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Systematic Review of the Relationship Between Ambulance Response Time and Patient Outcomes in Cardiac and Trauma Emergencies

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Background: Ambulance response time (ART) is a key indicator of emergency medical system performance and a potential determinant of survival in cardiac and trauma emergencies. Although shorter response intervals are presumed to improve patient outcomes, empirical findings remain inconsistent across settings and conditions.

Objective: This systematic review aimed to synthesize current evidence on the relationship between ambulance response time and patient outcomes in cardiac and trauma emergencies, highlighting trends, methodological differences, and implications for healthcare systems.

Methods: Following PRISMA 2020 guidelines, a comprehensive search was conducted in *PubMed*, *Scopus*, *Web of Science*, and *Science Direct* for studies published between 2000 and 2025. Eligible studies examined ART as an exposure variable and survival, mortality, or neurological outcomes as endpoints. Two reviewers independently screened, extracted, and appraised study quality using the Newcastle–Ottawa Scale (NOS) and AMSTAR-2 tools.

Results: Twenty-seven studies met inclusion criteria—14 on cardiac arrests, 10 on trauma, and 3 on mixed EMS populations. Most cardiac studies showed that response times under eight minutes significantly increased survival to hospital discharge and neurological recovery. Each one-minute delay beyond six minutes was associated with a 7 percent reduction in survival odds (He et al., 2023). Trauma outcomes were more variable; shorter response times improved survival primarily in resource-limited or non-physician EMS systems, whereas advanced on-scene care mitigated time effects in well-resourced settings. Overall evidence quality was moderate to high ($\kappa = 0.89$).

Conclusions: Shorter ambulance response times are strongly linked to improved survival in cardiac emergencies and modestly associated with better trauma outcomes when prehospital capability is limited. Achieving optimal ART thresholds (< 8 min) remains crucial; however, enhancing prehospital care quality, dispatch accuracy, and system integration may yield greater benefits than speed alone. These findings support performance-driven EMS reforms under initiatives such as *Saudi Vision 2030*.

Keywords: Ambulance response time, cardiac arrest, trauma, emergency medical services, survival, prehospital care, systematic review.

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Introduction

Timely emergency medical services (EMS) response represents a critical link in the chain of survival for patients experiencing life-threatening conditions such as out-of-hospital cardiac arrest and severe trauma. The interval from emergency call activation to arrival of a properly equipped ambulance at the scene—commonly termed *response time*—is often viewed as a modifiable system parameter with potential to influence morbidity and mortality. Yet, despite its intuitive importance and its frequent use as a performance metric in EMS systems, the empirical evidence on how variations in ambulance response time translate into patient outcomes remains heterogeneous.

In the domain of cardiac emergencies, particularly out-of-hospital cardiac arrest (OHCA), shorter EMS response times are generally thought to improve the chances of survival and favorable neurological outcomes, primarily by enabling more rapid initiation of cardiopulmonary resuscitation (CPR) and defibrillation. Several observational studies have indeed documented associations between shorter response intervals and increased rates of return of spontaneous circulation (ROSC), survival to hospital admission or discharge, and neurologic recovery (e.g., Huang et al., 2021). However, the literature is not unequivocal: some studies report weak or non-significant associations after adjustment for confounders, raising questions about threshold effects, context dependence, and diminishing returns beyond certain time limits (e.g., response times > 8 minutes (Alumran, 2020). The optimal "cut-off" response time, and whether this differs across settings or patient subgroups (e.g. witnessed arrest, bystander CPR, public vs private location), remains a matter of debate (Huang, et al, 2021).

In the case of trauma emergencies, the relationship between EMS response time and patient outcomes is likewise biologically plausible: faster response may lessen the duration of uncontrolled hemorrhage, prevent prolonged hypoxia or shock, and permit more timely stabilization or transport. Early evidence has suggested that shorter prehospital intervals—comprising response time, on-scene time, and transport time—are associated with lower mortality in undifferentiated trauma cohorts. For example, Feero et al. (1995) demonstrated a decline in odds of death when response or transfer times were reduced. More recently, Dinh et al. (2023) examined 9,012 trauma cases and reported associations between shorter prehospital times and reduced 30-day mortality. Still, the effect sizes are often modest, and trauma systems vary widely in terms of field interventions, triage protocols, and transport policies, complicating cross-study comparisons.

Despite decades of attention, several gaps persist in the literature. First, many individual studies are limited by retrospective design, potential residual confounding (e.g., severity of injury or cardiac arrest, bystander actions, EMS staffing and capabilities), and heterogeneity in definitions of response time and outcome measures. Second, few reviews have integrated both cardiac and trauma emergencies within a unified framework, which might allow identification of shared mechanisms or differences in effect magnitude. Third, the relative importance of response time may not be linear or uniform — that is, reducing response from 8 to 6 minutes might yield more marginal gain than from 12 to 8 minutes. Finally, evolving EMS models—such as community first-responders, drone-delivered defibrillators, and advanced on-scene capabilities—may alter the relevance or practical implications of response time improvements.

Therefore, the aim of this systematic review is to synthesize the existing empirical evidence on the relationship between ambulance response time and patient outcomes in both cardiac and trauma emergencies, evaluating the strength, consistency, and potential modifiers of that relationship. Specifically, our review seeks to (a) characterize how response time is defined and measured across studies, (b) summarize associations (adjusted where possible) between response time and survival or functional outcomes, (c) explore whether threshold effects or non-linearities are reported, and (d) discuss implications for EMS policy, resource allocation, and future research directions.

Background

Ambulance response time (ART) is a crucial determinant of emergency medical outcomes, representing the time interval between the receipt of an emergency call and the arrival of emergency medical services (EMS) personnel at the scene. In both cardiac and trauma emergencies, minutes can be the difference between life and death. For cardiac arrest cases, rapid response facilitates early cardiopulmonary resuscitation (CPR) and defibrillation—two factors consistently associated with higher survival and better neurological outcomes (He et al., 2023; Siriporn et al., 2025). Similarly, in trauma cases, early intervention can prevent irreversible physiological deterioration by controlling bleeding, maintaining airway patency, and stabilizing patients before transport to definitive care (Dinh et al., 2023; Feero et al., 1995).

Despite widespread consensus on the importance of timely EMS response, the empirical evidence remains inconsistent. While many studies have shown that shorter response times correlate with improved survival and functional recovery (Jensen et al., 2019; Prekker et al., 2019), others suggest that these effects may plateau beyond specific thresholds or depend on contextual variables such as urban density, EMS system design, or hospital proximity (Walsh et al., 2008; Ma et al., 2015). Furthermore, outcome variations between cardiac and trauma emergencies suggest that the mechanisms by which ART affects prognosis differ across conditions—rapid defibrillation and CPR for cardiac cases versus hemorrhage control and rapid transport for trauma cases.

Globally, healthcare systems—including those in Saudi Arabia and other Gulf nations—are under increasing pressure to meet response-time benchmarks in line with international standards and Vision 2030 performance indicators. However, the evidence base guiding these targets remains fragmented, with limited systematic synthesis integrating findings across cardiac and trauma populations.

Therefore, this systematic review aims to consolidate current evidence on the relationship between ambulance response time and patient outcomes in cardiac and trauma emergencies. By examining methodological variations, effect magnitudes, and potential confounders, this study seeks to identify consistent patterns and highlight research gaps to guide future EMS policy and clinical practice.

Methods

Study Design

This research follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. A systematic review approach was used to identify, appraise, and synthesize published studies examining the relationship between ambulance response time and patient outcomes in cardiac and trauma emergencies.

Search Strategy

Comprehensive searches were conducted in PubMed, Scopus, Web of Science, and Science Direct databases for articles published between January 2000 and September 2025. The following search terms were used in various combinations:

("ambulance response time" OR "EMS response interval" OR "prehospital delay") AND ("cardiac arrest" OR "trauma" OR "injury" OR "emergency") AND ("survival" OR "mortality" OR "neurological outcome" OR "patient outcomes").

Manual screening of references from relevant studies and reviews was also conducted to identify additional eligible studies.

Inclusion Criteria

Studies were included if they:

1. Examined cardiac or trauma emergencies requiring EMS activation;
2. Reported ambulance response time as an exposure variable;
3. Assessed patient outcomes such as survival, mortality, neurological recovery, or functional status;
4. Were peer-reviewed observational studies (cohort, case-control, or cross-sectional) or systematic reviews/meta-analyses;
5. Were published in English between 2000 and 2025.

Exclusion Criteria

Studies were excluded if they:

- Focused solely on dispatch or transport times without reporting response intervals;
- Lacked outcome data;
- Were case reports, conference abstracts, or simulation studies;
- Were not published in English.

Data Extraction and Quality Assessment

Two independent reviewers extracted data on study design, setting, sample size, response time definitions, outcomes, and key results. Disagreements were resolved by consensus. Study quality was assessed using the Newcastle-Ottawa Scale (NOS) for observational studies and the AMSTAR-2 tool for systematic reviews.

Data Synthesis

Findings were narratively synthesized, emphasizing trends in effect direction, statistical significance, and quality of evidence. Where possible, pooled odds ratios or relative risks were extracted from meta-analyses. Subgroup analyses compared cardiac versus trauma emergencies, urban versus rural settings, and response-time thresholds (e.g., <8 min vs. ≥8 min).

Results

Study Selection

The initial search yielded 1,462 records, of which 178 were duplicates. After title and abstract screening, 93 full-text articles were reviewed. Ultimately, 27 studies met the inclusion criteria: 14 focused on cardiac emergencies, 10 on trauma-related emergencies, and 3 addressed mixed EMS populations. Figure 1 (PRISMA flow diagram) summarizes the selection process.

Study Characteristics

Included studies were conducted across diverse regions—North America (n = 9), Europe (n = 7), Asia (n = 6), and the Middle East (n = 5). Study designs included prospective cohort (n = 8), retrospective registry-based analyses (n = 14), and systematic reviews or meta-analyses (n = 5). Ambulance response time was defined variably across studies, ranging from *dispatch-to-scene* intervals to *call-to-first-patient contact*. Reported mean ARTs ranged between 5 and 14 minutes in urban areas and 10 to 20 minutes in rural regions.

Cardiac Emergencies

Evidence from large-scale registries (e.g., Huang et al., 2021; Siriporn et al., 2025) showed that shorter ambulance response times were consistently associated with higher survival to hospital admission and discharge. In most studies, survival rates dropped sharply when ART exceeded 8 minutes. For instance, He et al. (2023) reported that every 1-minute delay beyond 6 minutes reduced the odds of survival by **7%** (AOR = 0.93; 95% CI: 0.90–0.96)**.** Early CPR initiation and defibrillation were strong mediators of this effect. However, studies that controlled for bystander CPR, witnessed arrest, and EMS capability found the strength of association attenuated, suggesting response time interacts with community and system factors rather than acting independently.

Trauma Emergencies

Trauma literature revealed a more complex relationship. Although several studies (e.g., Dinh et al., 2023; Feero et al., 1995) indicated that shorter prehospital times improved 30-day survival, others (Prekker et al., 2019; Ma et al., 2015) found no significant differences once patient injury severity and prehospital interventions were considered. Notably, urban trauma systems with physician-staffed ambulances often showed longer response times but comparable or better outcomes due to higher on-scene care quality. This suggests that *response efficiency* may depend as much on *capability* as *speed*.

Combined or Mixed Populations

Studies analyzing all EMS calls (e.g., Jensen et al., 2019) observed a U-shaped relationship between response time and mortality: extremely short response times sometimes reflected high-acuity cases (patients dying rapidly despite prompt EMS) whereas very long times predicted systemic delay-related deaths. Thus, contextual and confounding effects must be interpreted carefully.

Quality Assessment

According to the Newcastle–Ottawa Scale (NOS), 19 studies were high quality**,** 6 moderate, and 2 low due to incomplete confounder adjustment or unclear definitions. Interrater agreement between reviewers was excellent ($\kappa = 0.89$).

Discussion

This systematic review highlights the pivotal yet nuanced relationship between ambulance response time (ART) and patient outcomes in both cardiac and trauma emergencies. Across cardiac arrest studies, the evidence strongly supports that rapid response—especially within 4–8 minutes—is associated with improved survival and neurological recovery (He et al., 2023; Siriporn et al., 2025). These findings reinforce the "chain of survival" concept, where each minute of delay reduces the probability of return of spontaneous circulation and favorable neurological outcomes by 7–10%.

In contrast, trauma outcomes showed heterogeneous associations. While prompt arrival facilitates early hemorrhage control and faster transport, the "golden hour" principle appears context-dependent. Some high-resource systems achieve good outcomes despite longer ARTs, owing to advanced prehospital capabilities (Dinh et al., 2023; Prekker et al., 2019). This indicates that quality and timing must be balanced—shorter response alone does not guarantee better survival if prehospital care is inadequate.

Our review also reveals that definitional heterogeneity remains a barrier to synthesis. Response time components—such as call-to-dispatch, dispatch-to-scene, and scene-to-patient—are often inconsistently reported. Standardizing these metrics is essential for benchmarking across EMS systems (Jensen et al., 2019; Ma et al., 2015). Additionally, studies seldom adjust for factors like urban congestion, resource availability, and first-responder networks, which may confound the relationship between ART and outcomes.

From a systems perspective, reducing ART below 8 minutes remains a reasonable operational goal, particularly for cardiac emergencies. However, for trauma and mixed cases, system capacity-building—such as public CPR training, improved dispatch triage, and strategic ambulance stationing—may yield greater benefits than chasing small reductions in mean response time.

Implications for Practice and Policy

For healthcare leaders, especially within Saudi Arabia's Vision 2030 framework, this review underscores the need for data-driven EMS performance indicators. Reducing response times should remain a national priority, but quality metrics such as *time to first CPR*, *time to first defibrillation*, and *prehospital stabilization effectiveness* should also be tracked. Policymakers should invest in geospatial modeling, AI-assisted dispatch, and integrated emergency networks linking hospitals, dispatch centers, and ambulance fleets to optimize both speed and efficiency.

Limitations

This review was limited by heterogeneity across studies, potential publication bias, and limited data from low- and middle-income settings. Most studies were retrospective, and only a few reported adjusted effect estimates. Future research should adopt standardized EMS datasets, include multivariate analyses, and explore non-linear models to identify threshold and interaction effects.

Conclusions

Ambulance response time is a critical, though context-dependent, determinant of patient survival in cardiac and trauma emergencies. Evidence consistently supports rapid response as vital in cardiac arrests, while in trauma, prehospital care

quality and timely transport may outweigh raw response-time metrics. Integrating speed with preparedness, advanced training, and real-time monitoring systems can strengthen EMS effectiveness, reduce preventable deaths, and align emergency care delivery with sustainable healthcare goals under Saudi Vision 2030.

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