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Original Research Article

Study of Spinal Injuries in Fatal Road Traffic Accidents in Eastern Uttar Pradesh (Uttar Pradesh)

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Abstract:

Background: Road traffic accidents (RTAs) are a leading cause of trauma-related mortality in India. Spinal injuries, particularly cervical spine injuries, significantly contribute to fatal outcomes due to associated neurological compromise and polytrauma.

Objective: To evaluate the demographic profile, pattern, and level of spinal injuries in fatal RTAs in Eastern Uttar Pradesh.

Methods: A retrospective observational study was conducted on 70 fatal RTA cases with documented spinal injuries. Data were collected from medico-legal records and hospital case files. Statistical analysis was performed using SPSS v26. Chi-square test was applied; $p < 0.05$ was considered significant.

Results: Males constituted 78.6% of cases. The 21–40-year age group was most affected (45.7%). Cervical spine injuries were most common (41.4%). A significant association was found between cervical spine injury and instant death ($\chi^2 = 9.47$, $p = 0.002$).

Conclusion: Cervical spine injuries are the predominant and most lethal spinal injuries in fatal RTAs in this region. Strengthened road safety enforcement and early trauma care access are essential.

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Introduction

Road traffic injuries are among the most significant public health challenges globally. The World Health Organization (WHO) estimates approximately 1.19 million deaths annually due to road traffic crashes [1]. Low- and middle-income countries account for nearly 93% of global road fatalities [2].

India contributes substantially to this burden, reporting over 1.5 lakh road traffic deaths annually [3]. Young adults represent the most vulnerable population group [4]. Spinal injuries are frequently encountered in high-velocity trauma and significantly influence morbidity and mortality [5].

The vertebral column protects the spinal cord; disruption may result in permanent neurological damage or immediate fatality [6]. Cervical spine injuries are particularly associated with respiratory compromise due to involvement of the phrenic nerve roots (C3–C5) [7].

Epidemiological studies suggest that RTAs are the most common cause of spinal cord injury worldwide [8]. The cervical region is the most commonly involved spinal segment in fatal trauma [9]. Thoracolumbar junction injuries are also frequently observed because of transitional biomechanical stress [10].

Inadequate helmet use, non-compliance with seatbelt regulations, and high-speed vehicular movement increase the risk of severe spinal trauma [11]. Regional data from Northern India indicate increasing trends of fatal RTA-related spinal injuries [12].

Despite the high burden, data from Eastern Uttar Pradesh remain limited. Understanding the pattern and distribution of spinal injuries is essential for preventive strategies and trauma system improvement.

Materials and Methods

Study Design and Setting: This retrospective descriptive observational study was conducted at the Trauma Centre of Maa Vindhyavasini Autonomous State Medical College, Mirzapur, Uttar Pradesh, India. The institution serves as a tertiary referral center for trauma cases from Eastern Uttar Pradesh and adjoining districts. The study period extended from 1 July 2023 to 30 June 2025.

Study Population: The study included all fatal road traffic accident (RTA) cases admitted to or brought dead at the trauma centre during the study period in whom spinal injury was documented either radiologically or during medico-legal postmortem examination. A total of 70 cases fulfilling the eligibility criteria were included in the final analysis.

Inclusion Criteria

1. Confirmed history of road traffic accident as documented in medico-legal records.
2. Fatal outcome (death at scene or during hospital stay).
3. Radiological evidence (X-ray, CT scan, or MRI) or postmortem confirmation of spinal injury.

Exclusion Criteria

1. Deaths due to causes other than road traffic accidents.
2. Cases with incomplete clinical, radiological, or medico-legal documentation.
3. Patients with isolated head injury without documented spinal involvement.

Data Collection Procedure: Data were retrieved from hospital medical records, trauma registry entries, emergency department case sheets, operative notes (where applicable), and medico-legal autopsy reports. A structured data collection proforma was used to ensure uniform extraction of variables.

The following parameters were recorded:

- Demographic details (age, sex)
- Circumstances of injury (type of road user, when available)
- Level of spinal injury (cervical, thoracic, lumbar, or multiple levels)
- Type of vertebral injury (compression fracture, burst fracture, fracture-dislocation, complete cord transection)
- Presence of associated injuries (head, thoracic, abdominal, limb fractures)
- Timing of death (instant death at scene or delayed death after hospital admission)

Radiological findings were reviewed from archived imaging reports. In cases brought dead, postmortem findings documented by the forensic department were considered definitive for classification of spinal injury.

Operational Definitions

- **Cervical spine injury:** Injury involving vertebrae C1–C7 with or without spinal cord involvement.
- **Thoracic spine injury:** Injury involving vertebrae T1–T12.
- **Lumbar spine injury:** Injury involving vertebrae L1–L5.
- **Multiple level injury:** Involvement of more than one anatomical spinal region.
- **Instant death:** Death occurring at the accident site or before definitive hospital-based resuscitation.
- **Delayed death:** Death occurring after hospital admission despite medical intervention.

Ethical Considerations: Institutional ethical approval was obtained prior to data collection. As the study involved retrospective analysis of deceased individuals' records, informed consent was waived by the ethics committee. Confidentiality of patient identity was strictly maintained, and data were anonymized before analysis.

Statistical Analysis: All data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables such as age were expressed as mean ± standard deviation (SD) and median where appropriate. Categorical variables including gender, level of spinal injury, type of vertebral injury, associated injuries, and timing of death were summarized as frequencies and percentages. Association between categorical variables was assessed using the Chi-square (χ^2) test. The strength of association between cervical spine injury and instant mortality was evaluated using cross-tabulation analysis. A p-value of less than 0.05 was considered statistically significant. All tests were two-tailed, and confidence intervals were calculated at the 95% level wherever applicable.

Results

A total of 70 fatal road traffic accident (RTA) cases with documented spinal injuries were analyzed during the study period (July 2023–June 2025).

1. Demographic Characteristics

Age Distribution

The age of the victims ranged from 8 to 72 years, with a mean age of 36.8 ± 14.2 years and median age of 34 years. The majority of cases belonged to the 21–40-year age group (45.7%), followed by 41–60 years (28.6%). The detailed distribution is shown in Table 1.

Table 1: Age Distribution of Cases (n = 70)

Age Group (Years)	Frequency (n)	Percentage (%)
0–20	8	11.4
21–40	32	45.7
41–60	20	28.6
>60	10	14.3

The predominance of young adults is illustrated in **Figure 1**.

Figure 1: Age-wise Distribution of Fatal Spinal Injury Cases

Gender Distribution: Out of 70 cases, 55 were males (78.6%) and 15 were females (21.4%), resulting in a male-to-female ratio of 3.7:1. This distribution is presented in Table 2 and depicted in Figure 2.

Table 2: Gender Distribution (n = 70)

Gender	Frequency (n)	Percentage (%)
Male	55	78.6
Female	15	21.4

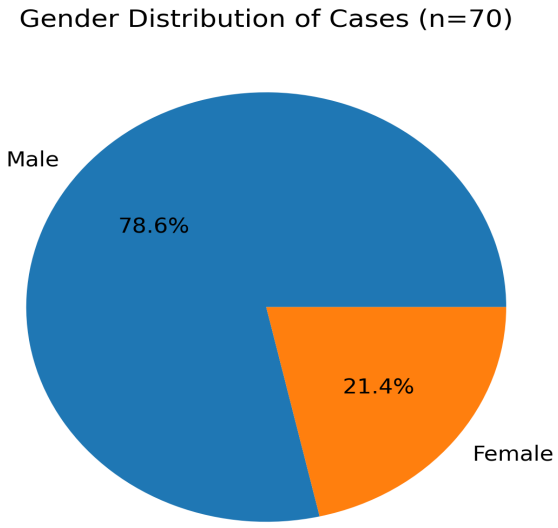

Figure 2: Gender Distribution of Cases

2. Pattern of Spinal Injury

Level of Spinal Injury: The cervical spine was the most frequently involved segment (41.4%), followed by thoracic (30.0%) and lumbar (20.0%). Multiple level involvement was seen in 8.6% of cases. These findings are summarized in Table 3 and illustrated in Figure 3.

Table 3: Distribution According to Level of Spinal Injury (n = 70)

Spinal Level	Frequency (n)	Percentage (%)
Cervical	29	41.4
Thoracic	21	30.0
Lumbar	14	20.0
Multiple	6	8.6

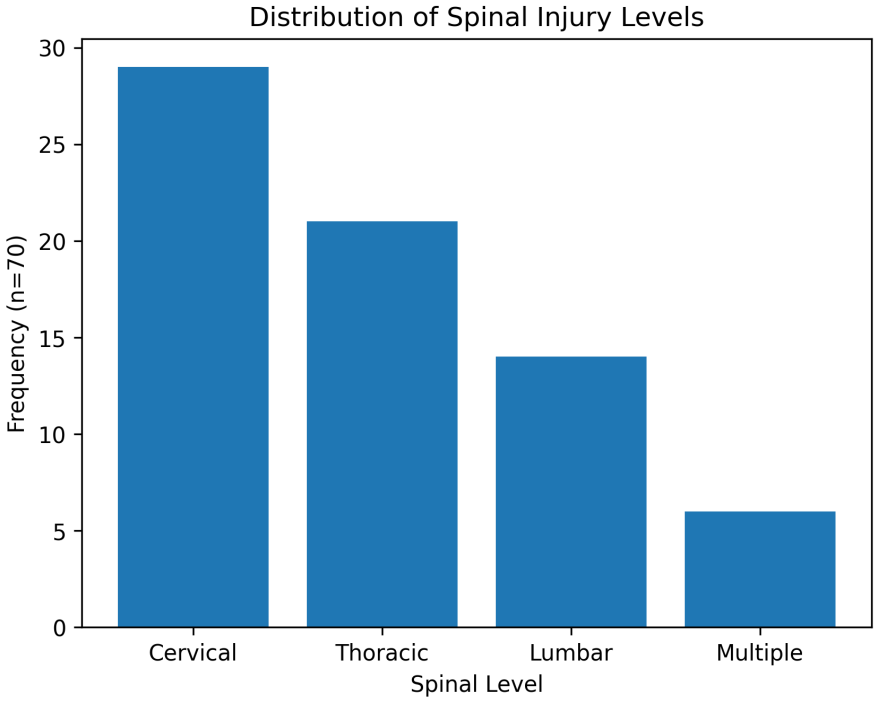

Figure 3: Distribution of Spinal Injury Levels

3. Type of Vertebral Injury

The most common vertebral injury pattern was compression fracture (31.4%), followed by fracture-dislocation (25.7%), burst fracture (21.4%), and isolated complete cord transection without major vertebral disruption (21.4%)

Table 4: Type of Vertebral Injury (n = 70)

Type of Injury	Number (n=70)	Percentage (%)
Compression fracture	22	31.4
Burst fracture	15	21.4
Fracture-dislocation	18	25.7
Complete cord transection (isolated)	15	21.4
Total	**70**	**100**

4. Associated Injuries

Associated injuries were frequently observed. Head injury was present in 68.6% of cases, thoracic injuries in 50.0%, abdominal injuries in 31.4%, and limb fractures in 38.6%. These findings are summarized in Table 5.

Table 5: Associated Injuries in Fatal RTA Cases (n = 70)

Associated Injury	Frequency (n)	Percentage (%)
Head injury	48	68.6
Thoracic injury	35	50.0
Abdominal injury	22	31.4
Limb fractures	27	38.6

5. Mode and Timing of Death

Out of 70 cases, 36 victims (51.4%) died instantly at the scene, while 34 (48.6%) died after hospital admission.

6. Association Between Cervical Spine Injury and Instant Death

Among 29 cases with cervical spine injury, 21 (72.4%) died instantly, compared to 15 (36.6%) among those without cervical involvement. This association was statistically significant as shown in Table 6.

Table 6: Association Between Cervical Spine Injury and Instant Death

Cervical Injury	Instant Death	Delayed Death	Total
Present (n=29)	21	8	29
Absent (n=41)	15	26	41

This indicates a statistically significant association between cervical spine injury and instant mortality ($\chi^2 = 9.47$, df = 1, p = 0.002).

7. Correlation Between Age Group and Level of Injury

A higher proportion of cervical spine injuries was observed in the 21–40-year age group (15 cases, 51.7% of cervical injuries). However, the association between age group and level of spinal injury was not statistically significant ($\chi^2 = 5.11$, df = 6, p = 0.53).

Summary of Key Statistical Findings

The present study demonstrated that the mean age of victims was 36.8 ± 14.2 years, with nearly half (45.7%) belonging to the 21–40-year age group, indicating a predominance of young adults. A marked male predominance was observed (78.6%), with a male-to-female ratio of 3.7:1. Cervical spine injuries constituted the largest proportion of spinal trauma (41.4%), followed by thoracic (30.0%) and lumbar (20.0%) injuries. Compression fractures were the most common vertebral injury pattern (31.4%). Associated head injury was present in 68.6% of cases, indicating a high rate of polytrauma. Importantly, a statistically significant association was found between cervical spine injury and instant death ($\chi^2 = 9.47$, df = 1, p = 0.002), suggesting that cervical involvement substantially increases the risk of immediate mortality. However, no statistically significant association was observed between age group and level of spinal injury ($\chi^2 = 5.11$, df = 6, p = 0.53).

Discussion

The present study demonstrates that spinal injuries in fatal RTAs predominantly affect young adult males, consistent with global epidemiological findings [13].

The predominance of the 21–40-year age group reflects increased vehicular exposure and occupational mobility [14]. Male predominance aligns with previous Indian trauma studies [15].

Cervical spine injuries were the most frequent, corroborating earlier autopsy-based analyses [16]. The anatomical vulnerability of the cervical region and its mobility contribute to higher injury rates [17].

The significant association between cervical injury and instant death supports evidence that high cervical cord injuries result in rapid respiratory arrest [18].

Thoracolumbar injuries observed in this study are consistent with biomechanical transition zone vulnerability described in spine trauma literature [19].

High incidence of associated head injury reflects polytrauma patterns documented in fatal RTA studies [20]. Combined craniospinal trauma significantly increases mortality risk [21].

Compression and fracture-dislocation patterns suggest high-energy mechanisms typical of vehicular collisions [22].

Studies have shown that helmet and seatbelt compliance reduce both spinal and head injury severity [23]. Strengthening enforcement in Uttar Pradesh may reduce fatality rates.

Improved trauma systems and early spinal immobilization protocols have demonstrated reduced preventable deaths in developing countries [24]. Regional trauma registry development is recommended.

The findings highlight the urgent need for preventive strategies including road safety education, stricter traffic law enforcement, and enhanced trauma care facilities [25].

Limitations

This study was conducted in a single tertiary care center and included a relatively small sample size of 70 cases, which may limit generalizability of the findings. As an autopsy-based study, clinical correlation and long-term survival analysis were not possible. Additionally, overlap between associated injuries may have influenced mortality outcomes. Multicenter studies with larger sample sizes are

recommended for broader applicability.

Conclusion

Spinal injuries constitute a critical component of fatal road traffic trauma in Eastern Uttar Pradesh, with the cervical spine being the most frequently involved and strongly associated with instantaneous mortality. Young adult males represent the most vulnerable population, reflecting high exposure to vehicular risk and occupational mobility. The high prevalence of associated head and thoracic injuries further underscores the polytrauma nature of fatal RTAs. These findings emphasize the urgent need for strengthened traffic regulation enforcement, improved helmet and seatbelt compliance, rapid prehospital stabilization, and development of structured regional trauma systems. Focused preventive strategies and enhancement of trauma care infrastructure may significantly reduce mortality attributable to severe spinal injuries.

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