The New In-Depth, At-the-Scene, Accident Investigation Database in India

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Abstract   India's staggering record of traffic fatalities has created an urgent need to understand, and mitigate, the factors involved in these crashes. But understanding relies on having quality, in-depth data available for analysis. To provide such data, a consortium of vehicle manufacturers and researchers, with support from the police, developed a methodology for investigating and recording crash and injury details for road traffic accidents occurring on South Indian highways. This paper describes key features of the India-centric data collection methodology, which uses established techniques to make it compatible with studies in countries such as the USA, UK, and Germany while addressing issues unique to India. The paper also offers recent findings from this ongoing study. A total of 377 accident investigations carried out in Coimbatore District (Tamil Nadu) over a period of two years involved analysis of 150 fatal crashes (with 167 rider/occupant and pedestrian fatalities), 147 serious-injury crashes (219 injuries), 45 minor-injury crashes (65 injuries), and 35 no-injury crashes. Of the 377 accidents investigated, 40% were fatal, 39% were serious, and the majority of the impacts were head-on frontals (31%) followed by front-side collisions (15%). Significantly, motorcycle collisions with trucks, cars and buses constituted 34% of the accidents.

Keywords   Road accidents in India, in-depth data, accident investigation, injury causation

I.   INTRODUCTION

Reports from the World Health Organization indicate that India has the highest number of traffic accident fatalities in the world [1]. Obviously, there is an urgent need to understand road safety issues and develop immediate measures to mitigate accidents and injuries on Indian roads. This calls for in-depth accident data to be collected in a standardized format to identify major problem areas and determine feasible solutions.

Background

Many developed countries have in-depth accident data collection programs that are used not only to understand accidents and injury causation, but also to develop safety strategies aimed towards improving vehicle safety and road infrastructure. India currently has only one mechanism for collecting road accident data, and that is from police accident investigations. This data collection method is similar to that used by police in other countries, and the data are used for similar purposes. The police data are analyzed by two government organizations to publish two annual reports: "Accidental Deaths and Suicides in India" [2], published by the National Crime Record Bureau, and "Road Accidents in India" [3], published by the Transport Research Wing, Ministry of Road Transport and Highways (MORTH). These reports provide an understanding of fatal road traffic accidents at a national level and include information such as type of road users (age, sex, and vehicle type), incidence rates for states and cities, road type, etc. Data from these reports clearly show that the number of fatal accidents has been increasing over the last 10 years. In fact, a recent MORTH report shows that the rate of fatal traffic accidents (as a share of all road traffic accidents) on Indian roads has steadily increased from just under 18% in 2001 to over 24% by 2011, with accident severity showing a similar climb, from 19.9 persons killed per 100 accidents in 2001 to 28.6 persons killed per 100 accidents by 2011 [3].

Figure 1 shows the percentage distribution of fatalities by road user type for India in 2011 [2]. Of the 136,834 fatalities recorded that year, motorized two-wheeler (M2W) riders accounted for 22%, followed by heavy truck occupants at 19%. These statistics indicate a stark difference from developed countries, where occupants of passenger vehicles (cars and light trucks) account for the highest numbers of traffic fatalities.

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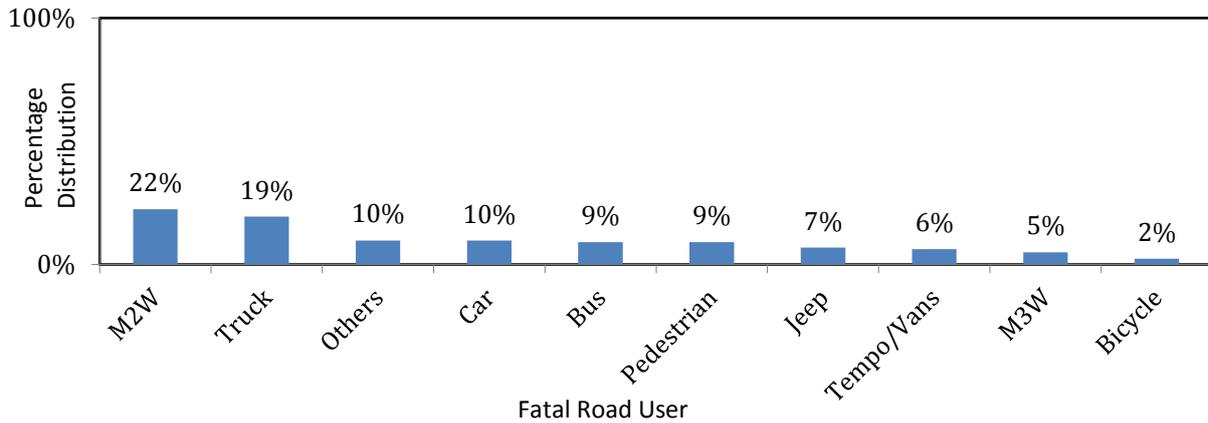
Figure 1. Percentage Distribution of Fatalities in India by Road User Type for 2011 [2]
Source: National Crime Records Bureau (NCRB)

About 63% of road accident fatalities in India occur on national and state highways [3], which constitute only about 7% of the Indian road network [4]. Currently, in-depth accident investigation and data collection at a national level is not available in India; however, some in-depth investigations of road traffic accidents have been carried out over the last few years on some national highways in the Indian state of Tamil Nadu [5]-[8]. The accelerating economic growth in India, coupled with an increasing vehicle population and the lack of a national in-depth accident data collection warrants an urgent approach for developing a standardized data collection scheme in India. Hence this study.

An In-depth Accident Database for India

An ongoing, standardized in-depth accident investigation and data collection study was established by JP Research India Pvt. Ltd. (JPRI) in 2011, subsequent to pilot studies conducted in a few regions with the cooperation of state police authorities between 2008 and 2010. This database, which is the first of its kind in India, is called the "Road Accident Sampling System – India" (RASSI), and it is currently supported by a consortium of automobile and component manufacturers. This paper describes the methodology and preliminary results associated with the RASSI data collection effort. The study also highlights some of the realities of performing data collection studies in a developing country.

RASSI evolved from a project that was conceived and implemented by JPRI and its parent company, JP Research, Inc. (JPR-USA), starting in January 2008. During the first two years, effort was extended to develop standardized in-depth data collection on vehicle accidents (including computerized database development). Pilot studies were conducted by JPRI from 2008-2010 in the districts of Kanchipuram and Coimbatore with the cooperation of the Tamil Nadu State Police to ensure on-scene, in-depth data collection was possible in India.

In 2011, the RASSI consortium was established. Robert Bosch GmbH became the first consortium member and contributed valuable suggestions and inputs during the initial stages of data collection, documentation and crash investigation in 2010-2011. Currently, RASSI consortium members include: JPR-USA, Mercedes-AG, Robert Bosch GmbH, Nissan Motor Company, Renault SAS and Hyundai Kia Motor Company.

II. METHODS

The accidents investigated by the crash researchers are coded in the RASSI analytical database. This comprehensive database is based on international databases such as the US National Automotive Sampling System – Crashworthiness Data System (NASS-CDS), the German In-Depth Accident Study (GIDAS), and the UK's Co-operative Crash Injury Study (CCIS), but it was designed and developed to reflect Indian conditions.

Standardized crash selection criteria, a relational database, coding manuals and definitions of variables to accurately record Indian road accident experience were developed from the onset. Currently, RASSI collects information on over 700 variables for human, vehicle, road and environmental factors associated with crashes, making it the most comprehensive crash data collection effort in India. A number of detailed system validations are conducted to check the accuracy, completeness, quality and reliability of data entries, and the entire process — from crash investigation, through accident reconstruction, injury coding and correlation, data review and quality control — is completed within 70 days from the date of accident inspection.

Crash Notification Sources

Notifications about crashes in the study area are obtained from the following three sources using toll-free numbers monitored throughout the day:

- **Police** – The police use the toll-free numbers to inform study teams about crashes that have occurred in their limits. This includes calls made by police stations and highway patrols.
- **Ambulances** – Toll-free calls are also received from ambulances (EMS) while travelling to the scene of an accident. Notifications of crashes occurring in the study area are also received in the form of text messages from government-operated ambulances.
- **Crash Teams** – In India, there is no systematic, immediate police crash notification to date. To conduct on-scene inspections, the teams must reach the sites while scene evidence is still available. Currently, only 4% of RASSI crashes are notified by police. A significant effort is, therefore, made by the teams to locate crashes on their own. This includes**:** teams patrolling the study areas every day; calls made to the individual police stations every day; visits to the police stations in person to pick up accident notifications; and self-notification of accidents happened-upon while travelling to a police station or accident scene. The problems involving lack of immediate crash notification process in India are discussed in detail under the Discussion section of this paper.

Study Area

The first data collection center was established in Coimbatore in 2011 (a city in the state of Tamil Nadu). Subsequently, in 2012, an additional center was established (in Pune). This study focuses on crashes investigated in Coimbatore. The geographical area includes urban, semi-urban and rural limits of Coimbatore district and covers four national highways and four state highways for a stretch of roads totaling around 151 km (Figure 2). The crashes seen in the study area are mostly fatal and serious.
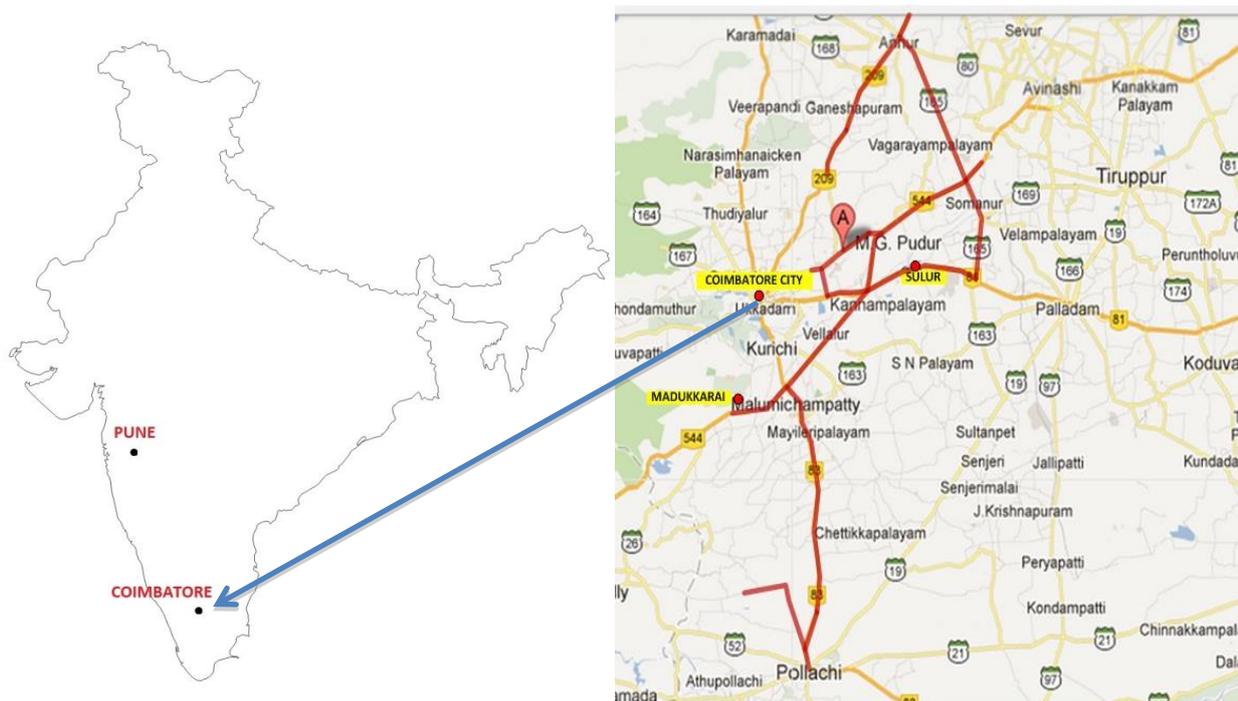
Figure 2. Map of India showing Coimbatore and Pune Districts, with the Study Stretches marked in red. The location of the study office is also shown (A).

Accident Selection Criteria

The basic criteria to be met for investigating a crash are as follows:

1. Accident must involve at least one motorized vehicle.
2. Crash spot has to be on a public road within the study area.

However, for an accident to be eligible for RASSI, the following provisions also need to be met:

1. The crash spot should be identifiable by: known final rest positions (photographs, etc.); vehicle

trajectories (skid or brake marks, etc.); or other evidence (debris, damaged fixed objects, eyewitness).

2. The crash spot should also yield measurements of the road, skid marks, and any other evidence.
3. Vehicles should be examined to obtain data such as direct damage details, crush profile, intrusions, contacts, and safety system use.
4. Make and model of all the vehicles involved in the crash should be known.
5. In case of pedestrian, bicyclist, or M2W crashes, the other vehicle should be available for inspection.
6. The vehicles with highest injury severities must be available for inspection for all other crash types.

Crash Investigation

Each team consists of researchers trained in vehicle inspection, scene examination and injury coding. Interviews are also conducted at the scene, if possible.

Scene Examination— Crash scene inspection includes taking pictures of roadways and vehicle paths, as well as final rest positions of the vehicles if they are still at the scene. In addition, photos are taken of any scene evidence, such as skid marks, debris or gouges in the roadway. A scene sketch of the crash scene is then created, which includes the roadway, vehicle trajectories, scratch marks, debris location, oil pool, blood pool and final rest positions of the involved vehicles. A measuring wheel is used to take scene measurements based on a Cartesian coordinate system. These measurements are then input into the software (Figure 3). Global Positioning System (GPS) logs are also taken for every accident, in order to map out the crash locations. Finally, infrastructure variables are collected on scene to be entered into the database. These include road and roadside configuration, traffic control information, road and weather conditions and other pertinent information.
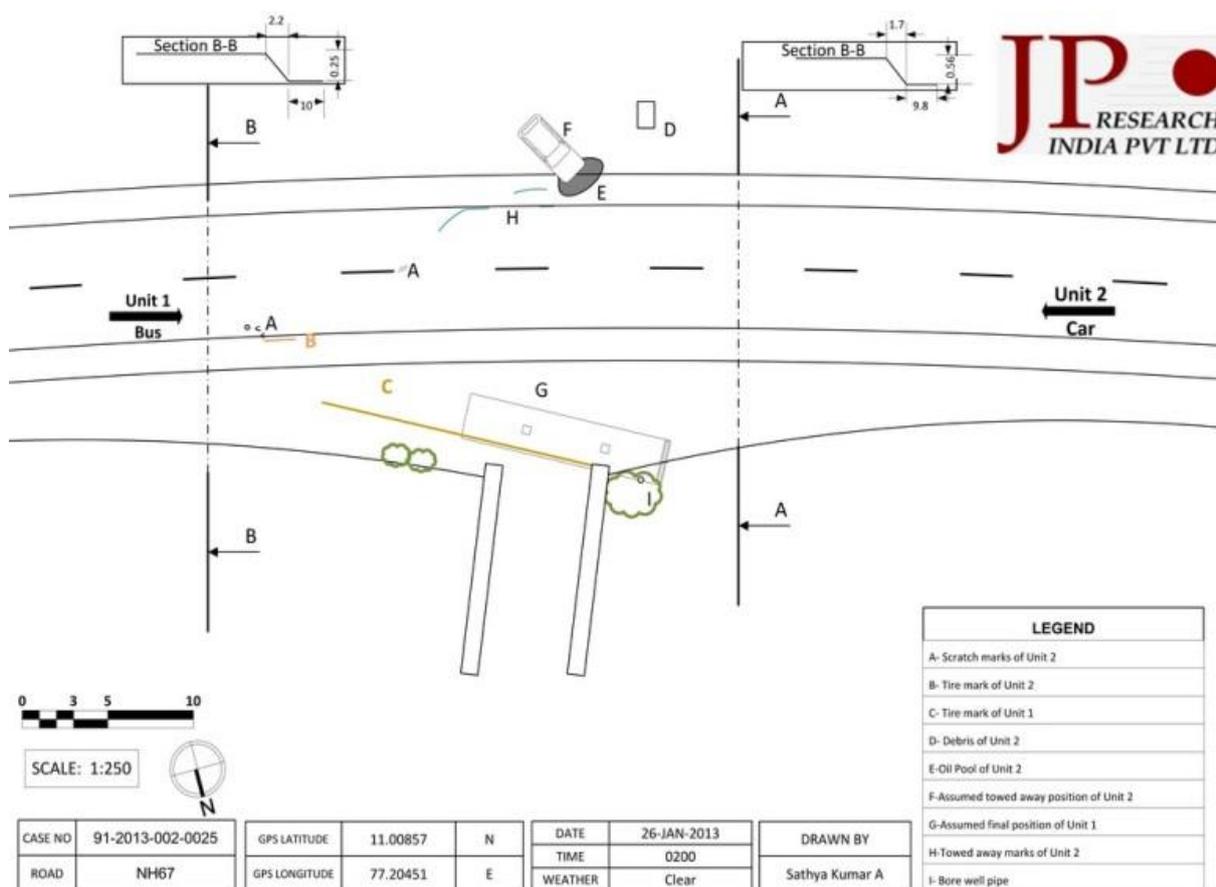
Figure 3: Microsoft Visio Drawing of Scene and a Scene Picture with Truck's Final Position

Vehicle Examination— Crash vehicles are examined at the crash scene when possible. If crash vehicles were already towed away, vehicle inspection is conducted at the police station.

Exterior Examination: The exterior parts of the vehicle are examined to ascertain the impact and damage profile (direct and indirect). The impact is coded using the well-established Collision Deformation Classification (CDC) [9] code developed by the Society of Automotive Engineers: SAE J224. A similar code for Truck Deformation Classification (TDC, SAE J1301) [10] is also available. However, codes to describe the impact on

vehicles such as M2Ws and buses are not available. In such cases, a truncated CDC using only the first 3 digits is used.

The impact damage is also quantitatively measured along the crush profile. The depth of the damage (crush) is measured at several equidistant points (Figure 4). The depth of damage at its maximum point on the impact (maximum crush) is also ascertained. These values are required for determining other properties of impact such as collision severity (e.g., delta-V, EES). Finally, whenever possible, each impact is correlated to the impacts on the collision partner. The impacts are examined for evidence, such as paint transfer or deposited debris (e.g., metal, tree bark, graze from contact with a solid object), that can confirm such correlations.

Figure 4. Crush Profiling

Road user contacts (e.g., motorcycle riders, pedestrians) on the exterior surface of the vehicle are recorded on a vehicle outline sketch. In case of pedestrian impacts, contact points made by the pedestrian on the vehicle are mapped on a pedestrian-vehicle interaction mapping sketch. One horizontal axis is drawn at the base of the windshield, and another along the longitudinal axis of the vehicle. The contact points are then measured along both axes and plotted on the sketch along with respective coordinates (Figure 5). The wrap-around distance is measured and recorded wherever possible.
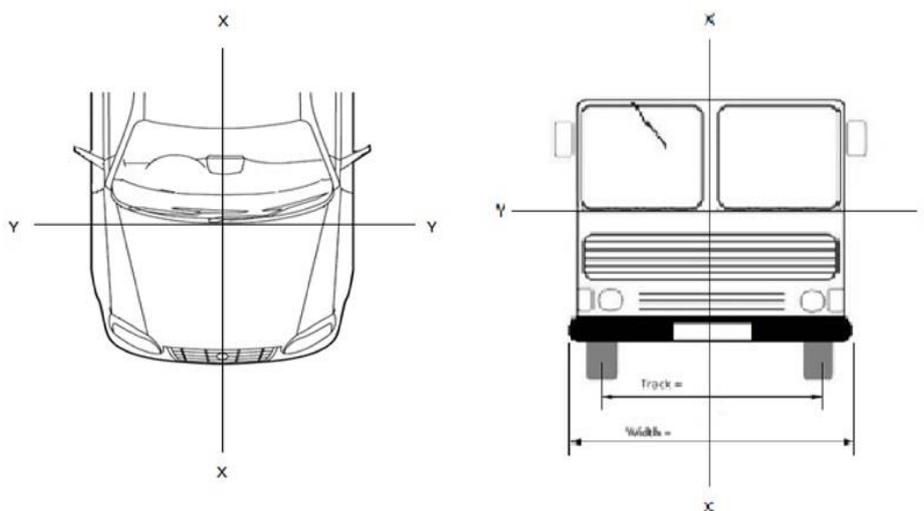
Figure 5. Pedestrian Contact Mapping on Vehicles

Tire pressures and tread depth are also measured and recorded for all wheels of the accident vehicle, and any damage or restriction to the tire or wheel rim is noted. In addition to the above, regulatory compliance is also checked for features such as wipers, tail lamps, head lamps, rear view mirrors, indicators, reflective markings, cargo and overloading.

Interior Examination: The interior of the vehicle is examined to identify any intrusion into the passenger compartment, any occupant contacts with the interior components and structures, and any use of and deployment of safety systems such as seat belts, pre-tensioners and airbags. The intruding component is identified, and reduction in occupant space in any of the 3 axes (longitudinal, lateral or vertical) is determined. Deformation of structures due to loading from occupants and interior occupant contacts are used in identifying the occupant kinematics during the crash. Airbags and seat belt components (webbing, pre-tensioners, etc.) are also examined using well-established methods to ascertain whether they have been deployed or used by the occupant. Finally all views of the vehicle, the damage locations, occupant contact evidence and any salient points on the vehicles and collision partners are photographed.

Pre-Crash Event— The pre-crash event is an important indicator of road user action prior to the collision. Bosch (a consortium member) obtained the permission from GDV (German Insurance Association), who developed this Accident Classification System, and modified the pre-crash event codes for Indian condition. The modifications are based on factors aggregated into the following seven primary categories: Loss of control, turning off, turning in, avoiding or colliding with parked vehicles, pedestrian crossing, lateral traffic and "other" accidents. A detailed description of these events is presented in Appendix 1.

Accident Reconstruction

Reconstruction of an accident is performed based on the accident data collected during the examination of the crash scene and the crash vehicles. Accident reconstruction helps to estimate important crash severity indicators, including pre-impact vehicle speeds, heading angle, acceleration/deceleration rate and delta-V. The accident data collected combined with the vehicle specification data are used for crash reconstruction using the proprietary accident simulation software PC Crash [11]. In some cases, empirical formulas, in combination with laws of physics, are used for estimating the necessary values. Currently, no publicly available data on vehicle stiffness are available for Indian vehicles. Hence, sister vehicles or comparable vehicles sold in Europe/USA are used as vehicle parameters input to PC Crash.

Injury Coding and Correlation

Injury data are obtained from the police or hospitals. The police station responsible for dealing with the particular accident will also routinely obtain injury details from the hospital and coroner's office. However in cases of non-police reported accidents, injury details need to be obtained directly from hospitals and coroners. The injury severities of the accidents are coded as per the police records and witness statements, in the absence of injury reports of the victims.

The injuries are then coded using the Abbreviated Injury Scale (AIS), version 2005, developed by the Association for the Advancement of Automotive Medicine (AAAM) [12]. AIS-coded injuries are then correlated with the occupant contacts to identify the injury mechanisms that can be subsequently used in developing injury mitigating measures. Finally, all the data collected from the accident scene, vehicle examination, and occupant injury files are collated in a systematic manner and input to the RASSI database.

As part of this study, a total of 377 accidents were investigated on various national and state highways in Coimbatore District over nearly 151 km of roads. Of these 377 accidents, 150 crashes resulted in fatalities, 147 resulted in serious injuries, 45 resulted in minor injuries, and 35 resulted in no injury.

III. RESULTS

This section presents some of the results based on the first few years of the RASSI crash investigation and documentation project in India. Of the 377 crashes investigated, 15% were single-vehicle crashes and 11% were pedestrian crashes. About 74% were multiple-vehicle crashes.

Crash Configuration

Figure 6 shows the distribution of crashes by first event in the crash sequence. Most of these accidents occurred on undivided roadways, which may account for the larger number of head-on collisions. 10% of the crashes involved collision with an object (fixed or non-fixed), and 5% were first event rollovers. Rear-end collisions accounted for nearly 14% of investigated crashes.

Injury Severity

Figure 7 shows the distribution of crashes by injury severity. About 80% of crashes investigated were fatal and serious injury crashes.
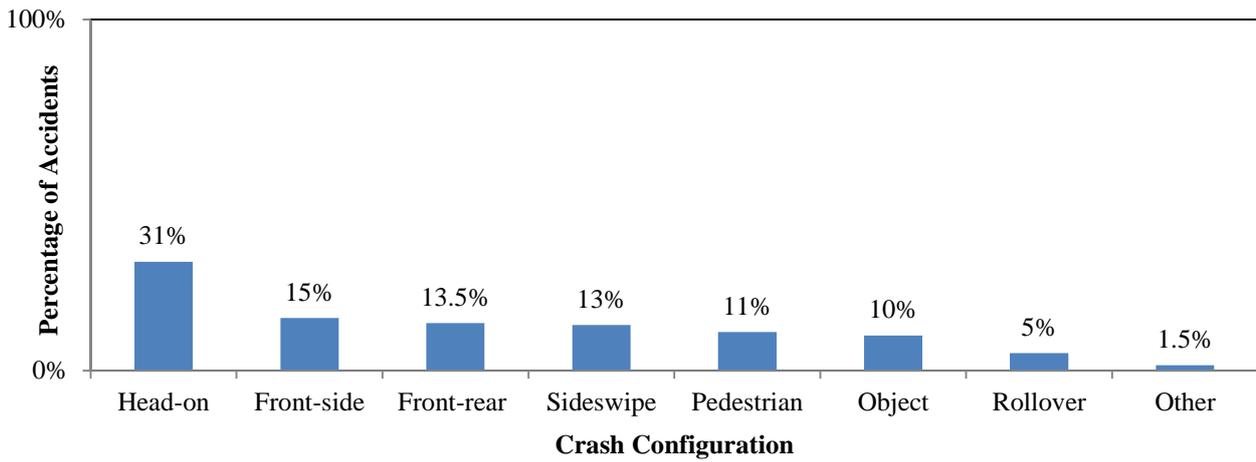
Figure 6. Distribution of Crashes by Crash Configuration
Source: RASSI database (2011-2013)
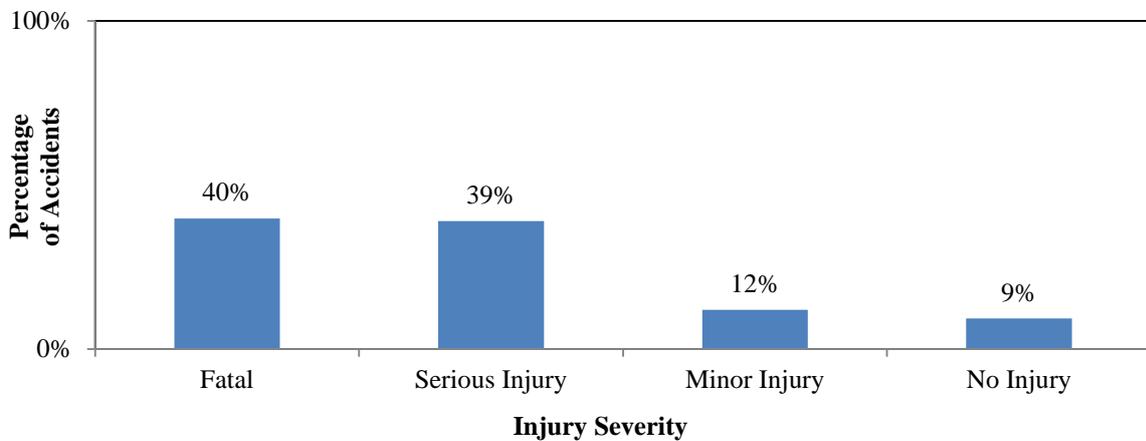
Figure 7. Distribution of Crashes by Injury Severity
Source: RASSI database (2011-2013)

JPRI teams obtained autopsy reports from the police for over 80% of the 150 fatal crashes. Figure 8A shows the distribution of MAIS (Maximum Abbreviated Injury Scale) injuries sustained by those fatally injured. The data show that 90% of the fatal victims sustained MAIS 3, 4 or 5 injuries.
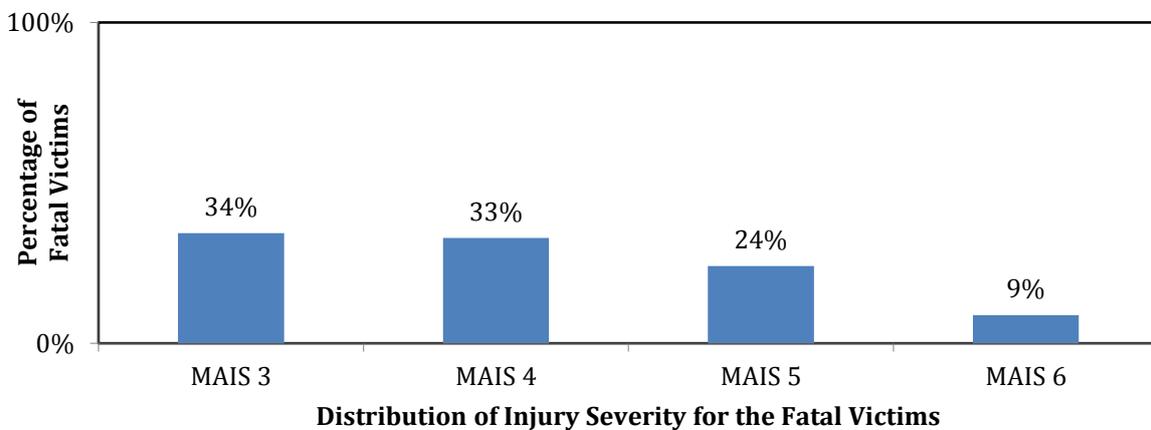
Figure 8A. Distribution of Fatalities by Maximum Abbreviated Injury Scale
Source: RASSI database (2011-2013)

Figure 8B shows the nature of injury by body region for fatal victims in cars, on motorcycles or fatal pedestrians. As can be seen in Figure 8B, serious head injuries were predominant, followed by thorax injuries

for car, motorcycle, and pedestrian fatalities. Most of the fatal motorcycle victims were not using helmets and car occupants were not using seat belts. These field data clearly indicate an urgent need for strong enforcement of helmet laws and seat belt laws to reduce head and thorax injuries.
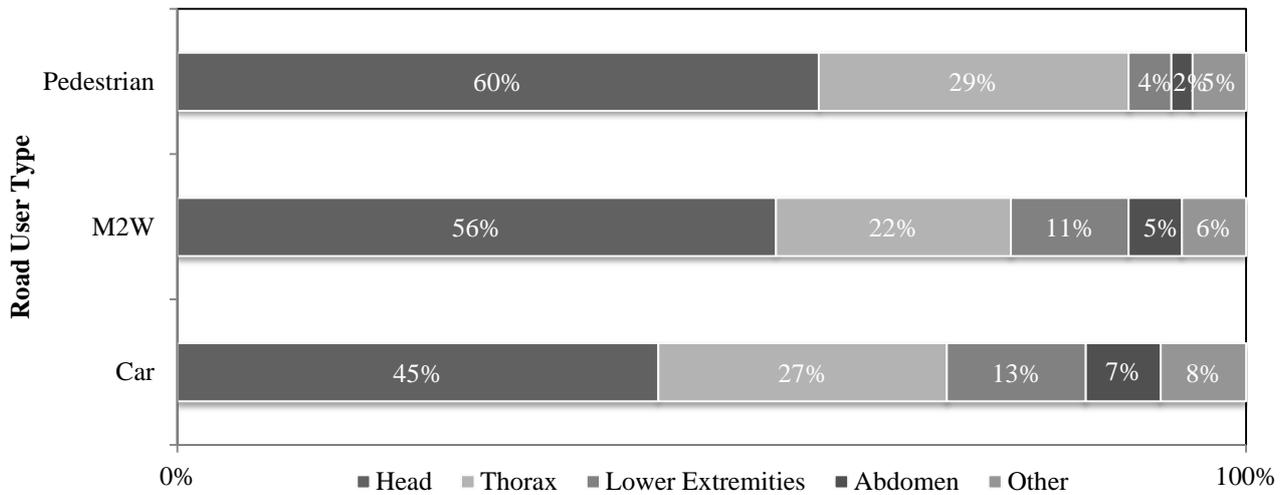
Figure 8B. Distribution of AIS 3+ Injuries for Fatal Victims by Body Region and Road User Type
Source: RASSI database (2011-2013)

Figures 9A and 9B show the corresponding injury severity distribution for non-fatal victims. Figure 9A shows that most of the non-fatal injuries were MAIS 1 and 2.

Examination of injury distribution by body region for non-fatal victims who sustained AIS 2+ injuries shows significant differences in injury patterns among various road users (Figure 9B). For M2W riders, 47% of AIS 2+ injuries were lower extremity injuries, while for car occupants, 36% of AIS 2+ injuries were lower extremity injuries. The car occupants also sustained higher percentages of AIS 2+ injuries to the face and upper extremities compared to M2W riders and pedestrians. For pedestrians, lower extremities and head contributed significantly to AIS 2+ injuries.
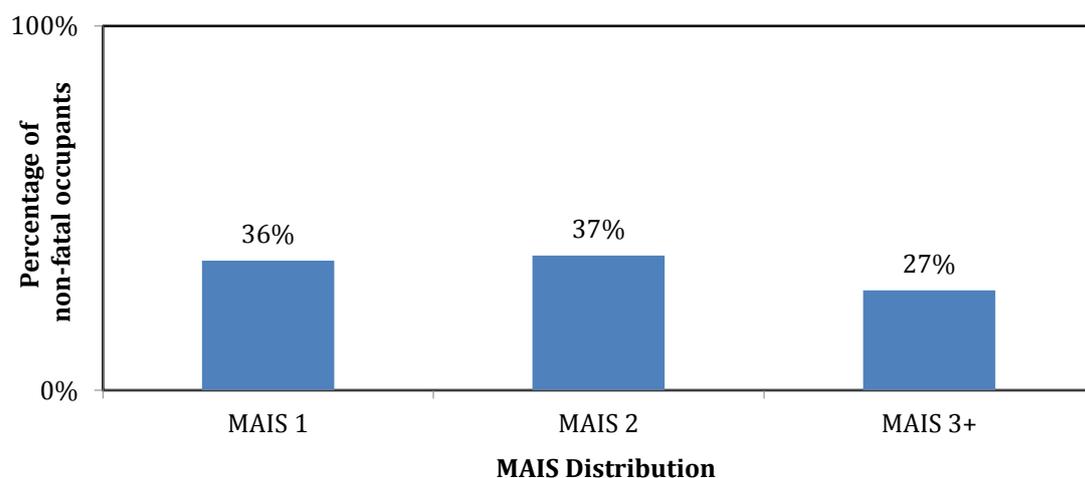
Figure 9A. Distribution of Non-Fatal Injury Severity by Maximum Abbreviated Injury Scale
Source: RASSI database (2011-2013)

Road Users						
Pedestrian	32%	9%	34%	10%	11%	4%
M2W	27%	3%	47%	17%	2%	4%
Car	20%	16%	36%	20%	5%	3%

0%   100%

■ Head   ■ Face   ■ Lower Extremities   ■ Upper Extremities   ■ Thorax   ■ Other
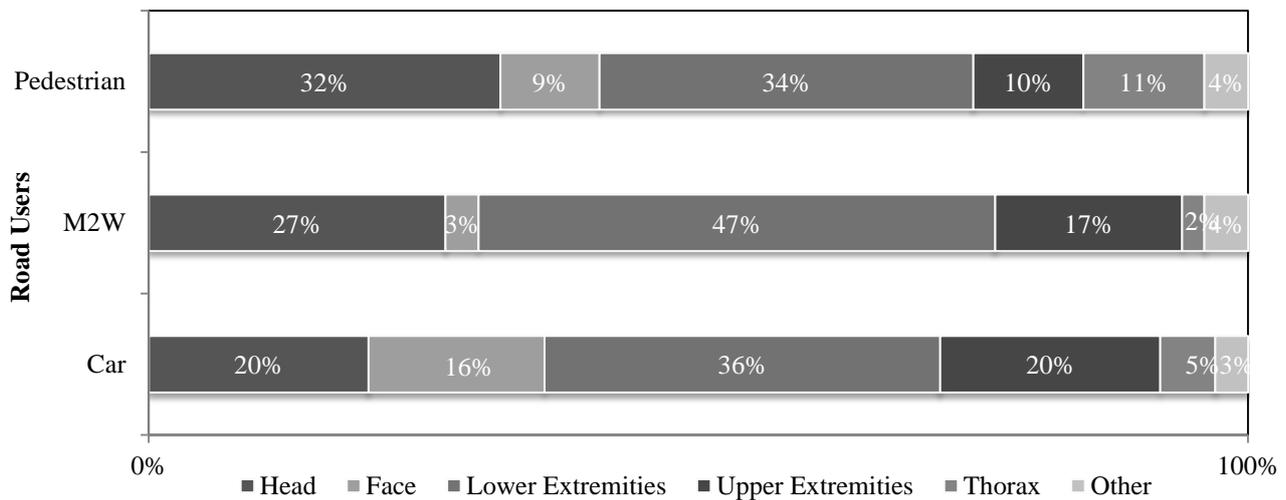
Figure 9B. Distribution of AIS 2+ Injuries for Non-Fatal Victims by Body Region and Road User Type
Source: RASSI database (2011-2013)

Injury Types and Injury Causation for M2W Riders, Car Occupants and Pedestrians

M2W Riders— For motorcyclists in this study, 56% of the AIS 3+ injuries were to head, of which the highest percentages were brain hemorrhage (46%) and skull fractures (45%). These severe head injuries were often caused by contact with the ground or due to striking the head against the windshield of the other vehicle. About 20% of the AIS 3+ injuries were to the thorax. These injuries were mainly rib fractures (57%) and lung lacerations (29%) due to contact of the rider's body with the front structure of the other vehicle (such as the hood, fender, and headlamp) and, in some cases, ground contact. Injuries to the lower extremities constituted 17% of AIS 3+ injuries seen. Of these, fractures (75%) predominated and were primarily due to contact with the front bumper and ground.

Car Occupants— For car occupants, results show 40% of the AIS 3+ injuries were to the head and mainly constitute skull fractures (43%) and brain hemorrhage (40%). These severe head injuries were caused by contacting vehicle interior components such as A/B pillar, windshield and steering assembly. About 26% of the AIS 3+ injuries were to the thorax. Of these, rib fractures (57%) and lung lacerations (39%) were the most significant injuries seen, caused mainly by contact with the steering assembly. Lower extremity injuries contributed to 22% of AIS 3+ injuries, all of which were fractures and caused by contact with steering column, instrument panel, seat back.

Pedestrians— For pedestrians, 61% of AIS 3+ injuries were to the head and most were hemorrhage (61%) and skull fractures (37%) caused by contact with the windshield and front components of the striking vehicle, and also due to ground contact post-impact. About 25% of AIS 3+ injuries were to the thorax and resulted in rib fractures (63%) and lung laceration (32%) due to contact with the front of the striking vehicle, protruding components on the vehicle sides, or the ground. Findings indicate 8% of the injuries to lower extremity were fractures caused by contact with front bumper, bull bars or hood edge.

Pre-Crash Events

The RASSI data were examined to address important pre-crash events (Figure 10). Accidents in lateral traffic accounted for nearly 47% of the crashes. Head-on collision, sideswipe and front-rear were the most common crash configurations seen in accidents in lateral traffic.

The driver factors that influenced "lateral traffic" crashes were overtaking and misjudgment of travel speed. Overtaking was shown to be the main factor contributing to head-on collisions, particularly where visibility of the oncoming lane was obstructed, as by a curve or hill. Other key driver errors in this category included following too closely and misjudging stopping distance. Other significant pre-crash events included "Turning in and Turning off" accidents (21%). These were associated with driver errors resulting from improperly merging onto or from priority roads. Some of these driver errors included not giving right of way to the priority road user or not giving the proper signal before exiting/entering a road.
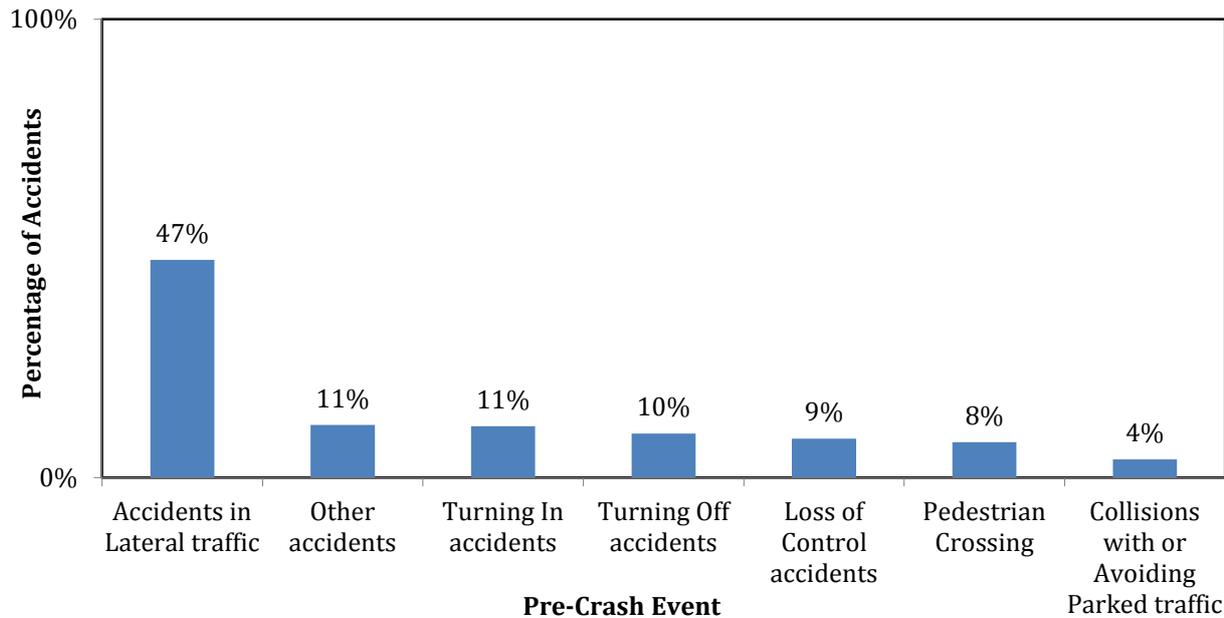
Figure 10. Distribution of Crashes by Pre-Crash Event
Source: RASSI database (2011-2013)

"Other" accidents (11%) included accidents associated with driver falling asleep, animal crossing and vehicle factors such as tire blow out, steering lock, and brake lockup leading to crashes. In addition, 9% of crashes involved loss of control resulting from driving too fast for road conditions.

The pre-crash events clearly indicate a need for driver training, awareness, infrastructure improvements (clearly marked exit signs, merging lanes, and visibility of parked vehicles), strict enforcement of safe speed on curves, and use of vehicle systems such as anti-brake (ABS) and electronic stability control systems.

Road Users and Collision Partners

The 377 accidents investigated involved 739 "road users": 694 vehicles and 45 pedestrians. Of the 694 crash-involved vehicles, 29% were M2Ws, 29% were cars and 27% were trucks, as shown in Figure 11A. In case of crashes involving pedestrian, cars (33%) had the highest crash-involvement, followed by M2Ws (27%) and buses (22%), as shown in Figure 11B. In the U.S., only 1% of police-reported crashes involve motorcycles. Hence, the vehicle mix seen in India is markedly different from that seen in other western countries.
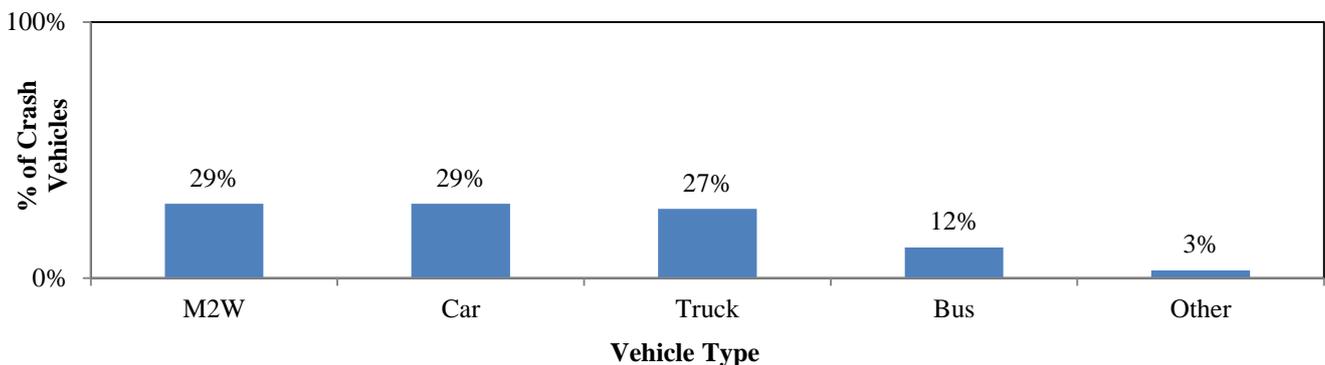

Figure 11A. Percentage Distribution of Crash-Involved Vehicles, by Type (All Crashes)
Source: RASSI Database (2011-2013)
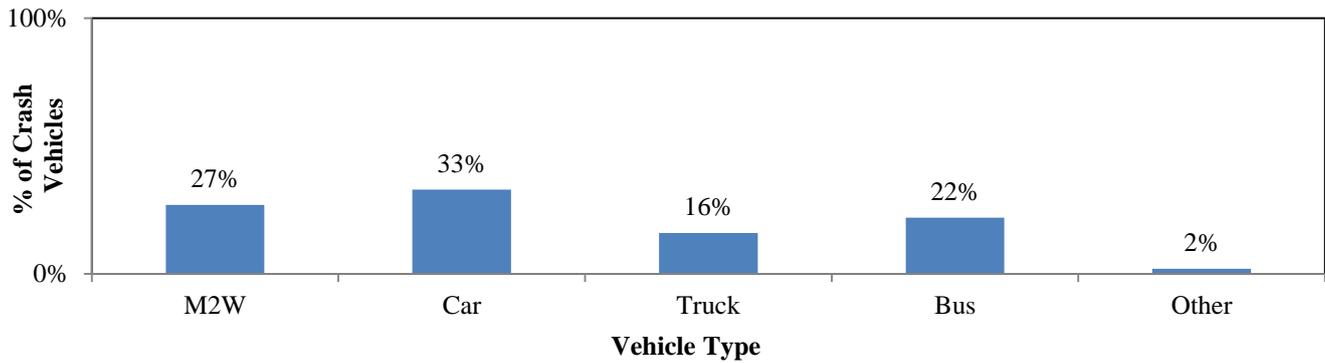
Figure 11B. Percentage Distribution of Vehicle Types Involved in Pedestrian Crashes
Source: RASSI Database (2011-2013)

In addition, there were significant vehicle incompatibility issues for Indian road crashes, as can be seen in Figure 12. Figure 12 shows that 34% of crashes in this study involved M2Ws colliding with larger vehicles (cars, trucks and buses). And while single-vehicle accidents accounted for 15% of crashes, this fraction was nearly matched by the percentage of crashes (13%) involving cars colliding with heavy vehicles such as trucks and buses.
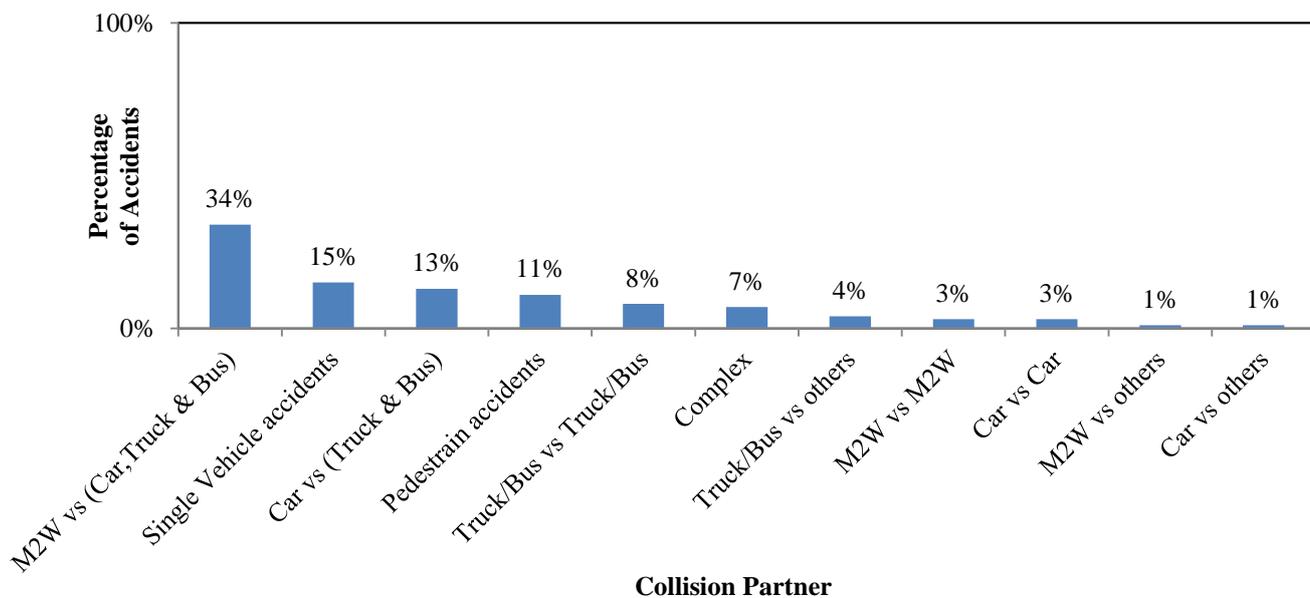
Notes: "Complex" includes accidents involving more than 2 vehicles; "Others" include farm tractors, bicyclists, etc.

Figure 12. Percentage Distribution by Vehicle Collision Partners
Source: RASSI database (2011-2013)

Belt use and Helmet use

Of the 401 car occupants involved in crashes, only 30 (7.5 %) were belted; the remaining 371 (92.5%) were unbelted, and 13 of these occupants had belts that were inoperative. This is especially discomforting in light of the fact India is introducing cars/trucks with airbags. The incremental benefit of airbags without seat belt use is minimal and public awareness on this must be established along with strict enforcement laws to belt occupants. Of 299 M2W riders and pillion riders involved in crashes, only 19 (6%) were wearing helmets; the other 280 (94%) were helmetless. A strong enforcement of belt and helmet laws is warranted to reduce injuries/fatalities.

Accident Reconstruction

Due to data and collection limitations (see the Discussion section); many crash cases are not good candidates for a full reconstruction. About 40% of the crashes are currently being reconstructed using PC Crash. For crashes

with sufficient information to enable reconstruction, PC Crash software was used to estimate delta-V and EES (Energy Equivalent Speed). Some initial results indicate that, for single-vehicle crashes, the average delta-V was 21 kmph, and for two-vehicle (car/truck vs. car/truck) crashes, the average delta-V was 40 kmph. For M2W vs. car/truck crashes, the average delta-V was estimated as 42 kmph. These speeds are much lower than the 64 kmph frontal offset crash test of EURONCAP.

IV.   DISCUSSION

Realities of Collecting Accident Data in India

Several problems need to be addressed when collecting crash data on Indian roads. Foremost among these is the difficulty of getting timely notification of crashes from the police or other entities. This is followed closely by the problem of many crashes not meeting case selection criteria due to missing scene evidence, vehicles, etc. Two major problems have arisen that are not experienced in the Western world. These problems, unique to Indian crash data collection, concern: 1) Police notification of crashes immediately after they occur, and 2) availability of scene evidence/vehicle. Both are discussed below.

Researchers on this study are currently initiating nearly twice as many investigations as can be used for RASSI. Late or no notification and incomplete data collection and evidence retention by police (often due to their having not been called to the scene, or called late, themselves) results in a waste of valuable manpower and, worse, a loss of otherwise valuable case data.

Police Crash Notification— Unlike in developed countries, systems for police notification of crash cases are not established efficiently in India. Only 4% of crashes investigated for FY 2012 under the RASSI project came from police notification. In some cases, police were in fact notified about crashes by researchers after they had come upon the accidents on their own while travelling through the study areas. Because this method has proved fruitful, the crash teams now frequently do their own scouting for crashes, but this is time-consuming and increases their on-road exposure.

Late notification of accidents to the police by the vehicle owners (or other involved persons) is not an uncommon problem, and some conditions wherein this may occur include:

- Fatal/Serious/Minor Injury Accidents — If the occupants involved in the accident died or were admitted to the hospital with injuries, there may be no one at the crash site to immediately make an accident complaint to the police. It could be days, even a week, after the accident before close relations file a complaint to the police. This usually happens in case of accidents involving two-wheelers and pedestrians.
- No-Injury Accidents — Vehicle owners/persons involved in the accident will often first attempt to come to agreement concerning the expenses to repair the crash-involved vehicles. Only if all the involved parties fail to agree to the compromises suggested will they then go to the police with an accident complaint.
- "Hit and Run" Accidents

Even when accidents are reported to police as soon as the crash happens, there are numerous reasons it could take a while for a crash team to be notified. Police are often held up with other activities directly after they have been notified of an accident. It is observed that the police are more focused on ensuring proper traffic movement at an accident site, passing information to higher officials about the accident and arranging for ambulances or fire services, if needed. Accident research is often a low priority. As mentioned under Methods, one solution has been to develop notification agreements with ambulance/EMS services, but other solutions are needed.

Missing Scene Evidence and Vehicles— A second problem with the current system is that, of the cases identified for or by the researchers, many do not qualify as RASSI cases due to missing or inadequate scene evidence, photos, or vehicle information, or they may not meet case selection criteria. For some months, the number of non-RASSI cases investigated were equal to or exceeded those that qualified as RASSI cases, but still the teams had to go to the scene, take photos, and document the case before it could be determined whether the case meets the criteria or not.

Limitations of Current RASSI Project

The RASSI data collection is retrospective. Pre-crash factors help identify the sequences of events leading to the crashes that are being investigated, but crash avoidance factors are outside the scope of this study.

Representativeness of Data— Most in-depth accident data collection programs are based on stratified samples. Hence, representativeness of the sample of data collected through such programs is of utmost importance. RASSI aims for representativeness in its sample for the study area being covered. This is a challenging activity in India, considering that representativeness requires a more detailed and reliable database of all road accidents to be made available. Unfortunately, this is a problem as the agencies such as the District and State Crime Record Bureaus do not code variables such as crash configuration, single- or multiple-vehicle crashes, details of vehicle body types involved, road type, etc. in their database.

To address this issue, researchers visit the police stations in the study area and manually code the details of all police-reported road accidents every month from the police case files. These details include date and time of accident, date and time of reporting, vehicle types involved, road type, injury severity, number of casualties, crash configuration, pre-crash event and the highest injury severity road user. It is envisioned that this data, collected over several years, can then be used to obtain an idea about the representativeness of the RASSI sample of accidents and for refinement of RASSI case selection criteria in the future.

Early Results— Finally, it is acknowledged that results of this study indicate marked differences in injury pattern and severity outcomes compared to those of similar studies in Europe and USA. Further investigations are being conducted to identify these differences, the reasons for the differences and their implications for traffic safety in India.

V. CONCLUSIONS

This study shows that a comprehensive, standardized methodology for in-depth accident investigations and data collection programs can be successfully developed for use in newly "motorized" countries such as India. The methodologies used here are comparable to those already established in motorized countries of Europe and in the USA although some modifications are necessary to meet the local traffic conditions and environment.

The study results show an immediate need for understanding crash experience through a well-established scientific data collection scheme such as RASSI so there is a solid basis for assigning priorities to improve road infrastructure, vehicle design, and public awareness relating to road safety in India. The results also clearly indicate a local environment with its own vehicle mix and infrastructure problems that cannot be solved by simply adopting western methods and safety standards.

While the successful development of an in-depth accident investigation program has been established, typical of any accident sampling scheme, there remains a need for continuous enhancement of the crash notification methodologies. A key reality of collecting on-scene accident data in India relates to lack of immediate crash notification from police. Even though the police have been extremely cooperative with JPRI teams, many crashes get notified days after the crash has occurred, and by that time, critical scene evidence is not available.

Cooperative agreements with ambulance services and hospitals can solve some of these problems, particularly with nationwide policy enforcement from federal agencies to trauma centers around the country. At this point, nothing like this has been established; however, global safety organizations that focus on mitigating road fatalities and improving infrastructure in developing countries might be a good place to start. Such organizations could help authorities to establish a well-connected, immediate crash notification system for the whole country, making it possible to collect better data for more effective road safety decision-making at every level.

The lack of seat belt and helmet use seen in this study, and misconception of the protection that can be afforded by airbags, can only be addressed with field data showing the need for a strict enforcement for belt use. National and international safety communities must focus on using field data to educate the public on seat belt and helmet use and other safety features.

VI. ACKNOWLEDGEMENTS

VII. REFERENCES

[1] World Health Organization, *Global Status Report on Road Safety*, "Time for Action", 2009.
[2] National Crime Records Bureau, "Accidental Deaths and Suicides in India", Ministry of Home Affairs, reports for years 2000, 2006, 2007, 2008, 2009, 2010 and 2011.
[3] Transport Research Wing, "Road Accidents in India", Ministry of Road Transport and Highways, India, 2011.
[4] National Highways Authority of India, "Road Network", Internet: http://www.nhai.org/roadnetwork.htm
[5] Padmanaban J, Hassan AM, Rajaraman R, Rehan M, "Accident Data Collection Methodology for Building a Traffic Accident Database for Tamil Nadu and India", SAE Paper No. 2009-26-008, 2009.
[6] Rajaraman R, Hassan AM, Padmanaban J, "Analysis of Road Accidents on NH45 (Kanchipuram District)", SAE Paper No. 2009-28-0056, 2009.
[7] Padmanaban J, Rajaraman R, Narayan S, Ramesh B, Stadter G, "Analysis of In-Depth Crash Data on Indian National Highways and Impact of Road Design on Crashes and Injury Severity", 4th International ESAR Conference, Hanover, Germany, 17 September, 2010.
[8] Padmanaban J, Rajaraman R, Narayan S, Ramesh B, Stadter G, "Heavy Truck Crash Investigation and Data Collection Methodology on Indian National Highways", 4th International ESAR Conference, Hanover, Germany, 17 September, 2010.
[9] Collision Deformation Classification, SAE J224, March 1990.
[10] Truck Deformation Classification, SAE J1301, August 2003.
[11] PC Crash Operating Manual Version 9, Dr. Steffan Datentechnik, July 2011.
[12] Abbreviated Injury Scale, Association for the Advancement of Automotive Medicine, 2005.

VIII. APPENDIX 1:
TYPES OF PRE-CRASH EVENTS

Pre-crash event codes for Indian conditions were developed for RASSI based on factors aggregated into seven primary categories, defined below:

Type 1: Driving Accident
A driving accident occurs when the driver loses control over his vehicle because he chose the wrong speed according to the run of the road, the road profile, the road gradient or because he realized the run of the road or a change in profile too late. Driving accidents are not always single-vehicle accidents where the vehicle leaves the road. A driving accident can also lead to a collision with other road users.

Type 2: Turning Off Accidents
A turning accident occurs when there is a conflict between a turning road user and a road user coming from the same direction or the opposite direction (pedestrians included!). This applies at crossing, junctions of roads and farm tracks as well as access to properties or parking lots.

Type 3: Turning In / Crossing Accident
A turning in/crossing accident occurs due to a conflict between a turning in or crossing road user without priority and a vehicle with priority. This applies at crossings, junctions of roads and farm tracks as well as access to properties or parking lots

Type 4: Pedestrian Crossing Road Accident
A pedestrian accident occurs due to a conflict between a pedestrian crossing the road and a vehicle, unless the vehicle is turning off. This is independent of whether the accident occurs at a place without special pedestrian crossing facilities or at a zebra crossing or similar.

Type 5: Accident with Parking Traffic
An accident with standing traffic (also bus stop) occurs due to a conflict between a vehicle from moving traffic and a vehicle which is parking, has stopped or is maneuvering to park or stop. This is independent of whether stopping/parking is permitted or not.

Type 6: Accident in Lateral Traffic
An accident in lateral traffic occurs due to a conflict between road users moving in the same or in the opposite direction. This applies *unless* the conflict is the result of a conflict corresponding to another accident type.

Type 7: Other

"Other" accidents are accidents that cannot be assigned to Accident Types 1-6. Examples: Turning around, backing up, accidents between two parking vehicles, objects or animals on the road, sudden vehicle defects.

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