Heavy Motor Vehicle Crashes and Injury Patterns: Implications for Vehicular Safety in India

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INTRODUCTION

- Heavy Motor Vehicles (HMV) such as buses are used by 90% of the Indian population and is the preferred mode of transportation.
- They are involved in 5-10% of the total fatal road crashes compared to the 0.5-1.6% in developed nations
- *Significant gap*: Lack of robust crash testing standards for HMVs in India poses a major gap in ensuring safe vehicular design

STUDY OBJECTIVE

- To identify vulnerabilities in HMV design and analyze injury outcomes due to design flaws.



METHODS

- ***Forensic Investigation*** data from 3 HMV crashes involving 4 buses and 58 fatal victims was collected between 2022-2023.
- Forensic Crash Investigation included:

1.Site Investigation
2.Vehicular Investigation
3.Crash reconstruction in specialized software
4.Injury analysis and coding using AIS
5.Correlation between vehicle damage and injuries

- ***Crash Simulation***: We generated crash simulations using PC-Crash software. This was used to cross-reference simulations with medical injury reports.
- ***Injury Classification***: Injury severity scoring by body region using Maximum Abbreviated Injury Scale (MAIS).
- ***Quantify Relationships***: Measured associations between crash sequence and MAIS injury patterns using Spearman's rank correlation.

OVERVIEW

Case (First event)	Fatalities Examined	Crash Configuration: Most Harmful Event	Crash Contributing Factor	Injury Contributing Factors		
				Entrapment	Ejection	Intrusion
Case 1 (Bus Vs Object)	25 (43%)	Vehicle Rollover	•Speeding (50kmph) •Absent Crash Barrier •Narrow Road Width	No	Yes	Yes
Case 2 (Bus Vs Bus)	8 (14%)	Rear End Collision	•Speeding (98 kmph) •Absent Crash Barrier •Driver Fatigue	No	Yes	Yes
Case 3 (Bus Vs Object)	25 (43%)	Fire	•Speeding (107 kmph) •Drunk Driving	Yes	No	No

RESULTS: CRASH CONFIGURATION

- Number of victims involved in 3 crashes = 102
- Number of fatalities in 3 crashes = 58 (57%)
- In two cases, the 1st event involved an impact with an object, resulting in 50 fatalities.
- However, the third case, which resulted in eight fatalities, had a rear-end collision as the 1st event.

RESULTS: DRIVER BEHAVIOR

- Speed Analysis:

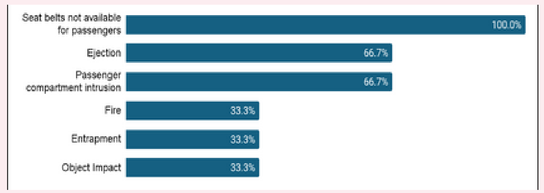
- 57% fatalities in HMVs traveling above 50 mph.
- Direct correlation between speeds and fatalities ($p < 0.001$)

- 27% of the drivers reported fatigue

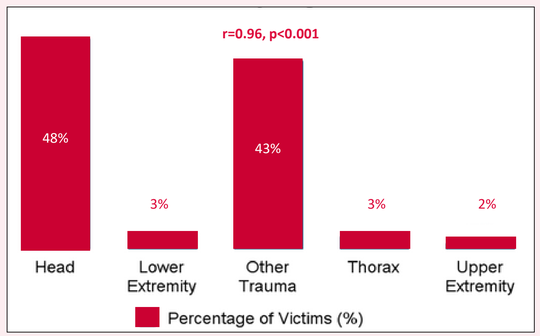
RESULTS: HMV SAFETY FEATURES

- None of the buses involved in fatal crashes had seatbelts for all passengers.
- 38% of fatal bus crashes involve seat deformation
- None of the vehicles had Anti-lock Braking systems
- Airbags were present in one vehicle only.

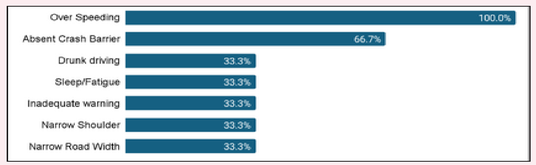
INJURY CONTRIBUTING FACTORS



INJURY PATTERNS



CRASH CONTRIBUTING FACTORS



CONCLUSION

- The probability of fatal injuries is directly proportional to the speed of the vehicles.
- Object impacts are particularly deadly and may involve subsequent harmful crash configurations (e.g.; fire and rollover).
- Non-availability of seat belt, intrusion and ejection noted are noted as key injury factors.
- High rates of fire and entrapment were also noted.
- The study revealed critical safety gaps in HMV standards and design.
- Implementing stringent crash test policies and ratings can help enforce vital improvements in stability controls, body construction, rollover protection, and occupant restraint technology.