%

Contributing Human Factors (Pedestrian accident occurrence)	No. of Accidents	% Influenced
<i>Pedestrian related</i>	24	15%
Pedestrian dangerous behaviour on roadway	19	12%
Pedestrian Inattention	4	3%
Pedestrian sleeping on road	1	<1%

TABLE 1: CONTRIBUTING HUMAN FACTORS INFLUENCING THE OCCURRENCE OF 156 ACCIDENTS

As shown in table 1, 15% of the total accidents involved at least one pedestrian related factor. Out of the 39 pedestrians involved in the 34 pedestrian accidents considered in this study, 49% (19 Pedestrians) of them behaved dangerously on the road which solely or in combination contributed in the occurrence of accidents.

Countering Human Factors that Contribute to Accidents

Improper lane change/ Lane usage – 13%

(8 M2Ws, 6 Trucks, 2 Cars, 2 Buses, 1 M3W, 1 Mini truck)

Turning suddenly or without indication – 2%

(1 M3W, 1 M2W, 1 Truck, 1 Tricycle)



Improper lane change and improper lane usage is a driver behavioural error that topped the list for being the most common reason behind accident occurrence. Improper lane change is due to a driver/ rider either weaving diagonally across lanes (rather than moving through one after another in an orderly progression) or failing to check mirrors or indicate intention to other drivers before changing lanes, catching other drivers by surprise. Many motorcyclist and motorists have been observed changing lanes without giving proper indication or trying to squeeze themselves between the tiny gaps present in traffic. Improper lane usage includes travelling on shoulder of roadways, travelling on wrong lanes for conditions (Taking right turn from center or left lane) and travelling partially on more than one lanes. Turning suddenly or without indication is a similar scenario where the driver performs a precipitous turning maneuver.

What can be done to keep drivers in their proper lanes or convince them to use indicators?

Education and awareness

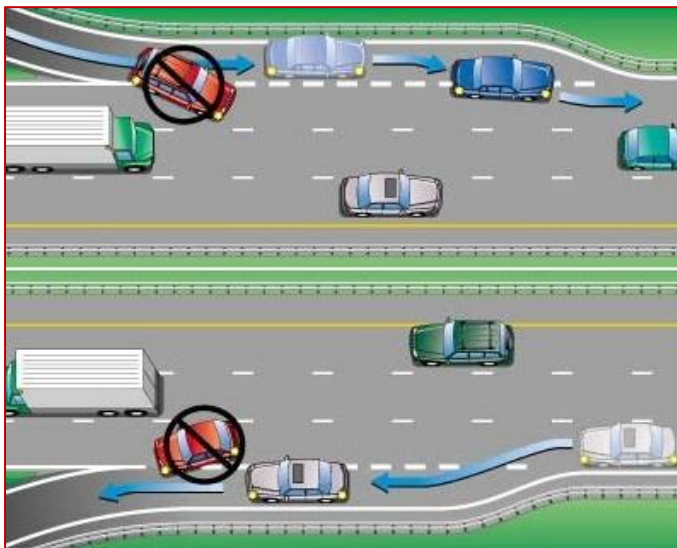
Use of indicators to communicate to other drivers about the intention to turn or change lanes is important and must be mandated for safe driving. Proper lane discipline can be enforced through educating drivers to use the left (slow) lanes in all possible conditions unless they need to overtake. The right most lane (fast lane) should be used only as an overtaking lane.

Infrastructure solution: Road studs



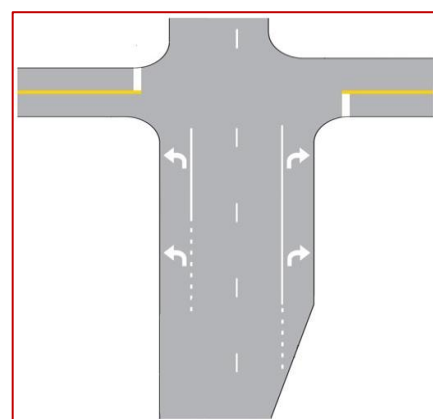
Road marker cats eye/ road stud placed on road marking of a highway are effective solutions to warn driver of an improper lane change / lane usage. This alerts the driver acoustically (tyre noise) and physically (vibrations) once the vehicle is driven over it. This makes the driver travel in one particular lane and reduces frequent lane changing practice. This also serves as lane and road delineators during night time.

Infrastructure solution: Speed change lanes or auxiliary lanes or turning lanes



These lanes are an important element of infrastructural improvements which has to be planned in the design phase, so as to allow steady change in travel speed and to let turning maneuvers happen outside of the main (through) traffic flow.

Acceleration/ deceleration lane (auxiliary lane) includes tapered areas, for the purpose of enabling a vehicle entering/ exiting a roadway to increase/decrease its speed to a rate at which it can more safely merge with through (main) traffic.



A sudden lane change, so as to perform a turn maneuver is highly undesirable and is likely to cause a rear end collision and this situation can be avoided by creating right/ left turn lanes. These are similar to auxiliary lane, includes tapered areas or diverging lane, which demands prior lane change maneuvers so as to gain access to perform a turn maneuver. This lane also accommodates the stop-go traffic conditions (during peak hours) without disturbing the through (straight) traffic flow.

Vehicle Engineering: Lane Departure Warning Systems



Many times, drivers forget or do not care to signal other road users before negotiating a turn maneuver. The lane departure warning system, has a camera or sensors that tracks the road markings and the vehicle's movement with respect to the markings. In case of departure from the travel lane without the use of turn indicators, the system sends in visual,

acoustical and physical warning (differs from individual systems). If the driver fails to react, the system automatically activates the brakes on one side of the vehicle and help guide the vehicle back into the travel lane, thus encouraging the practice of using turn indicators to signal a lane change maneuver.

Illegal road usage (includes travelling in the wrong direction) - 12%
(9 M2Ws, 4 Cars, 2 Buses, 2 M3Ws, 1 Truck, 1 Bicycle)

S P Ring Road



ISRO BRTS



Illegal road usage is a driver/ rider behaviour related (human) error which lead to the occurrence of an accident in at least 12% of the total 262 vehicles considered in the study. This is crucial factor because in most occasions this human error is seen to be performed deliberately for meagre gains.

Illegal road usage includes wrong-way driving which is the act of driving a motor vehicle against the direction of traffic. This may be due to driver inattention or impairment, or because of insufficient or confusing road markings or signage. Also in many occasions people intentionally drive in the wrong direction because they missed an exit or to access a roadway whose access point (to access other side of a divided roadway) is a tad far, so they prefer to drive wrong way jeopardizing safety of all other road users and theirs in order to save fuel and time. Habitual wrong way driving can commonly be observed in places like Khodiyarnagar junction, Odhav fire station junction, Shri Dongre Maharaj Marg and many more places in Ahmedabad city, such drivers never even see this as a violation.

Not always the vehicle users are at fault, in some occasions improper positioning of gap in medians, work zones, poor intersection design, poor access road to service and connecting roads confuses or displeases a road user and leads to wrong way driving. Illegal road usage also includes driving on limited access roadways or restricted roadways like BRTS corridor where access is restricted only to certain buses. Travelling in such restricted highways poses a greater risk for other road users as the roadway is designed specifically for travelling of particular type vehicle and, all road features and equipment incorporated may not suit other vehicle user and in many occasions may cause several safety issues. For example positioning of signage and other road safety equipment in this roadway might be positioned considering the ride height of the vehicle, average speed of travel etc.

What can be done to curb intentional and unintentional wrong way driving?

Enforcement:

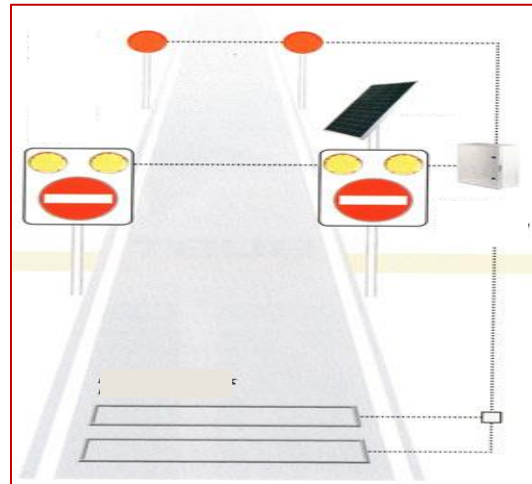
Violations such as travelling in wrong direction is likely to endanger other road users and hence must be treated as a serious crime. Road users liable to such crime must be penalised with suspension of license and hefty fine amounts.

Infrastructure solution: LED signage



Unintentional wrong way driving can be prevented by adding signboards with LED lights which will naturally grab the attention of the driver and also reduces navigational issues. Repetitive and effective positioning of signboards may also help reduce unintentional violations.

Infrastructure solution: Automatic wrong way detection device



This system might be helpful in preventing intentional wrong way driving. This solar powered device tracks the movement of vehicle in the wrong direction using radar technology or induction technology, provides advance warning by activating the blinkers, thus alerting the vehicles travelling in the correct directing about the impending danger. This system can also be integrated with cameras which shall help penalise the violators, thus keeping a check on wrong way driving.

Sudden steering / braking / both - 10%
(12 M2Ws, 2 Cars, 2 M3Ws)



Sudden steering/ braking/ both in most cases is a sudden avoidance maneuver that precipitated the accident, like a motorized two wheeler rider braking suddenly to avoid colliding against a crossing animal, where he/she might have successfully avoided the impact with dog but slipped and fell down as a result of braking. This is very common contributing factor leading to an accident in city conditions, and can be due to traffic and non-traffic condition. As far as this factor is concern, in most occasion the road users who actually created a critical situation are not the ones who meet with an accident.

How to reduce accidents precipitated by sudden avoidance maneuver?

Disciplined and safe driving practices such as maintaining safe distances between vehicles etc., by all the road users is the main thing that can see a reduction of influence of this factor in accident occurrence. Vehicle systems like ABS and combi brakes can enhance stability of vehicle during evasive manoeuvres. Education on lane discipline, reckless driving; creating better infrastructure; and adopting stringent road enforcement policies together can only solve this problem.

Speeding - excessive speed for conditions - 17%
(10 Cars, 10 M2Ws, 1M3W, 5 Trucks, 1 Bus)

Speeding - exceeding speed limit - 10%
(5 M2Ws, 9 Cars, 1 Truck)

Speeding - speed limit unknown - 4%
(4 Cars, 1 M2W, 1 Mini truck)

Having a wide and open road tend drivers to speed on them. Most of the roads here don't have any posted speed limit and hence nearly every vehicle speed on them.

Technically speaking, speeding does not directly lead to an accident but it is a prime accident and injury causation factor, the reason being; the higher the speed - the lesser the time you have to react to the situation, the higher the speed - the higher the force exchange between the collision partners, The higher the speed - the greater the risk of sustaining serious or fatal injuries.



Crash risk increases as speed increases, especially when we lose control at high speeds – as it is difficult to regain control; at road junctions – as the reaction time is very limited; while overtaking - as road users underestimate the speed and overestimate the distance of an approaching or oncoming vehicle.

How to reduce speeding related accidents?

In most cases, drivers travel at speeds of their choice, as they have no speed restrictions to adhere to. The solution to this is to post speed limits at reasonable intervals as reminders (and to alert any drivers who overlooked the first signs due to other moving vehicles blocking their vision, etc.). Also provide speed limit information after intersections to ensure that drivers turning onto the roads from major connecting roads always have a sign within the first five hundred meters or so.

If roads, however, have posted speed limits, and drivers still ignore these, it is worth trying to determine why. Do they consider them appropriate for other vehicle types, but not for theirs? Do they think it is too slow for the conditions? It may be worth performing localized studies in areas with higher-than-average speeding problems to understand what drivers feel is a safe speed based on the road features and the vehicle being driven. Many countries have improved on arbitrarily set speed limits by applying speed management techniques such as one described below.

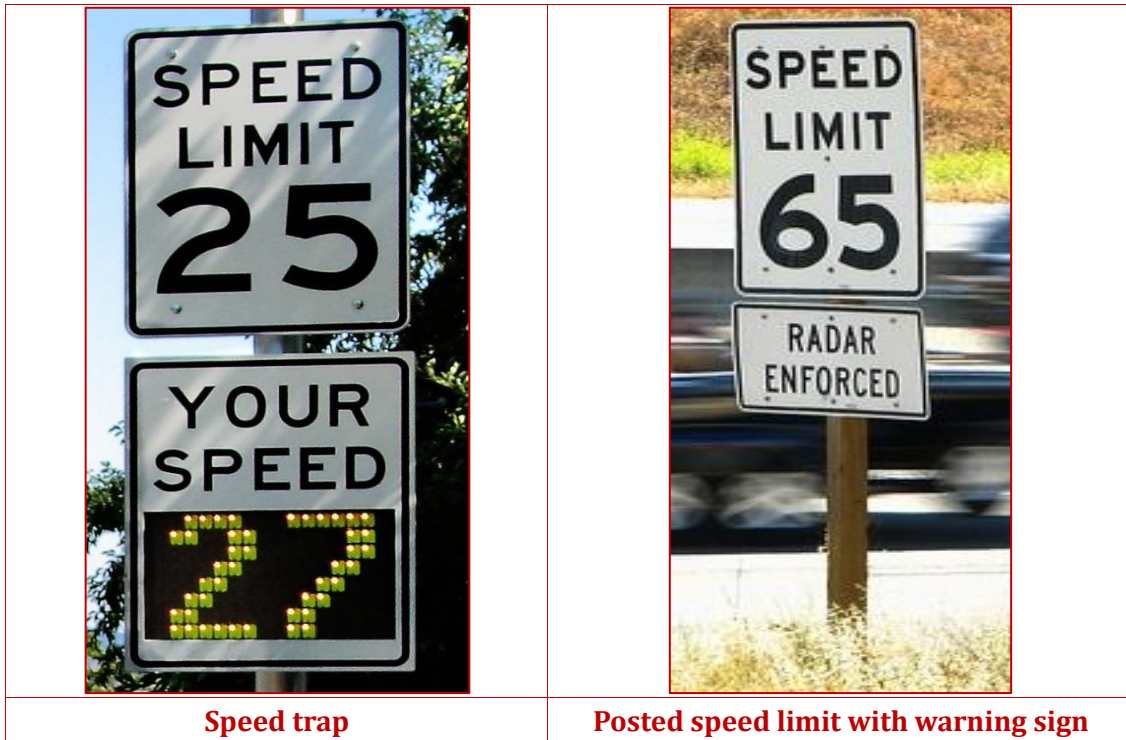
Step 1: Collect Speed Data: Identify whether the posted speed limits are acceptable to the traffic by conducting traffic speed studies. These help identify speeds being driven by various vehicle types (cars, trucks, buses, mini trucks, etc.) for a sample stretch and time period. Then determine the 85th percentile speed (the speed below which 85% of the sample vehicle population is travelling on a stretch of road).

Step 2: Set New Speed Limits: Using this speed data, road engineers can plan for reliable and safe speed limits on various sections of the roadways in Ahmedabad. Based on the traffic mix in India, different speeds for different vehicle types is not an effective solution, especially in urban areas where all types of motorized and non-motorized vehicles share the same road space. The speeds can differ preferably by the lane of travel, but only when lanes are clearly marked and identified.

Step 3: Inform Drivers of the New Speeds: Changes in speed limits need to be effectively communicated to the habitual road users. Drivers need to be alerted to the new posted speed limit by additional signs that warn of a change. Communication of changes can be enhanced through road markings and traffic calming measures, if these are appropriate, so that the road environment itself would influence the driver to follow a safe speed limit. It should be noted that a speed limit not only indicates the upper limit, but also indicates the lower limit of travel speed as well. As slow moving vehicles on a high speed lane are also hazardous and lead to traffic accidents, drivers need to be informed and educated about the lowest speed for travelling. A general convention that can be followed is that vehicles can travel up to 10 kmph above or below the posted speed limit, especially on highways. It is also important to aware people about the maximum speed any road user can travel under city limit irrespective of the presence and absence of posted speed limit

Step 4: Enforce: Stringent speed enforcement practices must be adopted to control driver speeds. Installation of automated speed cameras and setting up speed traps creates an enforcement on the drivers to maintain safe speed on roads. The police officer, monitoring speeding, must be able to provide evidence (through photos, speed readings, etc.) to the offender. Heavy penalisation must be levied on delinquents, and the policies made must have provisions for suspension or even termination of licence for repeated offenders.



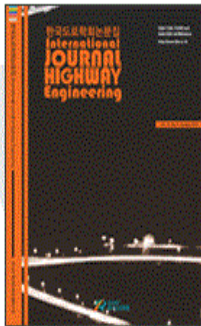


Infrastructure solution: Perceptual pavement marking



Perceptual cues are one potential method of influencing motorists to slow down, and ultimately save lives. Perceptual pavement markings are low cost countermeasures for speeding and decreased attention. Perceptual pavement markings give the driver the illusion of traveling faster than his or her actual speed in order to decrease the driver's comfort at excessive speeds. At locations where drivers are expected to reduce their speed, such as the beginning of a school zone, approach to an intersection, or prior to a sharp horizontal curve, a converging pattern of pavement markings can be used to give the perception to the drivers that they are increasing their speed if they fail to slow down at a sufficient rate. Pavement markings can also be used for other perceptual applications, such as to give the illusion of lane narrowing. This method is intended to reduce a driver's comfort at an excessive speed while proceeding through the markings, as a way to encourage deceleration. This type of treatment has potential applications along the entire length of a corridor. There are various types of perceptual pavement markings like transverse line markings, peripheral transverse line markings, converging chevron markings, Dragon's teeth, etc., and all of them serve the same purpose of speed reduction and to attract driver's attention.

Though it requires periodic maintenance, it is still an effective and economic solution to mitigate speeding related accidents.



International Journal of Highway Engineering

A detailed report on Perceptual pavement markings is published on "International journal of Highway engineering", which is a good guide for any policymaker, road engineer, police officer or even the general public to understand the applications and advantages of different pavement markings.

<http://www.ijhe.or.kr/journal/article.php?code=6294>

Infrastructure solution: Speed cushions and speed humps

Speed humps



Speed cushions



Speed humps are traffic calming devices which are similar to speed breakers/ speed bumps, but are used where a less drastic vehicle slowing is desired. This can be installed on main roads just before an approach to an intersection so as to bring down the speeds to a moderate level and, will also reduce the reaction time while encountering critical situations as this feature grabs the attention of the road user. If this system is planned (planning also includes forecasting of vehicle population growth) and installed properly, those roads will see a better average travel speed than the roads installed with repetitive speed bumps, thereby saving driving time and reducing driving related frustration.

Speed cushions are similar structures which are used specifically to reduce the travel speed of certain lanes. This when installed on the fast lanes (right lanes) or deceleration lane before an intersection, compels the road user to reduce their travel speed before a turning maneuver or before passing through an intersection, thereby reducing the probability of occurrence of an accident. Positioning of these structures must be planned properly so as to avoid vision obstruction problems due to slowing vehicles.

Driver Inattention/ misjudgement - 22%
(18 M2Ws, 6 Cars, 3 M3Ws, 5 Trucks, 1 Mini Truck, 1 Tricycle, 1 Bicycle)

Driver distraction inside vehicle -2%
(1 Mini truck, 2 Cars)

Driver distraction outside vehicle - <1%
(1 M2W)

Driver inattention and driver misjudgement together have contributed to the occurrence of maximum number of accidents and tops the list of human related contributing factor that led to accidents in Ahmedabad city.

Driver inattention or poorly allocated attention is basically a human error where the driver gets distracted in the course of driving a vehicle. Distracted driving occurs when some kind of triggering event external to the driver, results in the driver shifting attention away from the driving task. Distraction can be from inside or outside the vehicle.

Driver misjudgement is an important contributing factor, where a poor judgement or poor ascertainment of a scenario/ condition before performing a maneuver led to an accident. This includes both the intentional and unintentional risky maneuver performed by the road users that lead to an accident. The most commonly observed driver misjudgement pattern in Ahmedabad city is that the driver failed to ascertain properly the speed of the other vehicle or the distance between the vehicles before performing a maneuver.



Mobile phone



Lost in thought



Distraction outside the vehicle



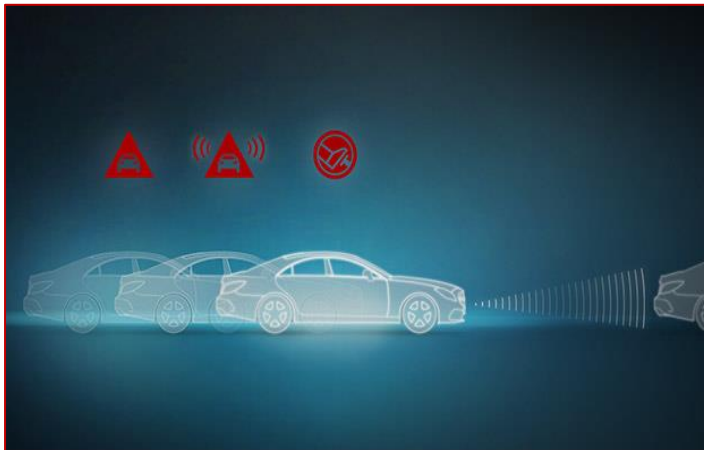
Distraction inside the vehicle

How can distracted drivers be alerted?

Enforcement and Education

Stringent policies against use of mobile while driving is crucial in preventing crashes due to distraction. Better road infrastructure, adequate road information, self-explanatory roads and signboards can help reduce distraction of driver to a great extent. Advertisement hoardings are an important form of distraction outside the vehicle and these must be permitted only on selective sections of the roadway where the traffic movement is generally slow and less chaotic. Active Road and traffic safety activities, awareness programs will bring in change in the minds of all road users.

Vehicle Engineering: Forward collision warning with adaptive braking



This system uses cameras, radars or both to detect the risk of an impending collision. Typically, the driver is first alerted visually and acoustically. This is followed by pre loading of brakes to provide maximum braking once the brake pedal is pressed. If the driver fails to react and if the system detects that the crash is imminent, the system initiates automatic braking system and brakes are applied automatically.

Infrastructure solution: Continuous Rumble Strips



Continuous rumble strips are designed to alert inattentive drivers to potential danger by causing a tactile vibration and audible rumbling, transmitted through the wheels into the vehicle's frame. A continuous rumble strip is usually applied along an edge or centreline to alert drivers when they drift from their lane.

Rumble strips are effective (and cost-effective) for reducing accidents due to inattention or sleepiness, and they are also effective for keeping drivers in their lanes in low visibility conditions such as fog or dense rain. Shoulder rumble strips are most effective when they are a part of a wide, stable shoulder which can be used to regain control of the vehicle. That is, the driver should have enough space to maneuver the vehicle back onto the road in case of a sudden loss of control. Such strips may also prevent drivers from using the shoulder lane as an overtaking lane.



Usage of traffic calming devices and perceptual pavement markings as explained above (In speeding section) can also help see a reduction.

Pedestrian dangerous behaviour on roadway - 12%

Pedestrian Inattention- 3%

Pedestrian sleeping on road - <1%



Pedestrian dangerous behaviour is the leading pedestrian related human factor which contributed to the occurrence of accidents to 49% of pedestrians considered in this study (a total of 39 pedestrians were a part of this study).

Pedestrian dangerous behaviour is a scenario where the pedestrian's unsafe action led to an accident. This includes situations where pedestrians attempt to cross the road hurriedly or jump a fence/ median, putting their lives and other road user's lives in peril.

Pedestrian intention is a situation where a pedestrian's lack of attention to roadway and surrounding environment led to the occurrence of an accident.

What can be done to improve pedestrian's behaviour and attention?

Enforcement and Education

Better regulations and new laws should come into being, where a pedestrian can be criminally charged and penalised for his misbehaviour on the roadway. More and more awareness must be created amongst the pedestrians regarding the ill effects and danger of using mobile phones and other similar devices on busy streets and crosswalks. Pedestrian safety practices must be institutionalised and must be taught in schools. Better pedestrian infrastructure facilities must be provided and the facilities provided must accommodate and be user friendly for pedestrians of all ages.

VEHICLE FACTORS INFLUENCING ACCIDENT OCCURRENCE

For the 156 accidents examined, the following are the contributing vehicle factors determined to have influenced the occurrence of an accident and its influence per road user. The table shows both the number and the percentage of accidents influenced by each factor. *Please note that more than one factor can influence an accident; hence, the sum of percentage influence may not be equal to sum of vehicle factors influencing accidents (8%). Also factors with negligible counts have not been included in the table for analysis.*

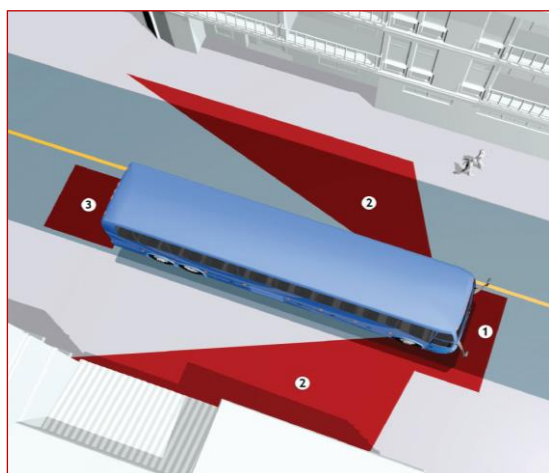
Contributing Vehicle Factors (Accident Occurrence)	Number of Accidents	% Influenced
Vision Obstruction – Due to vehicle interior (2 Buses, 1 Truck)	3	2%
Defective tires (1 M3W, 1 M2W)	2	1%
Vehicle misuse – Over loading of people (2 M2Ws)	2	1%
Absence of reflectors (1 Truck, 1 Bicycle)	2	1%
Defective brakes (1 Bus)	1	<1%
Defective or missing mirrors (1 Truck)	1	<1%
Defective Front axle (1 M3W)	1	<1%
Goods not secured properly (1 Unknown)	1	<1%

Table 2: Contributing vehicle factors influencing the occurrence of 156 accidents

Countering Vehicle Factors that Contribute to Accidents

Vision obstruction due to vehicle interiors - 2%

(2 Buses, 1 Truck)



Vision obstruction due to vehicle interior is basically a vehicle design limitation that restricts the driver's vision. These vision obstructing locations inside the vehicle are termed as blind spots. Blind spots are most prevalent in heavy vehicles such as buses and trucks, but not always limited to it.

Blinds spots in vehicles is mostly created by "A pillar", obstructing the driver's vision in 11 O'clock and 1 O'clock angles. Other spots includes sides and rear of the vehicles which are not completely visible through rear view mirrors.

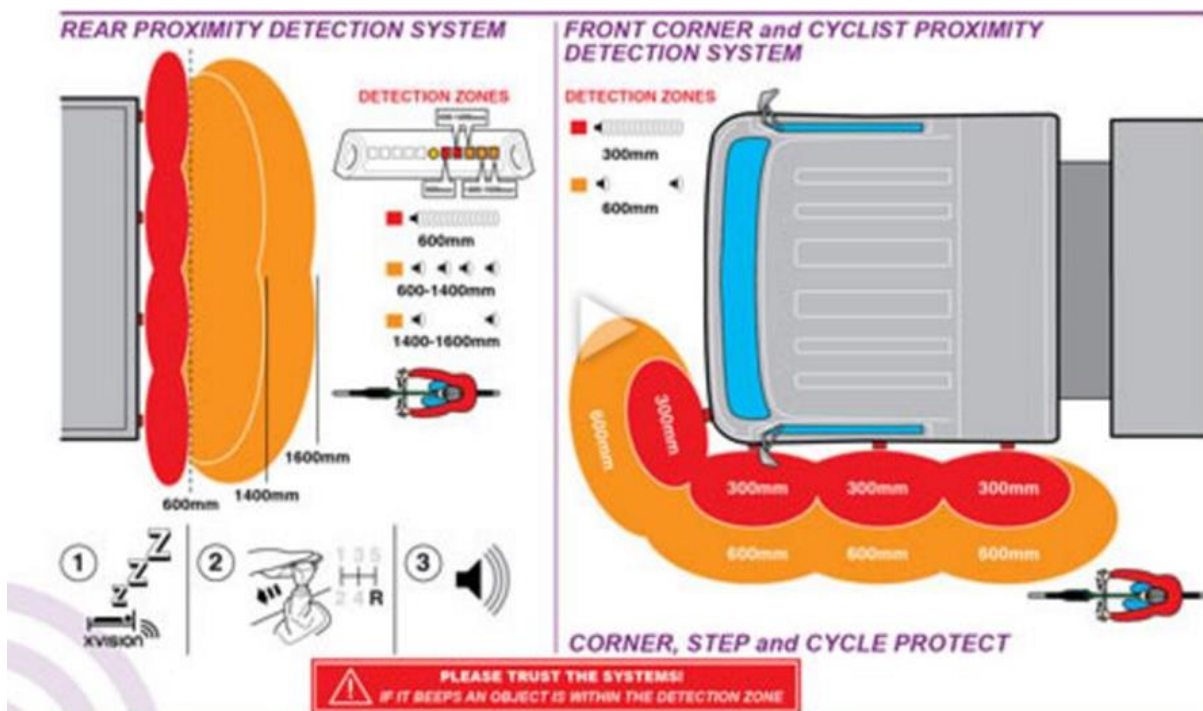
How to deal with problems relating to Blind spots?

Vehicle Engineering: Additional rear view mirrors



All heavy vehicles must be incorporated with multiple rear view mirrors which covers all or majority of the vehicle's surrounding areas. Areas surrounding the rear of the vehicle can be seen through cameras or reverse assistance sensors can come in handy to solve this problem. This is also much convenient for the drivers and brings in more confidence in reversing the vehicle.

Vehicle Engineering: Blind spot detection system



Blind spot detection system is a technology that uses various sensors to detect the presence of vehicles or pedestrians in the blind spot area and warns the driver by providing visual and acoustic signals.

Defective Tyre - 1%
(1 M3W, 1 M2W)

Defective tyre is basically a collective term representing all sorts of tyre related issues (such as a broken hub, tyre burst etc.) that lead to crash. Tyres are the only part of the vehicle which are in



contact with the ground and therefore become the most crucial component while performing a sudden evasive maneuver. While definitive investigation of tyre bursts and defects require detailed tyre investigation, analysis and testing, which is outside the scope of this study, researchers were able to confidently identify two accidents where a defective tyre was the accident causation factor. Defective tyre includes any defect to wheel hub, rim and tyres. These kind of defects generally happen due to poor vehicle maintenance and overstressing the component until the point of failure.

Periodic maintenance of tyres such as tyre pressure monitoring, knowledge on recommended tyre pressure, tyre rotation etc. can enhance the life of tyre and prevent tyre failures. Prevention of overloading of vehicle can help minimize mechanical failures. Usage of tubeless run flat tyres can prevent sudden loss of vehicle control in an event of a tyre failure. Replacement of tyre is recommended over a tyre which has been repaired for punctures, multiple times. Traffic authorities must be trained to identify the conditions/ defects in a tyre and must advice the respective road user to perform corrective measures. General awareness among public on tyre care may also help resolve this problem.

Overloading people - 1%
(2 M2Ws)



Overloading of people is a scenario where the number of occupants in the vehicle exceeds the seating capacity specified by the manufacturer. Overloading of people impedes the driver's ability to control and maneuver the vehicle as the driver's operating space is reduced. This leads to driver distraction as well. Overloading

increases the stresses on brakes and suspension drastically which eventually leads to reduced traction and failure of stressed components. This condition overloads the engine as well, reducing its life and efficiency.

How to stop the practice of overloading people?

Enforcement and Education

Government bodies should enforce stringent laws to overcome the problem of overloading. Heavy fines must be levied on vehicles overloaded with people. Proper education on road safety and consequences of overloading of people must be spread all over to visualize the change amongst the public.

INFRASTRUCTURE FACTORS INFLUENCING ACCIDENT OCCURRENCE

For the 156 accidents examined, the following are the contributing infrastructure factors found to have influenced the occurrence of an accident. The table shows both the number and the percentage of accidents influenced by each factor. *Please note that more than one factor can influence an accident; hence, the sum of percentage influence will not be equal to the sum of infrastructure factors influencing accidents (46%). Also factors with negligible counts have not been included in the table for analysis.*

Contributing Infrastructure Factors (Accident Occurrence)	Number of Accidents	% Influenced
Poor road marking/signage	22	14%
Poor intersection design	11	7%
Undivided road	9	6%
Inadequate pedestrian crossing	8	5%
Poor pedestrian infrastructure crossing	7	4%
Illegal pedestrian crossing	7	4%
Vision obstruction due to trees / plantation	5	3%
Defective road surface	4	3%

Table 3: Contributing infrastructure factors influencing the occurrence of 156 accidents

Countering infrastructure Factors that contribute to accidents

Poor road marking/signage - 14%



The purpose of road marking and signage is to direct and guide the road users, helping them to quickly decide what to do and where to go, all while negotiating traffic. If proper road signs and markings are missing, the driving environment becomes more dangerous. In the current study, this factor was determined to have contributed in 14% of the analysed accidents.

The ability of a driver to see, read, comprehend and make decisions are largely dictated by the placement, size, visibility and illumination of the signboards, which is a huge subject, and detailed discussion is beyond the scope of this document. However, often the problems are so obvious that most frequent road users are aware of them, and solutions to improve such problems of missing or misleading information are not difficult.

Poor intersection design – 7%



Crashes frequently occur where two or more roads cross each other, also known as intersections. Particularly if a district/local road crosses a National Highway, it becomes an accident prone zone. Activities such as crossing and turning left/right have the potential for conflicts among all road users, particularly when non-vehicular traffic is added to the mix, for example - pedestrian crossings. Good intersection design must

clearly indicate to all the road users how to traverse the intersection based on the desired direction the driver wishes to take. Intersections can be of different types like four way intersection, three way intersection, roundabouts etc. Intersections must be properly engineered with traffic signals, speed control devices, warning signs etc. In the current study, this factor was determined to have contributed in 7% of the analysed accidents.

Case study explaining poor intersection design, poor road markings and poor road signage

Accident date: 10/07/2016	Accident time: 01:30 Hours
GPS: 23.00706N 72.60948E	Accident location: Anupam bridge
Fatality Count: 1	Road structure: T Junction
Accident summary	
A truck was travelling towards east, approaching Anupam cinema T-junction from Anupam bridge. A motorized two wheeler (M2W) was travelling south, was also approaching the T-junction and intended to take a right turn to join Anupam bridge and travel further towards west.	
It is a misaligned, poorly designed intersection with absence of signage and speed control devices.	
The M2W rider misjudged the speed of truck and initiated the turn and, the truck driver who was travelling at excessive speed for the conditions couldn't react on time and had a front-side collision with the M2W. Post this impact the rider of M2W was run over by the truck and he died on spot. The truck driver suffered no injuries.	
Contributing factors:	
Accident factors:	Injury factors:
<ul style="list-style-type: none"> • Poor intersection design • Driver misjudgment for M2W • Over speeding for conditions for truck 	<ul style="list-style-type: none"> • Knock-down • Run over



What role did the infrastructural defects play in the occurrence of this accident?

Although there are other human related errors that contributed in the occurrence of this accident, lack of good infrastructure also contributed equally in the occurrence of the accident. Presence of speed control or traffic calming devices at the end of the downward slope of the bridge could have significantly seen a decrease in travel speed of the truck, thereby increasing the time interval to think and react appropriately. Presence of speed limit and intersection signage, and road markings such as yield lines could have better guided the M2W rider to perform a calculated turn maneuver and could have prevented this accident from happening.

How to reduce accidents precipitated due to infrastructural defects?

Below (Figure 21) is a modified design of the same junction to overcome the above mentioned infrastructural defects. *Please note that JPRI researchers are not experts in road and traffic engineering. But the company is aware of solutions that have been implemented in other parts of the world and are already available. What might actually work best for any specific location is a decision to be made by government engineers and agencies based on the types of crashes being seen, existing infrastructure design constraints and cost effectiveness.*

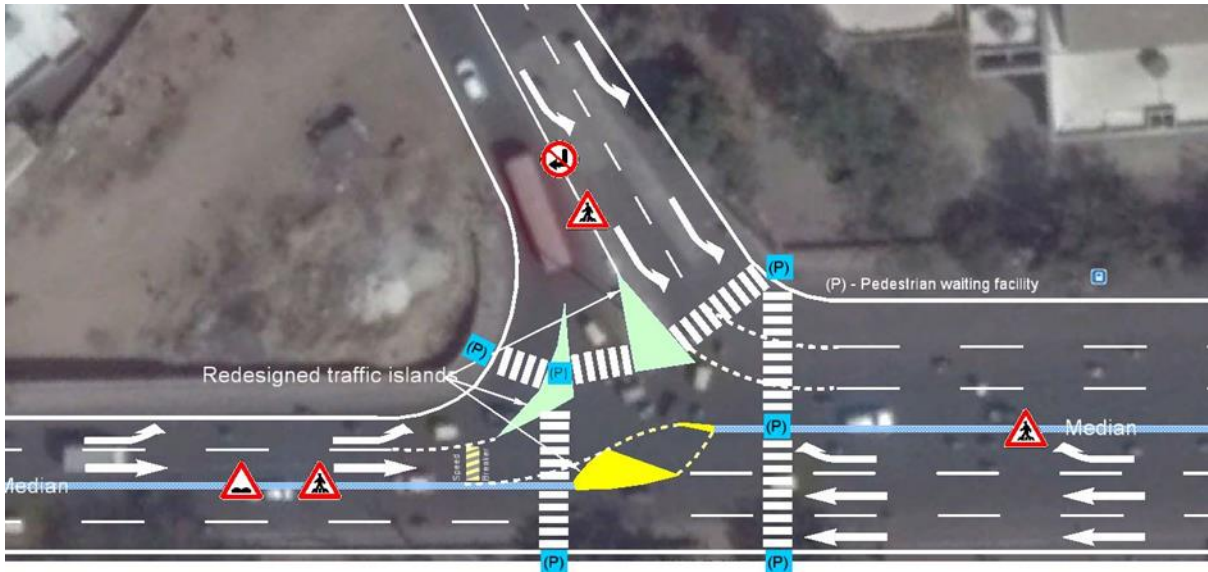


Figure 21: Design suggested by JPRI to overcome the problems faced in Anupam cinema junction

Similar accidents from our study



These are two more cases from our study where poor intersection design, Poor road markings/Signage contributed in Accident occurrence.

How to reduce accidents resulting due to Poor intersection design, Poor road marking and Poor road signage?

Why are intersections accident prone?

Some of the obvious reasons for mishaps at intersection include the following:

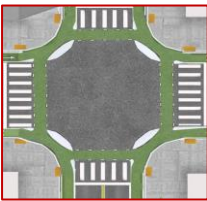
- ❖ Poor intersection design.
- ❖ Poor intersection alignment.
- ❖ Non-functional traffic signals.
- ❖ Vision obstructions.
- ❖ Poor road markings and signage.
- ❖ Poorly lighted intersections

Ajanta circle

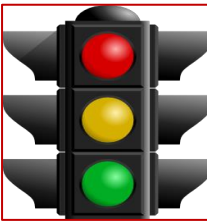


Misaligned four way intersection with no proper signage and inoperative traffic signal

How to abate problems associated with intersections?



The most primary thing is a flawless intersection design. Ideally the alignment of intersecting roads must be at an angle of 90 degrees. This makes it easy for drivers approaching the intersection to be able to see each other without much difficulty. Any traffic intersection must have a central traffic island to have an organized traffic flow.



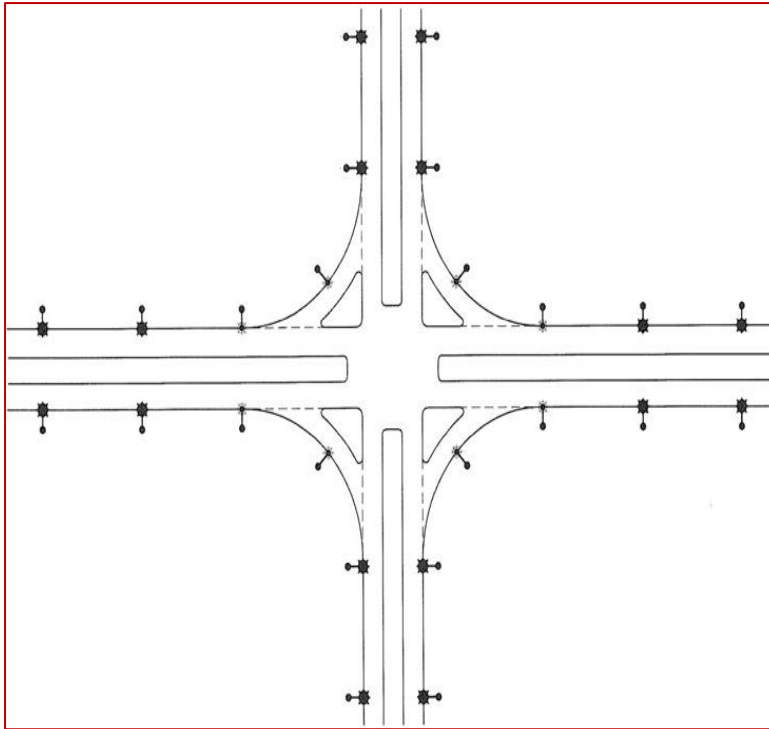
Traffic signals must be made operational at intersections to avoid chaos and confusion among road users. It helps prioritize the movement of traffic. Heavy fines must be levied on drivers who violate traffic signals. Data from traffic camera at intersections such as traffic density, entry speed into the intersection etc., may help understand them better and corrective measures can be mandated accordingly.



Any intersection that has a history of crashes and no traffic controls should be studied for traffic flow problems, and signals or clear signage indicating road design such as crossroads, turn lanes, the potential for stops/yields, signboards for navigation etc. should be considered. The signal or signage must be clear, conspicuous, visible and explanatory.

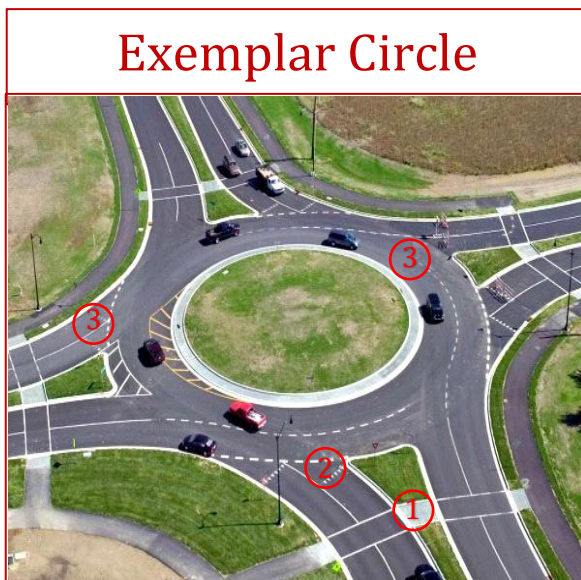


Every intersection must be checked for vision obstructions from all the sides to have hassle free flow of traffic by preventing obstruction of driver vision.



A good four way intersection design must incorporate turning islands on all sides along with operative traffic signals and effective signage to promote safe and smooth traffic flow. This also stands as solution to problems like violation of right of way, traffic congestion at intersection etc. The key function of this design is that it denies exit/entry into the service lanes at the intersections. This design deviates the left turning traffic prior to the intersection, thus promoting a continuous traffic flow on the through lanes and encourages lane discipline.

Roundabouts can be considered as a good solution. A roundabout is a type of circular intersection or junction in which road traffic flows almost continuously in one direction around a central island. Again, as in case of intersections, good design and geometry along with proper road markings, signage and visibility decide the success of a roundabout in reducing crashes. Below is the comparison of Vaishnodevi circle with an exemplar roundabout design,



Exemplar Circle



Vaishnodevi circle

- 1) The roundabout design must incorporate the usage of Splitter Island along with Central Island. Splitter Island is a kind of gap in median for pedestrian movement. This must be positioned well behind the start of the roundabout. In the case of Vaishnodevi circle, pedestrian crossings are present, but there is no opening provided in the median for the pedestrians to safely cross the road.

- 2) Yield lines must be present at all the entries of the roundabouts. Yield lines signifies the road user the concept of right of way to enter a roundabout i.e., the road users entering the roundabout must give way to the road users already present in the roundabout.
- 3) Lane markings must end before the entries of the roundabout and must continue later before the start of the exits of the roundabout.

General guidelines for roundabouts:

- Direct access to roundabouts from the service roads must be barred. Similarly direct access to service roads from roundabouts must also be prohibited. Entries/ exits for service roads must be provided (say 50 - 100 meters) after the roundabout.
- Narrowing of roads in the roundabouts, i.e. a three lane road converging in a two lane roundabout is highly undesirable and is likely to cause accidents.

Vision Obstruction due to trees and plantations / manmade structures - 3%



Vision obstruction due to infrastructure is an obstruction created by any road feature that blocks or delays the road users from viewing each other thereby creating a conflict which may directly or indirectly influence the occurrence of an accident. Our study shows, in most occasion trees and plantations positioned on the median and road side obstructed the vision of the driver and contributed to the occurrence of accidents, followed by vision obstruction due to other manmade structures such as building, advertisement hoardings, work zone fencing etc.

Vision obstruction generally results in decreased reaction timing and distance as a result of delayed or non-recognition of a critical situation.

Case study explaining vision obstruction due to trees and plantation

Accident date: 04/07/2016	Accident time: 10:45 Hrs
GPS: 23.12283N 72.56324E	Accident location: Tragad Road
Fatality Count: 1	Road structure: Four way intersection

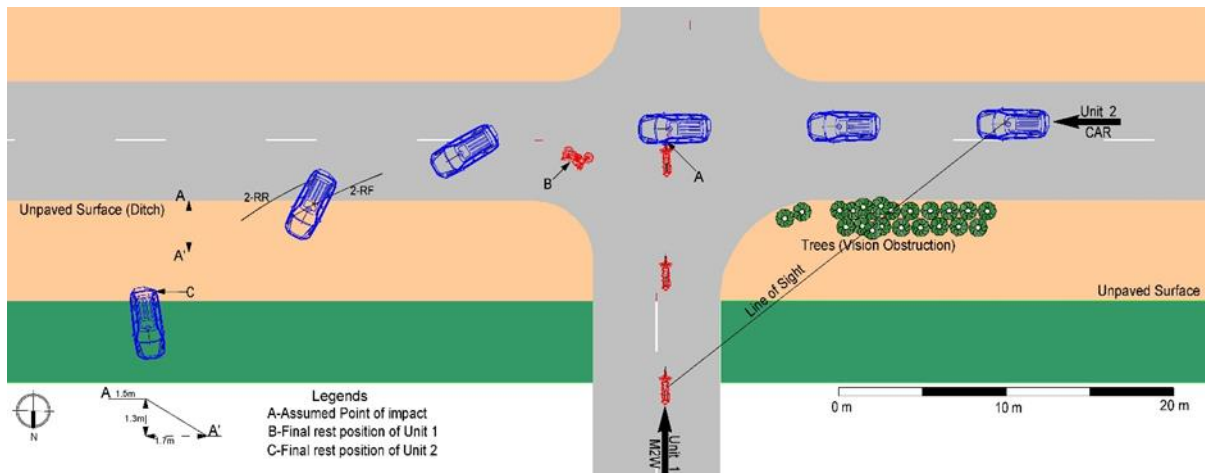
Accident summary

A car travelling towards east, was approaching the intersection and intended to cross the junction straight and travel further towards east. A motorized two wheeler (M2W) travelling towards south, was also approaching the intersection from left with respect to car’s travel direction.

The road structure is a misaligned four way intersection with trees and plantations with the presence of trees and plantation on the sides of the road.

Both the vehicles had a vision obstruction due to trees and plantation and could see each other until the point of impact. The vehicles had a front-side collision which resulted in the spontaneous death of M2W rider. The driver of car was unhurt.

Contributing factors:	
Accident factors:	Injury factors:
<ul style="list-style-type: none"> • Excessive speed for conditions for both vehicles • Poor intersection design • Vision obstruction due to Trees/Plantation 	<ul style="list-style-type: none"> • Helmet not used • Knock-down



Motorcyclist's vision obstructed by plants



Car driver's vision obstructed by Plants

What role did the vision obstruction play in the occurrence of this accident?

Although there are other human related errors that contributed in the occurrence of this accident, vision obstruction here played a major role in the occurrence of the accident. The presence of plantation obstructed the vision of both the rider and the driver, thereby drastically reducing the time and distance between the vehicles approaching the intersection. Had there been no plantation in that location both the vehicle users might have probably seen each other well before the junction, might have reduced their travel speed to an optimum level and probably would not even have faced a conflict or critical situation.

Similar accidents from our study showing the influence of vision obstruction in causing accidents

Odhav junction – 23.02489N 72.67307E



2 lives lost in 2 different accident

S.P. Ring Road – 23.00366N 72.66761E



1 life lost

In the first location (Odhav junction) mentioned above, two different accident took place as a result of vision obstruction due to manmade structure – fence of a work zone. In the second location (S.P. Ring road near Odhav), presence of plantations on the median restricted the vision of the road users resulting in an accident.

How to reduce accidents precipitated due to Vision obstructions?

Plantations on median, if not maintained properly often creates the problem of vision obstruction. To avoid such problems, always choose a plant breed that does not grow much in height, say not more than half a meter, this will also save the maintenance cost to some extent. Plantations on medians must not be present at least 50 to 75 meters from the start of an intersection or gap in median so as to have a clear vision on vehicles approaching the same. Authorities granting approvals for building and commercial complexes facing or connecting major roads must always check for vision obstruction related issues in the planning phase so as to allow any design changes, if required. Advertisement hoarding positioned on medians or elsewhere must be free from creating vision obstruction. This way the problem of vision obstruction can be greatly reduced.

Countering infrastructure Factors that contribute to pedestrian accidents

Inadequate pedestrian crossings - 5%



Inadequate pedestrian crossing means absence of pedestrian crossings or insufficient number of pedestrian crossings on a particular stretch of road where the pedestrian crossing density is somewhere between moderate to high. Inadequate pedestrian crossing facilities results in pedestrian, crossing or entering the road from anywhere, thus creating a potential safety threat to them and other fellow road users. This factor is many occasions also leads to pedestrian creating illegal openings

for them cross or access the road. This factor had its influence in 5% of the total 34 pedestrian accidents analysed in this study.

Poor pedestrian infrastructure crossing - 4%



A good pedestrian infrastructure consists of proper waiting facility for the pedestrians, signage indicating presence of pedestrian crossings, properly painted and maintained zebra crossings and presence of footpaths along the road. Absence of any of the mentioned factors results in an unsafe vehicle pedestrian interaction. This factor had its influence in 4% of the total 34 pedestrian accidents analysed in this study.

Illegal pedestrian crossing - 4%



Presence of inadequate and poor pedestrian infrastructure results in pedestrians creating illegal opening as per their convenience in many occasions as per the requirement. These are generally openings created on median or roadside barriers by tapering the basic structure of median or barrier. This is a serious issue because these openings were not a part of the planned road design and no other pedestrian infrastructural facilities will be available in that location like signage indicating presence of pedestrian crossing, and

often catches other vehicle users by surprise. This factor, in many occasion is also accompanied by vision obstruction, which again is a leading accident causation factor. This factor had its influence in 4% of the total 34 pedestrian accidents analysed in this study.

Case study explaining Poor pedestrian infrastructure, Inadequate and Illegal pedestrian crossing facilities.

Accident date: 09/10/2016	Accident time: 19:15 Hrs.
GPS: 23.03522N 72.51012E	Accident location: NH8C
Fatality Count: 1	Road structure: Straight road

Accident summary:
 A Motorized two-wheeler (M2W) was travelling towards north-east (towards Gandhinagar) on SG highway while a male pedestrian entered into the road from right with respect to M2W's travel direction with an intention to cross the road.
 Road structure is a six lane divided road (divided by median with raised curb) with poor pedestrian infrastructure and poor pedestrian crossing facility.
 As the pedestrian suddenly entered the roadway, the motorcyclist who was travelling at high speed had no time to react and collided with the pedestrian. The pedestrian died on spot and the motorcyclist suffered serious injuries.

Contributing factors:	
Accident factors:	Injury factors:
<ol style="list-style-type: none"> 1. Pedestrian inattention 2. Poor road marking/signage 3. Poor pedestrian infrastructure 4. Speeding – Exceeding speed limit 	<ol style="list-style-type: none"> 1. Knock-down 2. Helmet not used



No signage - indicating pedestrian crossing




Absence of zebra crossing on road

What role did the poor pedestrian infrastructure play in occurrence of this accident?

Although there are presence of other human related factors which were also responsible for this accident, poor pedestrian infrastructure played a main role too. Had there been proper road information like a sign board warning about the presence of pedestrian opening ahead and, a zebra crossing on the roadway, the motorcyclist would have been more attentive, might have looked in that direction for any impending danger and may have even reduced his travel speed in advance. All these possibilities might have eventually resulted in the motorcyclist not colliding against the pedestrian.

Similar accidents from our study in which improper and poor pedestrian crossing has contributed to accidents:

Naroda Road – 23.05472N 72.63163E



1 life lost – absence of cross walk and misaligned crossing

Paldi junction – 23.01411N 72.56509E



1 life lost – Poor pedestrian waiting facility

Similar cases from our study in which Inadequate/Illegal pedestrian infrastructure has contributed to the accident:

Iskcon bridge – 23.3134N 72.50865E



2 lives lost in 2 different accidents – Inadequate pedestrian crossing

S.P. Ring Road – 22.94832N 72.64980E



1 life lost – Illegal and inadequate pedestrian crossing

How to solve problems associated with pedestrian infrastructures?

To facilitate proper pedestrian infrastructure, it is required to study the density of pedestrian movement and their operation in that particular location. A good design will always avoid or keep the vehicle – pedestrian interaction at a minimum level. The design should accommodate pedestrians of all ages. A more sophisticated pedestrian infrastructure must be provided at locations where vehicle – pedestrian interaction is more prevalent, like intersections, shopping malls, school zones, etc. Pedestrian crossing facilities must be provided every 200 meters in residential and other densely populated pedestrian areas. Pedestrian crossing and waiting facilities must be clear from vision obstruction related problems.

Below is the link to a design guide created by the Institute for Transportation and Development Policy (ITDP) on footpath design.

Footpath design: A guide to creating footpaths that are safe, comfortable, and easy to use.

<https://www.itdp.org/wp-content/uploads/2014/07/Footpath-design-131030.pdf>

Below are few infrastructural solution which may help reduce pedestrian accidents:

Infrastructural solution: Raised pavement pedestrian crossing



Raised pedestrian crossing or ramps is a hybrid solution which not only contributes to safe pedestrian crossing environment but also calms the vehicle traffic in that location. This feature compels the road user to reduce the speed of the vehicle irrespective of the presence of pedestrian, thereby enhancing the safety of that location in general. This solves distraction and inattention problems to a good extent. This has proved to be very effective in the western world and is most suitable in cases of junctions, intersections and other pedestrian populated areas such as school zones etc.

Infrastructural solution: Pedestrian crossing with illuminated Traffic Sign & Spot Light



The above system is specially designed for night time applications. Here the pedestrian cross walk is painted with light reflecting paint which works in sync with the flash light placed above. The light from the flash light or street light is reflected by the paint on the pedestrian walking on the cross walk, thus decreasing the conspicuity related problems to a great extent in night time driving. This system also houses an advanced mode where the presence or an approach of a pedestrian into the road is picked up by the radar signal, which in turn cautions the oncoming vehicles by activating the secondary flash light incorporated with the system. The secondary flash light keeps blinking until the pedestrian walks out of the detection zone. This also enhances the attentiveness of the vehicle users, thus reducing accidents.

Infrastructural solution: Pedestrian crossing safety system with Radar & Flashing Lights



This solar powered system consists of different sensors which sends signals in the form of flashing lights to the vehicle users when a pedestrian is about to enter a cross walk. As soon as pedestrians enters into the detection area of this system, the LED lights starts flashing thus informing vehicles about the possibility of a pedestrian entering the roadway. This advance information cautions the road user to pay attention and reduce his travel speed, which eventually will result in smooth and safe vehicle – pedestrian interaction.

Factors Influencing Occurrence of Injuries (137 Fatal/Serious Accidents)

Of the 156 accidents considered for this study, 137 accidents involved fatal or serious injuries to at least one occupant or pedestrian. These 137 fatal or serious accidents were analyzed to determine the contributing factors influencing the occurrence of injuries. The distribution by contributing factors (human/vehicle/ infrastructure) is shown in the Venn diagram (Figure 22).

The diagram (Figure 22) shows that the vehicle factors solely had a contribution of 51% in the occurrence of fatal or serious injuries, followed by the combination of human and vehicle factors which had a contribution of 34% in causing fatal or serious injuries.

The influences of each factor in the occurrence of injuries were found to be:

Factor	All Combinations	Alone
Human	45%	4%
Vehicle	88%	51%
Infrastructure	10%	1%

As can be seen from the table above, Vehicle related factors solely or in combination had an influence of 88% in the occurrence of fatal or serious injuries, and Human related factors solely or in combination had an influence of 45% in the occurrence of fatal or serious injuries.

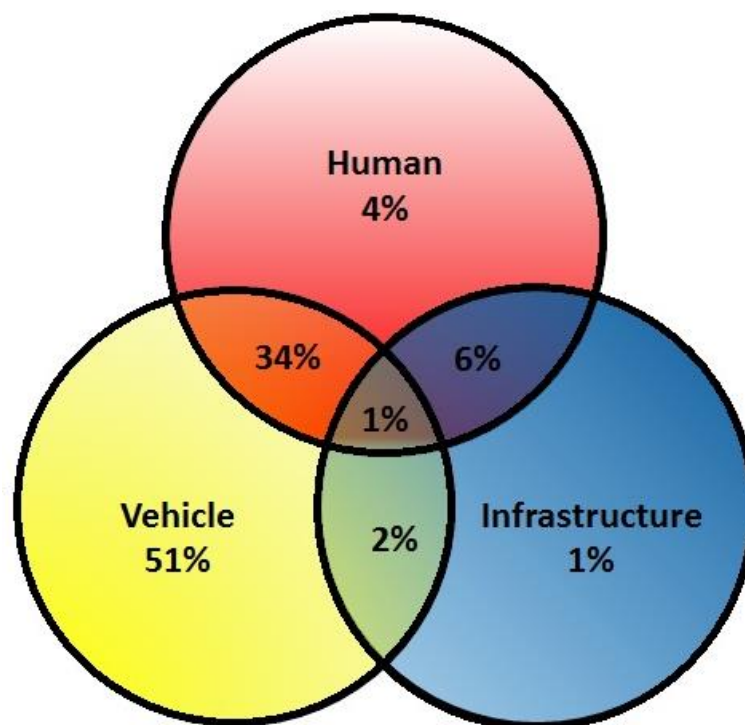


FIGURE 22: DISTRIBUTION OF 137 FATAL/SERIOUS INJURY ACCIDENTS BY CONTRIBUTING FACTORS INFLUENCING THE OCCURRENCE OF FATAL/SERIOUS INJURIES

HUMAN FACTORS INFLUENCING INJURY OCCURRENCE

For the 156 accidents examined, 137 accidents resulted in fatal or serious injuries. The following are the contributing human factors determined to have influenced the occurrence of an injury. The table below shows both the number and the percentage influenced by each factor for all fatal/seriously injured road user involved in this study. *Please note that more than one factor can influence injury; hence, the sum of the percentage influence will not be equal to sum of human factors influencing injuries (45%).*

Contributing Human Factors (Injury Occurrence)	Number of Accidents	% Influenced
Helmet not used (53 M2Ws, 2 Bicycles)	55	40%
Occupants in cargo area (2 Mini trucks, 1 M3W, 1 Tricycle)	4	3%
Improper helmet usage (3 M2Ws)	3	2%
Seat belt not used (1 Car)	1	<1%

Table 4: Contributing human factors influencing the occurrence of fatal/ serious injuries in 137 fatal/ serious accidents

Countering Human Factors that Contribute to Injury

Helmet not used - 40%
(53 M2Ws, 2 Bicycles)

Improper helmet usage - 2 %
(3 M2Ws)



India is the second largest Motorized two wheeler (M2W) market in the world, with more than 10 million M2Ws sold every year, but India's passion for M2Ws seems not to have extended to the one safety item that should be considered a crucial part of the riding experience. The "human factors" for injuries to M2W riders and pillion riders shrink to one major cause—helmet not used. A helmet is the most basic and compulsory safety gear to be used while riding. It protects the head by absorbing shocks in an event of a collision, and to not use one is to risk serious or fatal injury even in an otherwise survivable accident.

In Law and in Practice

As per Section 129 of the Motor Vehicles Act, 1988, everyone other than a Sikh wearing a turban should wear protective headgear (helmet) when riding on a motorcycle on a public road.

As seen from Table 4, non-usage of helmets and improper usage of helmets has resulted in serious and fatal injuries in 42% accidents considered in this study. 44% of crashes in this study involves at least one M2W or bicycle. Non usage of helmets led to serious and fatal injuries to 48% of riders of M2Ws and bicycles out of the total 116 vehicles (helmet usage applicable vehicles) considered in the study.

One approach to changing this statistic may be more awareness and safety campaigns, possibly funded through a Public-Private partnership, to make people understand the importance of helmets and the fragile (and irreplaceable) heads that they are designed to protect.

Helmet Quality is an Issue



Usage of substandard helmets may save some time and fine amount, but not one's life. Buying a quality helmet with a strong protective casing (full head covered is better than a half helmet or a hard hat) is a good first step, but riders also need to pay attention to the condition of the helmet. A helmet that has been in a crash is no longer fully protective, even if it "looks ok", and straps and buckles need to be fully operational. Clearly, any public education effort would have to also stress the importance of ensuring the equipment meets approved safety standards in *all* ways.



Damaged helmets found in few crashes indicates the use of sub-standard quality helmets.



The more protection, the better! The chin guard was effective in preventing facial injuries to the rider.

How Helmet is worn is Also Important



A helmet is not a cap to be worn slid off the back of the head, or fashionably unfastened at the chin. It needs to be the correct size and it should be properly fitted and fastened if it is to provide reliable protection in a collision. To bring awareness of the dangers of improper helmet use, public education campaigns are likely the only answer. However, much of this target audience is responsible enough to actually own a helmet, but independent enough to disdain being “told” facts about how to wear it (and why), so varied and inventive approaches may be necessary. Perhaps something such as a police-led campaign to hand out organ donor information cards to riders they see wearing a helmet improperly would get the point across: “If *you* don’t care about your vital organs, there is a waiting list of people who *do*,” etc.

A simple guide to avoid improper helmet usage:-

Know the size of your helmet:

- Measure the circumference of your head.
- Always ask for the size recommended by the manufacturer for a specific head size.
- All leading helmet manufactures provide size chart



Know the size of your helmet:

- Choose a helmet where you are able to feel the inside of the helmet against all parts of your head.
- Rotate the helmet from side to side and tilt the helmet from forward and back. It should stay in position and not move.
- Tilt your head forward and try to roll the helmet off your head by applying an upward force to the rear base of the helmet. It should not slip off the head.



Occupants in cargo area - 3%
(2 Mini trucks, 1 M3W, 1 Tricycle)



It is a common sight in India to observe workers and farmers travelling on the cargo areas of Trucks, mini trucks, loading motorized 3 wheelers which is a very risky act to do. This becomes more hazardous for these people in an event of an accident. In most cases, these occupants go and impact themselves against the hard metal surfaces of the cargo compartment, or the cargo shifts and impacts these occupants as result of sudden deceleration. Ejection of occupants is also very likely to happen which often results in fatal or at least serious

injuries. This factor was observed to have contributed in injury occurrence in 3% of vehicles out of 146 vehicles in which travelling in cargo space is applicable.

How to see a reduction in number of people travelling in cargo area?

Ahmedabad city sees a good amount of population travelling in the cargo space particularly on roads closer to industrial areas. This is often seen as a cheap mode of transportation by laborers and workers who cannot afford the luxury of travelling in private vehicles. Creating better public transport network can help see reduction. Heavy penalties must be levied on drivers and vehicle owners who carry these sort of practices.

VEHICLE FACTORS INFLUENCING INJURY OCCURRENCE

For the 156 accidents examined, 137 accidents resulted in fatal or serious injuries. The table below shows both the number and the percentage influenced by each factor for all fatal/seriously injured road user involved in this study. *Please note that more than one factor can influence injury; hence, the sum of percentage influence will not be equal to sum of vehicle factors influencing injuries (88%). Also factors with negligible counts have not been included in the table for analysis.*

Contributing Vehicle Factors (Injury Occurrence)	Number of Accidents	% Influenced
Knock-Down (42 M2Ws, 26 Pedestrians , 3 Bicycles)	71	52%
Run over (34 M2Ws, 14 Pedestrians, 4 Bicycles, 1 M3W, 1 Tricycle, 1 Bus)	55	40%
Fall – down (24 M2Ws, 1 Bicycle)	25	18%
Seat belt not available / usable (7 M3Ws, 1 Car)	8	6%
Non enclosed occupant cabin (7 M3Ws)	7	5%
Ejection (6 M3Ws)	6	4%
Passenger Compartment Intrusion - Underride/Override (2 Trucks, 1 Car)	3	2%
Passenger Compartment Intrusion - Other (1 Car, 1 M3W)	2	1%
Illegal alteration/ fitment – Bull bar (2 Cars)	2	1%

TABLE 5: CONTRIBUTING VEHICLE FACTORS INFLUENCING THE OCCURRENCE OF FATAL/SERIOUS INJURY IN 137 FATAL/SERIOUS ACCIDENTS

Countering Vehicle Factors that Contribute to Injury

Knock-Down – 52%

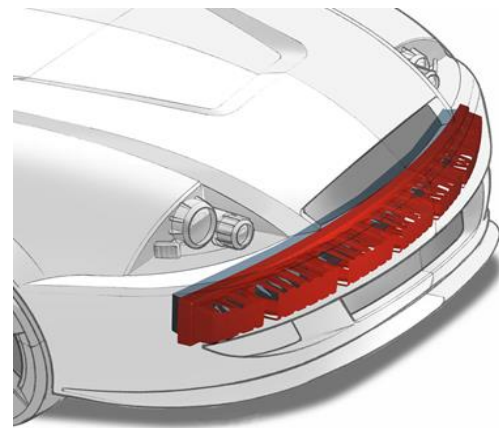
(42 M2Ws, 26 Pedestrians, 3 Bicycles)

During impact between a low mass road user (M2W/bicycle/pedestrian) and a higher mass vehicle (car/truck/bus), the M2W/bicycle rider or pedestrian is usually knocked down to the ground or thrown into the air to fall to the ground with greater force and velocity. This loss of stability is due to the sudden shift of centre of gravity of the road user due to which balance cannot be maintained. Such an occurrence is coded as a knock-down.



As seen from Table 5, Knock down resulted in serious or fatal injuries in 52% of the accidents. As per this study, 46% of the road users out the total 155 road users (knock down applicable road users such as M2W, bicycle and pedestrian) suffered fatal or serious injuries as a result of knock down. The road user type which saw maximum knock downs were the M2Ws (59%) followed by pedestrians (37%). Majority of the motorcyclists suffered serious or fatal injuries primarily to the head, thorax, abdomen and lower extremities (legs).

How to reduce knock down related injuries and its severity?



To reduce the severity of injuries sustained in such an unbalanced collision, M2W riders must wear proper safety gear. A standard, well-fitted, and properly worn helmet can greatly reduce injury severity through protecting the head. Protective gear for the body, (such as leather or abrasion-resistant riding wear) and upper and lower extremities (gloves and boots) are also effective in reducing serious/fatal outcomes.

For pedestrians, the best way is to bring up infrastructure solutions such as subways, overhead bridges etc. which will reduce vehicle-pedestrian interaction substantially. Other solutions involve redesigning cars, trucks, and buses to employ softer, pedestrian-friendly bumpers and other systems like active bonnets etc. A number of active and passive pedestrian protection systems are already being road-tested, although none are widely available yet.

Run over - 40%

(34 M2Ws, 14 Pedestrians, 4 Bicycles, 1 M3W, 1 Tricycle, 1 Bus)



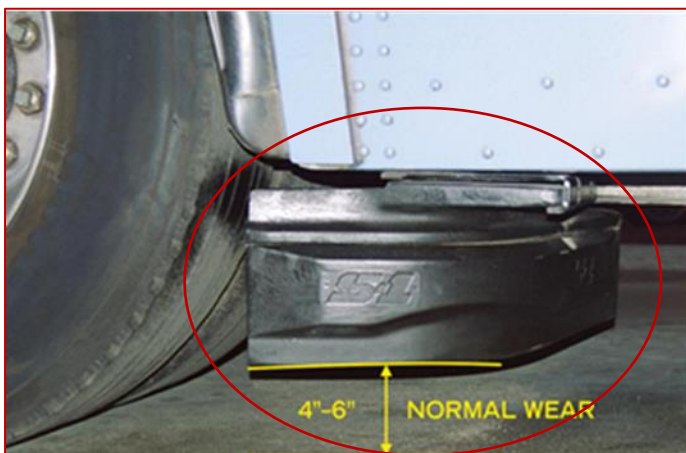
An accident which led to fatal or serious injuries as a result of single or multiple wheels of the vehicle travelling over any body part of an occupant or pedestrian is coded as a run over. This is often caused by vehicles which have high ground clearances such as buses or trucks where there is sufficient space between the lowest part of the vehicle's body structure and the ground for a road user to pass under the vehicle and reach the tyre. Although, trucks and buses are the most prevalent vehicles that cause run overs, it is not always

limited to them. Cars and vehicles with open wheels can also cause run overs.

Our study shows that, in majority of the cases the run over event was preceded by the knock down event, which makes complete sense, considering the shape and height of the vehicle that knocked and ran over the pedestrian – in most occasion heavy vehicles. As seen from Table 5, run overs has resulted in fatal and serious injuries in 40% of the total serious and fatal accidents considered in this study, this is because of the fact that in most occasions one or more body regions are critical injured due to high compressive forces, which leads to instantaneous death of a victim. In our study, 32% of vehicles/ pedestrians out of 172 road users (Sum of Bicycles, tricycles, M2Ws, M3Ws and Pedestrians) were fatally or seriously injured as a result of run over. M2W is the road user type that faced the maximum number of run overs recording 62% followed by pedestrians recording 25%.

How to prevent or stop run overs from happening?

Vehicle Engineering: Danger zone deflector and barrier



Danger zone deflector is a run over prevention device installed in public transport buses in many cities in western countries to deflect the road users from coming under the wheels of a bus. These devices are claimed to be highly effective for vehicles with high ground clearances, to save pedestrians, bus occupants, bicyclists, M2W riders from coming under the wheels. The device consists of a curved shaped, hard yet flexible plastic guard, which if

mounted in front of the rear wheels would deflect a person out of the path of the wheels, thus preventing tragic injuries from happening.



Danger zone barrier is again a run over prevention device which is similar to a side skirt setup that prevents or reduces the possibility of a person entering the under surface of the vehicle from the sides. Since it made of flexible material, these structures will be able to withstand impact from road obstacles as well

Fall down - 18%
(24 M2Ws, 1 Bicycle)



Fall down is a scenario where a motorcycle rider or bicyclist lost control of his vehicle, be it any reason like sudden braking or other avoidance maneuver (but not collision), fell down hard impacting against any surface, which resulted in fatal or serious injuries. This is limited only to motorized and non-motorized two wheelers because these are the vehicle types which can experience a self-fall as result of imbalance and instability.

Injury severity as a result of fall down can vary from fatal to minor injury and is mainly depend on type of fall, type of the contacted/ impacted surface (yielding or non-yielding), human body region that was subjected to high forces as a result of fall etc. As seen from Table 5, "Fall down" resulted in serious and fatal injuries in 18% of the total serious and fatal accidents considered in this study. This study also shows, "Fall down" led to fatal and serious injuries in 22% of the vehicles out of 116 vehicles in which fall down is applicable.

How to mitigate fall down related injuries?

There is as such no direct corrective or preventive measure to mitigate injuries during an event of a self-fall, but indirect precautionary measures such as usage of safety gear, road equipment with better impact absorbing properties can definitely prevent or at least reduce the severity of fall down related injuries. Educating road user about driving etiquette can also be a solution to reduce fall down conditions, so that road users should be courteous and stay alert while driving vehicle. Road users should follow lane discipline while driving as violating lane discipline leads to conflicts between vehicles which in turn leads to conditions of fall down.

Non - enclosed occupant cabin – 5%
(7 M3Ws)

Auto rickshaw, which is an economic and convenient alternative for public transport not only



tops the list of most preferred vehicle for city travel, but also tops the RASSI database as an important injury causing vehicle factor. As can be seen from table 5, this factor has led to serious and fatal injuries in 5% of the total serious and fatal accidents. Non-enclosed occupant cabin led to fatal and serious injuries in 37% of vehicles out of 19 vehicles in which this problem is applicable. Further, this open cabin design also adds to the problem of overloading.

How to reduce the risk of non-enclosed occupant cabin?



Three-wheeled passenger vehicles pose safety issues since they are dynamically unstable and hence more prone to roll over. Since the occupant cabin is not fully enclosed, the chances of occupants contacting the ground in case of a roll over is inevitable. A four-wheeled, fully enclosed quadricycle seems to be a safer option as a short distance commercial passenger vehicle, provided it is fully enclosed and restricted from entering highways where speeds are higher. Since they have four wheels, quadricycles inherently have better stability and overall dynamics compared to the three-wheeled auto rickshaws. If this is going to take time, the last option is to introduce Motorized three wheelers with enclosed cabins as they are in some South American and south Asian countries.

Seatbelts not available/usable – 6%
(7 M3Ws, 1 Car)

Although all cars are equipped with seat belts, it is common in Indian cars for the seat buckles to be kept tucked under the seat (especially in rear seats) to increase seating comfort. This action makes the seat belts unavailable and effectively unusable. While it is true that a seat belt buckle is not particularly comfortable when located under a tail bone, if the belt is strapped across the body properly as it is to be, this “problem” goes away entirely. And there is certainly nothing more uncomfortable than being thrown violently inside a vehicle in the event of an accident. As shown in table 5, non-availability of seatbelts and non-usability of seatbelts has led to serious and fatal injuries in 6% of accidents.

Examples of crash vehicles with inoperative seat belts or seat belts not available:



In almost every pickup truck in India, the seatbelt is either inoperative or not available



Almost every Indian truck has this issue – no seat belts at all



Although seat belts are present, people consider them a hindrance—so they hide the buckles



Auto rickshaws are vehicles that are not equipped with seat belts

As per our study, 54% of vehicles out of 127 seatbelt applicable vehicles had at least 1 seat per vehicle where the seat belt was found to be inoperative/ defective.

What can be done to improve seatbelt availability and seat belt maintenance?

Most trucks and buses in India do not have usable seatbelts. Vehicles like auto rickshaws cannot be equipped with seatbelts which makes it an unsafe mode of transport even under city limits. It has been proven worldwide that seat belts are the cheapest and most effective safety systems in vehicles today. Hence, truck and bus drivers should ensure that their vehicles are fitted with good quality seat belts. Manufacturers must also ensure that, all their vehicles are equipped with this principal safety system as a standard feature. Laws must enforce every occupant seated in a vehicle should be belted and offenders must be penalised heavily. Police authorities must regularly check vehicles not for seat belt usage but also for availability and condition of seatbelts.

INFRASTRUCTURE FACTORS INFLUENCING INJURY OCCURRENCE

For the 156 accidents examined, 137 accidents resulted in fatal or serious injuries. The table below shows both the number and the percentage of fatal/serious injury accidents influenced by each factor. *Please note that more than one factor can influence injury; hence, the sum of the percentage influence will not be equal to sum of infrastructure factors influencing injuries (10%).*

Contributing Infrastructure Factors (Injury Occurrence)	Number of Accidents	% Influenced
Object impact - roadside/median - manmade structures	10	7%
Roadside - steep slope/drop off	2	1%
Object impact – road side trees and plantation	1	<1%
Medical response – EMS availability	1	<1%

TABLE 6: CONTRIBUTING INFRASTRUCTURE FACTORS INFLUENCING THE OCCURRENCE OF FATAL/SERIOUS INJURY IN 137 FATAL/SERIOUS ACCIDENTS

Object impact - roadside/median - manmade structures - 7%



Object impacts on roads under city limits are often due to vehicle departing the roadway as a result of sudden evasive maneuver, driver distraction, loss of control, over speeding, driver fatigue, etc. The manmade objects include mesh fence, concrete barriers, bridge walls, guard rails, sign posts, lamp posts, flower pots, curb stones, etc. Flower pots and curb stones may look harmless, but in an event of an impact, these can be quite devastating for vehicles occupants and pedestrians.

Object impacts are highly undesirable as the risk of injuries in these cases are considerably high. In case of a two-wheeler or a three-wheeler colliding with an object, the occupants are more likely to have a direct impact with the collided object, which in most cases results in serious or fatal injuries. Hence, it is important to make these manmade structures more crash friendly and “forgiving”. Our analysis (table 6) show that, road side manmade structures resulted in serious and fatal injuries in 7% of the accidents.

Case study explaining ill effects of poor roadside manmade objects

Accident date: 8/10/2016	Accident time: 13:00 Hrs.
GPS: 23.06286N 72.52113E	Accident location: Sola bridge, NH8C
Fatality Count: 1	Road structure: Divided straight road
Accident summary	
Two female non-helmeted occupants were travelling on a motorized two-wheeler (M2W) on NH8C towards Gandhinagar direction, when the rider of M2W who had no much experience in riding two wheelers, lost control of the vehicle, impacted the roadside metal barrier and fell down.	
The rider of the two-wheeler died on spot while the pillion rider sustained minor injuries.	
Contributing factors:	
Accident factors:	Injury factors:
1. Rider lost control due to inexperience	1. Helmet not used 2. Road side manmade object



How much did the road side manmade object contribute in the death of the rider of M2W?

In this accident, although both the riders travelling in the two-wheeler were not helmeted and, were subjected to similar amount of impact forces, the rider sustained fatal injuries while the pillion sustained minor injuries. This huge difference in the injury outcomes in spite of both the riders being thrown forward almost at the same velocity is because of the fact that the rider contacted against a sharp, non-yielding metal structure (metal fence) which instantaneously decelerated her resulting in critical head injuries, whereas in case of the pillion rider this impact was cushioned by the body of the rider of M2W (which is a better yielding structure in comparison) and the deceleration happen much progressively there by resulting in minimum injuries. Had there been a safe and proper fencing set up in that location at the time of accident, this accident probably might not have resulted in a fatality. So the real thing to be blamed in the death of the rider here is not the accident or not her inexperience in driving, but the poor infrastructural setup.

Similar example cases from our study where roadside manmade objects was responsible behind the injuries sustained by the victims

Thaltej underpass – 23.04285N



1 life lost

ITI Road – 23.08629N 72.64691E



1 life lost

Kankaria Road – 23.00265N 72.59905E



1 life lost

Narol Road – 23.00778N 72.580247E



1 life lost

Conclusion:

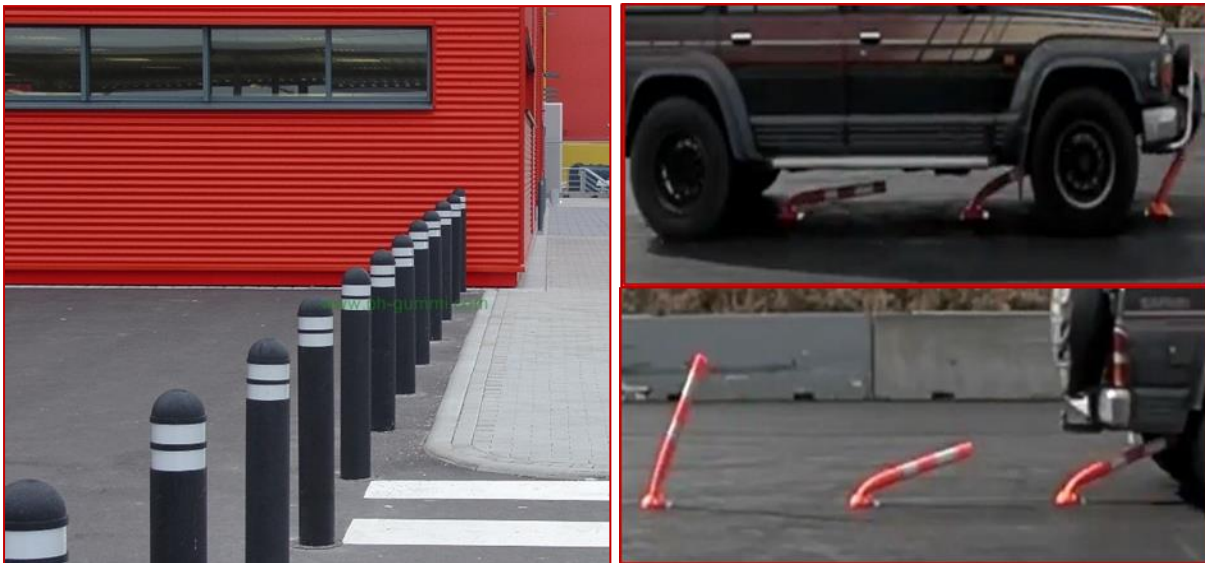
In all the above stated examples, although there are other human errors like non usage of helmet which contributed towards injury occurrence, unsafe and non-yielding infrastructural structure plays an equal role too. Presence of better and safer structures could have definitely made a significant difference in the severity irrespective of the usage of helmets.

How to make roadside manmade structures “forgiving”?

To facilitate forgiving roadside manmade structures, the roadside structures must be designed in a way to absorb forces which would result in decreasing the severity of injuries. Good Roadside infrastructure designs should be incorporated along with sharp-turn and accident prone zones where vehicles frequently lose their control, following are different solutions which will help reduce the such critical situations.

Few road safety equipment and technologies that can serve the purpose and still be crash friendly are listed below:

Infrastructural solution: Elastic Bollards



These flexible posts are elastic and a cost-efficient alternative to other street furniture used as for channelizing pedestrians in crossings. These will still serve the purpose of restricting vehicles from using pedestrian openings to cross, but will also be crash friendly. Since these structures are made of vulcanised rubber, they can take all the misuse and can be maintenance free too.

Infrastructural solution: Safety rolling barriers



This Safety rolling barrier can be installed at both side of roads, sharp curve areas, heavy traffic roadways, protruded sites, median strips etc. It is made of special compound which can act as a rigid structure in redirecting the errant vehicle back toward its original travel path without allowing gating, and can also act as a better yielding structure (when compared to concrete or metal) when directly contacted by occupants or pedestrians. It highly enhances the safety of both the vehicles and its occupants by

converting linear impact energy into rotational energy which will result in progressive deceleration. Since multiple individual components make up this structure, it is easy and cost effective in terms of maintenance.

Infrastructural solution: Impact attenuator



Impact attenuators are primarily designed to absorb the impact of a frontal collision with minimal damage to the structure it is protecting and the vehicle which is colliding. Some function like crumple zones in a vehicle, others offer a more resilient resistance, keeping their ability to protect even after they have been impacted. This basically absorbs and dissipates impact forces in a progressive fashion thus cushioning the vehicle and its occupants from impending forces.

Roadside steep slope/drop off - 1%



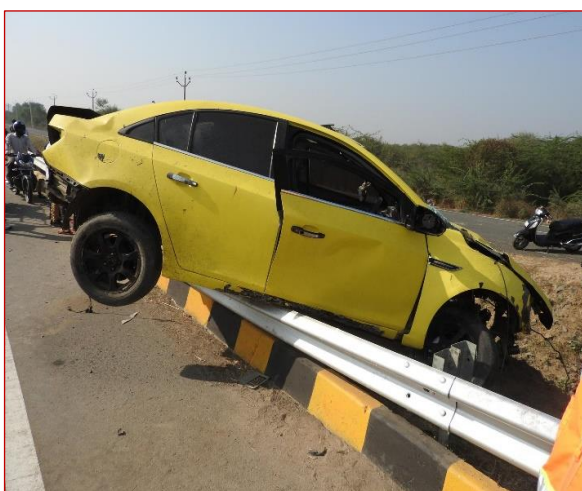
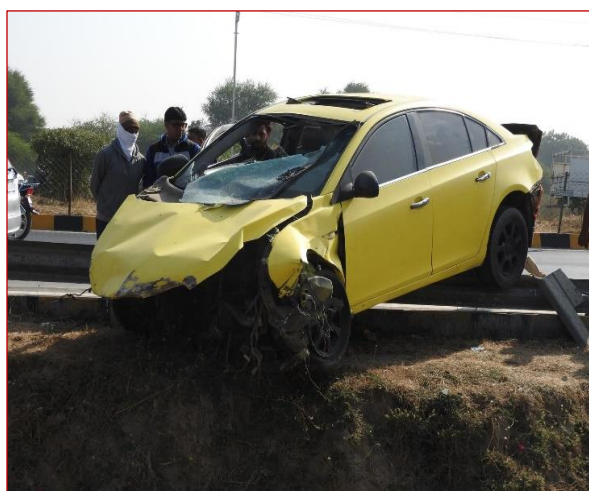
Safe road design is becoming increasingly important with the rise in traffic speed and volume. In general roadways include numerous bridges, flyovers with steep slopes and drop offs. Also road infrastructure includes presence of ditches and other similar structures for the purpose of drainage of water and in other occasions simply to separate or divide the roadways. In an event of an accident it is highly undesirable and unsafe to plough or roll down through these sort of structures,

which in majority of occasions result in fatal and serious injuries. Presence of road side steep slope or drop off contributed in the occurrence of injuries in 1% of accidents considered for the study.

Case study explaining the influence of roadside slopes in injury occurrence

Accident date: 26/12/2016	Accident time: 00:45 Hrs.
GPS: 23.07328N 72.48844E	Accident location: S.P. Ring Road
Fatality Count: 2	Road structure: Straight road
Accident summary A car with four occupants was travelling towards north on S. P. Ring road. The road structure is a four lane divided straight road with ditches on either side separating the main roads from service roads. As a result of over speeding, the driver of the car lost control over the vehicle, went off the road to the left side and fell into the ditch on the road side. The car landed hard on its nose, travelled a few meters inside the ditch and stopped finally after climbing over the guardrail. The left side occupants of both front and rear rows sustained fatal injuries, while the right side occupants of both the rows suffered serious injuries.	

Contributing factors:	
Accident factors:	Injury factors:
1. Speeding-Excessive speed for condition.	1. Seatbelt not used 2. Roadside steep slope/Drop off



How did the ditch contributed in the occurrence of injury

Even though there are other human factors like non usage of seatbelts that could be blamed for the injuries sustained by the occupants, the presence of unprotected road side ditch also played a significant role in injury occurrence. The car which fell into the ditch landed hard on its nose, transferring a tremendous amount of force inside the occupant's cockpit. The ditch here acted like a rigid wall almost yielding nothing, the car and its occupants were subjected to very high deceleration over a very small period of time which resulted in the occupants suffering critical and fatal injuries. A proper ditch design should incorporate a run-off area so to decelerate and regain vehicle control. In any situation, it should never allow rapid deceleration to occur. It must always be protected by guardrails on both the sides. Had there been a proper guardrail positioned in that location, it might have absorbed a lot of impact forces and would have probably deflected the vehicle back towards the road, or in the worst scenario could have at least led to a considerably soft landing car, which could have resulted in a less severe injury outcome. Ditch should be provided with proper run-off area to decelerate the vehicle gradually and gain the control back on the vehicle.

How to mitigate or reduce injuries associated with roadside steep slope?



Multilayer guard rail



Concrete Jersey barrier



Crash rolling barriers



Pultruded composite guide rail system

Predominantly, manmade objects placed on roadway, median, etc. must only serve the purpose of crash protection and road delineation. Any other manmade structures serving other vital purposes must be made crash friendly and forgiving. It is always safe to have roads without the presence of ditch or slopes, unless it serves a very essential purpose. In such cases the ditch design must not be steep or uneven.

Well engineered crash barriers must be added to the roadway, particularly on roads having a ditch or slope on its sides. The bridge walls must be crash friendly and tall enough to avoid tipping or fall of the vehicle. Crash barriers, irrespective of its type, must deflect and guide the vehicle back towards the road while keeping the level of damage to the vehicle, its occupants and the barrier at a minimum level. Ideally a crash barrier should present a continuous smooth face to an impacting vehicle, so as to slide over it without overturning. It should also be strong enough to withstand and absorb the impact forces. A good barrier design must always account for a slow and progressive deceleration. Advance barrier systems such as multilayer guardrails or composite guardrails uses materials of varied strength, positioned one behind the other so as to keep the deceleration levels low, which eventually reduces the severity of the injuries sustained. The crash barriers fitted in city roads must be designed in a way to accommodate vehicles of varying speeds and masses (from scooters to heavy duty trucks).

5 CONCLUSIONS

Currently, in-depth accident investigation and data collection at a national level are not available in India. However, in-depth investigations of road traffic accidents that have been carried out over the period of January 2016 to December 2016 on roads of Ahmedabad city—particularly those covered by this report—are beginning to spotlight some of the unique road traffic safety issues confronted by India, in general, and the state of Gujarat in particular.

Based on a year’s (January 2016 to December 2016) accident investigation data for Ahmedabad city, this study concludes the following:

1. Two wheelers pose the highest risk of accidents among all road users, involved in 36% of accidents.
2. Male victims belonging to the age group of 21 to 40 years were the most affected out of all the age groups contributing to 40% of the total fatalities. (51 fatal male victims out of 129 total fatal victims)
3. M2Ws are the most affected road user as far as injuries are concerned. 57% of M2W users recorded at least one fatality out of the total 124 road users involved in fatal accidents. And 82% of the total seriously injured road users were M2W users.
4. Pedestrians are the second most affected road user as far as injuries are concerned, recording 27% of the total fatalities.
5. “Collision between vehicle and pedestrian”, “Collision with turning or crossing vehicle” and Motorcyclist/Bicyclist self-fall are the most prevalent accident types occurring in Ahmedabad city as per the study, recording 21%, 19% and 19% of total accidents respectively.
6. The main contributing factors leading to accidents are:

Human	Vehicle	Infrastructure
<ul style="list-style-type: none"> • Driver and rider behaviour (58%) • Vehicle speeding (33%) • Driver and rider inattention/misjudgement (25%) • Pedestrian dangerous behaviour and inattention (15%) 	<ul style="list-style-type: none"> • Vision obstruction (2%) • Defective tires (1%) • Over-loading of people (1%) • Absence of reflectors (1%) 	<ul style="list-style-type: none"> • Poor road marking and signage (14%) • Improper pedestrian infrastructure (13%) • Poor road design (13%) • Poor road maintenance (6%)

7. The following solutions will help reduce road traffic accidents in Ahmedabad City:

- Implementation of speed management program i.e. to match speeds to conditions, warn drivers of changes, and then enforce posted limits to reduce speeding related accidents.
(Over speeding related causation factors were observed in 33% of total accidents.)
- Educating the road users through different public awareness campaigns teaching them about the consequences of distraction during driving, making harsh rules against the mobile use during driving. Incorporating advance vehicle technologies to mitigate the probable dangers due to driver misjudgments.
(Drivers/Riders inattention and misjudgment was observed in 25% of total accidents.)
- Educating the road users through different public awareness campaigns teaching them about the consequences of pedestrian behaving dangerously on roadway and inattention during walking or crossing the road. Enforcements to be made for following the traffic signals on intersections.
(Pedestrian dangerous behaviour on roadway and inattention contributed to 15% of total accidents.)
- Adopt stringent rules to help prevent illegal road usage. This includes traveling in wrong direction and also travelling in special lanes that are not meant for all road users. (BRTS lane for example)
(Illegal road usage contributed to 12% of total accidents.)
- Adequate road markings and signage, effective positioning of signage and proper maintenance of road markings can help reduce misperceptions while driving.
(Improper/ inadequate signage and road markings contributed to 14% of total accidents.)
- Improve Pedestrian Infrastructure especially on intersections. Also various stretches of roads where insufficient pedestrian crossings are seen for a huge pedestrian movement. There are many illegal openings made without any signage for the same, this has to be looked into and rectified.
(Poor pedestrian infrastructure, inadequate pedestrian crossing and illegal pedestrian crossing contributed to 13% of total accidents.)
- Proper intersection design can enhance the safety quotient of the roadway considerable for all road users with adequate signage, perceptual road markings, improved road engineering. Building divided roadway infrastructure can also help reduce accidents and resulting injuries considerably.
(Improper intersection design and undivided roads was responsible for 13% of total accidents)
- Maintenance such as leveling the road surface, keeping it free from oil and dirt, repairing the pot holes. Also vision obstruction due to median and road side trees and plantation has to be checked and maintained on regular basis by road authorities to ensure safety.
(Vision obstruction and defective road surface contributed to 6% of total accidents.)

8. The main contributing factors leading to fatal/serious injuries are:

Human	Vehicle	Infrastructure
<ul style="list-style-type: none"> • Helmet not used (40%) • Occupants in cargo area (3%) • Improper helmet usage (2%) 	<ul style="list-style-type: none"> • Knock-Down (52%) • Run over (40%) • Fall down (18%) 	<ul style="list-style-type: none"> • Object impact – roadside manmade structures (7%) • Road side - steep slope/drop off (1%)

9. The following actions are likely to reduce the severity of road accidents occurring in Ahmedabad city:

- Enforcing helmet usage (ensure that helmet meets the quality standards) and educating road users about proper helmet selection. Increasing the helmet usage rate is a critical need, because proper head protection can make a life-saving difference, equal effort should go towards making sure all helmets sold in India meet basic protective standards. Also, punishing the felony against overloading of occupants to mitigate fatal/ serious injury outcomes.
(Lack of helmet usage contributed 40% injuries in fatal and serious injury accidents.)
- Encouraging the motorists about usage of protective gears and improving pedestrian infrastructure to reduce possible serious and fatal injuries from knock down.
(Knock-down of motorized/non-motorized two-wheeler occupants and pedestrian contributed 52% of fatal and serious injury accidents)
- Implementing laws to force heavy vehicle users to incorporate recent vehicle technologies to mitigate the severe injuries to other road users as a result of run over.
(Run-over of road users contributed 40% of fatal and serious injury accidents)
- Incorporating advanced crash friendly road furniture, deployment of proper crash barriers based on the type and speeds of the road users on bridges and flyovers to overcome the problem of serious and fatal injuries during accidents.
(Rigid manmade structures and roadside steep slopes/drop offs has contributed to 8% of fatal and serious injury accidents.)

APPENDIX A: JPRI & RASSI CONTACT INFORMATION

For more information on JPRI, RASSI or this report, visit our websites, call or come by one of our offices, or drop us a line by email.

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APPENDIX B: ACCIDENT TYPE DEFINITION

01. Collision with another vehicle which starts, stops or is stationary.

Starting or stopping as used here refer to a deliberate stopover which is not caused by the traffic situation. Stationary vehicles within the meaning of this kind of accident are vehicles which stop or park at the edge of a carriageway, on shoulders, on marked parking places directly at the edge of a carriageway, on footpaths or parking sites. Traffic to or from parking spaces with a separate driveway belongs to Accident Type No. 5.

02. Collision with another vehicle moving ahead or waiting.

Accidents include rear-end collisions with vehicles which were either still moving or stopping due to the traffic situation. Rear-end collisions with starting or stopping vehicles belong to Accident Type No. 1.

03. Collision with another vehicle moving laterally in the same direction.

Accidents include collisions that occur when vehicles are driving side by side (sideswipe) or changing lanes (cutting in on someone).

04. Collision with another oncoming vehicle.

Accidents include collisions with oncoming traffic, none of the colliding partners having had the intention to turn and cross over the opposite lane.

05. Collision with another vehicle which turns into or crosses a road.

Accidents include collisions with crossing vehicles and with vehicles which are about to enter or leave from/to other roads, paths or premises. A rear-end collision with vehicles waiting to turn belongs to Accident Type No. 2.

06. Collision between vehicle and pedestrian.

Persons who work on the carriageway or still are in close connection with a vehicle, such as road workers, police officers directing the traffic, or vehicle occupants who got out of a broken down car are also considered to be pedestrians.

07. Collision with an obstacle in the carriageway.

These obstacles include, for instance, fallen trees, stones, lost freight as well as unleashed animals or game. Collisions with leashed animals or riders belong to Accident Type No. 10.

08. Run-off-road to the right.

09. Run-off-road to the left.

These kinds of accidents do not involve a collision with other road users. There may, however, be further parties involved in the accident, e.g., if the vehicle involved in the accident veered off the road trying to avoid another road user and did not hit him.

10. M2W rider / Bicyclist self-fall

An accident in which a M2W rider (also pillion) or bicyclist falls off his vehicle because of a driver loss of control or slipping or avoidance maneuver or any other reason, but without any physical contact or collision with another road user.

11. Rollover

Rollover describes the overturning of a vehicle along its longitudinal or lateral axis. This accident kind is selected when a vehicle loses control on the roadway and subsequently rolled over. Accident in which a vehicle loses control, goes off-road, and gets rolled over will

fall under category “Run-off-road to the right or left”. Also a rollover that occurs as a result of Collision between vehicle/pedestrian/object falls between the categories 1 to7.

12. Accident of another kind.

This category covers all accidents which cannot be allocated to one of the kinds of accidents listed under Accident Type Nos. 1 to 9.