Ahmedabad and Gandhinagar Road Accident Study

Analysis of 211 Accidents

Submitted by:

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Ahmedabad and Gandhinagar Road Accident Study

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Our sincere appreciation and gratitude to all the officers of Gujarat State Police for their support and co-operation. We hope that governments soon recognize their importance during accidents and road blockages and provide them with better protection, equipment, training 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 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 and Gandhinagar roads (including motorists) in helping make our journeys safer.
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 for the road accident study covers 99 kilometers of important roads and highways divided between Ahmedabad and Gandhinagar districts. It includes urban and rural areas, most of the roads under the study falls under Ahmedabad city limits. The roads covered under the study area are as follows:

2. Sardar Patel Ring Road - 27 km approx.
3. NH8-A – 13.5 km approx.
4. SH-17 – 11 km approx.
5. SH-71 – 16 km approx.

This report presents the results of the study of accidents that occurred on the above mentioned roads (Figure 1) that were examined by JP Research India (JPRI).
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 by the GVK-EMRI 108 Ambulance Service.

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 cooperation 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). Whenever possible, 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, de-identify all the details that go into the scientific database.

What is the objective of this report?

Over the period of 7 February 2014 through 6 February 2015, JPRI researchers examined 442 accidents that occurred in the study area, of which researchers were able to study 211 accidents in detail to determine the reasons for the occurrence of the accidents.

This report provides an in-depth analysis of these 211 accidents and provides information of the various factors influencing accidents and the resultant injuries on the roads of Ahmedabad and Gandhinagar. 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 in detail by JPRI teams in Coimbatore, Pune, Ahmedabad and Kolkata, 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 reviews 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 of root causes of India’s road traffic issues.

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

ACCIDENT DATA SAMPLE

Of the 442 accidents examined between 7th February 2014 and 6th February 2015, JPRI researchers were able to collect good data for 211 accidents. These 211 accidents involved 384 road users and resulted in 19 fatal victims and more than 100 serious injury victims.

How were these accidents found?

JPRI researchers identified 9 GVK-EMRI 108 ambulances who respond to road accidents in the study area. The GVK-EMRI 108 Control Room was requested to provide text notifications of all road accidents which are attended to by these 9 ambulances. On receiving the text message, JPRI researchers would travel to the crash scene and examine the road accident. Of the 211 accidents, 183 accidents were notified to JPRI researchers through text messages of GVK-EMRI Control Room. The remaining 28 cases were notified through other sources such as police, researchers seeing an accident while travelling to another accident, toll plaza personnel and private ambulances.

Most of the accidents examined are not reported to the police. Non-reported accidents were usually minor or no injury, but occasionally involved serious injuries. These crashes were not reported to the police as the vehicle owners preferred not to register a complaint. Such non-reported accidents are still important for accident analysis.

![Figure 3: Distribution of 211 accidents by police reported or not police reported cases.](image)

Why are such “Not Police Reported” accidents important?

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

1. Gives a more realistic indication of the number of fatal & serious injury accidents actually occurring on the streets of Ahmedabad & Gandhinagar.
2. Allows analysis of common contributing factors resulting into injuries for all fatal and serious injury accidents.
3. Allows analysts to determine which safety systems work well, and which ones do not work as desired, in preventing an accident or mitigating injuries.
CONTRIBUTING FACTORS – A PRIMER

Road traffic accidents are primarily influenced by three main factors:

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

Conventionally, accidents are analyzed for each of the above factors, and the accident 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 and infrastructure related solutions that can prevent accidents and mitigate injuries in spite of human errors.

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 that two accidents with similar contributing factors leading to the crash 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 5 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 moderate, in the case of this study, the focus was on serious/fatal injuries only.

**Case Study**

**Accident 1:** A car was travelling towards north on the right most lane of a six lane divided road. The driver was belted. A non-involved vehicle (unknown car) was travelling ahead of this car in the same direction, but in the center lane. Non-involved vehicle on seeing animal on its path changed lane and encroached into the path of the car. In order to avoid a collision, the car driver steered right and collided with the median (median with raised curb), after this impact vehicle went on to hit the metal fence. Then the car rolled (2 quarter turns) on its left side and rested on its roof. As per the ambulance paramedic, no one was injured in this accident.

**Accident 2:** A motorized 3-wheeler (M3W) was travelling on Sardar Patel Ring road towards North. M3Ws are vehicles which are not equipped with seatbelts. The M3W driver was under the influence of alcohol. As per the driver's statement, some unknown vehicle suddenly passed from his left side, so he steered right in panic and the front tyre went over the median, impacted a small pole and the vehicle rolled over on its left side (1 quarter turn). Due to the rollover, a female passenger got partially ejected through the door. As per the ambulance record, a female passenger seated at rear left seat had suffered serious leg injuries and the driver had sustained minor injuries.

Both accidents occurred on straight divided roads. In both accidents, due to similar circumstances, the vehicles went off the roadway towards the right, into the median and rolled over, but the injury outcomes for these accidents were entirely different. In the former accident the occupant (no ejection) was able to walk away from the accident with no injuries, while in the latter one, the occupant got partially ejected which led to serious injuries.
<table>
<thead>
<tr>
<th>Scene Photos – Taken along the direction of vehicle’s travel</th>
<th>Accident 1</th>
<th>Accident 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><img src="image1" alt="Scene Photos" /></td>
<td><img src="image2" alt="Scene Photos" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vehicle Photos – Damages sustained by the vehicle</th>
<th>Accident 1</th>
<th>Accident 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="Vehicle Photos" /></td>
<td><img src="image4" alt="Vehicle Photos" /></td>
<td><img src="image5" alt="Vehicle Photos" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Injury severity</th>
<th>No injury</th>
<th>Serious injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>No injury</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serious injury</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contributing factors – Leading to an accident</th>
<th>Accident 1</th>
<th>Accident 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over Speeding</td>
<td><img src="image6" alt="Over Speeding" /></td>
<td><img src="image7" alt="Driver under influence" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contributing factors – Leading to injuries</th>
<th>Accident 1</th>
<th>Accident 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not applicable (No injury)</td>
<td><img src="image8" alt="Not applicable" /></td>
<td><img src="image9" alt="Seatbelt not available" /></td>
</tr>
<tr>
<td>Seatbelt not available Non - enclosed occupant cabin (which led to ejection of the occupant)</td>
<td><img src="image9" alt="Seatbelt not available" /></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 6: Example Demonstrating Variability of Injury Outcomes from Similar Crash Configuration**
3 DATA ANALYSIS

The 211 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 211 road accidents by injury severity (based on the most severe injury sustained by any human involved in each accident) is shown in Figure 7. As can be seen, more than 40% of the accidents examined during this study resulted in fatal or serious injuries. In all, 88 accidents (by count) involved fatal or serious injury to at least one vehicle occupant or pedestrian.

![Figure 7: Distribution of the 211 Accidents by Highest Injury Severity](image)

**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 ACCIDENTS BY TIME OF OCCURRENCE

The 211 accidents were plotted against time durations of 3 hours (Figure 8) to identify times of occurrence. The data shows highest percentage of accidents occurred between 09:00 to 17:59 hours (81%). The highest percentages of accidents resulting in fatal/serious injury also occurred between 09:00 to 17:59 hours (75%).
**Figure 8: Percentage Distribution of 211 Accidents by Time of Occurrence**

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

**VEHICLES/ROAD USERS INVOLVED**

A total of 384 vehicles/road users were involved in the 211 road traffic accidents examined. Figure 9 shows the percentage distribution of the types of vehicles/road users involved in these 211 accidents. Please note that the figure is based on a count of the vehicles and pedestrians involved in the 211 accidents analyzed and not the number of occupants or accidents. In the case of pedestrians, each pedestrian is a single count.

**Figure 9: Percentage Distribution of Vehicle/Road User Type Involved (N=384)**

Findings show that the type of vehicles/road users most often involved in accidents are M2Ws (28%) and cars (28%), followed by M3Ws (15%) and trucks (15%).

For purposes of this report, all persons injured outside of a vehicle are considered pedestrians (refer “accident type” classification; see Appendix B). In total, 21 pedestrians were involved in the accidents examined.
VEHICLES/ROAD USERS AFFECTED IN CRASHES WITH FATAL OR SERIOUS INJURY

Figure 10 shows the percentage distribution of vehicles/road users 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.

As can be seen from Figure 10, the vehicles with the highest share of fatalities or serious injuries to occupants are M2Ws. M2Ws constitute 53% of road users which had at least one fatal occupant, and 47% of road users which had at least one seriously injured occupant. Cars, which are one among the highest involvement vehicles in accidents, as seen in Figure 9, also shares a good proportion in occupant fatality and serious injuries. Cars constitute 12% of vehicles which had at least one fatal occupant, and 12% of vehicles which had at least one seriously injured occupant. M3Ws also poses a fair contribution in fatal (6%) and serious injuries (16%).

Pedestrians account for only 5% of the 384 road users involved in the 211 accidents analyzed for this study (see Figure 9); however, figure 10 shows that they account for 12% of road users in fatal and 14% of road users in serious injury accidents.

ROAD TRAFFIC ACCIDENT TYPES

Figure 11 shows the distribution of the 211 accidents (including the 88 fatal/serious accidents) as categorized by accident type. The ten 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. Accident of another kind (involves crashes not covered by the other categories, such as truck jack-knifing, fires, and rollovers on the carriageway).
Figure 11: Percentage Distribution of Accidents by Accident Type

As can be seen from Figure 11, “Collision with another vehicle which turns into or crosses a road” accounts for 22% of all accidents and 27% of fatal or serious injury accidents, followed by “Collision with another vehicle moving laterally in the same direction”, which contributed to 22% of all accidents and 22% of fatal or serious injury accidents.
4 CONTRIBUTING FACTORS ANALYSIS

To determine the contributing factors influencing the occurrence of each accident, 211 road traffic accidents were analyzed in detail. In addition, the contributing factors influencing the occurrence of serious or fatal injury in 88 of these road accidents were also analyzed in detail.

ANALYZING ACCIDENT AND INJURY CAUSATION

Factors Influencing Occurrence of Accidents (211 accidents)

A distribution by contributing factors (human/vehicle/infrastructure) for the 211 accidents analyzed over a period of one year is shown in the Venn diagram (Figure 12). This diagram shows that human factors alone (49%) had the highest influence on the occurrence of accidents, followed by the combination of human and infrastructure factors (35%) and only infrastructure related problems (6%).

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

<table>
<thead>
<tr>
<th>Factor</th>
<th>All Combinations</th>
<th>Alone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>91%</td>
<td>49%</td>
</tr>
<tr>
<td>Vehicle</td>
<td>10%</td>
<td>3%</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>44%</td>
<td>6%</td>
</tr>
</tbody>
</table>

![Figure 12: Distribution of 211 Accidents by Contributing Factors influencing the Occurrence of Accidents](image-url)
Factors Influencing Occurrence of Injuries (88 fatal/serious accidents)

Of the 211 accidents, 88 accidents involved fatal or serious injury to at least one occupant or pedestrian. These 88 fatal or serious accidents were analyzed to determine the contributing factors influencing the occurrence of injury. The distribution by contributing factors (human/vehicle/infrastructure) is shown in the Venn diagram (Figure 13). This diagram shows that the vehicle factors alone (47%) had contributed to majority of fatal/serious injuries, followed by the combination of human and vehicle factors (40%).

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

<table>
<thead>
<tr>
<th>Factor</th>
<th>All Combinations</th>
<th>Alone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>50%</td>
<td>7%</td>
</tr>
<tr>
<td>Vehicle</td>
<td>93%</td>
<td>47%</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>6%</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Figure 13: Distribution of 88 Fatal/Serious Injury Accidents by Contributing Factors Influencing the Occurrence of Fatal/Serious Injuries**

Hence, it can be seen that human factors and a combination of human and infrastructure factors have the highest influence on the occurrence of accidents, while vehicle factors and the combination of vehicle and human factors have the highest influence on the occurrence of injuries.
**HUMAN FACTORS INFLUENCING ACCIDENT OCCURRENCE**

For the 211 accidents examined, the following are the contributing human factors determined 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 sum of human factors influencing accidents (91%). Also factors with negligible counts have not been included in the table for analysis.*

Table 1: Contributing human factors influencing the occurrence of 211 accidents.

<table>
<thead>
<tr>
<th>Contributing Human Factors (Accident Occurrence)</th>
<th>No. of Accidents</th>
<th>Percentage influenced</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Road User behaviour related</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Violation of right of way (11 M2Ws, 6 Trucks, 5 Cars, 3 M3Ws, 1 Bus, 1 Bicycle)</td>
<td>107</td>
<td>52%</td>
</tr>
<tr>
<td>Improper lane change/lane usage (7 M2Ws, 5 Cars, 1 Truck, 1 Bicycle, 1 Unknown)</td>
<td>27</td>
<td>13%</td>
</tr>
<tr>
<td>Parked vehicle on road (full or partial) (4 Cars, 3 Trucks, 2 M3Ws, 2 Other, 1 Bus)</td>
<td>15</td>
<td>7%</td>
</tr>
<tr>
<td>Following too closely (5 Cars, 4 M3Ws, 2 Trucks, 1 M2W)</td>
<td>12</td>
<td>6%</td>
</tr>
<tr>
<td>Driver under influence of alcohol (4 Cars, 3 M3Ws, 2 Trucks, 1 M2W)</td>
<td>12</td>
<td>6%</td>
</tr>
<tr>
<td>Illegal road usage (includes travelling in the wrong direction) (4 M2Ws, 4 Cars, 2 M3Ws)</td>
<td>10</td>
<td>5%</td>
</tr>
<tr>
<td>Turning suddenly or without indication (3 M3Ws, 2 Cars, 2 M2Ws, 2 Trucks, 1 Bicycle)</td>
<td>10</td>
<td>5%</td>
</tr>
<tr>
<td>Pedestrian dangerous behaviour on roadway (6 Pedestrians)</td>
<td>6</td>
<td>3%</td>
</tr>
<tr>
<td>Overtaking on undivided road (2 M2Ws, 1 Car)</td>
<td>3</td>
<td>1%</td>
</tr>
<tr>
<td>Vehicles stopped due to traffic (1 Truck, 1 Bus)</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td><strong>Speeding related</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speeding - excessive speed for conditions (15 Cars, 8 M2Ws, 4 M3Ws, 3 Trucks, 2 Buses, 1 Mini truck, 1 Unknown)</td>
<td>89</td>
<td>42%</td>
</tr>
<tr>
<td>Speeding - exceeding speed limit (14 M2Ws, 10 Cars, 2 Trucks, 2 Buses)</td>
<td>34</td>
<td>16%</td>
</tr>
<tr>
<td>Speeding - speed limit unknown (17 Cars, 3 M2Ws, 3 Trucks, 1 Mini truck, 1 Bus, 1 Minibus, 1 Unknown)</td>
<td>28</td>
<td>13%</td>
</tr>
<tr>
<td><strong>Road User inattention/distraction related</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver Inattention (reasons unknown) (7 M2Ws, 4 Cars, 4 M3Ws, 2 Buses, 1 Truck, 1 Bicycle)</td>
<td>40</td>
<td>18%</td>
</tr>
<tr>
<td>Pedestrian Inattention (reasons unknown) (7 Pedestrians)</td>
<td>19</td>
<td>9%</td>
</tr>
<tr>
<td>Driver - Sleep/Fatigue/Drowsiness (2 Trucks, 1 Mini truck, 1 Car, 1 M3W)</td>
<td>7</td>
<td>3%</td>
</tr>
<tr>
<td>Driver distraction outside vehicle (2 Cars, 1 M3W, 1 M2W)</td>
<td>5</td>
<td>2%</td>
</tr>
<tr>
<td>Driver using mobile phone (1 M2W, 1 Car, 1 M3W)</td>
<td>4</td>
<td>2%</td>
</tr>
<tr>
<td>Driver distraction inside vehicle (2 M3Ws)</td>
<td>3</td>
<td>1%</td>
</tr>
</tbody>
</table>

As can be seen from table 1, driver behaviour, speeding and driver distraction/inattention are the main contributing human factors influencing accidents.

**Countering Human Factors that Contribute to Accidents**

The important human factors, influencing occurrence of accidents, identified in Table 1 are described in brief in the following paragraphs, and information is provided on existing solutions to counter these human errors. Please note that the solutions identified here are merely suggestions. JPRI researchers are not experts in road engineering, vehicle design, driving regulation or enforcement. But the company is aware of solutions that have been implemented in other parts of the world and are already available; these are outlined here. What might actually work best for any specific situation 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.

**Violation of right of Way – 13%**

*(11 M2Ws, 6 Trucks, 5 Cars, 3 M3Ws, 1 Bus, 1 Bicycle)*

Right of way is a concept which specifies the priority a road user has got over another road user in any given situation. Violation of right of way is a situation where a road user unintentionally or deliberately failed to yield way (give way) to another road user. Violation can be of many types, for example running a red light, endangering oncoming traffic while turning, improper passing etc. Illegal road usage is another similar condition where the road rules are deliberately violated by the road user, for example travelling in the wrong direction on a divided highway.

**How to inculcate the concept of right of way among road users?**

**Policy making: Right of way**

In India there are no pre-set road regulations on the right of way concept, and hence the violations addressed here are based on the informal driving norms socially adhered. With over 1,40,000 people dying on roads every year and with a steep growth in vehicle population, it is high time that the Indian government must focus on policies emphasising right of way. The following link explains the concept of “Right of way” followed in Ontario, Canada.

There are many signage indicating right of way and adding them amongst other signage may help resolve the problem.

http://mutcd.fhwa.dot.gov/

The above mentioned link may be of help in setting up revised and uniform traffic control devices across the country. The policies brought in must be similar to informal driving policies socially adhered, any drastic change in policy may create confusions among road user, thereby depreciating the significance of the new regulation.

**Enforcement and Education:**
Once the above mentioned system is in place, it is important to make the road users aware of the system and to educate the significance of the system. Effective awareness campaigns in schools, awareness campaigns involving fleet owners and rickshaw operators can result in quick adaptation and smooth operation of the system.

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. Increase in number of signboards, effective positioning of signboards may help reduce unintentional violations.

**Improper lane change/ Lane usage — 7%**
(7 M2Ws, 5 cars, 1 Truck, 1 Bicycle, 1 Unknown)

**Turning suddenly or without indication 5%**
(3 M3Ws, 2 Cars, 2 M2Ws, 2 Trucks, 1 Bicycle)

This problem is due to a driver 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 motorists have been observed changing lanes without giving proper indication.

**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 marker cats eye**

Road marker cats eye 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.

**Speeding - excessive speed for conditions – 16%**  
(15 Cars, 8 M2Ws, 4 M3Ws, 3 Trucks, 2 Buses, 1 Mini truck, 1 Unknown)

**Speeding - speed limit unknown – 13%**  
(17 Cars, 3 M2Ws, 3 Trucks, 1 Mini truck, 1 Bus, 1 Minibus, 1 Unknown)

**Speeding - exceeding speed limit – 13%**  
(14 M2Ws, 10 Cars, 2 Trucks, 2 Buses)

Having a wide and open road under them, drivers tend 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 Gandhinagar and 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.

**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.
Driver inattention – 9%
(7 M2Ws, 4 Cars, 4 M3Ws, 2 Buses, 1 Truck, 1 Bicycle)

Driver distraction outside vehicle – 2%
(2 Cars, 1 M3W, 1 M2W)

Driver using mobile phone – 1%
(1 M2W, 1 Car, 1 M3W)

Driver distraction inside vehicle – 1%
(2 M3Ws)

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.
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. 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.
VEHICLE FACTORS INFLUENCING ACCIDENT OCCURRENCE

For the 211 accidents examined, the following are the contributing vehicle factors determined 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 may not be equal to sum of vehicle factors influencing accidents (10%). Also factors with negligible counts have not been included in the table for analysis.

<table>
<thead>
<tr>
<th>Contributing Vehicle Factors (Accident Occurrence)</th>
<th>Number of Accidents</th>
<th>Percentage Influenced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defective Tyre (3 M2Ws, 4 M3Ws)</td>
<td>7</td>
<td>3%</td>
</tr>
<tr>
<td>Overloading people (5 M3Ws, 1 M2W)</td>
<td>6</td>
<td>3%</td>
</tr>
<tr>
<td>Defective Brakes (1 M2W, 1 Other)</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>Lack of reflectors (1 Bus, 1 Bicycle)</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>Other defect (2 Trucks)</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>Goods not secured properly (1 M3W)</td>
<td>1</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

Table 2: Contributing vehicle factors influencing the occurrence of 211 accidents

Of all the vehicle factors contributing to an accident, defective tyres and overloading of people has accounted to 6% of the accidents.

Countering Vehicle Factors that Contribute to Accidents

Defective Tyre – 3%
(3 M2Ws, 4 M3Ws)

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 seven 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 – 3% (5 M3Ws, 1 M2W)**

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 211 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 (44%). Also factors with negligible counts have not been included in the table for analysis.

<table>
<thead>
<tr>
<th>Contributing Infrastructure Factors (Accident Occurrence)</th>
<th>Number of Accidents</th>
<th>Percentage influenced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intersection (NH-8C – 9, SP Ring Road – 8, NH-8A – 3, SH-71 – 3, Other – 4)</td>
<td>27</td>
<td>13%</td>
</tr>
<tr>
<td>Gap-in –median (NH-8C – 4, SH-71 – 3, SP Ring Road – 3, NH-8A – 2, SH-17 – 2, Other – 1)</td>
<td>15</td>
<td>7%</td>
</tr>
<tr>
<td>Poor road marking/signage (NH-8A – 4, SH-71 – 3, SP Ring Road – 3, SH-17 – 2, NH-8C – 1, Other – 1)</td>
<td>14</td>
<td>7%</td>
</tr>
<tr>
<td>Sharp curvature (SH-17 – 12, Other – 1)</td>
<td>13</td>
<td>6%</td>
</tr>
<tr>
<td>Animal/object on roadway (NH-8C – 6, NH- 8A – 2, SH-17 – 1, SH-71 – 1, Other – 2)</td>
<td>12</td>
<td>6%</td>
</tr>
<tr>
<td>Undivided road (SH-71 – 3, NH-8C – 2, NH-8A – 1, Other – 1)</td>
<td>7</td>
<td>3%</td>
</tr>
<tr>
<td>Work Zone (SH-71 – 2, NH-8C – 1,SH-17 – 1, SP Ring Road – 1, Other – 1)</td>
<td>6</td>
<td>3%</td>
</tr>
<tr>
<td>Deposits on road surface (oil, mud, fluids, etc.) (NH-8A – 2, SH-71 – 1, SP Ring Road – 1, Other – 1)</td>
<td>5</td>
<td>2%</td>
</tr>
</tbody>
</table>

Table 3: Contributing infrastructure factors influencing the occurrence of 211 accidents

Countering Infrastructure Factors that Contribute to Accidents

This section offers a brief description on the top four contributing infrastructure factors that influence accidents on some locations where they are prevalent.
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.

**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.

**Navapura Patiya**

**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,

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
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 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.

**Gap-in-median – 7%**

(NH-8C – 4, SH-71 – 3, SP Ring Road – 3, NH-8A – 2, SH-17 – 2, Other – 1)

When roads are divided by medians or barriers, the issue of crossing these becomes a problem. To help motorists on divided roads to change direction, the simple solution of providing an opening in the median was devised. What was forgotten in the process was basic traffic flow theory, and thus this "solution" has become a deadly feature on modern divided carriageways, challenging its very purpose: to allow smooth and safe travel.

**How to overcome the problems related to gap-in-median?**

At any point, a directional gap-in-median with deceleration lane is the most convenient design for all the road users. Median of width which is much greater than the average vehicle width may be a less desired alternate design for directional gap in median. This greater width serves as a stopping area or waiting area, thereby easing the through traffic flow. Adequate and effective positioning of signage indicating the existence of a deceleration lane before a gap-in-median is essential. Signage placed must be conspicuous even during dark lighting condition. Blinkers must be installed at the gap in medians, so that the road user can be aware of the existence of the gap in median. Gaps-in-median within city limits must be well lit. Shrubs and bushes planted on the median must be stopped at
least 20 to 40 meters before the start of the gap-in-median, so as to avoid problems related to vision obstruction. There must not be any gap-in-median at curved roads, hill crest, end of downhill, etc.

**Poor road marking/signage – 7%**
(NH-8A – 4, SH-71 – 3, SP Ring Road – 3, SH-17 – 2, NH-8C – 1, Other – 1)
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 to 7% 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.

**Sharp curvature – 6%**
(SH-17 – 12, Other – 1)
Curved roads have been recognized as a significant safety issue for many years, and the risk of a crash increases as the degree of curvature increases. The situation get worsened when it is accompanied by a change in the road gradient. A typical example for this condition is the curvature on Saij Bridge on SH-71. Studies have shown that loss-of-control accidents on curved roads result from a combination of incorrect anticipatory behavior and
inadequate perception of the demands of the curve. Successful curve negotiation depends upon the choice of appropriate approach speed and adequate lateral positioning through the curve. Negotiating curves thus requires more attention of the driver than while driving on a straight section of road.

**What are the reasons behind crashes at sharp curvature?**

Poor driver attention or failure to notice a curve ahead is the primary reason for crashes on curved roads. This may be due to familiarity with the route, fatigue, poor road information, poor road delineation, etc. The factor associated with decreased attention is that drivers may fail to notice warning signs and other cues needed to anticipate curves. The other factors influencing crashes in curved road are misperception of speed, misperception in trajectory and poor lane positioning. The most common reason behind curvature related crashes as perceived from this study is that the driver intends to maintain a speed in excess of the posted limit but below a level at which they believe they can safely negotiate the curve. Inadvertent speeding phenomenon is another important factor influencing accidents on curved roads. Drivers who have been traveling at a relatively high rate of speed for an extended period of time may habituate to that speed and underestimate the degree to which they are lowering their speed upon approaching a curved road.

**How to mitigate crashes on curved roads?**

**Infrastructure solution: Road information, signage and road delineation**

The key to safe vehicle operations is clear and adequate information about the road design. Speed control devices must indicate and induce the road user to maintain safe speeds required to negotiate the curve. To achieve this the following infrastructure solutions must be adopted.

- Advance warning sign with posted speed limits well ahead of the start of the curve.
- Speed limit must be posted at short intervals throughout the curve.
- Chevron signage with ‘repeater’ signs must be installed throughout the curve.
- Rumble strips or road markings must be installed on center and edge lines throughout the curve.
A proper localized speed data study is required to determine the speed limit of every accident prone location, which in turn will help in reduction of crashes.

**Infrastructure solution: Perceptual pavement marking**

Perceptual pavement markings are low cost countermeasures for speeding and decreased attention. Perceptual pavement markings give a psychological appearance of narrowing of road and/or increase in travel speed. Perceptual cues are one potential method of influencing motorists to slow down, and ultimately save lives. 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 crashes on curved road.

**Infrastructure solution: Super elevation**
Super elevation is another important infrastructure solution to prevent lateral acceleration on sharp curvature. Super elevation are banking of roads which creates a negative lateral acceleration. This feature enhances the rollover stability safety margin as well. Super elevation needs to be developed over some distance and transition curves are also often used to develop the super elevation. Rapid changes in super elevation can induce dynamic effects on the vehicle which may have a negative impact on stability and on road width requirements. The objective of preventing loss of control through super elevation can be achieved only with a proper design.

Vehicle Engineering: Electronic stability Control

In critical driving situations most drivers are overburdened with the task of stabilizing the vehicle. Electronic Stability Control (ESC) is an active safety system which has shown potential in preventing or reducing the severity of crashes on sharp road curvatures. This system essentially is an extension of technologies used in Anti-lock Braking System (ABS) and Traction Control System (TCS). ESC compares the driver’s steering intentions with the vehicle’s heading direction and intervenes by braking individual wheels and/or by reducing engine torque to correct for any variance. ESC considerably reduces the risk of loss of control, rollovers, lateral acceleration, etc. by

- Correcting impending over steer and under steer maneuvers.
- Stabilizing the vehicle during sudden evasive maneuvers e.g. swerving
- Improving handling on slippery terrains, e.g. loose gravel, wet roads, etc.
**HUMAN FACTORS INFLUENCING INJURY OCCURRENCE**

For the 211 accidents examined, 88 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 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 human factors influencing injuries (50%).*

<table>
<thead>
<tr>
<th>Contributing Human Factors (Injury Occurrence)</th>
<th>Number of Accidents</th>
<th>Percentage influenced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helmet not used (26 M2Ws, 1 Bicycle)</td>
<td>27</td>
<td>31%</td>
</tr>
<tr>
<td>Seat belt not used (11 Cars, 1 Mini truck)</td>
<td>12</td>
<td>14%</td>
</tr>
<tr>
<td>Overloading of occupants (number of occupants &gt; seating capacity) (2 M3Ws, 1 M2W, 1 Minibus)</td>
<td>4</td>
<td>5%</td>
</tr>
<tr>
<td>Occupants in cargo area (1 M3W)</td>
<td>1</td>
<td>1%</td>
</tr>
</tbody>
</table>

**Table 4: Contributing human factors influencing the occurrence of fatal/ serious injuries in 88 fatal/ serious accidents**

As can be seen from the table, Helmet not used, Seatbelt not used and Overloading of occupants together has contributed to 50% of injuries in fatal and serious injury accidents.

**Countering Human Factors that Contribute to Injury**

**Helmet not used – 31% (26 M2Ws, 1 Bicycle)**

India is the second largest 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**

The statistics are bleak. Over 50% of crashes in the RASSI database involved at least one M2W, and 51% of those riders suffered fatal injuries and 41% sustained serious injuries.
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. However, despite stringent safety regulations and laws, the RASSI data shows that approximately 85% of M2W riders involved in crashes in India did not wear the single most protective piece of equipment available to them—a helmet.

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.**
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.

**Seat belt not used – 14%**  
(11 Cars, 1 Mini truck)

Seat belts are designed to secure occupants in a safe position within the vehicle in the case of an accident or sudden stop. Seat belts have been proven to reduce injury severity by preventing occupants being ejected from the vehicle entirely or from the seat and into hard objects such as the windshield. Seat belts should be worn by all occupants, including rear seat occupants and usage of child seats must be promoted. Seat belts are compulsory even for commercial vehicle drivers. The photos shown below were taken a few milliseconds after an impact to show how belted and unbelted rear occupants move in an accident.
As can be seen in the above figure, the belted rear occupant is restrained to his seat position, while the unbelted rear occupant moves forward and impacts the driver's seat back. Hence, rear row occupants can cause serious (and avoidable) injuries to the front row occupants by impacting them from behind, even if the vehicles are equipped with airbags.

The majority of occupants in the crashes had not worn seat belts, and this was a major factor in determining the nature and severity of the injuries sustained. Bodies governing transportation and traffic safety should focus on some serious strategies and regulations to enforce usage of seatbelts. Public awareness campaigns encouraging belt use should stress that (1) all occupants in a vehicle should wear seat belts and (2) that airbags are secondary restraints, and as such are not effective—and sometimes dangerous—if seat belts are not used as the primary restraint system (as shown in the above image).

**Overloading of occupants — 5%**
(2 M3Ws, 1 M2W, 1 Minibus)

Overloading of people is not only a serious accident causation factor (as seen earlier in this report), this is an important injury causation factor as well. Overloading can have serious consequences, particularly in an accident situation. In an event of a collision the occupants get thrown violently against the direction of colliding force contacting fellow occupants, at times even crushing the occupants. Secondly, overloading of people reduces the possibility of fastening seatbelts so as to accommodate more people, non-usage of seatbelts as described earlier is a prime injury causation factor.
**How to restrict overloading of people?**

As most countries have learned, public education is the first step, followed by enforcement. Public education must emphasize the safety issues related to travelling on an overloaded vehicle and must promote usage of public transport instead. At control points, such as police beat, Traffic signals, etc., heavy fines must be levied on vehicles which are overloaded with occupants (as shown in the picture on the left). Children, especially should be counted as occupants and must be given proper seating space (child seats must be used) rather than accommodating them on laps of other occupants. Police could be notified of vehicles that appear to be in violation.
VEHICLE FACTORS INFLUENCING INJURY OCCURRENCE

For the 211 accidents examined, 88 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 percentage influence will not be equal to sum of vehicle factors influencing injuries (93%). Also factors with negligible counts have not been included in the table for analysis.

<table>
<thead>
<tr>
<th>Contributing Vehicle Factors (Injury Occurrence)</th>
<th>Number of Accidents</th>
<th>Percentage Influenced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knock-Down (29 M2Ws, 8 Pedestrians, 2 Bicycles)</td>
<td>39</td>
<td>44%</td>
</tr>
<tr>
<td>Seatbelts not available/usable (12 M3Ws, 3 Trucks, 2 Buses, 1 Mini truck, 1 Other)</td>
<td>19</td>
<td>22%</td>
</tr>
<tr>
<td>Non-enclosed occupant cabin (11 M3Ws, 1 Other)</td>
<td>12</td>
<td>14%</td>
</tr>
<tr>
<td>Ejection (9 M3W, 1 Truck, 1 Bus, 1 Other)</td>
<td>12</td>
<td>14%</td>
</tr>
<tr>
<td>Passenger Compartment Intrusion – Other (5 Cars, 2 Buses, 1 Mini truck, 1 Other, 1 M3W)</td>
<td>10</td>
<td>11%</td>
</tr>
<tr>
<td>Fall - down (10 M2Ws)</td>
<td>10</td>
<td>11%</td>
</tr>
<tr>
<td>Run over (for Pedestrian, M2W riders) (3 M2Ws, 2 Trucks)</td>
<td>5</td>
<td>6%</td>
</tr>
<tr>
<td>Passenger Compartment Intrusion - Underride/Override (3 Cars, 1 Minibus)</td>
<td>4</td>
<td>5%</td>
</tr>
<tr>
<td>Entrapment (1 Car)</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Protruding/oversized cargo (1 Truck)</td>
<td>1</td>
<td>1%</td>
</tr>
</tbody>
</table>

As can be seen from the table, the top four factors has contributed to 94% of the fatal and serious injuries.

Countering Vehicle Factors that Contribute to Injury

**Knock-Down – 44%** *(29 M2Ws, 8 Pedestrians, 2 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 can be seen from table 5, two wheeler occupants were the most affected (75%) due to knock down related injuries and fatalities. Majority of the motorcyclists suffered serious or fatal injuries primarily to the head, thorax and upper and lower extremities (arms and legs). Pedestrians did not fare well in this mismatched contest either.

Reducing Severity of Injuries

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. A number of active and passive pedestrian protection systems are already being road-tested, although none are widely available yet.

Seatbelts not available/usable – 22%

(12 M3Ws, 3 Trucks, 2 Buses, 1 Mini truck, 1 other)

Although all cars are equipped with seat belts, it is common in Indian cars for the seat buckles to be 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 protectively, as designed, this “problem” goes away entirely. And there is certainly nothing comfortable about being thrown around a vehicle in the event of an accident.

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

<table>
<thead>
<tr>
<th>In almost every pickup truck in India, the seatbelt is either inoperative or not available</th>
<th>Almost every Indian truck has this issue – no seat belts at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>Although seat belts are present, people consider them a hindrance—so they hide the buckles</td>
<td>Auto rickshaws are vehicles that cannot be equipped with seatbelts</td>
</tr>
</tbody>
</table>
Non-enclosed occupant cabin – 14%
(11 M3Ws, 1 Other)
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 shown in Table 5, non-enclosed occupant cabin has contributed to 14% of serious or fatal injuries and the condition is most prevalent in cases involving Auto rickshaws. 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.

Ejection – 14%
(9 M3Ws, 1 Truck, 1 Bus, 1 Other)
Ejection is a condition where an occupant is thrown out partially or completely outside the vehicle through any medium in an event of crash. As can be seen from table 5, the condition is most prevalent in auto rickshaws. Ejection in auto rickshaws are a consequence of poor vehicle design such as improper weight distribution, poor vehicle dynamics, non-enclosed occupant cabin and non-availability of seatbelts. Due to friable cabin construction, ejection through roof is also prevalent. Ejection in other vehicles such as trucks and buses are a result of non-availability/non-usage of seatbelts and poor construction of occupant cabin.
How to prevent an occupant from ejection?

As mentioned earlier in this report, quadricycles which are reasonably safer than the auto rickshaws is the only solution to overcome the limitations of an auto rickshaw. Quadricycles are dynamically stable, and is less prone to occupant ejection, the reason being, it is enclosed on all sides and can be equipped with seatbelts. This also answers the problem of overloading of occupants. As far as heavy vehicles are concerned, usage of seatbelts must be mandated for all commercial vehicle drivers. Buses and trucks equipped with factory built coaches and cabins must be promoted. Newly built aftermarket coaches and cabins must meet specific safety standards which are on par with OEM standards. Only few preset coach and cabin designs, which are verified and approved by automakers and government bodies for cabin crashworthiness must be used on trucks and buses. This way the homologation issue among third party built coaches and cabins can also be answered. All existing commercial vehicles must be thoroughly scrutinized for cabin integrity and occupant safety.
INFRASTRUCTURE FACTORS INFLUENCING INJURY OCCURRENCE

For the 211 accidents examined, 88 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 (6%).

<table>
<thead>
<tr>
<th>Contributing Infrastructure Factors (Injury Occurrence)</th>
<th>Number of Accidents</th>
<th>% Influenced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object impact - roadside/median - manmade structures (NH-8C – 2, SH-71 – 1, Other – 2)</td>
<td>5</td>
<td>6%</td>
</tr>
<tr>
<td>Roadside - steep slope/drop off (NH-8C – 1, SH-71 – 1)</td>
<td>2</td>
<td>2%</td>
</tr>
</tbody>
</table>

**Table 6: Contributing Infrastructure Factors Influencing the Occurrence of Fatal/Serious Injury in 88 Fatal/Serious Accidents**

As can be seen from the table, man-made structures along the side of the road or in the median and roadside steep slopes or drop offs influenced injury occurrence in 8% of the fatal-serious accidents.

**Countering Infrastructure Factors that Contribute to Injury**

**Object impact - roadside/median - manmade structures (NH-8C - 2, other roads - 2, SH-71 - 1)**

Object impact on national highways and state highways under city limits are often due to vehicle departing the roadway as a result of sudden evasive maneuver, driver distraction, loss of control, 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 and occupants.

Object impacts are highly undesirable as the risk of injuries in these case 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”.
**How to make roadside manmade structures “forgiving”?**

<table>
<thead>
<tr>
<th>Variable W beam guardrail</th>
<th>Concrete Jersey barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact attenuator</td>
<td>Pultruded composite guide rail system</td>
</tr>
</tbody>
</table>

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. Devices such as crash barriers and impact attenuators are classic solutions to such problems. These devices are designed to reduce the damage to both the structures and to the vehicles and their occupants. Impact attenuators, for example, 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. Various types of barriers are, in contrast, designed to redirect the vehicle away from the hazard or provide a solid defense against being breached. Advanced crash barriers like pultruded composite guiderail or guardrail system, incorporates glass fiber composites which offer a controlled deceleration even at high speed collisions. Proper repair and maintenance (post-crash) of these barriers offer best protection and determines the success of these barriers in long run.
Safe road design is becoming increasingly important with the rise in traffic speed and volume. Generally roadways include numerous bridges, flyovers with steep slopes and drop offs. It has been noted that adequate barriers are not provided to prevent vehicles from tipping over and plummeting down the slopes, thereby causing injuries to the vehicle occupants.

**How to reduce the risk involved in steep slopes and drop offs?**

**Infrastructure solution: Crash barriers**

Well engineered crash barriers must be deployed on roadway. Crash barriers, irrespective of its type, are expected to guide the vehicle back on the road while keeping the level of damage to the vehicle as well as to the barriers within acceptable limits. Ideally a crash barrier should present a continuous smooth face to an impacting vehicle, so that the vehicle is redirected, without overturning and passing over the barrier, and the rate of deceleration must be such as to cause the minimum risk of injury to the passengers. The crash barriers must be designed to accommodate vehicles of varying speeds and masses (from scooters to heavy duty trucks).
Infrastructure solution: Clear zone

Another way to avoid such impacts is to not have any immovable objects in the space around roads. This is not always possible to retrofit, but can be planned for in the design stage. This concept, called clear zones, is being used in many countries around the world.

A Clear zone is an unobstructed, relatively flat area beyond the edge of the roadway that allows a driver to stop safely or regain control of a vehicle that has left the roadway. It consists of a shoulder, a recoverable slope, a non-recoverable slope and/or a clear run-out area. The desired minimum width of a clear zone is dependent upon the traffic volumes, speeds and the roadside geometry.
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 February 2014 to February 2015 on select highways and other roadways of Ahmedabad and Gandhinagar districts—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 (February 2014 to February 2015) accident investigation data for the important roads, this study concludes the following:

1. Cars and motorized two wheelers pose highest risk of accidents among all road users, each contributing 28% of accidents.

2. M2Ws are the most affected road user as far as injuries are concerned. M2Ws constitute 53% of road users consisting of at least one fatal occupant and 47% with at least one seriously injured occupant.

3. “Collision with vehicle moving in the same direction” and “Collision with turning or crossing vehicles” are the most prevalent accident types occurred in our study area, each type contributing 22% of accidents.

4. Human factors had the major influence on the occurrence of all accidents and vehicle factors had major influence on the occurrence of fatal / serious injury accidents.
   - Human factors alone (49%) had the highest influence on the occurrence of accidents followed by the combination of human and infrastructure factors (35%).
   - Vehicle factors alone (47%) had the greatest influence on the occurrence of fatal / serious injuries followed by a combination of human and vehicle factors (40%).

5. The main contributing factors leading to accidents are:

<table>
<thead>
<tr>
<th>Human (91%)</th>
<th>Vehicle (10%)</th>
<th>Infrastructure (44%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Speeding</td>
<td>• Defective Tyre</td>
<td>• Intersection</td>
</tr>
<tr>
<td>(42%)</td>
<td>(3%)</td>
<td>(13%)</td>
</tr>
<tr>
<td>• Violation related</td>
<td>• Overloading of People</td>
<td>• Gap-in -median</td>
</tr>
<tr>
<td>(18%)</td>
<td>(3%)</td>
<td>(7%)</td>
</tr>
<tr>
<td>• Driver distractions</td>
<td></td>
<td>• Poor road marking and signage</td>
</tr>
<tr>
<td>(13%)</td>
<td></td>
<td>(7%)</td>
</tr>
<tr>
<td>• Improper lane change &amp; poor turning maneuvers</td>
<td></td>
<td>• Sharp curvature</td>
</tr>
<tr>
<td>(12%)</td>
<td></td>
<td>(6%)</td>
</tr>
</tbody>
</table>

6. The following solutions will help reduce road traffic accidents and its severity in Ahmedabad and Gandhinagar districts:
   - 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 (Speeding, the most influential human error contributed to 42% of the road accidents.)
• Rulemaking, educating road users the concept of right of way, strict law enforcements to inculcate the practice of right of way among road users and stop rule breaking practices. (Violation related human errors contributed to 18% of the road accidents.)

• Public awareness campaigns educating the consequence of distracted driving, stringent rules against mobile driving, incorporating advanced vehicle technologies and improved road engineering to reduce driver distractions. (Driver distraction, an inherent human error contributed to 13% of road accidents.)

• Enhanced road design, improved road furniture, incorporating advanced vehicle technologies to mitigate accidents during sudden turning maneuvers and to encourage lane discipline and proper signaling. (Improper lane change/ lane usage and sudden turning maneuvers contributed to 12% of the accidents.)

• Traffic Safety awareness campaigns emphasizing the significance of tyre maintenance and public-private partnerships in setting up free vehicle fitness checkup camps to solve the problem of tyre failures. (Defective tyre, a predominant vehicle defect seen in our study has contributed to 3% of accidents.)

• Educating people on the consequences of overloading and stringent enforcement against overloading of occupants can help reduce the problem of overloading of occupants. (Overloading of occupants, a serious delinquent commonly neglected by traffic authorities of Ahmedabad and Gandhinagar has contributed to 3% of road accidents.)

• Enhanced infrastructure solutions, futuristic road design to reduce accidents at intersections and gap in medians. (Intersections and gap in medians are leading infrastructural factors that has contributed to 20% of 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 has contributed to 7% of accidents.)

• Enhanced road information, perceptual road marking techniques, improved road engineering and integrating advanced vehicle equipment to reduce accidents related to road curvature issues. (Sharp curvature, a problem limited to a single location in our study has contributed to 6% of the accidents.)
7. The main contributing factors leading to fatal/serious injuries are:

<table>
<thead>
<tr>
<th>Human (50%)</th>
<th>Vehicle (93%)</th>
<th>Infrastructure (6%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helmet not used</td>
<td>Knock-Down</td>
<td>Object impact – roadside</td>
</tr>
<tr>
<td>(31%)</td>
<td>(44%)</td>
<td>manmade structures</td>
</tr>
<tr>
<td>Seatbelts not used</td>
<td>Seatbelts not available or not usable</td>
<td>Road side - steep slope/drop off</td>
</tr>
<tr>
<td>(14%)</td>
<td>(22%)</td>
<td>(6%)</td>
</tr>
<tr>
<td>Overloading</td>
<td>Non-enclosed occupant cabin and ejection</td>
<td>(2%)</td>
</tr>
<tr>
<td>(5%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. The following actions are likely to reduce the number of accidents that result in fatality or serious injury on the selected roads of Ahmedabad and Gandhinagar districts:

- **Enforcing usage of helmets (ensure that helmet meets the standardized quality) and seat belts. Also punishing the felony against overloading of occupants to mitigate fatal/serious injury outcomes.**
  (Failure to use helmets, failure to use seat belts and overloading of occupants, the topmost human errors together has contributed to 50% injuries in fatal and serious injury accidents.)

- **Improved pedestrian infrastructure and promoting usage of riding gears among motorists to bring down knock-down related fatal and serious injuries.**
  (Knock-down of motorized two wheeler occupants and pedestrians has contributed to 44% of fatal and serious injury outcomes.)

- **Mandating safety equipment and their usage among all vehicles, improved cabin integrity, crashworthiness and rollover protection among trucks and buses to mitigate fatal and serious injury outcomes.**
  (Non-availability/ non-usage of seatbelts, poor occupant enclosure and ejection together has contributed in occurrence of 50% of fatal and serious injuries.)

- **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 serious and fatal injury outcomes.)

Even implementation of few of the suggested measures will help achieve significant reduction in the number of accidents and injuries on the roads of Ahmedabad and Gandhinagar.

In addition, changes in vehicles such as enhanced compartment integrity and crash compatibility among trucks and buses, phasing out motorized three wheelers and promoting factory built trucks and coaches (altogether vehicle factors contributed to 94% of fatal/serious injury outcomes) could make a big difference in the injury outcomes, but would take some years to implement all the recommended changes.
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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Mr. Ajit Dandapani (ajitd@jpresearch.com)

Website: www.rassi.in
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. 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.