Characteristics of Passenger Car Accidents in India

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Abstract

Road traffic accidents are one of the leading causes of injury and mortality in India. This study aims to conduct a comprehensive study of the characteristics of passenger car accidents in India by utilizing data from MoRTH (Ministry of Road Transport and Highways) and RASSI (Road Accident Sampling System - India). An examination of these datasets provides valuable insights on various aspects of passenger car accidents, including collision types, injury severity, and contributing factors. Analyzing collision types in passenger car accidents helped us to identify the most prevalent crash scenarios on Indian roads. This understanding is crucial for designing targeted interventions and implementing appropriate safety measures. The study also investigates the range of injury severity resulting from passenger car accidents. Additionally, the study investigates the pre-crash factors – human, vehicle, and infrastructure factors – that contribute to the occurrence of passenger car accidents. By conducting a detailed analysis of passenger car accidents, this study aims to identify and describe the specific characteristics of these incidents. The findings will help in formulating evidence-based strategies and interventions to reduce the frequency and severity of passenger car accidents, ultimately improving road safety and saving lives on Indian roads.

Keywords Car accident characteristics, contributing factors, real-world safety, data-driven approach, road safety

I. INTRODUCTION

Road traffic accidents are a major global public health issue, causing significant loss of life and economic impact. In India, 461,312 accidents in 2022 led to 168,491 fatalities, with passenger vehicles accounting for about a quarter of these deaths. This highlights the urgent need to understand accident causes and to implement preventive measures. Our study analyses passenger car accidents in India using data from MoRTH and RASSI, focusing on collision types, injury severity, and contributing factors through the Haddon Matrix framework. This approach provides insights into the complex nature of these accidents and can be used to inform strategies to improve road safety, with regard to contributing factors from pre-crash to post-crash phases.

Traffic and Road Infrastructure in India

Road accidents in India are intricately linked with the country's road network and the exponential growth of its vehicle population. India's road network is immense, ranking second globally, with an extensive coverage of approximately 63.73 lakh km.

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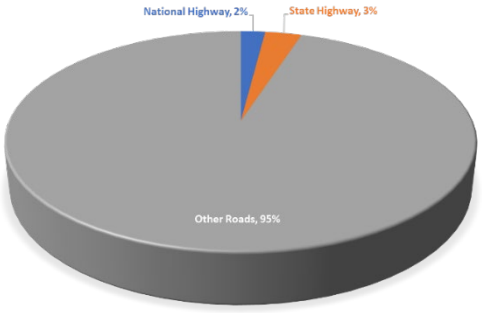

Fig. 1. Road network in India.

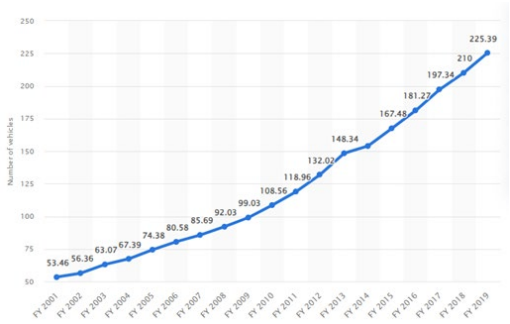

Fig. 2. Registered vehicles per 1,000 people.

The surge in vehicle ownership in India plays a vital role in road traffic dynamics. In FY 2019, the country recorded around 225 registered vehicles for every thousand people. This trend has risen consistently over the past two decades, posing significant challenges to traffic management.

Car ownership in India is projected to rise from 20 cars per 1,000 people today (2025) to 175 per 1,000 by 2040, resulting in a six-fold increase in road traffic. The World Energy Outlook (WEO) indicates that this growth, along with expanding infrastructure, will pose significant road safety challenges. This underscores the need for targeted interventions and strategies to reduce accidents and fatalities.

Accident Statistics – India

The 2022 MoRTH accident report shows 168,491 fatalities, with 53,033 linked to car accidents. Of these, 21,040 were car occupants and 31,993 were other road users. Notably, 42% of car occupant fatalities resulted from collisions with other vehicles or from self-inflicted accidents like rollovers. Additionally, 24% were from collisions with trucks, and 11% were from collisions with two-wheelers.

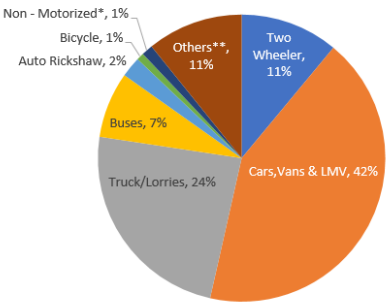

Fig. 3. Car fatalities for the impacting users.

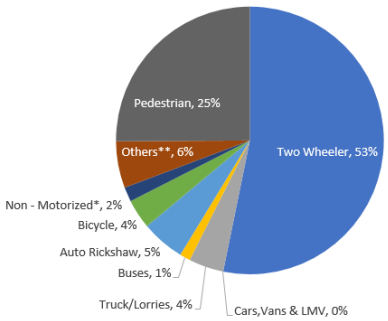

Fig. 4. Fatalities among the impacting users.

As shown in Fig. 4, when cars are involved in accidents, 53% of the resulting fatalities are two-wheeler riders and 25% are pedestrians, highlighting their vulnerability. These statistics underscore the critical need to address the safety concerns of these vulnerable road users (VRUs).

II. METHODS

We analysed 2,036 crashes from RASSI data involving 2,246 passenger cars (Hatch, Sedan, Van, SUV, and MUV) using the Haddon Matrix framework. This framework examines factors across the pre-crash, crash, and post-crash phases, providing in-depth insights. It systematically evaluates factors along two axes – accident phases and involved parties (human, vehicle, and infrastructure) – enabling a comprehensive understanding of accident causes for evidence-based road safety strategies.

TABLE I

HADDON MATRIX FRAMEWORK

	Human	Vehicle	Infra
Pre-Crash	Speeding overtaking Driver drowsiness	Vehicle defect	Poor road marking/signage Vision Obstruction Sharp Curvature
Crash	Seat Belt not used	Passenger Compartment Intrusion	Object Impact
Post-Crash	First Aid Skill	Entrapment Ejection	Ambulance Availability

Key Findings and Analysis

Our analysis of 2,036 passenger car accidents using the Haddon Matrix framework provides key insights into accident factors.

Fig. 5. Contributing factors in the pre-crash and crash phases.

In the pre-crash phase, human factors lead at 71%, followed by infrastructure at 43%. During the crash phase, human factors remain significant (31%), while vehicle-related factors increase to 61%, with infrastructure contributing 17%. Figure 5 visually highlights the relative importance of these factors. The following sections delve deeper into phase- and mode-wise causes of passenger car accidents.

Pre-crash Phase

The pre-crash phase plays a key role in accident events, with various factors involved. Insights from this phase will guide the development of Active Safety Systems, infrastructure, and phased implementation.

Our analysis identifies key human factors in passenger car accidents in India. Over-speeding is the leading cause, followed by improper overtaking and lane usage. Driver distraction and drowsiness are also significant contributors. Addressing these factors will be essential for effective road safety strategies.

Infrastructure-related factors also contribute significantly. Poor road markings and signage, undivided roads, vision obstructions, and poor intersection design highlight the need for better road

design, signage, and visibility. Vehicle-related factors, though less prominent, include tyre defects and vision obstructions inside vehicles, emphasizing the importance of vehicle safety maintenance.

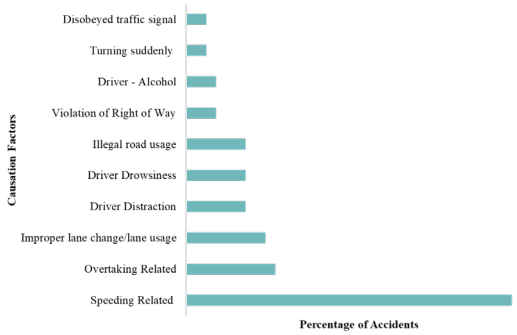

Fig. 6. Top 10 human factors.

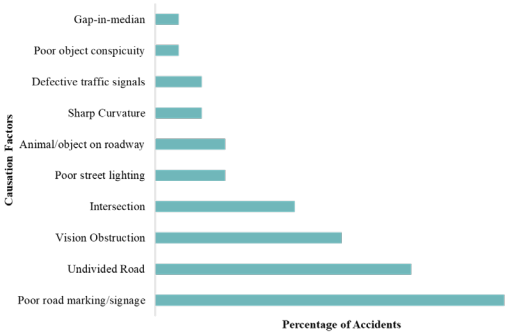

Fig. 7. Top 10 infrastructure factors.

Crash Phase

The crash phase involves impact and deformation, both crucial for improving Passive Safety Systems. The most significant human factor was the rate of seat-belt use, which shows the need for increased seat-belt compliance. Vehicle-related factors revealed VRU knockdowns, highlighting the vulnerability of pedestrians and non-motorized users. Additionally, passenger compartment intrusions underscore the importance of vehicle safety features. Infrastructure-related factors, particularly object impacts, played a role too, emphasizing the need to address road design and object placement to reduce risks.

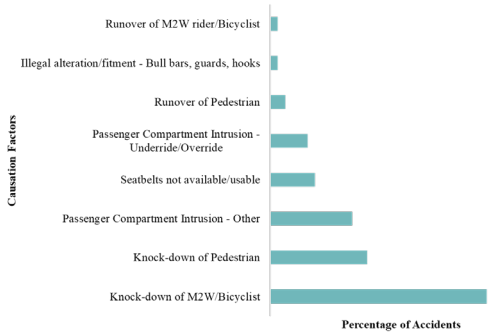

Fig. 8. Vehicle factors (crash phase).

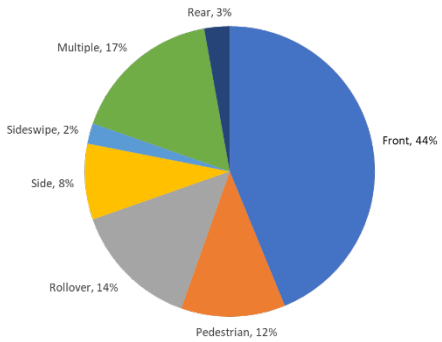

Fig. 9. M1 accidents by impact type.

To better understand the cash phase of passenger car accidents, we analysed impact types. Figure 9 shows that frontal impact, accounting for 44% of accidents, is the most common and involves head-on collisions, making it a primary crash safety concern. Multiple impacts, which was observed in 16% of cases, involve vehicles experiencing multiple events during an accident, increasing the risk of severe injuries. Rollover incidents, making up 14% of impacts, involve vehicle overturning, which can lead to occupant ejections or serious injuries.

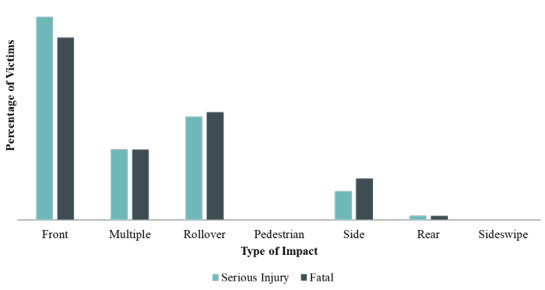

Fig. 10. Car occupants' injuries.

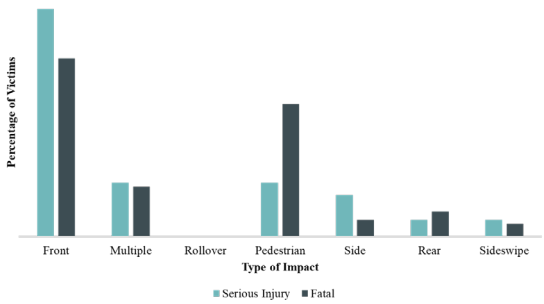

Fig. 11. Collision partners' injuries.

Figure 11 shows the distribution of car occupant fatalities and serious injuries by impact type, with the majority from frontal impacts, followed by rollovers and multiple impacts. Figure 12 highlights the severity of collision partner injuries, with the highest number of fatalities linked to frontal impacts, followed by pedestrian impacts and multiple impacts.

III. DISCUSSION

This study provides valuable insights into the nature of passenger car accidents in India, emphasizing the prevalence of human errors in the pre-crash phase, the critical importance of seat-belt usage, structural intrusion issues during the crash phase, and concerns related to ejection and entrapment in the post-crash phase. Furthermore, it highlights the significance of addressing infrastructure-related factors. To comprehensively enhance road safety, it is imperative to adopt a holistic approach that is based on a deep understanding of the factors contributing to accident occurrence and the severity of injuries sustained by both car occupants and other involved road users. The comprehensive strategy should encompass: Engineering, with a focus on vehicle safety enhancements and infrastructure development; Education, with an emphasis on public awareness campaigns; Enforcement, involving stringent law and data-driven regulations; and Evaluation, encompassing ongoing research and studies to continually assess and improve road safety measures.

IV. ACKNOWLEDGEMENTS

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