Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/av8fkp52

# EVALUATION OF DELAYS IN EMERGENCY CARE OF TRAUMA PATIENTS USING THE THREE-DELAY FRAMEWORK: A PROSPECTIVE OBSERVATIONAL STUDY AT A TERTIARY CARE HOSPITAL

**Dr. Anup Kumar Dokania[1], Dr. Ajay Kumar Kundan[2] Dr. Amar Satyam[3*]**

[1]Associate Professor, Department of Orthopedics, Gouri Devi Institute of Medical Sciences and Hospital, Durgapur, West Bengal
[2]Associate Professor, Department of Orthopedics, Shyamlal Chandrashekhar Medical College & S.P.N.M. Speciality Hospital, Khagaria, Bihar
[*3]Assistant Professor, Department of Orthopedics, Shyamlal Chandrashekhar Medical College & S.P.N.M. Speciality Hospital, Khagaria, Bihar

***Corresponding Author:** Dr. Amar Satyam
*[3]Assistant Professor, Department of Orthopedics, Shyamlal Chandrashekhar Medical College & S.P.N.M. Speciality Hospital, Khagaria, Bihar
(Email id: dr.amarsatyam@gmail.com)

Accepted:- 13 October 2025 Published:-12 November 2025

**Abstract**

**Introduction:** Trauma remains a leading cause of mortality and morbidity globally, with outcomes significantly influenced by timeliness of care. The golden hour concept emphasizes that definitive treatment within 60 minutes of injury optimizes survival. However, multiple barriers delay trauma care in resource-limited settings. This study aimed to evaluate delays in emergency trauma care using the three-delay framework and identify factors associated with each phase of delay.

**Methods:** A prospective observational study was conducted at Gouri Devi Institute of Medical Sciences and Hospital, West Bengal, from March to August 2025. Two hundred adult trauma patients requiring emergency care were enrolled using consecutive sampling. Data on demographics, injury characteristics, and delays across three phases (decision to seek care, reaching healthcare facility, and receiving treatment) were collected using a structured proforma. Statistical analysis included chi-square tests, t-tests, and multivariate logistic regression.

**Results:** Only 12% of patients received definitive care within the golden hour, with median total delay of 156 minutes. Phase 2 delays (median 68 minutes) contributed most substantially. Mortality was significantly higher among patients with delays exceeding 120 minutes (9.9% vs. 3.4%, p=0.048). Independent predictors of prolonged delay included rural residence (OR: 2.86), referral from other facilities (OR: 4.24), distance exceeding 20 km (OR: 3.12), unawareness of emergency helpline (OR: 2.14), and off-hours arrival (OR: 1.86).

**Conclusion:** Substantial delays exist across all phases of trauma care, with transportation and referral-related factors contributing most significantly. Systematic interventions addressing geographic accessibility, emergency service awareness, and healthcare system capacity are urgently needed to improve trauma outcomes.

**Keywords:** Trauma care delays; Three-delay model; Golden hour; Emergency medical services; Prehospital care

## Introduction

Trauma remains a formidable global health challenge, accounting for approximately 4.4 million deaths annually and representing nearly 8% of all deaths worldwide. The burden is particularly severe in low and middle-income countries, which bear approximately 90% of trauma-related mortality despite having significantly limited healthcare resources (Gosselin et al., 2009). In India, trauma constitutes a major public health crisis, with road traffic accidents alone causing over 150,000 deaths and injuring nearly 500,000 individuals each year, imposing substantial economic and social burdens on families and healthcare systems (Joshipura et al., 2004). Beyond mortality, trauma results in significant long-term disability affecting millions of individuals during their most productive years, with profound implications for economic productivity and quality of life.

The concept of time-sensitive care in trauma management has been well-established since the introduction of the "golden hour" principle by R. Adams Cowley in 1975, which posits that critically injured patients receiving definitive care within 60 minutes of injury have significantly improved survival outcomes (Cowley, 1975). This foundational concept has driven the development of trauma systems globally and underscores the critical importance of minimizing delays at every stage of the care continuum. Research by Hsieh et al. (2022) demonstrated that even within the two-hour window, shorter time to definitive care was positively associated with patient survival and favorable functional outcomes, particularly among patients with major trauma and torso injuries. The association was most pronounced in subgroups where hemorrhage control and surgical intervention were paramount to survival.

Delays in emergency trauma care represent a multifaceted problem influenced by factors operating at individual, community, healthcare facility, and system levels. The three-delay model, originally developed by Thaddeus and Maine (1994) for maternal mortality analysis, has been increasingly applied to trauma care research to systematically categorize and understand barriers to timely treatment. This framework delineates delays into three distinct phases: delay in deciding to seek care (Phase 1), delay in reaching a healthcare facility (Phase 2), and delay in receiving appropriate care upon arrival (Phase 3). Application of this model to trauma settings has revealed that each phase contributes uniquely to adverse outcomes, with the relative importance varying based on geographic, socioeconomic, and health system factors (Whitaker et al., 2021).

Phase 1 delays encompass the interval between injury occurrence and the decision to seek medical care. These delays are influenced by injury recognition, perceived severity, cultural beliefs regarding healthcare seeking, financial concerns, and awareness of available emergency services. Studies from developing countries have documented that lack of awareness about emergency helpline services, underestimation of injury severity, and reluctance to seek immediate care due to anticipated costs significantly contribute to Phase 1 delays (Kharkongor et al., 2024). In the Indian context, research has shown that substantial proportions of trauma victims and bystanders remain unaware of emergency contact numbers such as the 108 ambulance service, despite over two decades of implementation.

Phase 2 delays involve the time required to reach a healthcare facility following the decision to seek care. These delays are influenced by distance to healthcare facilities, availability and accessibility of transportation, road infrastructure quality, traffic conditions, and the presence or absence of organized prehospital emergency medical services. In many low and middle-income countries, including India, the absence of formal emergency medical systems compounds transportation challenges. Studies have demonstrated that population density, road network density, number of available ambulances, and geographic distribution of healthcare facilities significantly influence ambulance response and transport times (Bhatt et al., 2023). Multiple referrals between healthcare facilities before reaching definitive care centers further exacerbate Phase 2 delays, with patients often being transferred from primary to secondary to tertiary facilities, each transfer adding critical time to the care pathway.

Phase 3 delays occur within healthcare facilities and encompass the time from patient arrival to initiation of definitive treatment. These delays are influenced by emergency department overcrowding, triage efficiency, availability of diagnostic services, specialist availability, operating theater access, and adequacy of critical care resources. Research from Indian tertiary care centers has documented significant Phase 3 delays attributable to high patient loads, lack of in-house specialists during off-hours, insufficient beds in intensive care units, inadequate radiological facilities, and administrative procedures requiring online requisitions before investigations (Coats & Goode, 2020). Emergency department overcrowding has emerged as a particularly significant contributor to treatment delays, with studies demonstrating associations between prolonged waiting times and adverse patient outcomes including increased mortality.

The relationship between prehospital time intervals and trauma outcomes has been extensively investigated with somewhat conflicting results. While some studies support the golden hour concept and demonstrate improved outcomes with shorter prehospital times, others have failed to establish significant associations between total prehospital time and mortality, particularly for undifferentiated trauma populations (Harmsen et al., 2015). However, research examining specific patient subgroups has revealed that rapid transport benefits patients with penetrating trauma, hemodynamic instability, and traumatic brain injury, where timely intervention can prevent secondary injury progression and hemorrhagic death. A multicenter Asian study by Chen et al. (2020) found that while prehospital time was not significantly associated with 30-day mortality, every 10-minute delay in total prehospital time was associated with a 6% increase in odds of poor functional outcome, supporting the continued relevance of rapid transport principles.

In-hospital delays have received increasing attention as healthcare access has improved in many settings. Studies examining preventable trauma deaths have consistently identified delays in emergency department treatment, particularly delays to emergency surgery for hemorrhage control, as major contributors to preventable mortality. Research from Ghana documented that 60% of trauma deaths were preventable, with in-hospital delays, especially in emergency departments, identified as significant contributing factors alongside prehospital delays (Yeboah et al., 2014). Similar findings from Indian institutions highlight the need for systematic assessment of in-hospital care processes to identify and address bottlenecks in trauma management pathways.

Understanding the specific determinants of delays in emergency trauma care within local contexts is essential for developing targeted interventions to improve outcomes. Regional variations in healthcare infrastructure, population characteristics, injury patterns, and socioeconomic factors necessitate context-specific assessments to guide resource allocation and system improvement efforts. West Bengal, with its diverse population, varying levels of healthcare access between urban and rural areas, and significant trauma burden from road traffic accidents and occupational injuries, presents an appropriate setting for investigating delays in emergency trauma care and their determinants.

The aim of this study is to assess the delays in emergency care of trauma patients presenting to a tertiary care hospital and to identify the associated determinants influencing each phase of delay, thereby providing evidence to guide interventions for improving timeliness of trauma care delivery.

## Methodology

### Study Design

The present study was conducted as a prospective observational study.

### Study Site

The study was conducted at Gouri Devi Institute of Medical Sciences and Hospital, West Bengal, India.

**Study Duration**
The study was conducted over a period of six months, extending from March 2025 to August 2025.

**Sampling Technique and Sample Size**
A consecutive sampling technique was employed wherein all eligible trauma patients presenting to the emergency department during the study period were approached for enrollment. This non-probability sampling method was selected to minimize selection bias and ensure representation of the full spectrum of trauma cases and delay patterns encountered at the study site. The sample size was established at 200 patients based on review of previous studies investigating delays in emergency care, which have employed similar sample sizes for adequate statistical power in identifying significant associations between delay determinants and outcomes.

**Inclusion and Exclusion Criteria**
The study enrolled adult patients aged 18 years and above presenting to the emergency department with acute traumatic injuries requiring emergency care, irrespective of mechanism of injury, who consented to participate either directly or through legally authorized representatives in cases of incapacitation. Patients were required to have accurate information available regarding injury time and care-seeking timeline, either from the patient, accompanying persons, or referring facility documentation. The exclusion criteria encompassed patients below 18 years of age due to different care pathways and decision-making processes in pediatric populations, patients declared dead on arrival before any emergency department assessment, those with isolated minor injuries not requiring emergency department management or hospital admission, patients presenting with injuries older than 24 hours where accurate timeline reconstruction was not feasible, cases of drowning and burns which involve distinct care pathways and delay patterns warranting separate investigation, and patients or their representatives who declined to participate or were unable to provide necessary timeline information.

**Data Collection Tools and Techniques**
Data collection was performed using a pre-designed, structured proforma developed specifically for this study based on the three-delay framework and validated through pilot testing on an initial cohort of 20 patients who were not included in the final analysis. The proforma was refined based on pilot experience to optimize clarity and completeness of data capture. The data collection instrument encompassed multiple domains systematically capturing information relevant to each delay phase.
Demographic and socioeconomic information collected included age, sex, educational status, occupation, monthly household income, residence type (urban, semi-urban, rural), and distance from residence to the hospital. Injury characteristics documented included mechanism of injury, anatomical distribution of injuries, injury severity assessed using the Revised Trauma Score parameters (Glasgow Coma Scale, systolic blood pressure, respiratory rate), and type of trauma (blunt or penetrating).
For Phase 1 delay assessment, information was gathered regarding the time of injury occurrence, time of decision to seek medical care, reasons for any delay in decision-making including lack of awareness about injury severity, financial concerns, waiting for family members, attempting home remedies, and awareness of emergency services including knowledge of 108 ambulance helpline.
Phase 2 delay parameters included mode of transport to first healthcare facility (private vehicle, auto-rickshaw, ambulance, other), time of departure for healthcare facility, time of arrival at first point of care, distance traveled, road conditions encountered, number of healthcare facilities visited before reaching the study hospital, and reasons for referrals if applicable.

Phase 3 delay assessment captured time of arrival at study hospital emergency department, time of initial assessment by emergency physician, time of completion of investigations, time of specialist consultation, time of decision for definitive management, time of initiation of definitive treatment (surgical intervention or admission for conservative management), and factors contributing to in-hospital delays including emergency department crowding, bed availability, investigation delays, and specialist availability.

Outcome variables documented included patient disposition (discharge, ward admission, intensive care admission, emergency surgery, death), length of hospital stay, and in-hospital mortality. Data were collected by trained research assistants under supervision of the principal investigator. Patient interviews were conducted once the patient was stable, using local language with translators when necessary. Information was cross-verified with accompanying persons and medical records to ensure accuracy. For referred patients, efforts were made to obtain documentation from referring facilities to accurately reconstruct the care timeline.

**Data Management and Statistical Analysis**

The collected data were entered into Microsoft Excel spreadsheets with appropriate coding for categorical variables. Double data entry was performed for a random 20% sample to verify accuracy, with discrepancies resolved by reference to original proformas. Statistical analysis was conducted using Statistical Package for Social Sciences (SPSS) version 26.0 software. Descriptive statistics were employed to characterize the study population and describe delay patterns. Continuous variables were expressed as mean with standard deviation for normally distributed data and median with interquartile range for skewed distributions. Categorical variables were presented as frequencies and percentages. The Kolmogorov-Smirnov test was used to assess normality of data distribution. Bivariate analysis was performed to identify factors associated with delays in each phase. Categorical variables were compared using Chi-square test or Fisher's exact test as appropriate. Continuous variables were compared using independent samples t-test or Mann-Whitney U test based on distribution characteristics. Variables demonstrating statistically significant associations ($p<0.05$) or clinical relevance were entered into multivariate logistic regression models to identify independent determinants of delay in each phase. Adjusted odds ratios with 95% confidence intervals were calculated. The association between delays and patient outcomes including mortality was assessed using appropriate statistical tests. A p-value less than 0.05 was considered statistically significant for all analyses.

**Ethical Considerations**

The study protocol was submitted to the Institutional Ethics Committee of Gouri Devi Institute of Medical Sciences and Hospital for review and approval prior to commencement of data collection. Ethical clearance was obtained in accordance with the Indian Council of Medical Research guidelines for biomedical research involving human subjects and the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants or their legally authorized representatives in cases where patients were unable to provide consent due to altered consciousness or severity of injuries.

**Results**

**Table 1: Demographic and Clinical Characteristics of Trauma Patients (N=200)**

| **Variable** | **Category** | **Frequency (n)** | **Percentage (%)** |
|---|---|---|---|
| **Age (years)** | 18-30 | 72 | 36 |
| | 31-45 | 64 | 32 |
| | 46-60 | 42 | 21 |
| | >60 | 22 | 11 |

| | | | |
|---|---|---|---|
| **Sex** | Male | 162 | 81 |
| | Female | 38 | 19 |
| **Residence** | Urban | 54 | 27 |
| | Semi-urban | 68 | 34 |
| | Rural | 78 | 39 |
| **Education** | Illiterate | 36 | 18 |
| | Primary | 48 | 24 |
| | Secondary | 72 | 36 |
| | Higher Secondary & above | 44 | 22 |
| **Mechanism of Injury** | Road Traffic Accident | 128 | 64 |
| | Fall from Height | 38 | 19 |
| | Assault | 18 | 9 |
| | Occupational Injury | 12 | 6 |
| | Others | 4 | 2 |
| **Type of Trauma** | Blunt | 176 | 88 |
| | Penetrating | 24 | 12 |
| **Injury Severity (RTS)** | Mild (RTS >6) | 118 | 59 |
| | Moderate (RTS 4-6) | 56 | 28 |
| | Severe (RTS <4) | 26 | 13 |
| **Outcome** | Discharged | 156 | 78 |
| | ICU Admission | 28 | 14 |
| | Expired | 16 | 8 |

*Mean age: 38.24 ± 14.56 years; Mean distance from residence to hospital: 32.4 ± 18.6 km*

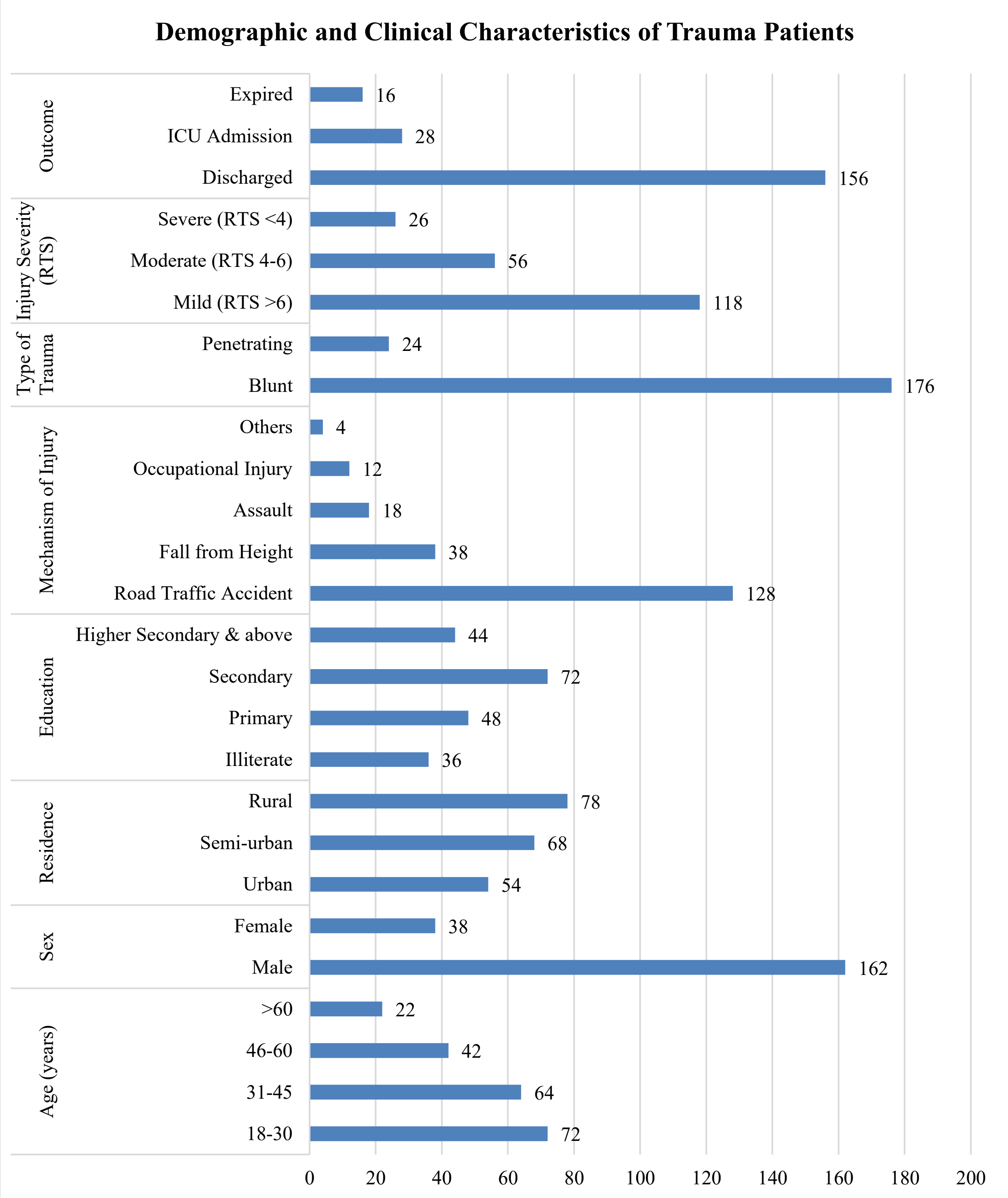


**Fig: 1**

**Table 2: Distribution of Delays Across Three Phases Among Trauma Patients (N=200)**

| **Phase of Delay** | **Parameter** | **Value** |
|---|---|---|
| **Phase 1 (Decision to Seek Care)** | Median time (IQR) in minutes | 18 (8-42) |
| | Mean time ± SD in minutes | 28.6 ± 32.4 |
| | Patients with immediate decision, n (%) | 86 (43.0%) |
| | Patients with delayed decision (>15 min), n (%) | 114 (57.0%) |
| **Phase 2 (Reaching Healthcare Facility)** | Median time (IQR) in minutes | 68 (42-112) |
| | Mean time ± SD in minutes | 82.4 ± 54.6 |
| | Patients reaching within 60 min, n (%) | 72 (36.0%) |

| | | |
|---|---|---|
| | Patients with delay >60 min, n (%) | 128 (64.0%) |
| | Patients with referral from other facility, n (%) | 94 (47.0%) |
| **Phase 3 (Receiving Care at Hospital)** | Median time (IQR) in minutes | 52 (34-86) |
| | Mean time ± SD in minutes | 64.8 ± 42.2 |
| | Patients receiving care within 60 min, n (%) | 108 (54.0%) |
| | Patients with delay >60 min, n (%) | 92 (46.0%) |
| **Total Delay (Injury to Definitive Care)** | Median time (IQR) in minutes | 156 (98-224) |
| | Mean time ± SD in minutes | 175.8 ± 96.4 |
| | Patients within Golden Hour (≤60 min), n (%) | 24 (12.0%) |
| | Patients exceeding Golden Hour, n (%) | 176 (88.0%) |

*IQR: Interquartile Range; SD: Standard Deviation; RTS: Revised Trauma Score*

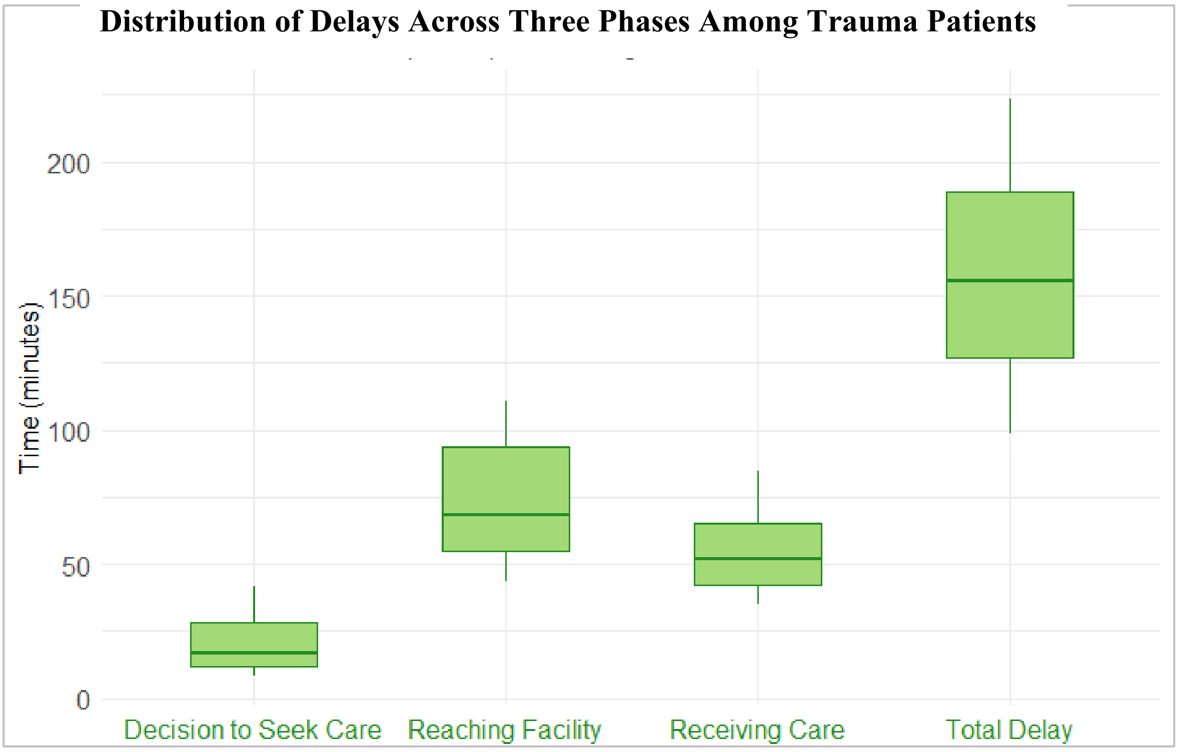


**Fig: 2**

**Table 3: Factors Associated with Phase 1 Delay (Decision to Seek Care)**

| **Factor** | | **Delayed Decision (n=114)** | **Immediate Decision (n=86)** | **χ²/t-value** | **p-value** |
|---|---|---|---|---|---|
| **Residence** | Urban | 22 (19.3%) | 32 (37.2%) | 12.84 | 0.002* |
| | Semi-urban | 38 (33.3%) | 30 (34.9%) | | |
| | Rural | 54 (47.4%) | 24 (27.9%) | | |
| **Education** | Illiterate/Primary | 58 (50.9%) | 26 (30.2%) | 8.62 | 0.003* |
| | Secondary & above | 56 (49.1%) | 60 (69.8%) | | |
| **Awareness of 108 Helpline** | Yes | 42 (36.8%) | 56 (65.1%) | 15.68 | <0.001* |
| | No | 72 (63.2%) | 30 (34.9%) | | |
| **Financial Concerns** | Present | 68 (59.6%) | 28 (32.6%) | 14.24 | <0.001* |
| | Absent | 46 (40.4%) | 58 (67.4%) | | |
| **Perceived Injury Severity** | Underestimated | 76 (66.7%) | 32 (37.2%) | 16.82 | <0.001* |
| | Correctly estimated | 38 (33.3%) | 54 (62.8%) | | |
| **Alcohol** | Present | 34 (29.8%) | 12 (14.0%) | 6.84 | 0.009* |

| | | | | | |
|---|---|---|---|---|---|
| **Intoxication** | Absent | 80 (70.2%) | 74 (86.0%) | | |
| **Time of Injury** | Day (6 AM - 6 PM) | 58 (50.9%) | 54 (62.8%) | 2.82 | 0.093 |
| | Night (6 PM - 6 AM) | 56 (49.1%) | 32 (37.2%) | | |

*Statistically significant (p<0.05)*

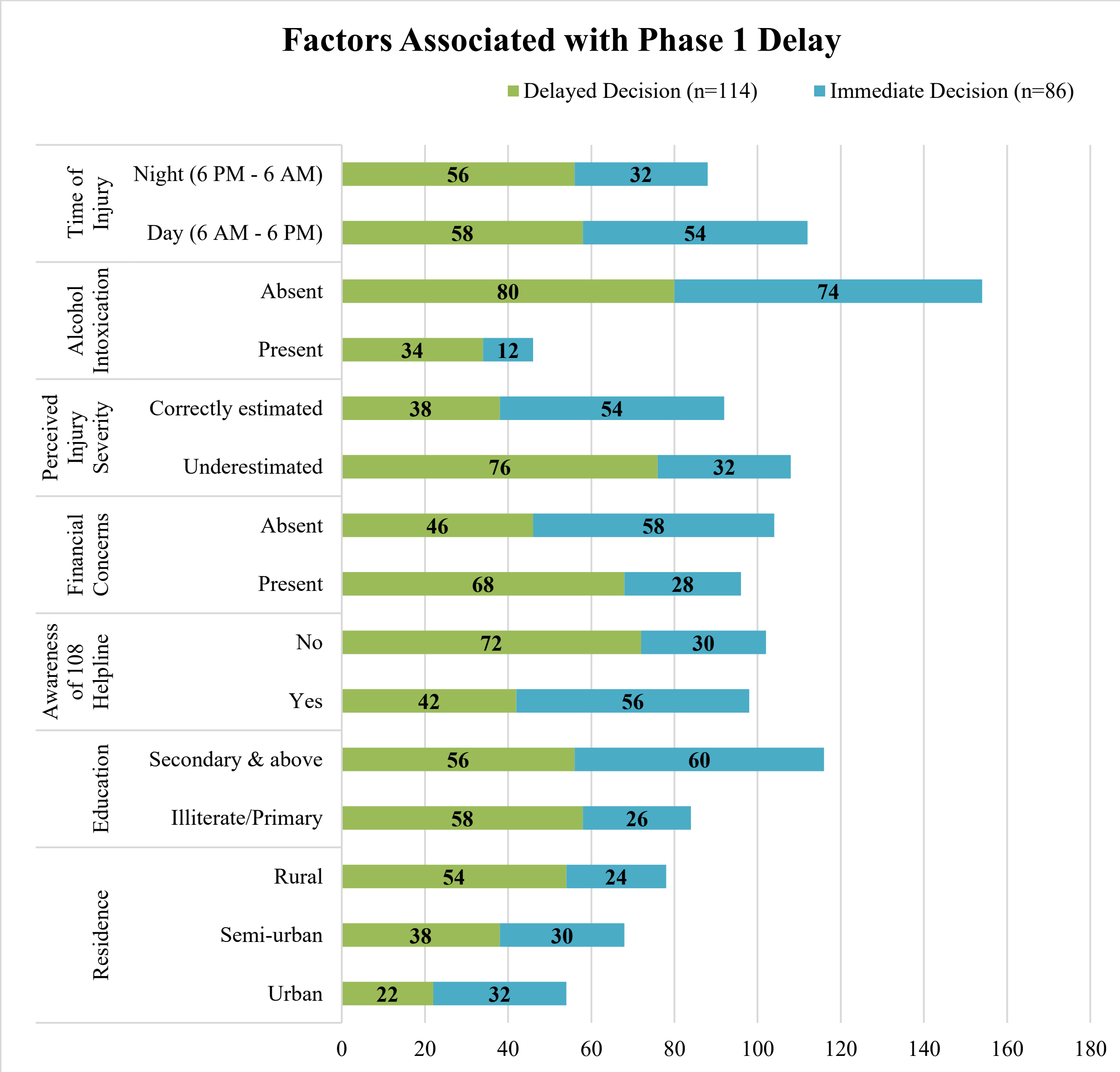


**Fig: 3**

**Table 4: Factors Associated with Phase 2 Delay (Reaching Healthcare Facility)**

| **Factor** | | **Delayed (>60 min) (n=128)** | **Not Delayed (n=72)** | **χ²/t-value** | **p-value** |
|---|---|---|---|---|---|
| **Distance from Hospital** | ≤20 km | 32 (25.0%) | 46 (63.9%) | 28.64 | <0.001* |
| | >20 km | 96 (75.0%) | 26 (36.1%) | | |
| **Mode of Transport** | Ambulance (108/Private) | 38 (29.7%) | 34 (47.2%) | 6.24 | 0.012* |
| | Private vehicle/Other | 90 (70.3%) | 38 (52.8%) | | |
| **Road Condition** | Good | 42 (32.8%) | 44 (61.1%) | 14.86 | <0.001* |
| | Poor | 86 (67.2%) | 28 (38.9%) | | |
| **Referral Status** | Direct admission | 48 (37.5%) | 58 (80.6%) | 34.28 | <0.001* |
| | Referred from other facility | 80 (62.5%) | 14 (19.4%) | | |

| | | | | | |
|---|---|---|---|---|---|
| **Number of Facilities Visited** | One (Direct) | 48 (37.5%) | 58 (80.6%) | 32.46 | <0.001* |
| | Two | 52 (40.6%) | 12 (16.7%) | | |
| | Three or more | 28 (21.9%) | 2 (2.8%) | | |
| **Residence Type** | Urban | 24 (18.8%) | 30 (41.7%) | 14.62 | 0.001* |
| | Semi-urban | 44 (34.4%) | 24 (33.3%) | | |
| | Rural | 60 (46.9%) | 18 (25.0%) | | |
| **Time of Day** | Day (6 AM - 6 PM) | 68 (53.1%) | 44 (61.1%) | 1.18 | 0.277 |
| | Night (6 PM - 6 AM) | 60 (46.9%) | 28 (38.9%) | | |

*Statistically significant (p<0.05)*

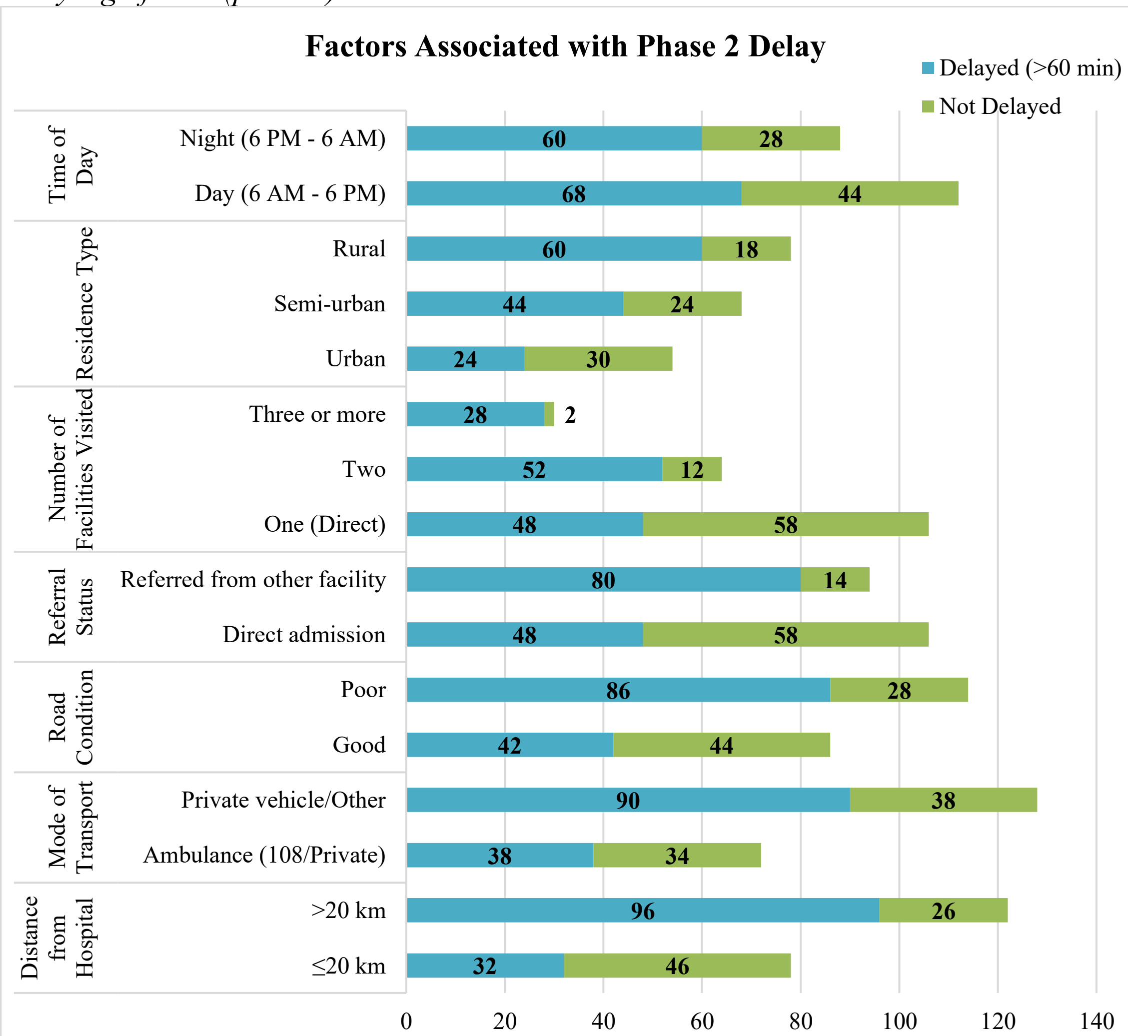


**Fig: 4**

**Table 5: Factors Associated with Phase 3 Delay (Receiving Care) and Patient Outcomes**

| **Factor** | | **Delayed (>60 min) (n=92)** | **Not Delayed (n=108)** | **χ²/t-value** | **p-value** |
|---|---|---|---|---|---|
| **Emergency Department Crowding** | High patient load | 64 (69.6%) | 38 (35.2%) | 22.84 | <0.001* |
| | Normal patient load | 28 (30.4%) | 70 (64.8%) | | |
| **Specialist Availability** | Available on-site | 34 (37.0%) | 72 (66.7%) | 17.24 | <0.001* |
| | Required to be called | 58 (63.0%) | 36 (33.3%) | | |
| **Investigation Delays** | Present | 56 (60.9%) | 32 (29.6%) | 19.36 | <0.001* |
| | Absent | 36 (39.1%) | 76 (70.4%) | | |
| **Bed Availability** | Available | 42 (45.7%) | 78 (72.2%) | 14.28 | <0.001* |

| | | | | | |
|---|---|---|---|---|---|
| | Not available | 50 (54.3%) | 30 (27.8%) | | |
| **Time of Arrival** | Office hours (8 AM - 5 PM) | 32 (34.8%) | 58 (53.7%) | 6.92 | 0.009* |
| | Off-hours | 60 (65.2%) | 50 (46.3%) | | |
| **Injury Severity (RTS <4)** | Present | 18 (19.6%) | 8 (7.4%) | 6.24 | 0.012* |
| | Absent | 74 (80.4%) | 100 (92.6%) | | |

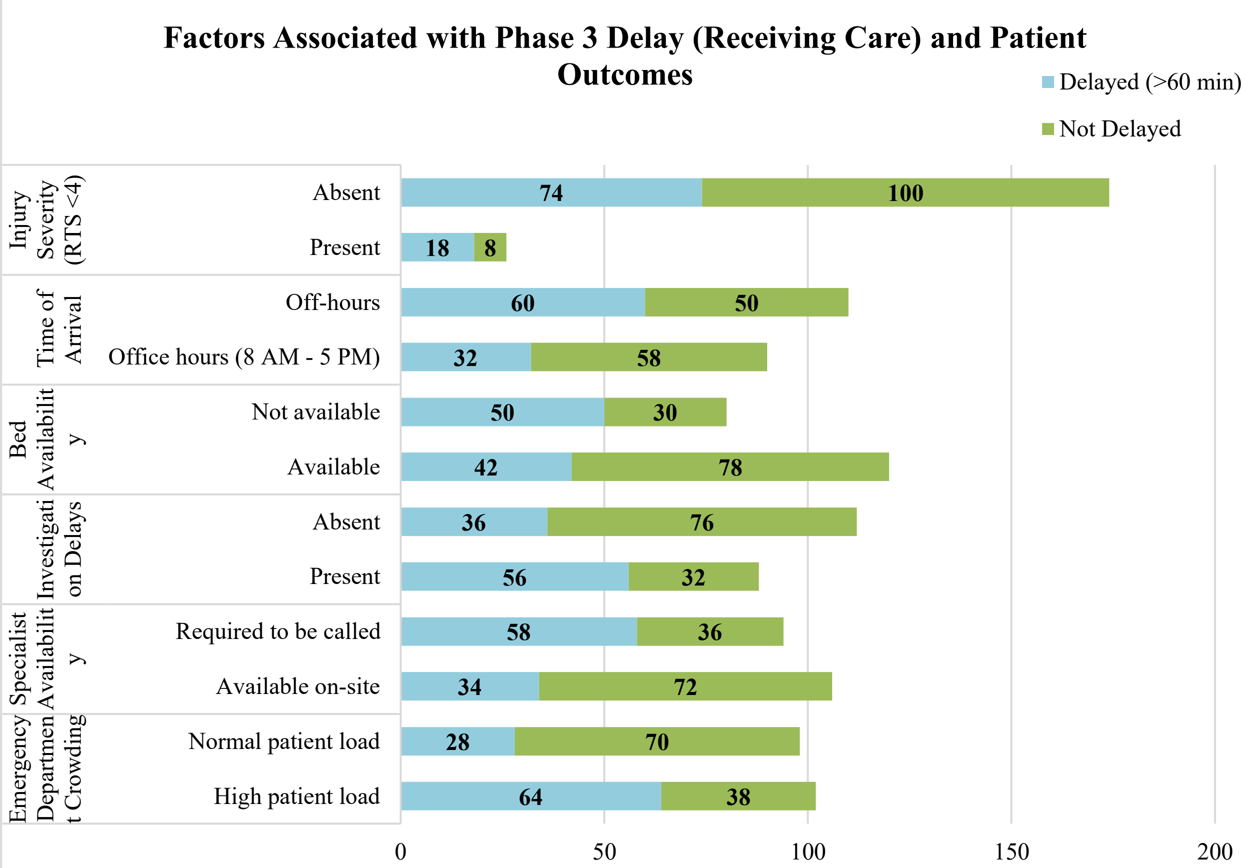


**Fig: 5**

**Association of Delays with Patient Outcomes:**

| **Outcome Parameter** | **Total Delay ≤120 min (n=58)** | **Total Delay >120 min (n=142)** | **χ²/OR** | **p-value** |
|---|---|---|---|---|
| Mortality | 2 (3.4%) | 14 (9.9%) | 2.28 | 0.048* |
| ICU Admission | 4 (6.9%) | 24 (16.9%) | 3.46 | 0.042* |
| Hospital Stay >7 days | 12 (20.7%) | 56 (39.4%) | 2.58 | 0.012* |

**Logistic Regression - Independent Predictors of Total Delay >120 minutes:**

| **Variable** | **Adjusted OR** | **95% CI** | **p-value** |
|---|---|---|---|
| Rural residence | 2.86 | 1.42 - 5.76 | 0.003* |
| Referral from other facility | 4.24 | 2.18 - 8.26 | <0.001* |
| Distance >20 km | 3.12 | 1.56 - 6.24 | 0.001* |
| Unawareness of 108 helpline | 2.14 | 1.12 - 4.08 | 0.021* |
| Off-hours arrival | 1.86 | 1.02 - 3.38 | 0.043* |

*OR: Odds Ratio; CI: Confidence Interval; *Statistically significant (p<0.05)*

**Discussion**

The present study systematically evaluated delays in emergency care of trauma patients presenting to Gouri Devi Institute of Medical Sciences and Hospital, West Bengal, utilizing the three-delay framework. The findings provide comprehensive insights into the temporal patterns of care-seeking, transportation, and in-hospital management, along with identification of key determinants influencing delays at each phase.

The demographic analysis revealed a predominance of male patients (81%) with a mean age of 38.24 years, consistent with global and Indian literature documenting that young adult males constitute the majority of trauma victims due to greater occupational exposure and vehicular travel patterns. Mathew et al. (2017) reported similar male predominance (73.6%) and mean age (40.2 years) among trauma patients presenting to a tertiary care emergency department in South India. Road traffic accidents constituted the leading mechanism of injury (64%), aligning with findings from multiple Indian studies and reflecting the substantial burden of vehicular trauma in developing countries (Joshipura et al., 2004). The predominance of rural residents (39%) in our study population has significant implications for understanding delay patterns, as geographic accessibility to healthcare facilities varies considerably between urban and rural settings.

A striking finding of our study was that only 12% of trauma patients received definitive care within the golden hour of 60 minutes from injury, with a median total delay of 156 minutes. This observation underscores the substantial gap between recommended standards and actual practice in resource-limited settings. Similar findings were reported by Roy et al. (2016), who documented mean prehospital times exceeding 2 hours among trauma patients in Mumbai despite the presence of tertiary trauma facilities. The concept of the golden hour, while foundational to trauma care principles, remains largely unachieved in many developing country contexts due to infrastructure limitations, transportation challenges, and healthcare system constraints (Sasser et al., 2006).

Chen et al. (2020) in their multicenter Asian study demonstrated that while prehospital time was not significantly associated with 30-day mortality, longer delays were associated with poor functional outcomes. Our findings support this observation, with total delays exceeding 120 minutes showing significant associations with increased mortality (9.9% vs. 3.4%, p=0.048), ICU admission rates, and prolonged hospital stay. These results emphasize that while the precise 60-minute threshold may be debated, minimizing delays remains crucial for optimizing trauma outcomes.

More than half (57%) of patients experienced delays in deciding to seek care following injury. The median Phase 1 delay of 18 minutes, while seemingly brief, represents critical time during which hemorrhage continues, secondary brain injury progresses, and physiological deterioration occurs. Rural residence, lower educational attainment, lack of awareness about emergency services, financial concerns, and underestimation of injury severity emerged as significant determinants of Phase 1 delay.

The finding that 63.2% of patients with delayed decisions were unaware of the 108 ambulance helpline is particularly concerning, given that this emergency service has been operational for over two decades in many Indian states. Kharkongor et al. (2024) reported similar findings from Jodhpur, where 65% of trauma patients were unaware of emergency helpline services. This knowledge gap represents an actionable target for public health interventions aimed at reducing care-seeking delays.

Financial concerns significantly influenced decision-making, with 59.6% of patients experiencing delays citing anticipated costs as a barrier. This finding aligns with research from other developing countries documenting that economic considerations frequently delay healthcare seeking even in emergency situations (Kobusingye et al., 2005). The association between alcohol intoxication and delayed decisions (29.8% vs. 14.0%, p=0.009) reflects the dual burden of alcohol as both a risk factor for trauma and an impediment to appropriate care-seeking behavior.

Phase 2 delays were substantial, with 64% of patients taking longer than 60 minutes to reach the first healthcare facility. The median transport time of 68 minutes exceeded the entire golden hour duration, highlighting transportation as a critical bottleneck in the trauma care continuum. Distance from hospital emerged as the strongest determinant, with 75% of delayed patients residing more than 20 km from the facility compared to 36.1% of those not delayed (p<0.001).

Referral from other healthcare facilities was associated with markedly increased Phase 2 delays, with 62.5% of delayed patients having been referred compared to 19.4% of non-delayed patients. Multiple facility visits compounded delays, with patients visiting three or more facilities before reaching definitive care experiencing the longest transport times. This pattern of sequential referrals reflects deficiencies in primary care facility capabilities and absence of defined referral protocols, findings consistent with observations by Uthkarsh et al. (2016) regarding inadequate trauma care resources at district-level hospitals in South India.

Only 36% of patients utilized ambulance services for transportation, with the remainder relying on private vehicles and other modes. Bhatt et al. (2023) documented similar ambulance utilization patterns in Maharashtra, identifying population density, road infrastructure, and ambulance availability as key determinants of emergency medical services accessibility. The significant association between poor road conditions and transport delays (67.2% vs. 38.9%, $p<0.001$) underscores the need for infrastructure improvements alongside healthcare system strengthening.

In-hospital Phase 3 delays affected 46% of patients, with emergency department crowding, specialist unavailability, investigation delays, and bed shortages identified as significant contributors. These findings align with research from Indian tertiary care centers documenting that high patient loads and resource constraints contribute to emergency department delays (Mitra & Sarkar, 2014). Patients arriving during off-hours experienced significantly greater Phase 3 delays (65.2% vs. 46.3%, $p=0.009$), reflecting reduced staffing levels and specialist availability outside regular working hours.

Investigation delays affected 60.9% of patients experiencing Phase 3 delays, highlighting the need for streamlined diagnostic pathways in emergency trauma care. Yeboah et al. (2014) identified delays in emergency department treatment as major contributors to preventable trauma deaths in resource-limited settings, recommending systematic quality improvement approaches to address identified bottlenecks.

Multivariate analysis identified rural residence (OR: 2.86), referral from other facilities (OR: 4.24), distance exceeding 20 km (OR: 3.12), unawareness of emergency helpline (OR: 2.14), and off-hours arrival (OR: 1.86) as independent predictors of total delay exceeding 120 minutes. These findings collectively highlight the intersection of geographic, socioeconomic, health system, and temporal factors in determining timeliness of trauma care.

The three-delay framework proved valuable for systematically identifying modifiable factors across the care continuum. Whitaker et al. (2021) in their systematic review of trauma care assessments in low and middle-income countries noted that most research has focused on Phase 3 delays, with relatively less attention to Phases 1 and 2. Our study contributes to addressing this gap by documenting the substantial contribution of pre-hospital phases to overall delay, information essential for developing comprehensive interventions.

## Conclusion

This study demonstrates that delays in emergency trauma care are substantial and multifactorial, with only 12% of patients receiving definitive care within the golden hour. Phase 2 delays related to transportation and referrals contributed most significantly to total delay. Rural residence, multiple facility referrals, distance from hospital, lack of awareness about emergency services, and off-hours presentation emerged as independent predictors of prolonged delays. The significant association between delays exceeding 120 minutes and adverse outcomes including mortality, ICU admission, and prolonged hospitalization underscores the urgent need for systematic interventions addressing all three delay phases to improve trauma care delivery and patient outcomes in resource-limited settings.

## Recommendations

Comprehensive interventions are required including community awareness campaigns about emergency helpline services, strengthening of primary and secondary healthcare facilities to reduce unnecessary referrals, improvement of road infrastructure in rural areas, enhancement of ambulance coverage and distribution, implementation of standardized trauma protocols with dedicated trauma bays, ensuring round-the-clock specialist availability, and regular monitoring of delay indicators as quality improvement metrics in emergency departments.

## References


- Bhatt, S., Goel, S., Gupta, A., & Singh, A. (2023). Examining district-level disparity and determinants of timeliness of emergency medical services in Maharashtra, India. *Scientific Reports*, 13(1), 21324. https://doi.org/10.1038/s41598-023-48713-1
- Chen, C. H., Shin, S. D., Sun, J. T., Jamaluddin, S. F., Tanaka, H., Song, K. J., Kajino, K., Kimura, A., Huang, E. P., Hsieh, M. J., Ma, M. H., & Chiang, W. C. (2020). Association between prehospital time and outcome of trauma patients in 4 Asian countries: A cross-national, multicenter cohort study. *PLOS Medicine*, 17(10), e1003360. https://doi.org/10.1371/journal.pmed.1003360
- Coats, T. J., & Goode, A. (2020). Delays in trauma care. *Injury*, 51(6), 1193-1195. https://doi.org/10.1016/j.injury.2020.04.016
- Cowley, R. A. (1975). A total emergency medical system for the State of Maryland. *Maryland State Medical Journal*, 24(7), 37-45. PMID: 1142842
- Gauss, T., Ageron, F. X., Devaud, M. L., Debaty, G., Travers, S., Garrigue, D., Raux, M., Harrois, A., & Bouzat, P. (2019). Association of prehospital time to in-hospital trauma mortality in a physician-staffed emergency medicine system. *JAMA Surgery*, 154(12), 1117-1124. https://doi.org/10.1001/jamasurg.2019.3475
- Gosselin, R. A., Spiegel, D. A., Coughlin, R., & Zirkle, L. G. (2009). Injuries: The neglected burden in developing countries. *Bulletin of the World Health Organization*, 87(4), 246-246. https://doi.org/10.2471/BLT.08.052290
- Harmsen, A. M., Giannakopoulos, G. F., Moerbeek, P. R., Jansma, E. P., Bonjer, H. J., & Bloemers, F. W. (2015). The influence of prehospital time on trauma patients outcome: A systematic review. *Injury*, 46(4), 602-609. https://doi.org/10.1016/j.injury.2015.01.008
- Hsieh, S. L., Hsiao, C. H., Chiang, W. C., Shin, S. D., Jamaluddin, S. F., Son, D. N., Hong, K. J., Sun, J. T., Tsai, W., Chien, D. K., Chang, W. H., & Chen, T. H. (2022). Association between the time to definitive care and trauma patient outcomes: Every minute in the golden hour matters. *European Journal of Trauma and Emergency Surgery*, 48(4), 2709-2716. https://doi.org/10.1007/s00068-021-01816-8
- Joshipura, M. K., Shah, H. S., Patel, P. R., Divatia, P. A., & Desai, P. M. (2004). Trauma care systems in India. *Injury*, 35(7), 686-692. https://doi.org/10.1016/j.injury.2003.10.027
- Kharkongor, M., Rao, S. M., Sharma, V., & Meena, R. K. (2024). Factors influencing treatment delays in trauma patients: A three-delay model approach. *Journal of Emergencies, Trauma and Shock*, 17(3), 108-115. https://doi.org/10.4103/jets.jets_13_24
- Kobusingye, O. C., Hyder, A. A., Bishai, D., Hicks, E. R., Mock, C., & Joshipura, M. (2005). Emergency medical systems in low- and middle-income countries: Recommendations for action. *Bulletin of the World Health Organization*, 83(8), 626-631. PMID: 16184282
- Mathew, J., Mukherjee, C., Joseph, M., Sharma, N., & Bhoi, S. (2017). Profile of trauma patients in the emergency department of a tertiary care hospital in South India. *Journal of Family Medicine and Primary Care*, 6(3), 558-563. https://doi.org/10.4103/2249-4863.222054
- Mitra, S., & Sarkar, A. P. (2014). Arrival time pattern and waiting time distribution of patients in the emergency outpatient department of a tertiary level health care institution of North India. *International Journal of Medicine and Public Health*, 4(3), 266-270. https://doi.org/10.4103/2230-8598.137715
- Nielsen, K., Mock, C., Joshipura, M., Rubiano, A. M., Zakariah, A., & Rivara, F. (2012). Assessment of the status of prehospital care in 13 low- and middle-income countries. *Prehospital Emergency Care*, 16(3), 381-389. https://doi.org/10.3109/10903127.2012.664245

- Rogers, F. B., Rittenhouse, K. J., & Gross, B. W. (2015). The golden hour in trauma: Dogma or medical folklore? *Injury*, 46(4), 525-527. https://doi.org/10.1016/j.injury.2014.08.043
- Roy, N., Murlidhar, V., Chowdhury, R., Patil, S. B., Supe, P. A., Vaishnav, P. D., & Vatkar, A. (2016). Where there are no emergency medical services: Prehospital care for the injured in Mumbai, India. *Prehospital and Disaster Medicine*, 25(2), 145-151. https://doi.org/10.1017/S1049023X00007883
- Sasser, S. M., Varghese, M., Joshipura, M., & Kellermann, A. (2006). Preventing death and disability through the timely provision of prehospital trauma care. *Bulletin of the World Health Organization*, 84(7), 507. https://doi.org/10.2471/blt.06.033605
- Staton, C. A., Msilanga, D., Kiwango, G., Vissoci, J. R., de Andrade, L., Lester, R., Hocker, M., & Gerber, L. M. (2017). A prospective registry evaluating the epidemiology and clinical care of traumatic brain injury patients presenting to a regional referral hospital in Moshi, Tanzania. *International Journal of Injury Control and Safety Promotion*, 24(1), 69-77. https://doi.org/10.1080/17457300.2015.1061562
- Thaddeus, S., & Maine, D. (1994). Too far to walk: Maternal mortality in context. *Social Science & Medicine*, 38(8), 1091-1110. https://doi.org/10.1016/0277-9536(94)90226-7
- Uthkarsh, P. S., Suryanarayana, S. P., Gautham, M. S., Shivraj, N. S., Murthy, N. S., & Pruthvish, S. (2016). Assessment and availability of trauma care services in a district hospital of South India: A field observational study. *Bulletin of Emergency and Trauma*, 4(2), 93-100. PMID: 27331065
- Van Rooyen, M. J., Sloan, E. P., Barrett, J. A., & Smith, R. F. (1995). The golden hour and the silver day: Detection and correction of occult hypoperfusion within 24 hours improves outcome from major trauma. *Journal of Trauma*, 39(3), 492-498. https://doi.org/10.1097/00005373-199509000-00017
- Whitaker, J., Nepogodiev, D., Leather, A., & Davies, J. (2021). Assessing trauma care systems in low-income and middle-income countries: A systematic review and evidence synthesis mapping the Three Delays framework to injury health system assessments. *BMJ Global Health*, 6(5), e004324. https://doi.org/10.1136/bmjgh-2020-004324
- Yeboah, D., Mock, C., Karikari, P., Agyei-Baffour, P., Donkor, P., & Ebel, B. (2014). Minimizing preventable trauma deaths in a limited-resource setting: A test-case of a multidisciplinary panel review approach at the Komfo Anokye Teaching Hospital in Ghana. *World Journal of Surgery*, 38(7), 1707-1712. https://doi.org/10.1007/s00268-014-2452-z