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Road Traffic Accident Trends, Contributing Factors, and Predictive Analytics in India: A Data-Driven Analysis (2021–2023)

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Abstract

Road traffic crashes remain a major public-safety challenge in India, which records among the highest absolute crash and fatality counts of any country. This paper synthesises official crash statistics from India's Ministry of Road Transport and Highways (MoRTH) for 2021–2023 with recent peer-reviewed literature on machine-learning-based crash-severity prediction. National accidents rose from 412,432 (2021) to 480,583 (2023) and fatalities from 153,972 to 172,890. Overspeeding, non-use of helmets/seatbelts, and concentration of crashes on highways are the dominant factors; two-wheeler riders and pedestrians bear the largest fatality share. Recent ML/deep-learning models show measurable gains in severity-prediction accuracy, supporting more targeted interventions. Engineering, enforcement, and data-infrastructure recommendations are discussed.

Keywords: road traffic accidents; road safety; crash severity prediction; machine learning; India; MoRTH

1. Introduction

WHO's Global Status Report on Road Safety recorded about 1.19 million road deaths worldwide in 2021 (≈15/100,000 population; >3,200 deaths/day). Low- and middle-income countries account for ~92% of fatalities despite <1% of global vehicles; vulnerable road users (pedestrians, cyclists, motorcyclists) comprise ~53% of deaths, and road injury is the leading cause of death for ages 5–29, costing ~3% of global GDP (~US$1.8 trillion/year). India recorded 480,583 accidents in 2023 (172,890 deaths, 462,825 injured) — about 55 accidents and 20 deaths every hour, the highest fatality count on record, continuing an upward trend from 2021 (412,432 accidents, 153,972 deaths). Victims aged 18–45 accounted for over two-thirds of fatalities for the fourth consecutive year. This paper (i) consolidates 2021–2023 MoRTH statistics, (ii) reviews recent ML-based crash-prediction literature, and (iii) discusses engineering/policy implications.

2. Literature Review

Indian crash statistics derive mainly from MoRTH's “Road Accidents in India” and NCRB's “Accidental Deaths and Suicides” series, both built from police-station reports, with modest cross-source discrepancies (Tiwari et al., 2023). A systematic review of ML/DL crash-severity models (2014–2025) found mean F1-scores rose from ~73.2% (2014–2017) to ~84.3% (2024–2025), coinciding with a shift toward deep-learning and transformer architectures, with gains diminishing beyond ~85% due to inherent crash-outcome stochasticity. Liu et al. (2025) combined crash records, road geometry, and text descriptions in a multimodal deep-learning framework to improve severity prediction. Koramati et al.

(2023) built an ANN-based crash-prediction model for Hyderabad, showing city-scale models capture localised patterns national models miss. Sohail et al. (2023) identify data quality and granularity as the key constraint on model reliability.

3. Methodology

This is a secondary data-analysis study. Crash/fatality/injury statistics (2021–2023) were compiled from MoRTH annual reports; global figures from WHO (2024). Descriptive statistics (YoY change, severity index = deaths/100 accidents) were computed from reported totals. Recent (2023–2026) peer-reviewed literature on ML-based severity prediction was reviewed to identify methodological trends.

4. Results

Year	Accidents	Deaths	Injured	Severity
2021	412,432	153,972	384,448	37.3
2022	461,312	168,491	443,366	36.5
2023	480,583	172,890	462,825	≈36.0

Table 1. National road accident statistics, India (Source: MoRTH, 2021–2023).

Overspeeding caused ~68% of 2023 fatalities, followed by wrong-side driving (~5.5%). MoRTH reported 54,568 deaths of persons not wearing a helmet and 16,025 deaths of persons not wearing a seatbelt in 2023. Two-wheeler occupants accounted for 44.8% of fatalities, pedestrians 20.4%, and car/taxi/van occupants 12.4%. National/state highways (<5% of road length) accounted for >53% of accidents and 59% of fatalities. The 6–9 p.m. window recorded the most accidents (20.4% of the 2022 total); rural areas accounted for ~68% of 2022 fatalities versus 32% urban. ML/DL literature shows crash-severity prediction accuracy (F1-score) rising from ~73% to ~84% over 2014–2025, with multimodal and city-scale models (e.g., Hyderabad ANN) outperforming generic national models.

5. Discussion

Speed management, helmet/seatbelt enforcement, and highway-corridor engineering remain priority levers, consistent with MoRTH's black-spot rectification (>5,000 sites), mandatory safety audits, and electronic enforcement programmes. The disproportionate fatality share among two-wheeler riders and pedestrians mirrors the global vulnerable-road-user pattern and supports investment in segregated lanes and pedestrian infrastructure. Predictive accuracy gains in the ML literature depend on richer data (geometry, weather, text); India's police-report-based system would benefit from GPS-tagged, telematics-integrated crash records to enable scalable city-level models.

6. Conclusion

Road fatalities in India reached a record high in 2023, driven largely by preventable factors — overspeeding, non-use of protective equipment, and highway-corridor risk concentration — with two-wheeler riders and pedestrians most affected. ML-based severity-prediction models show growing accuracy and, combined with richer geo-tagged crash data, offer a path to targeted, corridor-level interventions. Future work should prioritise harmonised national crash databases and rigorous before–after evaluation of engineering/enforcement measures, in line with India's Brasilia Declaration commitments.

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