

An Autopsy Based Observational Study and Medico-Legal Aspects of Railway Accidents at a Tertiary Care Centre in Jaipur

Authors:

Dr. Nishant Barwar¹, Dr. Anil Solanki², Dr. Naveen Kumar Simatwall³, Dr. Rajesh Kumar Verma³, Dr. Sumanta Dutta³

¹Postgraduate Resident Doctor, Department of Forensic Medicine & Toxicology, S.M.S. Medical College and Attached Hospitals, Jaipur, Rajasthan, India.

²Professor, Department of Forensic Medicine & Toxicology, S.M.S. Medical College and Attached Hospitals, Jaipur, Rajasthan, India.

³Assistant Professor, ³Senior Professor, ³Senior Professor & Head of Department, Department of Forensic Medicine & Toxicology, S.M.S. Medical College and Attached Hospitals, Jaipur, Rajasthan, India.

Corresponding Author:

Dr. Naveen Kumar Simatwall, Department of Forensic Medicine & Toxicology, S.M.S. Medical College and Attached Hospitals, Jaipur, Rajasthan, India.

DOI: <https://doi.org/10.5281/zenodo.23151527>

Received: 02 September 2026, Revised: 16 September, Accepted: 29 September 2026, Online First: 05 October 2026

ABSTRACT

Background: Railway systems serve as critical socio-economic lifelines, but they carry a high burden of traumatic morbidity and mortality. Unlike road traffic accidents, railway fatalities involve immense mechanical force and kinetic energy, resulting in unique, highly mutilated trauma patterns that challenge forensic identification and manner-of-death determination. This study examines the epidemiological, socio-demographic, and injury patterns of fatal railway accidents in Jaipur, Rajasthan. **Material and Methods:** This was an autopsy-based, observational study conducted at the Department of Forensic Medicine & Toxicology, SMS Medical College and Attached Hospitals, Jaipur. All railway-track-related fatalities brought for medicolegal post-mortem examination over the study period were included. Institutional Ethics Committee (IEC) clearance was secured, and data were compiled using a structured study proforma, meticulous external and internal injury charting, and a master chart overview. **Results:** predominant age group, gender distributions, ratio of accidental falls (e.g., footboard/roof riders) versus suicidal track crossings, and specific frequency of traumatic amputations, decapitations, or post-mortem injuries used to conceal homicides. **Conclusion:** Fatal railway injuries represent a massive public health challenge in developing regions due to encroached tracks, open fencing, and train overcrowding. Comprehensive forensic autopsy tracking provides vital epidemiological metrics necessary for implementing targeted structural barriers, improved railway signaling, and targeted socio-legal safety policies.

Keywords: Railway Accidents; Autopsy Findings; Medico-legal Aspects; Traumatic Amputations; Jaipur.

INTRODUCTION

Transportation networks act as structural foundations for socio-economic progression, with Indian Railways processing millions of commuters daily. However, this expansive infrastructure brings a grim cost: disproportionately high rates of traumatic morbidity and mortality. In forensic medicine, railway-related deaths present an intricate and uniquely destructive pattern of mechanical trauma, separate from standard road traffic accidents (RTAs). While RTAs often feature vehicle

crumple zones and decelerating rubber tire impacts, railway injuries manifest as extreme interactions between high-mass, rigid steel operating equipment traveling at high velocity and fragile human tissue.

Investigating officers and medico-legal experts regularly face extensive challenges in diagnosing railway deaths due to severe body mutilation, fragmentation, and issues involving unidentifiable remains. Furthermore, forensic pathologists must distinguish true track mishaps from

homicidal cover-ups, where bodies are placed post-mortem onto tracks to disguise crime.

While affluent Western societies have significantly lowered track accidents via advanced signaling and robust physical barriers leaving suicide as the predominant manner of death less affluent regions continue to exhibit massive accidental fatality counts. This disparity stems from illegal track crossings, urban encroachments near track boundaries, and overcrowded trains. Jaipur serves as a major logistical hub, operating approximately 150 local and superfast trains daily through densely populated areas. This study fills a regional data gap by systematically analyzing demographic variations, environmental parameters, and definitive injury-fracture distributions across fatal railway incidents.

MATERIALS AND METHODS

Study Design and Setting: This descriptive, cross-sectional observational study was carried out at the Mortuary of the Department of Forensic Medicine & Toxicology, S.M.S. Medical College and Attached Group of Hospitals, Jaipur, Rajasthan, India.

Ethical Clearance: Prior to initiation, the institutional protocol was reviewed and approved by the Research Review Board and Institutional Ethics Committee of SMS Medical College (Ref. No. 1168/MC/EC/2024, Dated 24/10/2024). Informed written consent was systematically acquired from the relatives or legal representatives of the deceased before compiling study parameters.

Study Population and Period: The target universe comprised all non-institutional medico-legal railway fatalities brought for post-mortem analysis from October 2024 to December 2025. A calculated sample size of 72 cases (based on standard index literature) was set, and data collection continued until 80 valid cases were successfully recorded.

Inclusion and Exclusion Criteria: Cases presenting with a clear, verified history of train-related impact (such as track run-overs, platform mishaps, track crossings, or falls from operational carriages) were included. Cases with doubtful background histories or advanced decomposition obscuring skeletal evaluation were strictly excluded.

Data Collection Protocol: Information regarding socio-demographics (age, sex, religion, education, socio-economic standing) was cross-checked using official documentation and relative interviews. Police inquest files and scene-of-crime reports provided incident details, such as the timing, location, train type, and initially suspected manner of death.

Autopsy Methodology: Forensic autopsies involved detailed internal and external reviews. External checks logged tissue cuts, clothing debris, vital reactions,

traumatic amputations, and decapitations. Internal inspection followed systematic multi-cavity procedures, evaluating cranio-spinal, thoracic, abdominal, and pelvic cavities to chronicle visceral lacerations, hemorrhages, and underlying bone fractures.

Statistical Analysis: Compiled details were managed in Microsoft Excel 2019 and processed using SPSS Version 22.0. Discrete variables are described using frequencies and percentages, and the baseline distributions are displayed in structured analytical tables.

RESULTS

1. Socio-Demographic Parameters

Of the 80 cases evaluated, **86.25%** (n=69) were male and **13.75%** (n=11) were female, demonstrating a highly skewed gender ratio. The most affected age bracket was 21–30 years (**35.00%** overall), followed closely by individuals aged 31–40 years (**28.75%**). Religious profiling showed a major concentration within the Hindu community (**88.75%**), while Muslims represented **5.00%**. Educational stratification revealed that **51.25%** were graduates, whereas **12.50%** were completely uneducated. Regarding socioeconomic parameters, **45.00%** belonged to the lower class, while only **2.50%** originated from the upper stratum.

2. Situational and Environmental Findings

Geographically, **82.50%** (n=66) of the accidents occurred within the metropolitan zone of Jaipur. Diurnal assessment revealed a higher incidence during daylight hours (**56.25%**) compared to nighttime (**43.75%**), with a pronounced diurnal spike during peak travel hours between 4:00 PM and 8:00 PM (**22.50%**). Seasonally, the highest volume of autopsies was registered during the Winter season (**43.75%**), followed by Summer (**21.25%**). High-speed Express trains accounted for **61.25%** of the incidents, whereas traditional Passenger trains were involved in **20.00%**.

3. Medico-Legal and Fatality Characteristics

The dominant legal manner of death was determined to be accidental (**77.5%**), with intentional suicide accounting for **10.00%**. Track run-overs represented the primary traumatic mechanism (**46.25%**), followed by accidental falls from moving trains (**26.25%**) and direct train hits (**22.50%**). The identification status at the time of autopsy showed that **86.25%** were known individuals, while **13.75%** remained unidentified. The admission status revealed that **72.50%** of victims were brought dead to the center, and **57.50%** suffered instant, on-scene mortality. Shock was the primary physiological cause of death in **80.00%** of cases, with coma accounting for **20.00%**.

4. Anatomical Injury and Fracture Profile

The external state of bodies included fragmented remains in **25.00%** of cases and severely mutilated structures in **6.25%**. Multiple injuries across diverse

anatomical boundaries were documented in **91.25%** of cases. Traumatic limb amputations were observed in **31.25%** of autopsies, and complete decapitation was noted in **11.25%**.

Regional injury presentation showed that head and face trauma occurred in **85.00%** of cases, while matching thoraco-abdominal visceral injuries were present in **71.25%**. Skeletal fractures were highly prevalent across the dataset (Table 1).

Table 1: Distribution of Skeletal Fractures in Railway Fatalities (\$N=80\$)

S. No.	Anatomical Fracture Site	Present (Cases)	Percentage (%)	Absent (Cases)	Percentage (%)
1	Upper Limb Bones	69	86.25%	11	13.75%
2	Lower Limb Bones	69	86.25%	11	13.75%
3	Skull Bones	68	85.00%	12	15.00%
4	Rib Bones	56	70.00%	24	30.00%
5	Vertebral Column	37	46.25%	43	53.75%
6	Pelvic Ring	34	42.50%	46	57.50%

DISCUSSION

The findings of this cross-sectional study highlight the destructive nature of high-momentum railway trauma. The striking male-to-female ratio (**86.25%** vs. **13.75%**) is consistent with external literature, such as *Patil et al. (2011)* and *Moses & Ammani (2019)*, which consistently document male vulnerability exceeding 80% to 90%. This pattern reflects higher occupational mobility, risk-taking behaviors, and increased commuting among the working male demographic. The concentration of fatalities in the young, bread-earning age bracket of 21–40 years (accounting for over 60% cumulatively) underscores a significant socio-economic loss.

A notable finding is the high rate of accidental deaths (**77.5%**), driven primarily by illegal track crossings and passenger falls from moving compartments. This aligns closely with *R.K. Punia et al. (2017)*, who evaluated the same region historically and noted a similar accidental dominance. However, our results diverge from *Rao et al. (2022)* in Bangalore, where intentional suicide was the primary manner of death (75%), highlighting how local urban architecture and track layout influence trauma etiology.

The high frequency of winter incidents (**43.75%**) may be linked to seasonal fog, which drastically reduces visibility for both pedestrians and locomotive operators. This drop in visibility, paired with high-velocity Express trains (**61.25%**), reduces reaction windows, leading to a high rate of instant mortality (**57.50%**) and a large portion of victims being declared brought dead (**72.50%**).

Anatomically, the high prevalence of matching upper and lower limb fractures (**86.25%** each) reflects primary and secondary impacts, where bodies are caught or run

over by train wheel flanges. Skull fractures (**85.00%**) and thoraco-abdominal trauma (**71.25%**) were also highly common, demonstrating that high-energy railway mishaps present primarily as severe polytrauma. This explains why shock from massive internal hemorrhage was the primary physiological cause of death in **80.00%** of cases.

STRENGTHS OF THE STUDY

1. The study was based on medico-legal autopsy findings, allowing systematic documentation of the actual anatomical patterns and severity of fatal railway trauma.
2. A relatively comprehensive dataset of 80 railway-related fatalities was evaluated, covering socio-demographic, situational, medico-legal, and injury-related parameters.
3. The study provides region-specific data from a major tertiary care centre in Jaipur, which may be useful for understanding the local epidemiology of railway fatalities.
4. Detailed external and internal autopsy examinations enabled assessment of traumatic amputations, decapitation, visceral injuries, and skeletal fracture patterns.
5. Integration of autopsy findings with police inquest and scene-of-occurrence information strengthened the medico-legal interpretation of the cases.
6. The findings identify potentially preventable circumstances, particularly track run-overs and falls from moving trains, thereby providing a basis for targeted railway safety interventions.

LIMITATIONS OF THE STUDY

1. The study was conducted at a single tertiary care centre in Jaipur; therefore, the findings may not be directly generalizable to other regions of India.
2. The study included only fatal cases subjected to medico-legal autopsy and therefore does not represent non-fatal railway injuries or victims treated successfully in hospitals.
3. The observational design limits the ability to establish causal relationships between environmental or socio-demographic factors and railway fatalities.
4. Some information regarding the circumstances of the incident was obtained from police records and relatives and may therefore have been subject to incomplete documentation or recall bias.
5. The sample size was relatively limited and the study period was approximately 15 months; larger multicentric studies with longer surveillance periods may provide more robust epidemiological estimates.
6. Detailed information regarding factors such as alcohol or substance use, psychiatric history, mobile-phone use, exact train speed, and precise environmental conditions was not consistently available for all cases.

FUTURE DIRECTIONS

Future research should involve multicentric and longitudinal surveillance of railway-related fatalities and non-fatal injuries to establish broader regional and national epidemiological patterns. Geographic mapping of railway accident hotspots may help identify locations requiring immediate safety interventions. Further studies should incorporate detailed assessment of environmental factors, track accessibility, railway infrastructure, train speed, visibility, substance use, and behavioural risk factors. Collaboration between forensic departments, railway authorities, municipal agencies, law-enforcement agencies, and public-health professionals could facilitate development of evidence-based prevention strategies. Prospective evaluation of interventions such as fencing, pedestrian overbridges, improved lighting, automated warning systems, and public awareness programmes may help determine their effectiveness in reducing railway-related fatalities.

CONCLUSION

This study highlights that fatal railway trauma in the Jaipur region primarily affects young adult males from lower socio-economic backgrounds, with most incidents categorized as accidental track run-overs or train falls. The high rates of immediate on-scene mortality and severe body fragmentation underscore the immense kinetic forces involved, which frequently cause fatal hemorrhagic shock.

To address these preventable fatalities, coordinated action between municipal planners and railway authorities is essential. Key interventions should include:

1. Constructing robust concrete boundary walls and fencing along urban rail corridors.
2. Building pedestrian foot overbridges at high-risk track junctions.
3. Implementing stricter automated platform gate controls and safety monitoring systems.
4. Launching public education campaigns to reduce track trespassing and mobile phone distractions.

DECLARATIONS

Ethics Approval and Ethical Considerations

The study protocol was reviewed and approved by the Research Review Board and Institutional Ethics Committee of S.M.S. Medical College, Jaipur, Rajasthan, India (Ref. No. 1168/MC/EC/2024, dated 24/10/2024). The study was conducted in accordance with applicable ethical principles and institutional requirements for medico-legal autopsy-based research.

Consent for Study Participation

As this was an autopsy-based medico-legal observational study involving deceased individuals, data were obtained from official medico-legal records, police documentation, and autopsy findings. Where required by institutional protocol, relevant information was obtained from relatives or legally authorized representatives. Personal identifiers were not included in the research dataset.

Consent for Publication

No individually identifiable personal information, photographs, or other identifying material is presented in this manuscript. Therefore, individual consent for publication was not required beyond the institutional ethical requirements applicable to the study.

Conflict of Interest

The authors declare that they have no conflict of interest related to this study, its findings, or publication.

Funding

The authors received no specific financial support, grant, or external funding for this study.

Authors' Contributions

Dr. Nishant Barwar contributed to the study conception and design, data collection, medico-legal autopsy documentation, analysis and interpretation of findings, and preparation of the initial manuscript. **Dr. Anil Solanki** contributed to study supervision, scientific and methodological guidance, interpretation of medico-legal and autopsy findings, and critical revision of the manuscript. **Dr. Naveen Kumar Simatwall** contributed to study supervision, interpretation of forensic findings, critical review and revision of the manuscript, and

coordination of the study. **Dr. Rajesh Kumar Verma** contributed to the interpretation of autopsy findings, scientific review, critical revision of the manuscript, and verification of the reported data. **Dr. Sumanta Dutta** contributed to overall supervision, scientific guidance, interpretation of findings, critical review of the manuscript, and final approval of the submitted version.

All authors reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Data Availability Statement

The data supporting the findings of this study are derived from medico-legal and autopsy records. Because these records contain sensitive medico-legal information, individual-level data are not publicly available. De-identified data may be made available from the corresponding author, subject to institutional approval and applicable ethical and legal restrictions.

Acknowledgements

The authors acknowledge the Department of Forensic Medicine & Toxicology, S.M.S. Medical College and Attached Hospitals, Jaipur, and the personnel involved in medico-legal investigations and autopsy procedures for their support in conducting this study.

AI Use Disclosure

The authors declare that no generative artificial intelligence tools were used to generate or substantially modify the scientific content of this manuscript.

REFERENCES

1. Das A. A retrospective study of deaths due to railway accidents autopsied in a tertiary care teaching hospital of Tripura. *Indian J Forensic Med Toxicol.* 2023;17(4):142-148.
2. Mason JK. *The Pathology of Trauma*. 2nd ed. London: Edward Arnold; 1993.
3. Ozdogan M, Cakar S, Agalar F, et al. Epidemiology of railway-related casualties. *Ulus Travma Acil Cerrahi Derg.* 2006;12(3):235-241.
4. Patil B, Raghavendra KU, Uzair S, Pall DB. A study of pattern of injuries in railway deaths. *Indian J Forensic Med Toxicol.* 2011;5(1):20-22.
5. Rådbo H, Andersson R. Patterns of suicide and other trespassing fatalities on state-owned railways in greater Stockholm: Implications for prevention. *Int J Environ Res Public Health.* 2012;9(3):772-780.
6. Kumar RKM, Khaja S, Singh U, Panda SS. A demographic profile of railway accidents occurring in Khammam region. *Indian J Forensic Med Toxicol.* 2013;7(1):164-167.
7. Kumar RKM, Singh U, Panda SS, Khaja S. A study of pattern of injuries due to railway accidents occurring in Khammam region, Andhra Pradesh. *Indian J Forensic Med Toxicol.* 2014;8(2):72-76.
8. Puttaswamy. A five-year review of railway-related deaths in Mandya town of Karnataka: A retrospective study. *J Evid Based Med Healthc.* 2015;2(37):5871-5875.
9. Shandil A, Kumar SR. Study of deaths in railway accident in medico-legal autopsy. *J Indian Acad Forensic Med.* 2017;39(1):37-39.
10. Moses TMK, Ammani J. A comprehensive study of deaths due to railway accidents reported at a tertiary care hospital mortuary during the period of January to December 2015. *Int J Contemp Med Res.* 2019;6(8):H6-H10.
11. Manigandaraj G, Selvakumar R. Comprehensive analysis of pattern of deaths due to train traffic accidents in Chennai. *MedPulse Int J Forensic Med.* 2021;18(3):16-21.
12. Meena RK, Punia RK, Verma RK, Sharma DK, Simatwall NK. Assessment of load and descriptive analysis of fatal railway injuries at SMS Hospital, Jaipur: An autopsy-based study during the year 2014-15. *Indian J Forensic Med Toxicol.* 2017;11(1):143-146.
13. Chatterjee A, Das R, Mukherjee A, Das S. A cross-sectional study on the determinants of railway fatalities in different age groups. *Int J Res Med Sci.* 2023;11(1):80-84.
14. Shobhana SS, Satish KV, Kumar M, Raviraj KG. Retrospective study on railway-related deaths in South India. *Ain Shams J Forensic Med Clin Toxicol.* 2024;43(1):1-6.
15. Narayanan S, Ramalingam S, Vedanayagam T, Caroline WA. Retrospective analysis of deaths due to railway accidents: An autopsy-based study. *SEEJPH.* 2024;25:3253-3267.
16. Rao D. An autopsy study of railway fatalities. *IP Int J Forensic Med Toxicol Sci.* 2022;7(2):46-49.