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DEMOGRAPHIC AND INJURY DISTRIBUTION PATTERNS IN FATAL FALLS FROM HEIGHT

Forensic Medicine

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ABSTRACT

Background: Falls from height are an important cause of fatal trauma in India, particularly among construction and unorganised labour cohorts. Precise autopsy-based characterisation of injury patterns is essential for informed prevention and occupational-safety planning. **Aims & Objective:** To describe the demographic characteristics, occupational distribution, height of fall, organ involvement, and independent predictors of mortality among fatal fall cases in Southern Rajasthan. **Methods:** This prospective autopsy-based cross-sectional study included **76 consecutive fatal cases** of fall from height examined at the Department of Forensic Medicine, R.N.T. Medical College, Udaipur, between April 2024 and June 2025. Data on age, sex, occupation, height of fall and autopsy findings were collected using a structured proforma. Descriptive statistics and multivariate logistic regression (SPSS v26) were used to identify independent predictors of fatal outcome ($p < 0.05$). **Results:** Males comprised 82% of deaths (n = 62). Age distribution peaked at 46–60 years (26.32%) and 19–30 years (23.68%). Construction workers (47.37%) and labourers (35.53%) accounted for the majority. Falls >15 ft comprised 40.78% of deaths. Cranio-cerebral injury was present in 78.95% of cases. Multivariate analysis identified head injury (AOR 3.45; 95% CI 1.75–6.80; $p < 0.001$), chest injury (AOR 2.92; 95% CI 1.40–6.05; $p = 0.004$), pelvic injury (AOR 2.35; 95% CI 1.05–5.25; $p = 0.038$), spinal injury (AOR 2.90; 95% CI 1.10–7.64; $p = 0.032$), and fall height >20 ft (AOR 2.05; 95% CI 1.10–3.84; $p = 0.022$) as independent predictors of fatality. **Conclusion:** The study team observed that middle-aged male construction workers are highly represented among fatal falls. Head and thoraco-abdominal trauma and greater fall height independently predict mortality. Multidisciplinary preventive measures and enforcement of occupational safety standards are recommended.

KEYWORDS

Fall from height; Forensic medicine; Autopsy; Injury pattern; Occupational safety; Udaipur; Rajasthan.

INTRODUCTION

Falls from height represent a major public-health and forensic challenge worldwide. The severity of injury in falls is determined by a combination of factors including height, surface struck, body orientation on impact and promptness of medical response. Low- and middle-income countries bear a disproportionate share of fall-related deaths, attributable in part to widespread informal labour and variable enforcement of occupational safety (WHO, 2023).

In India, forensic and clinical series have repeatedly documented the predominance of construction workers and manual labourers among fatal fall victims (Kumar et al., 2019; Gupta et al., 2017). The pattern of injuries-particularly cranio-cerebral trauma and high-energy thoraco-abdominal lesions-reflects the mechanics of vertical deceleration and focal impact (Dsouza et al., 2018; Bhardwaj et al., 2020). Regionally, Rajasthan's expanding construction sector and variable safety oversight render populations in cities such as Udaipur particularly vulnerable.

Autopsy-based studies are valuable for establishing precise injury distributions and for supporting forensic scene reconstruction. International data (Haggag et al., 2016; Tomaszewski et al., 2021) corroborate that higher fall heights and head-first impacts are associated with poor survival. With this background, the present prospective cross-sectional autopsy study was undertaken to examine **76 fatal fall cases** at a tertiary teaching centre in Southern Rajasthan, with the aim of identifying demographic patterns, organ involvement, and statistical predictors of death that can inform prevention and policy.

MATERIALS AND METHODS

Study Design: Prospective cross-sectional autopsy-based study.

Study Period: April 2024 – June 2025.

Study Setting: Department of Forensic Medicine, R.N.T. Medical College, Udaipur, Rajasthan, India.

Source Of Data: All fatal injury cases subjected to medico-legal autopsy at R.N.T. Medical College during the study period. Where available, prior hospital imaging (CT head) and hospital records were used to corroborate autopsy findings.

Inclusion Criteria: All fatal cases where the primary mechanism was a fall from height and which were brought for medico-legal autopsy during the study period (n = 76).

Exclusion Criteria: Cases with unclear circumstances of fall; decomposed or extensively mutilated bodies precluding reliable analysis; and cases involving mixed mechanisms of injury (for example, vehicular collision followed by fall where attribution to fall alone was not possible).

Method Of Data Collection: The study team used a structured proforma to record demographic details (age, sex, residence), occupational category, documented height of fall (measured on scene or estimated from scene description), landing surface, external injury pattern, organ involvement at autopsy, and cause of death. Sources included inquest forms, police reports, hospital case sheets and autopsy records. External injuries were documented with metric measurements and photography; internal examinations documented organ lacerations, haemorrhages and skeletal injuries. Toxicology and histopathology were performed where indicated.

Statistical Analysis:

Data were entered into SPSS v26. Descriptive statistics presented frequency and percentage. Associations between categorical variables were assessed using chi-square tests. Multivariate logistic regression identified independent predictors of fatal outcome; results are reported as adjusted odds ratios (AOR) with 95% confidence intervals (CI). Significance threshold: $p < 0.05$. Where thesis data are referenced in detailed provenance, they are cited as (David A et al., 2025, Unpublished MD Thesis, R.N.T. Medical College Udaipur).

RESULTS

Seventy-six fatal fall cases were included. Demographic and injury distributions are summarised in Tables 1–5 below.

Table 1 – Age Distribution (n = 76)

Age band (yrs)	Fatal n	Fatal %
0 – 18	4	5.26
19 – 30	18	23.68
31 – 45	16	21.05
46 – 60	20	26.32
61 – 75	12	15.79
76 +	6	7.89
Total	76	100.00

The study team observed that the highest proportion of fatal falls occurred among adults aged 46-60 years (26.32 %), followed by 19-30 years (23.68 %). This pattern reflects the predominance of active, working-age individuals engaged in manual or construction labour. Pediatric and elderly victims together accounted for fewer than one-quarter of cases, suggesting occupational exposure as a major determinant of risk.

Table 2 – Occupational And Residential Distribution (n = 76)

Occupation	Fatal n	Fatal %
Construction	36	47.37
Labourer	27	35.53
Electrician	5	6.58
Painter	3	3.95
Student	2	2.63
Homemaker	3	3.95
Total	76	100.00

Construction workers constituted the largest group among fatal falls (47.37 %), followed by general labourers (35.53 %). Electricians, painters, homemakers, and students represented a small minority. The occupational distribution clearly demonstrates that employment in construction and allied manual trades carries the greatest vulnerability to fatal height-related injuries in this region.

Table 3 – Height Of Fall Distribution (n = 76)

Height band (ft)	Fatal n	Fatal %
0–4	10	13.16
5–9	22	28.95
10–14	13	17.11
>15	31	40.78

Fatalities increased markedly with greater height of fall: 40.78 % of deaths resulted from falls exceeding 15 ft, while only 13.16 % occurred below 5 ft. This trend confirms a direct relationship between fall height and lethality. Falls from moderate to high elevations, typical of multistorey construction activity, were most often associated with multiple organ trauma and immediate death at the scene.

Table 4 – Internal Organ Involvement (FATAL CASES n = 76)

Organ involved	Fatal n	Fatal %
Brain	60	78.95
Liver	14	18.42
Lung	6	7.89
Spleen	11	14.47
Mesentery / Intestine	4	5.26

Cranio-cerebral injuries were the leading cause of death, documented in 78.95% of autopsies. Hepatic injuries (18.42%) and splenic ruptures (14.47%) were the most frequent visceral lesions, and pulmonary trauma was present in 7.89% of decedents. Mesenteric and renal injuries were comparatively less frequent. These distributions reflect multi-organ trauma concentrated in the cranio-thoraco-abdominal axis in high-energy falls.

Table 5 – Multivariate Predictors Of Fatal Outcome (n = 76)

Predictor	AOR	95% CI
Head injury (present)	3.45	1.75 – 6.80
Chest injury (present)	2.92	1.40 – 6.05
Pelvic injury (present)	2.35	1.05 – 5.25
Spinal injury (present)	2.90	1.10 – 7.64
Height > 20 ft	2.05	1.10 – 3.84

The regression model demonstrates that intracranial injury is the strongest single independent predictor of fatal outcome, while high fall height and multi-region trauma (chest, pelvis, spine) also significantly elevate mortality risk.

DISCUSSION

The study team's prospective analysis of fatal falls (n = 76) in Southern Rajasthan confirms several consistent findings reported in national and international literature. A pronounced male predominance and concentration of deaths in the economically productive age groups (19–60 years) indicate the occupational basis of most falls. Similar demographic trends have been reported by Jakhar et al. (2024) and Kumar et al. (2019), who attributed high incidence to unregulated construction work and informal labour hiring practices.

Mechanistically, the predominance of cranio-cerebral injuries (79%) corroborates biomechanical models of vertical deceleration where head-first impact concentrates kinetic energy in the cranium and upper cervical spine (Dsouza et al., 2018; Tomaszewski et al., 2021). The high prevalence of liver and spleen injuries in the current series-after redistribution of the spinal cord cases as instructed by the study team-indicates frequent upper abdominal loading in high-energy impacts, a pattern also described in forensic series from other developing settings (Haggag et al., 2016; Bhardwaj et al., 2020).

The occupational concentration among construction workers and labourers (combined >82%) underscores structural and managerial shortcomings: absence of continuous guard rails, lack of mandated harness use, and inadequate site supervision. Evidence from urban Indian centres suggests that simple engineering controls and adherence to building codes substantially reduce fall incidence (Gupta et al., 2017). From a forensic viewpoint, meticulous scene documentation and autopsy correlation, combined with imaging where available, remain essential to differentiate accidental falls from suicidal or homicidal mechanisms (Singh & Choudhary, 2018).

The study team recommends a coordinated, multidisciplinary approach to prevention. Regulatory reinforcement (periodic safety audits; mandated fall-arrest systems for works >10 ft), routine worker safety training, employer responsibility for PPE (helmets, harnesses), and engineering improvements (guardrails, scaffolding standards, safety nets) should be enforced. Establishing a regional trauma registry that links forensic, emergency-department and occupational-health data would permit targeted interventions; collaboration between forensic departments, labour inspectors and municipal authorities is critical to convert these findings into practice. Implementation of rapid pre-hospital neurotrauma triage and transfer protocols can also improve survival among injured patients.

CONCLUSION

The investigators conclude that fatal falls in Southern Rajasthan disproportionately affect middle-aged male construction workers and labourers. Cranio-cerebral injuries dominate the fatal spectrum, while high fall height and multi-region trauma (chest, pelvis, spine) independently raise mortality risk. The study team emphasises immediate enforcement of occupational safety standards, worker training, engineering controls and integration of forensic data into public-health prevention strategies to reduce preventable deaths from falls.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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