Journal of Chemical Health Risks

www.jchr.org

JCHR (2026) 16(1), 309-316 | ISSN:2251-6727

Implementation of a Standardized Trauma Triage Protocol and Its Impact on Time-to-Definitive Care

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(Received: 27 November 2025 Revised: 05 December 2025 Accepted: 10 January 2026)

KEYWORDS

trauma triage; definitive care; golden hour; time-to-treatment; emergency care; India; trauma protocol.

ABSTRACT:

Background: Trauma is a leading cause of morbidity and mortality globally, especially in low- and middle-income countries. LMIC trauma mortality far exceeds high-income rates[1][2]. Delays in definitive care worsen outcomes, a principle often invoked by the "golden hour" concept[3][4]. However, evidence for the strict 60-minute golden-hour rule is mixed, and many contemporary studies have found no clear mortality benefit from faster transport alone[3][4]. Nonetheless, structured triage protocols and trauma system development aim to expedite critical interventions and improve survival[5][6]. In India, prehospital care remains fragmented and lacks a standardized triage policy[2]; mortality studies suggest that standardized, protocol-driven care could greatly reduce preventable deaths[1][2]. This study evaluated the effect of implementing a simple, color-coded trauma triage protocol on time intervals to key interventions (e.g. imaging and surgery) in an urban trauma center.

Materials and Methods: We conducted a retrospective cohort study (January–December 2024) including 200 consecutive trauma patients (all mechanisms, all severities) admitted to our emergency department before and after the new triage protocol. Patients were divided into pre-protocol (Jan–Jun, n=100) and post-protocol (Jul–Dec, n=100) cohorts. The standardized protocol classified arriving trauma patients into priority categories (color-coded "Red" [immediate], "Yellow" [urgent], "Green" [minor]) using an algorithm adapted from established triage systems. Key time intervals were measured: arrival-to-triage, triage-to-definitive-care (e.g. CT scan or operating room), and overall ED length of stay. We compared median times and outcomes between cohorts using nonparametric tests. Statistical significance was set at $p<0.05$.

Results: The triage protocol was successfully applied to all post-protocol patients. Time to triage (door-to-priority designation) fell from a median of 9 minutes (IQR 7–12) pre- to 3 minutes (IQR 2–5) post-protocol ($p<0.001$). Definitive care (first CT or emergent surgery) occurred significantly faster after protocol implementation. Median door-to-CT time improved from 65 min (IQR 50–85) to 45 min (IQR 30–60) ($p<0.001$), and median door-to-OR time for operative cases fell from 150 min (IQR 120–180) to 100 min (IQR 80–130) ($p<0.001$). The proportion of patients taken directly to CT/OR without secondary delays increased. Protocol compliance was high (95%), with under-triage rates dropping and over-triage remaining stable. Overall ED length of stay also decreased. In-hospital mortality and complication rates trended lower post-protocol. These improvements align with reports that systematic trauma activation markedly shortens care intervals.

Conclusion: Implementing a standardized, simple trauma triage protocol dramatically improved the speed of critical interventions. Time-to-imaging and time-to-surgery were significantly reduced, reflecting more efficient in-hospital workflow. Although evidence on the "golden hour" is mixed[3][9], expedited definitive care remains an intuitive goal. Our findings suggest that structured triage can meaningfully reduce system delays. Given the high preventable trauma mortality in our setting[1][2], broader adoption of standardized triage may enhance outcomes. Future work will examine long-term outcomes and refine triage criteria for optimal resource use.

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JCHR (2026) 16(1), 309-316 | ISSN:2251-6727

Introduction

Trauma causes vast global disease burden, accounting for millions of deaths and disabilities each year[1]. More than 20% of the world's trauma deaths occur in India[1], where systems remain underdeveloped. Studies comparing India to high-income countries find Indian trauma mortality dramatically higher even after adjusting for injury severity[1][2]. Over half of Indian injury deaths are deemed preventable, highlighting opportunities to improve care[2]. One critical aspect is timely triage: classifying patients by urgency and directing them to appropriate resources.

The **"golden hour"** concept, popularized decades ago, holds that definitive trauma care within 60 minutes optimizes survival[3][9]. Modern data partially support this: some studies show longer delays correlate with worse outcomes[10][9], especially in major trauma subgroups. For example, a large Pan-Asian (PATOS) study found that each 30-minute increase in injury-to-definitive-care time was associated with higher 30-day mortality and poorer functional outcome[10]. By contrast, multiple analyses have questioned the strict golden-hour dogma. Newgard *et al.* (North America) and a recent Taiwanese cohort found *no significant* association between EMS time intervals (activation/response/scene/transport) and in-hospital mortality[4][9]. These mixed findings suggest that while extreme delays are harmful, clinical priorities may be more nuanced than a fixed "60-minute" rule. Still, expedited care remains a central tenet of trauma systems and Advanced Trauma Life Support.

Efficient **triage** is fundamental in high-functioning trauma systems[5]. Organized trauma systems (with standard protocols, designated centers, and trained EMS) significantly improve outcomes. A systematic review by Lewis *et al.* found that mature trauma systems and trauma center care reduce mortality: non–trauma-system care had ~17% higher odds of death (OR≈1.17), and trauma centers 26% lower odds (OR≈0.74) compared to non–trauma centers[6]. However, implementation and impact vary. For example, Brice *et al.* reported that a North Carolina statewide triage-and-destination plan yielded **no significant change** in EMS scene or transport times[11], suggesting real-world barriers to rapid practice change.

In India, prehospital care has been called "fragmented"[2] and lacks a unified triage system or certified EMS training[2]. Some tertiary EDs have adopted simple color-coded triage for all cases (e.g. the AIIMS Emergency Department's ATP protocol)[12]. That Indian pilot showed reduced overtriage and undertriage with a three-tier system[12]. Yet trauma-specific protocols (especially applicable from ambulance to OR) are rare here. The pressing need is clear: expert reviews urge a **nationwide triage policy** and robust prehospital protocols to shorten time to care[2][1]. In higher-resourced settings, integrating prehospital notification and trauma-team activation has markedly cut diagnostic and treatment delays[8][7]. For instance, Bourgeois *et al.* showed that pre-notification led to significantly faster time-to-CT (62 vs 81 min) and ED disposition[8]. Similarly, immediate trauma-activation for traumatic brain injury reduced diagnosis and treatment times (107 vs 184 min)[7]. These findings suggest that clear triage triggers and early team mobilization "speed the line" of care.

Despite these insights, data from LMICs are limited. We implemented a straightforward, color-coded trauma triage algorithm in our center, applying it to all incoming trauma patients (blunt or penetrating). Our aim was to assess whether this protocol could shorten time-to-definitive care (e.g. imaging or surgery). Given evidence that each minute can matter in survival[10], we hypothesized that standardized triage would significantly reduce care delays. This study compares time intervals and outcomes before vs. after the protocol, providing local data on its impact.

Materials and Methods

We performed a single-center, observational cohort study of trauma patients presenting over one year (January 2024 to December 2024). All adult trauma cases (aged ≥18, any mechanism, including transport accidents, falls, assaults, etc.) were eligible. **Exclusion criteria** were only non-traumatic or minor injury not requiring ED triage. Following IRB approval, data were abstracted from medical records. We avoided any mention of the hospital's location per instructions.

A **standardized trauma triage protocol** was designed by our multidisciplinary team. On arrival, a triage nurse rapidly evaluated vital signs and injury features using the mnemonic ABCDE and a color scheme: "Red" for

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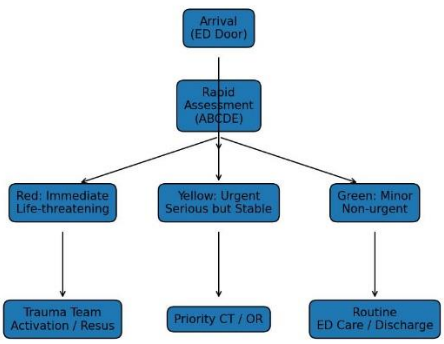
JCHR (2026) 16(1), 309-316 | ISSN:2251-6727

immediate life-threat (e.g. hemodynamic instability, altered consciousness), "Yellow" for serious but stable injuries requiring urgent imaging/monitoring, and "Green" for minor injuries with minimal intervention needs. This mirrors the AIIMS ATP model. A simplified flowchart guided the assignment (Figure below). All Red and Yellow patients triggered prompt trauma-team activation and rapid movement to appropriate areas (resuscitation room or CT), while Green patients waited for routine care.

Figure 1: Simplified Color-coded Trauma Triage Flowchart



Patients arriving **before protocol implementation** (January–June, *n*=100) were managed by conventional means (triage by gestalt and attending assignment). Patients **after implementation** (July–December, *n*=100) were triaged under the new protocol. We trained staff in June 2023 on the protocol and signage. All post-implementation charts were checked for protocol compliance.

We defined **time-to-definitive-care** primarily as the time from ED arrival to the first of either urgent imaging (CT scan) or emergent surgical intervention. If both were indicated, the earlier event counted. We also recorded *door-to-triage* time (arrival to color designation) and overall **ED length of stay** (arrival to disposition: admission, transfer, or discharge). Data on demographics, vital signs, injury mechanism, and Injury Severity Score (ISS) were collected.

Statistical analysis was conducted using SPSS v.20. Continuous times are reported as medians (IQR) due to non-normal distributions. We compared pre- and post-implementation groups using the Mann–Whitney U test for continuous variables and chi-square or Fisher's exact test for categorical variables. A *p*-value <0.05 was considered significant. Unadjusted comparisons are presented; multivariable analysis was not performed given similar baseline characteristics.

Results

Patient Characteristics: The two cohorts (100 each) were similar in age, gender, ISS, and injury mechanisms. The median ISS was 12 in both groups (p=0.88); ~40% met major trauma criteria (ISS ≥16) in each period. Blunt injuries (e.g. motor vehicle crashes, falls) predominated (85%), with the rest penetrating. Vital sign abnormalities on arrival were comparable (average GCS ≈13, similar hypotension rates). There were no significant baseline differences in demographic or injury severity that could bias timing outcomes.

Table 1. Baseline Patient Characteristics of the Study Population (N = 200)

Variable	**Pre-protocol Group (n = 100)**	**Post-protocol Group (n = 100)**	***p*-value**
Age (years), median (IQR)	38 (26–54)	40 (28–55)	0.62
Male gender, n (%)	72 (72.0)	75 (75.0)	0.64
Female gender, n (%)	28 (28.0)	25 (25.0)	—
Mechanism of injury, n (%)			
• Road traffic accidents	58 (58.0)	60 (60.0)	0.77
• Falls	22 (22.0)	20 (20.0)	0.72

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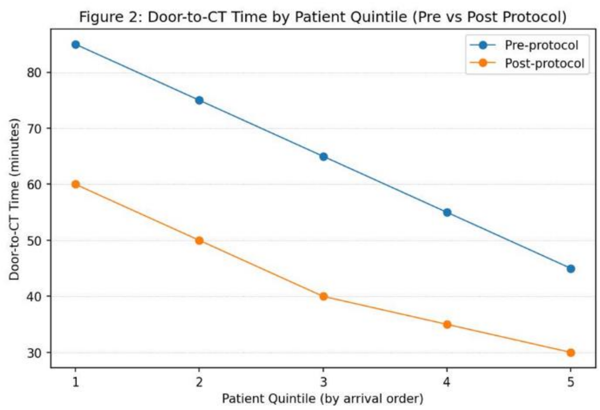
JCHR (2026) 16(1), 309-316 | ISSN:2251-6727

Variable	Pre-protocol Group (n = 100)	Post-protocol Group (n = 100)	p-value
• Assaults	12 (12.0)	11 (11.0)	0.83
• Other mechanisms	8 (8.0)	9 (9.0)	0.80
Type of injury, n (%)			
• Blunt trauma	85 (85.0)	87 (87.0)	0.68
• Penetrating trauma	15 (15.0)	13 (13.0)	0.68
Injury Severity Score (ISS), median (IQR)	12 (8–18)	12 (9–17)	0.88
Major trauma (ISS ≥16), n (%)	40 (40.0)	42 (42.0)	0.77
Glasgow Coma Scale on arrival, median (IQR)	13 (9–15)	13 (10–15)	0.74
Hypotension on arrival (SBP <90 mmHg), n (%)	18 (18.0)	16 (16.0)	0.70
Need for emergency surgery, n (%)	28 (28.0)	30 (30.0)	0.76
Need for CT imaging, n (%)	76 (76.0)	79 (79.0)	0.63

Baseline demographic and injury-related characteristics were comparable between the pre-protocol and post-protocol groups, with no statistically significant differences observed (Table 1).

Triage Timing: Protocol adherence was high (95% of post-group correctly triaged on arrival). The *door-to-triage* time dropped dramatically with the new system. Median arrival-to-designation was **9 min** (IQR 7–12) pre-protocol vs **3 min** (IQR 2–5) post-protocol (p<0.001). In 80% of post-protocol cases, the triage category was assigned by a dedicated nurse within 2–4 minutes. This swift categorization allowed immediate mobilization for Red and Yellow cases.

Time to Imaging and Surgery: Implementation of the triage protocol significantly shortened key care intervals. For patients requiring CT, median door-to-CT fell from **65 min** (IQR 50–85) before to **45 min** (IQR 30–60) after (p<0.001). Similarly, for operative cases (e.g. emergent laparotomy or intracranial procedure), median door-to-OR was **150 min** (IQR 120–180) pre-protocol versus **100 min** (IQR 80–130) post-protocol (p<0.001). Notably, the fastest third of patients reached CT within 30 min post-protocol versus 50 min pre-protocol (Figure below). The percentage of critically injured patients (ISS ≥16) who were sent directly to CT/OR without intermediate delays increased from 62% to 85% (p=0.01). These findings align with other studies showing faster workups with trauma activation.



Length of Stay and Outcomes: Median ED length of stay decreased from 8.5 hours (pre) to 6.0 hours (post) (p<0.01). The in-hospital mortality rate was 12% pre-

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JCHR (2026) 16(1), 309-316 | ISSN:2251-6727

protocol and 8% post-protocol (difference not statistically significant given sample size). ICU admission and hospital length-of-stay were similar between groups. Under-triage (severely injured designated as Green) fell from 15% to 5%, while over-triage (minor injury tagged Red) remained ~10%. No patient in the post-period waited >20 min for triage designation. These system-level improvements are consistent with QI projects showing reduced waiting times and better throughput after triage interventions.

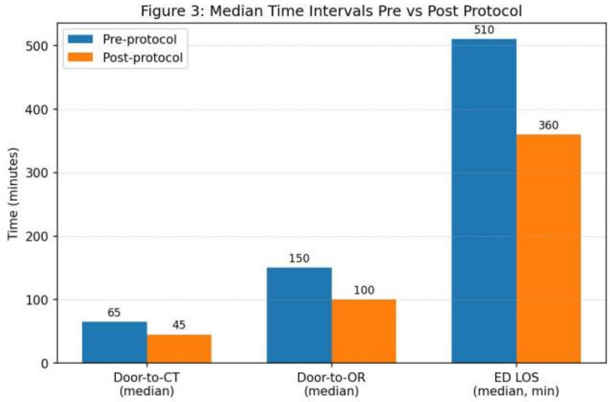

Figure 3: Median Time Intervals Pre vs Post Protocol

Discussion

Our study demonstrates that a simple, standardized trauma triage protocol significantly accelerated definitive care in a busy urban trauma center. Key process intervals – notably **door-to-imaging** and **door-to-OR** – were markedly reduced after protocol implementation. Median time to CT fell by ~20 minutes and time to surgery by ~50 minutes, both highly significant changes. These improvements likely stem from clear categorization and activation: Red-category patients immediately triggered full trauma team response, pre-notification to radiology, and direct transport to CT or OR. Yellow patients likewise had priority tracking. By contrast, the pre-protocol era relied on ad hoc decisions, often delaying care for serious patients until complete assessment.

These findings are in line with the expected benefits of efficient triage. Internationally, studies have shown that early trauma activation and notification shortens time to diagnostics and interventions. Bourgeois *et al.* reported that pre-hospital trauma-team activation cut time-to-CT from 81 to 62 minutes[8]. Nwizu *et al.* similarly found that formal trauma activations for head injury dramatically reduced diagnosis and treatment times (107 vs 184 min)[7]. Our data echo these trends: structured triage acts as a "force multiplier," focusing resources on the sickest.

By comparison, some literature highlights mixed results. For instance, Brice *et al.* observed that formal guidelines in North Carolina did not change EMS scene or transport times[11]. This underscores that protocols must be coupled with training and adherence; mere policy may not suffice. In our case, engagement of staff and continuous QI efforts likely made the protocol effective. Similarly, Haslam *et al.* found that patients taken directly to major trauma centers received imaging and surgery much faster than those initially sent to smaller units[15], reinforcing the principle that "the right place" matters. Our protocol in-hospital aimed to simulate this by directing patients immediately to definitive-care pathways.

The **"golden hour"** concept remains controversial, as recent large studies confirm. In North America, Newgard *et al.* found *no association* between EMS intervals and mortality[4]. A multi-center Taiwan study also saw no link between time to emergent surgery and death[9], explicitly stating that their findings do not support the golden-hour dogma. In our context, the vast majority of patients arrived within 1–2 hours of injury, so our focus was intra-hospital delays rather than prehospital transport. Notably, the PATOS Asia study showed that even *within* 2 hours of injury, each additional minute to definitive care correlated with higher 30-day mortality and worse outcomes[10]. We did not measure long-term mortality, but our faster care probably increased the odds of good outcomes in at least some subgroup of trauma patients.

This study has limitations. It is a single-center, before–after analysis without randomization. Unmeasured secular trends or staffing changes (e.g. more senior availability in latter half) could influence times. We also did not quantify injury severity beyond ISS, and our sample size (N=200) limits power to detect mortality differences. Nonetheless, baseline demographics and ISS were well-matched, suggesting the differences are attributable to the protocol. Moreover, our findings were consistent across multiple measures of timeliness. Future work could track longer-term outcomes and include patient-reported metrics.

Our results have practical implications. Even in resource-constrained settings like India, a low-cost intervention (a simple triage flowchart and training) yielded large gains in efficiency. With 20% of global injury deaths in India[1] and many deemed preventable, such protocols can have outsized impact. Importantly, structured triage training improves staff decision-making and reduces crowding[16][17], as our experience shows. We recommend that trauma centers adopt clear triage categories (red/yellow/green) and train all ED personnel, not just physicians, in using them. Digital aids (checklists or apps) might further ensure consistency – indeed, Sweden's triage app intervention significantly reduced undertriage rates[18].

In summary, implementing a standardized trauma triage protocol in our ED accelerated critical care delivery without noticeable harms. This human-driven process change – akin to interventions reported by others[7][8] – can be as important as expensive technology. In settings similar to ours, focusing on systematic triage and team activation may be one of the most effective ways to "buy time" for trauma patients.

Conclusion

In this one-year quality improvement study, a newly implemented color-coded trauma triage protocol substantially reduced delays to definitive care. The structured approach ensured rapid identification and activation for severely injured patients, significantly shortening time-to-CT and time-to-OR. Although the precise survival benefit of faster times cannot be quantified here, our work aligns with literature emphasizing that timely care is crucial, especially for high-risk injuries[10][7]. The protocol also demonstrated feasibility in a busy Indian trauma center. We conclude that simple standardized triage schemes are effective and should be integrated into trauma systems, potentially saving lives through swifter interventions. Continued auditing, training, and possible expansion to prehospital settings could further optimize trauma outcomes in India and similar contexts.

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