Risk of Severe Injury to Vehicle Occupants in Frontal Crashes on Indian Roads

Tara L. A. Moore, S. Balakumar, Ravishankar Rajaraman, Jeya Padmanaban

I. INTRODUCTION

The Road Accident Sampling System – India (RASSI) database was developed to provide in-depth accident and injury data on real-world crashes; such data can help researchers to better understand the factors contributing to road traffic accidents and crash-related injuries in India [1]. Data collection for RASSI began in 2011 [1], and limited injury data from RASSI has been presented previously [2]; however, until recently, there has not been enough information available about the body region injured, or injuries in specific crash configurations, to allow these subjects to be analysed in any detail. The purpose of this study was to analyse the nature, type, and severity of injuries sustained by vehicle occupants involved in frontal crashes in India and to determine their injury risk. This is the first use of Indian crash data specifically for analysis of injury mechanisms.

II. METHODS

RASSI data from single-event frontal crashes occurring from 2011 through early 2015 were used for this study. Frontal crashes were selected because they are the most common crash configuration in the RASSI data set [1-2]. Frontal crashes were identified by general area of damage (front of the vehicle) and the principal direction of force (PDOF) of the impact (11, 12, or 1 o'clock). Frontal impacts that included another crash event before or after the frontal impact were not included in this analysis. Information about the vehicle type, crash severity (change in velocity, or delta-V), occupant, restraint/helmet use, and injuries (nature and severity) was collected and reviewed, when available. Selected case studies of crashes in which occupants sustained serious injuries were reviewed for more detailed injury information, including injury mechanism and contact points.

III. INITIAL FINDINGS

The most up-to-date data for RASSI includes crashes from May 2011 - March 2015, during which period 796 vehicles experienced single-event frontal impacts. The vehicle types involved were distributed between personal "passenger vehicles" (cars/SUVs/vans), 37%; heavy trucks, 23%; motorised two-wheelers (M2Ws), 24%; buses, 14%; and "other" (auto rickshaws, bicycles, tractors and unknown vehicles), 2%.

Impact severity information, including delta-V, was available for 354 frontal impacts. The distribution of accident severity differed by vehicle type, with trucks and buses having fewer high-severity impacts than the passenger vehicles. Delta-V information was unavailable for the vast majority of M2W impacts (83%).

Of the 1,413 occupants involved in single-event frontal collisions, 74 were coded as using a seat belt and 73 restrained occupants were riding in passenger vehicles. Due to the low number of restrained occupants, no separate analyses were performed for belted and unbelted occupants. Abbreviated Injury Scale (AIS) data was available for 858 occupants. (The AIS scale ranks injury from minor (AIS1) to serious (AIS3) to maximum / currently untreatable (AIS6).) Most of the occupants sustained multiple injuries. Approximately 180 occupants (21%) sustained serious or greater (AIS3+) injuries, with each seriously injured occupant sustaining, on average, 2.7 AIS3+ injuries (total of 480 AIS3+ injuries). At-scene observations and detailed vehicle inspections indicated that only 13 seriously injured occupants were using a lap-and-shoulder seat belt. The risk of AIS3+ injury increased as crash severity increased. M2W riders had the highest risk of sustaining at least one AIS3+ injury (61%), while bus and heavy truck occupants had the lowest risk of AIS3+ injury (4% for both groups). Occupants in passenger vehicles sustained primarily AIS3+ head, thorax and lower extremity injuries, while M2W riders sustained a greater proportion of AIS3+ head injuries and fewer thorax injuries (Fig. 1). No analysis of body

Tara L. A. Moore is a Managing Engineer at JP Research, Inc. in Philadelphia, Pennsylvania, USA (+1 215-486-6847, tara@jpresearch.com). S Balakumar is Head of Injury Research, and Ravishankar Rajaraman is Technical Director, for JP Research India Pvt. Ltd, headquartered in Coimbatore, Tamil Nadu, India. Jeya Padmanaban is President of JP Research, Inc., in Mountain View, California, USA (+1 650-559-5999).

region injured was performed for bus and truck occupants due to the small number of AIS3+ injuries to these occupants.

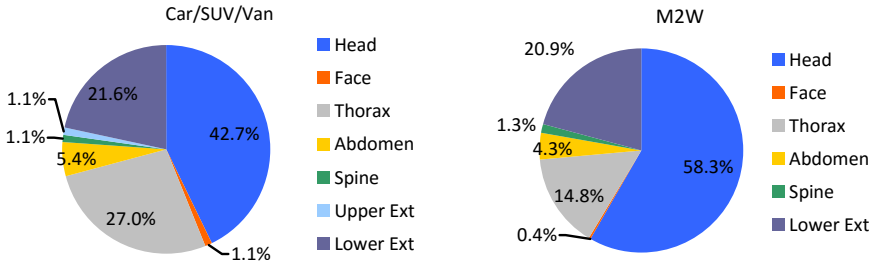

Fig. 1. AIS3+ injuries by body region for passenger car/SUV/van occupants and M2W riders.

AIS3+ injuries to occupants of passenger cars, SUVs and vans were reviewed in detail. Head injuries included skull fractures and brain contusions and lacerations. Thoracic injuries were mostly rib fractures, lung contusions, lacerations, ruptures, and haemothorax. There were three occupants with injuries to the heart. AIS3+ abdominal injuries consisted of lacerations and ruptures of abdominal organs. The majority of abdominal injuries were to the liver; however, kidney, spleen and small bowel injuries were also documented. Approximately 80% of AIS3+ lower extremity injuries were femur fractures to unrestrained occupants. The most common occupant contacts were head/face impacts to the windshield and nearby structures (header, visor, mirror, A-pillars). The vast majority of AIS3+ injuries from head and face contacts were head injuries. Other common contacts included chest-to-steering wheel contacts and knee-to-instrument panel contacts. Of the *restrained* occupants, 13 (in 9 vehicles) sustained AIS3+ injuries; these occupants were involved in very severe crashes with substantial occupant compartment intrusion, including underride collisions and crashes with delta-V in excess of 100 km/h.

IV. DISCUSSION

This study considered only single-event frontal collisions and did not include frontal impacts that occurred as part of a multi-impact crash event or that included non-impact events such as fire or immersion.

Most of the AIS3+ injuries to occupants in the current study were to the head, chest, and lower extremities. This is consistent with frontal crashes involving unrestrained occupants [3]. The types of injuries sustained by passenger vehicle occupants, e.g., skull fractures, thoracic and abdominal organ injuries, are consistent with high-energy impacts. The majority of injuries were caused by contact between unrestrained occupants and interior vehicle structures in front of them; use of a lap-shoulder belt would reduce the number and severity of these impacts. Studies have shown that lap-shoulder belt use reduces the overall likelihood of AIS3+ injuries by 80% [4]. Seventeen percent (17%) of vehicles experienced crashes with delta-V greater than 48 kph (30 mph). The proportion of high delta-V crashes is greater than seen in the US National Automotive Sampling System (NASS), an observation made in previous studies [2].

It was observed that M2W riders sustained a larger proportion of AIS3+ head injuries than passenger vehicle occupants. This difference in injuries seen is likely due to differences in post-impact occupant kinematics, contact points (exterior vehicle structures and ground contacts), and low helmet usage (< 10%) by M2W riders.

This study is the first to use Indian field accident data to explore injury mechanisms in crashes occurring on Indian roads. Data from this and future studies will be used to help develop injury criteria and test procedures to mitigate traffic injuries in the developing world. Note that this study presents raw data, as validated weighting factors for each crash are not yet available for the RASSI database.

V. REFERENCES

[1] Rameshkrishnan N, et al., IRCOBI, 2013.
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[4] National Highway Traffic Safety Administration, DOT HS 809 442, 2001.