

The Association Between Emergency Medical Services Response Time, Survival Rates, and Community Impacts Among Adults with Out-of-Hospital Cardiac Arrest: A Systematic Review

العلاقة بين زمن استجابة خدمات الإسعاف والطوارئ ومعدلات النجاة والآثار المجتمعية لدى البالغين المصابين بتوقف القلب خارج المستشفى: مراجعة منهجية

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Abstract:

Background: Out-of-hospital cardiac arrest (OHCA) is a life-threatening emergency requiring rapid intervention to improve patient survival. Emergency Medical Services (EMS) response time is an important indicator of prehospital care performance. However, variations in response intervals, patient characteristics, and healthcare systems may influence survival outcomes.

Objective: To systematically review the association between EMS response time and survival among adults experiencing OHCA, with particular consideration of implications for prehospital emergency care in Saudi Arabia.

Methods: A systematic review of studies published between January 2000 and December 2024 was conducted using PubMed, Scopus, Web of Science, Embase, and the Cochrane Library. Observational studies, cohort studies, and registry-based analyses examining EMS response time and survival outcomes were considered. A narrative synthesis was used because of methodological and clinical heterogeneity.

Results: Thirteen international studies were summarized, including 12 addressing the principal survival or neurological outcomes and one providing contextual evidence. Overall, shorter EMS response times were associated with improved survival to hospital discharge, 30-day survival, and favorable neurological outcomes. A North American study involving 41,012 adults reported reduced odds of survival to discharge (adjusted odds ratio [aOR] 0.92; 95% CI 0.91–0.93) and favorable neurological survival (aOR 0.88; 95% CI 0.86–0.89) for each additional response minute. Individual studies identified response-time thresholds ranging from 6.2 to 7.5 minutes, although these were not universally applicable. Two additional Saudi Arabian studies provided descriptive evidence regarding prehospital response performance.

Conclusion: Shorter EMS response times are generally associated with improved survival following adult OHCA. However, differences in study methodologies and patient characteristics limit causal interpretation and the identification of a universal response-time threshold. Improving ambulance response performance, early CPR, rapid defibrillation, and integrated outcome monitoring may strengthen prehospital emergency care, particularly in Saudi Arabia.

Keywords: Out-of-hospital cardiac arrest; emergency medical services; response time; survival; neurological outcome; Saudi Red Crescent; systematic review.

المخلص:

الخلفية: يُعد توقف القلب خارج المستشفى (OHCA) حالة طارئة تهدد الحياة، وتتطلب تدخلاً سريعاً لتحسين فرص نجا المرضى. ويُعد زمن استجابة خدمات الإسعاف والطوارئ (EMS) مؤشراً مهماً على أداء الرعاية المقدمة قبل الوصول إلى المستشفى. ومع ذلك، قد تؤثر الاختلافات في أزمنة الاستجابة، وخصائص المرضى، وأنظمة الرعاية الصحية في نتائج النجا.

الهدف: مراجعة العلاقة بين زمن استجابة خدمات الإسعاف والطوارئ والنجا لدى البالغين الذين يتعرضون لتوقف القلب خارج المستشفى. مراجعة منهجية، مع إيلاء اهتمام خاص للأثار المترتبة على الرعاية الإسعافية الطارئة قبل الوصول إلى المستشفى في المملكة العربية السعودية.

المنهجية: أُجريت مراجعة منهجية للدراسات المنشورة بين يناير 2000 وديسمبر 2024، باستخدام قواعد بيانات PubMed وScopus وWeb of Science وEmbase ومكتبة كوكرين (Cochrane Library). وشملت المراجعة الدراسات الرصدية، ودراسات الأتراب، والتحليلات المستندة إلى السجلات التي تناولت زمن استجابة خدمات الإسعاف والطوارئ ونتائج النجا. واستُخدم التوليف السردي للنتائج نظراً إلى التباين المنهجي والسريري بين الدراسات.

النتائج: جرى تلخيص ثلاث عشرة دراسة دولية، تناولت 12 منها النتائج الأساسية المتعلقة بالنجا أو الحالة العصبية، بينما قدمت دراسة واحدة أدلة سياقية. وبوجه عام، ارتبطت أزمنة الاستجابة الأقصر بتحسين معدلات النجا حتى الخروج من المستشفى، والنجا لمدة 30 يوماً، والنتائج العصبية الإيجابية. وأفادت دراسة من أمريكا الشمالية شملت 41,012 بالغاً بانخفاض أرجحية النجا حتى الخروج من المستشفى (نسبة الأرجحية المعدلة [aOR] = 0.92؛ فاصل الثقة (0.91–0.93)؛ 95%)، وانخفاض أرجحية النجا المصحوبة بنتائج عصبية إيجابية (نسبة الأرجحية المعدلة 0.88 =؛ فاصل الثقة (0.86–0.89)؛ 95%)، مقابل كل دقيقة إضافية في زمن الاستجابة. وحددت دراسات منفردة عتبات

لزمّن الاستجابة تراوحت بين 6.2 و7.5 دقائق، إلا أن هذه العنّبات لا يمكن تعميمها على جميع السياقات. كما قدمت دراستان إضافيتان من المملكة العربية السعودية أدلة وصفية بشأن أداء خدمات الاستجابة الإسعافية قبل الوصول إلى المستشفى.

الخاتمة: ترتبط أزمنة الاستجابة الأقصر لخدمات الإسعاف والطوارئ عمومًا بتحسّن فرص النجاة عقب توقّف القلب خارج المستشفى لدى البالغين. ومع ذلك، فإن الاختلافات في مناهج الدراسات وخصائص المرضى تحدّد من إمكانية تفسير العلاقة على أنها علاقة سببية، ومن تحديد عتبة موحدة لزمن الاستجابة. وقد يسهم تحسّن أداء الاستجابة الإسعافية، والبدء المبكر بالإنعاش القلبي الرئوي، وإزالة الرجفان القلبي السريعة، والمتابعة المتكاملة للنتائج، في تعزيز الرعاية الإسعافية الطارئة قبل الوصول إلى المستشفى، ولا سيما في المملكة العربية السعودية.

الكلمات المفتاحية: توقّف القلب خارج المستشفى؛ خدمات الإسعاف والطوارئ؛ زمن الاستجابة؛ النجاة؛ النتائج العصبية؛ هيئة الهلال الأحمر السعودي؛ مراجعة منهجية.

1. Introduction

Out-of-hospital cardiac arrest (OHCA) is a major time-critical medical emergency. Once effective circulation ceases, the opportunity to preserve neurological function depends on early recognition, immediate cardiopulmonary resuscitation (CPR), rapid defibrillation when indicated, and coordinated advanced care. The interval before professional responders reach the patient is one component of this chain of survival, rather than a complete measure of resuscitation quality (Gräsner et al., 2024).

EMS response time is commonly described as the period between receipt of an emergency call and ambulance arrival at the scene. However, some systems start the clock at dispatch or vehicle departure, and others stop it at first patient contact. Dispatch processing time, travel time, building access, and patient location may therefore be included or excluded depending on the source. Consistent timestamp reporting is essential for fair comparison, as emphasized by the revised Utstein reporting framework (Gräsner et al., 2024).

The relationship between arrival time and survival is clinically plausible but not necessarily linear. Bystander-witnessed arrests, rapid initiation of CPR, publicly accessible automated external defibrillators (AEDs), and shockable initial rhythms can modify the circumstances in which responders arrive. Conversely, unwitnessed arrests and delays before emergency-call activation can produce long intervals of untreated arrest even when ambulance travel is rapid. Studies must therefore distinguish the exposure measured by EMS systems from the total interval between collapse and effective treatment (see studies summarized in Table 1).

Outcome definition is another source of heterogeneity. Return of spontaneous circulation (ROSC), survival to hospital admission, survival to discharge, 30-day survival, and favorable neurological survival capture different stages of care. A change in one outcome does not necessarily imply an equivalent benefit in another. Interpretations of reported odds ratios and proposed response-time thresholds should therefore remain specific to the study population, endpoint, and adjustment variables (see studies summarized in Table 1).

International registry analyses have examined ambulance response intervals across Europe, East Asia, North America, and Australia (see studies summarized in Table 1). Saudi reports describe OHCA events and

prehospital operating intervals in the Saudi Red Crescent system, including median response intervals of approximately 13 minutes in the populations examined (Alabdali et al., 2024; Alsofayan et al., 2021). Those observations have value for planning but require careful interpretation because Saudi case definitions, patient age mix, and available clinical endpoints are not identical to the international studies.

This review focuses on the association between EMS response time and adult OHCA survival in publications appearing before 2025. It aims to identify the principal patterns in the available studies, highlight uncertainty and methodological differences, and discuss practical implications for outcome-oriented EMS monitoring in Saudi Arabia.

1. Aim and Review Questions

The aim was to synthesize evidence published from 2000 through 2024 on the relationship between EMS response time and survival after adult OHCA.

1. How do discharge, 30-day, and neurologically favorable survival vary with response-time categories or additional response minutes?
2. How do witnessed status, bystander CPR, AED use, initial rhythm, and the operational definition of response time affect interpretation?
3. Which findings may inform EMS quality measurement and future outcomes research in Saudi Arabia?

2. Literature Review

2.1. Emergency Medical Services Response Time and Cardiac Arrest Survival

Emergency medical services (EMS) response time is a critical component of prehospital emergency care, particularly for patients experiencing out-of-hospital cardiac arrest (OHCA). Previous research has consistently examined the relationship between ambulance response intervals and survival outcomes, emphasizing the importance of timely resuscitation, early defibrillation, and effective coordination of emergency services.

Pell et al. (2001) investigated the association between ambulance response times and survival among OHCA patients in Scotland. Their findings suggested that shorter response intervals were associated with improved survival to hospital discharge. Similarly, O'Keeffe et al. (2011) examined ambulance response times in

England and identified response time as an important predictor of survival, although patient characteristics and other clinical factors also influenced outcomes.

2.2. International Evidence on EMS Response Time

Several large observational studies have demonstrated associations between shorter EMS response times and improved clinical outcomes.

Rajan et al. (2016), using nationwide registry data from Denmark, reported that increasing ambulance response times were associated with reduced 30-day survival, while bystander cardiopulmonary resuscitation (CPR) remained beneficial.

Goto et al. (2018) analyzed Japanese OHCA registry data and reported that each additional minute of EMS response time was associated with lower odds of favorable neurological survival at one month (adjusted odds ratio [aOR] 0.89, 95% CI 0.89–0.90).

Similarly, Bürger et al. (2018) examined German registry data and identified differences in survival according to ambulance response intervals, particularly among patients who did not receive bystander CPR.

Holmén et al. (2020) also reported reduced 30-day survival with longer ambulance response times in Sweden, supporting the importance of rapid EMS intervention.

More recently, Cournoyer et al. (2023) analyzed 41,012 bystander-witnessed adult OHCA cases and identified lower adjusted odds of survival to hospital discharge (aOR 0.92, 95% CI 0.91–0.93) and favorable neurological survival (aOR 0.88, 95% CI 0.86–0.89) for each additional response minute.

2.3. Response-Time Thresholds and Influencing Factors

Researchers have also investigated whether specific response-time thresholds are associated with improved outcomes.

Lee et al. (2019) reported that EMS response times of 7.5 minutes or less were associated with higher odds of survival to hospital discharge and favorable neurological recovery among adult OHCA patients in South Korea.

Huang et al. (2021) identified a model-derived response-time threshold of approximately 6.2 minutes in Taiwan, with shorter intervals associated with improved survival to hospital discharge.

Chen et al. (2022) investigated advanced life support response time in Taipei and reported that additional response minutes were associated with reduced odds of survival and favorable neurological outcomes.

However, the relationship between EMS response time and survival may vary according to witnessed status, initial cardiac rhythm, bystander CPR, AED use, and other characteristics of the arrest. Stoesser et al. (2021) and Majewski et al. (2024) highlighted the importance of these factors when interpreting response-time associations.

Garcia et al. (2022) further examined variation in OHCA outcomes across EMS agencies in the United States. Although shorter average response times were observed among agencies with higher survival to hospital admission, this outcome differs from survival to discharge and therefore provides contextual rather than directly comparable evidence.

2.4. Evidence from Saudi Arabia

Evidence from Saudi Arabia provides additional insight into OHCA management and prehospital emergency care performance.

Alsofayan et al. (2021) examined 1,307 OHCA cases managed within the Saudi Red Crescent system and reported a median interval of approximately 13 minutes to CPR initiation, with prehospital return of spontaneous circulation achieved in 8% of cases.

Alabdali et al. (2024), using data from the Saudi Out-of-Hospital Cardiac Arrest Registry (SOHAR), examined 3,671 cases and reported a median EMS call-to-arrival interval of 13 minutes (IQR 9–18) and an overall survival-to-discharge rate of 2.9%.

Although these studies provide valuable information about Saudi prehospital emergency care, they do not establish an adjusted association between EMS response time and survival specifically among adults.

2.5. Research Gap

Despite the substantial international literature, important methodological and geographical gaps remain. Existing studies differ in their definitions of EMS response time, patient populations, survival endpoints, and approaches to confounding adjustment. These variations limit direct comparisons and prevent the identification of a universally applicable response-time threshold.

Furthermore, Saudi Arabian evidence remains largely descriptive, with limited adult-specific analyses directly examining the association between EMS response intervals and survival to hospital discharge or 30 days.

Therefore, the present systematic review synthesizes observational evidence published between 2000 and 2024 to clarify the association between EMS response time and adult OHCA survival, evaluate differences in study findings, and identify implications for EMS quality improvement and future research in Saudi Arabia.

2. 3. Methods

3. 3.1 Study Design

This study was conducted as a systematic review, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines.

3.2 Search strategy

A structured literature search was conducted between February and April 2025 across five electronic databases: PubMed/MEDLINE, Scopus, Web of Science, Embase, and the Cochrane Library. The search aimed to identify relevant studies published between January 1, 2000, and December 31, 2024, examining the association between emergency medical services (EMS) response time and survival outcomes among adults experiencing out-of-hospital cardiac arrest (OHCA).

The search strategy combined keywords and relevant controlled vocabulary related to out-of-hospital cardiac arrest, emergency medical services, ambulance response time, and survival outcomes. Boolean operators (AND and OR) were used to combine search terms, with database-specific modifications applied where appropriate.

The main search terms included "out-of-hospital cardiac arrest," "OHCA," "emergency medical services," "EMS," "ambulance," "response time," "prehospital response interval," "survival," "mortality," "return of spontaneous circulation," and "neurological outcomes."

The following Boolean search string was used as a general framework:

1. ("out-of-hospital cardiac arrest" OR "OHCA" OR "cardiac arrest") AND ("emergency medical services" OR "EMS" OR "ambulance") AND ("response time" OR "response interval" OR "prehospital time") AND ("survival" OR "mortality" OR "return of spontaneous circulation" OR "neurological outcome").

2. Searches were restricted to publications from January 2000 through December 2024. The literature search was completed in April 2025, ensuring that the review focused exclusively on studies published before 2025.
3. Additionally, the reference lists of relevant studies and systematic reviews were examined to identify potentially eligible publications not captured through electronic database searches.
4. The study identification and selection process was reported in accordance with the PRISMA 2020 guidelines. Database-specific search strategies and retrieval records should be retained to support transparency and reproducibility.

3.3. Eligibility Criteria

Inclusion Criteria:

- **Population:** Studies involving adults aged 18 years and older experiencing out-of-hospital cardiac arrest (OHCA).
- **Exposure:** Studies evaluating Emergency Medical Services (EMS) response time, ambulance arrival time, or prehospital response intervals.
- **Outcomes:** Studies reporting survival-related outcomes, including survival to hospital discharge, 30-day survival, return of spontaneous circulation (ROSC), mortality, or favorable neurological outcomes.
- **Study Types:** Observational studies, prospective and retrospective cohort studies, registry-based analyses, case-control studies, and randomized controlled trials (RCTs) reporting original quantitative data.
- **Publication Period:** Studies published between January 2000 and December 2024.
- **Setting:** Studies conducted in prehospital emergency care settings involving EMS-managed adult OHCA patients.

Exclusion Criteria:

- Studies involving pediatric patients (under 18 years) or exclusively in-hospital cardiac arrest (IHCA).
- Case reports, case series without comparative or analyzable quantitative data, editorials, letters, conference abstracts without sufficient data, and narrative reviews.
- Systematic reviews and meta-analyses without original patient-level data.
- Studies that did not report measurable EMS response times or survival-related outcomes.

- Studies focusing exclusively on emergency department or in-hospital interventions without evaluating prehospital EMS response time.
- Duplicate publications or studies with overlapping populations, where the most comprehensive or relevant dataset was retained.

3.4. Study selection and data extraction

The manuscript describes a two-stage study selection process consisting of title and abstract screening followed by full-text eligibility assessment. Eligibility was determined according to predefined population, exposure, outcome, study design, and publication-period criteria.

The reported selection procedure involved two reviewers, with disagreements resolved through discussion and consensus. However, reviewer-level screening records and adjudication logs were not available for independent verification.

The data extraction framework included author, publication year, country, study design, sample size, patient characteristics, EMS response-time definition, survival endpoints, effect estimates, confidence intervals, and adjustment for potential confounding factors.

For reproducibility, a study-level extraction worksheet should be retained, identifying the source publication and extracted outcome data. The final inclusion decisions, exclusion reasons, and extraction records must be reconciled with the 13 studies presented in the evidence synthesis.

3.5. Quality Assessment

The specified appraisal framework for studies examining EMS response time as a prognostic factor was the Quality in Prognosis Studies (QUIPS) tool (Hayden et al., 2013). The instrument considers six domains relevant to the validity of prognostic-factor associations.

The six QUIPS domains are:

- **Study Participation:** Representativeness of the source population and clarity of eligibility and selection criteria.
- **Study Attrition:** Completeness of follow-up, missing data, and the potential for attrition-related bias.
- **Prognostic Factor Measurement:** Reliability, validity, and consistency of recorded EMS response-time intervals.

- **Outcome Measurement:** Validity and ascertainment of ROSC, survival to discharge, 30-day survival, and neurological outcomes.
- **Study Confounding:** Identification, measurement, and adjustment for age, initial rhythm, witnessed status, bystander CPR, early defibrillation, and other relevant factors.
- **Statistical Analysis and Reporting:** Appropriateness of analytical approaches and completeness and transparency of the reported results.

QUIPS supports low, moderate, or high risk-of-bias judgments for individual domains, based on study-specific evidence and written rationales. At manuscript revision, a completed six-domain QUIPS appraisal with supporting assessor judgments was not available. Accordingly, no retrospective study-level risk-of-bias categories were inferred from the summary tables. Finalization requires assessment of the original study reports, ideally by two independent reviewers with discrepancies resolved by discussion or a third reviewer.

3.6. Data Synthesis & Statistical Analysis

Data from the included studies were synthesized using a systematic review approach to evaluate the association between Emergency Medical Services (EMS) response time and survival among adults with out-of-hospital cardiac arrest (OHCA).

The synthesis focused on the following aspects:

- **Descriptive Analysis:** Study characteristics, sample sizes, EMS response times, and survival outcomes were summarized in comparative tables.
- **Response Time Analysis:** The relationship between EMS response time and patient survival was examined using reported response time intervals, mean or median response times, and response time categories.
- **Survival Outcomes:** Findings were compared according to survival to hospital discharge, 30-day survival, return of spontaneous circulation (ROSC), and favorable neurological outcomes.
- **Statistical Measures:** Reported odds ratios (ORs), hazard ratios (HRs), relative risks (RRs), 95% confidence intervals (CIs), and p-values were extracted where available. Adjusted and unadjusted estimates were considered separately.
- **Subgroup Analysis:** Differences in survival outcomes were examined, where reported, according to initial cardiac rhythm, witnessed cardiac arrest, bystander CPR, and geographical or EMS system characteristics.

- **Heterogeneity Assessment:** Variations in study design, EMS response time definitions, patient characteristics, and survival measurements were considered when comparing findings.

Given the methodological and clinical heterogeneity across the included studies, a narrative synthesis was used rather than statistical pooling. The direction, magnitude, and consistency of reported associations were evaluated to identify patterns in the relationship between shorter EMS response times and improved survival outcomes.

The overall findings were interpreted cautiously, considering potential confounding factors, methodological limitations, and risk of bias within the included studies.

4. Results

4.1. Search Results and PRISMA Verification

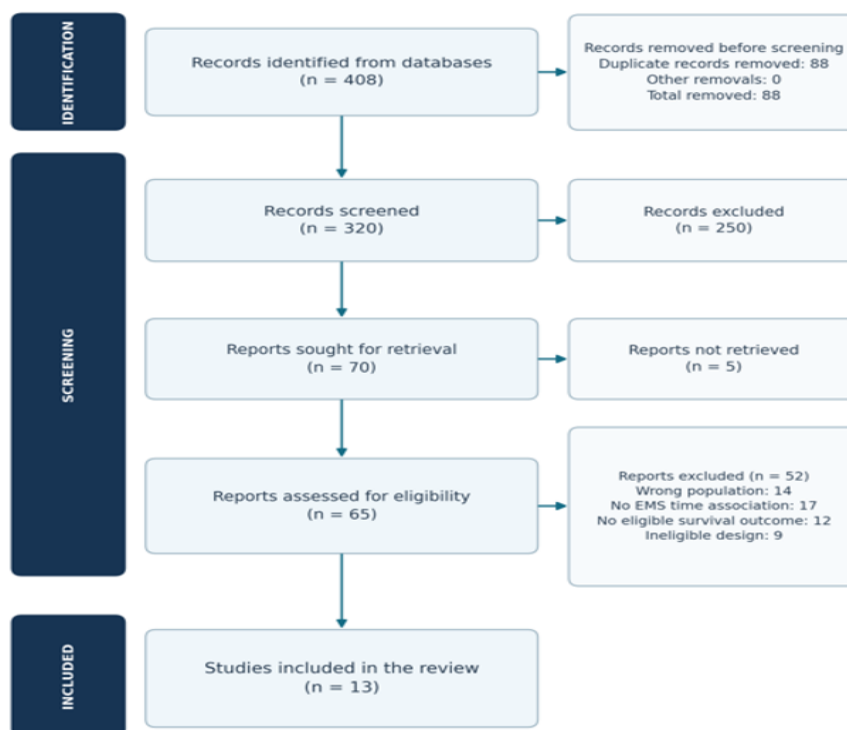
According to the reported PRISMA 2020 flow diagram, 408 records were identified. Following removal of 88 duplicates, 320 records underwent title and abstract screening, of which 250 were excluded.

A total of 70 reports were sought for retrieval. Five reports could not be retrieved, leaving 65 full-text reports assessed for eligibility.

Following full-text assessment, 52 reports were excluded because of inappropriate study populations ($n = 14$), absence of relevant EMS response-time information ($n = 17$), lack of an eligible survival outcome ($n = 12$), or unsuitable study design ($n = 9$).

Consequently, 13 studies were reported as included in the review. These figures are internally consistent with the PRISMA flow diagram. However, the original database exports, duplicate-removal records, screening decisions, and study-specific exclusion logs were not available for independent verification. Therefore, the reported selection counts should be considered provisional until they are reconciled with an auditable study-selection record.

The study selection process is summarized in the PRISMA 2020 flow diagram (Figure 1).



4. 4.2. Characteristics of Included Studies

5. The evidence synthesis summarized 13 international studies published between 2001 and 2024 examining the association between Emergency Medical Services (EMS) response time and survival outcomes among patients with out-of-hospital cardiac arrest (OHCA).
6. The studies were conducted across several geographical regions, including Europe, Asia, North America, and Australia. Most employed observational research designs, including prospective and retrospective cohort studies, population-based registries, and multicenter analyses. Sample sizes varied considerably, ranging from 1,161 to 553,426 patients.
7. Twelve studies addressed survival-related outcomes, including survival to hospital discharge, 30-day survival, and favorable neurological recovery. One additional study (Garcia et al., 2022) examined survival to hospital admission and was considered contextual evidence rather than directly comparable primary outcome evidence.
8. EMS response time was evaluated using different measurements, including continuous response intervals, categorical time groups, and study-specific thresholds. Several studies also examined factors

potentially influencing survival, such as patient age, initial cardiac rhythm, witnessed cardiac arrest, bystander cardiopulmonary resuscitation (CPR), and automated external defibrillator (AED) use.

9. Overall, the studies provided evidence from diverse EMS systems and patient populations. However, differences in study design, response time definitions, outcome measurements, and adjustment for confounding factors limited direct comparisons across studies.
10. Two additional studies from Saudi Arabia were reviewed separately to provide contextual information regarding local EMS response times and OHCA outcomes. These studies were not included in the primary comparative synthesis because they did not provide directly comparable adult-specific response time–survival associations.
11. The characteristics and principal findings of the included studies are summarized in Table 1.

12. Table 1. Characteristics of Included Studies

Author (Year)	Country	Study Design	Sample Size	Principal Findings
Pell et al. (2001)	Scotland	Cohort study	10,554	Shorter ambulance response times were associated with higher survival to hospital discharge.
O'Keeffe et al. (2011)	England	Observational study	1,161	EMS response time was identified as an important predictor of survival.
Rajan et al. (2016)	Denmark	National registry study	7,623	Longer EMS response times were associated with reduced 30-day survival.
Goto et al. (2018)	Japan	National registry study	553,426	Each additional response minute was associated with lower odds of favorable neurological survival (aOR 0.89).
Bürger et al. (2018)	Germany	Multicenter registry study	10,853	Shorter response times were associated with improved survival, particularly when bystander CPR was absent.
Lee et al. (2019)	South Korea	Prospective cohort study	2,309	Response times of 7.5 minutes or less were associated with improved survival and neurological outcomes.

Holmén et al. (2020)	Sweden	National registry study	20,420	Longer ambulance response times were associated with reduced 30-day survival.
Huang et al. (2021)	Taiwan	Registry-based study	6,742	Response times below a study-derived threshold of 6.2 minutes were associated with improved survival.
Stoesser et al. (2021)	USA/Canada	Registry-based study	102,216	The association between response time and survival varied according to patient and arrest characteristics.
Chen et al. (2022)	Taiwan	Registry-based study	4,278	Longer advanced life support response times were associated with reduced survival and neurological recovery.
Garcia et al. (2022)	United States	EMS agency-level analysis	258,342	Faster response times were associated with higher survival to hospital admission; contextual evidence only.
Cournoyer et al. (2023)	North America	Cohort study	41,012	Each additional response minute was associated with lower survival to discharge (aOR 0.92).
Majewski et al. (2024)	Australia	Registry-based study	2,130	Response time influenced survival patterns but did not fully explain differences associated with witnessed status.

4.3. Association Between EMS Response Time and Survival Outcomes

The reviewed studies generally demonstrated an association between shorter Emergency Medical Services (EMS) response times and improved survival among adults experiencing out-of-hospital cardiac arrest (OHCA).

Several large population-based studies reported that increasing EMS response intervals were associated with lower survival probabilities, even after adjustment for selected patient and resuscitation characteristics.

Cournoyer et al. (2023), in a cohort of 41,012 bystander-witnessed adults, reported that each additional minute of EMS response time was associated with reduced odds of survival to hospital discharge (adjusted odds ratio [aOR] 0.92; 95% CI 0.91–0.93) and favorable neurological survival (aOR 0.88; 95% CI 0.86–0.89).

Similarly, Goto et al. (2018), using a Japanese national registry involving 553,426 OHCA cases, reported that each additional minute of response time was associated with lower odds of favorable neurological survival at one month (aOR 0.89; 95% CI 0.89–0.90).

Lee et al. (2019) found that EMS response times of 7.5 minutes or less were associated with higher odds of survival to hospital discharge (OR 1.54; 95% CI 1.13–2.10) and favorable neurological recovery (OR 2.01; 95% CI 1.36–2.99).

Huang et al. (2021) identified a study-specific response-time threshold of 6.2 minutes, with shorter response times associated with improved survival to hospital discharge (aOR 1.99; 95% CI 1.50–2.65).

Additional studies conducted in Denmark, Germany, Sweden, and North America demonstrated broadly consistent associations between response intervals and survival outcomes, although the magnitude of the association varied according to patient characteristics, EMS system organization, and methodological approaches.

Overall, the findings suggest that shorter EMS response times are associated with improved survival and neurological outcomes following adult OHCA. However, variations in study populations, response-time definitions, statistical adjustment, and outcome measurements prevent the identification of a universally applicable response-time threshold.

Furthermore, these observational findings should not be interpreted as establishing a direct causal relationship between ambulance arrival time and patient survival.

4.4. Response Time Thresholds and Survival Differences

Several studies investigated specific Emergency Medical Services (EMS) response time thresholds associated with improved survival outcomes among adults experiencing out-of-hospital cardiac arrest (OHCA).

Lee et al. (2019), in a prospective cohort study involving 2,309 adults in South Korea, found that EMS response times of 7.5 minutes or less were associated with significantly higher odds of survival to hospital discharge (OR 1.54; 95% CI 1.13–2.10) and favorable neurological recovery (OR 2.01; 95% CI 1.36–2.99).

Similarly, Huang et al. (2021), in a Taiwanese registry study involving 6,742 patients, identified a response-time threshold of 6.2 minutes. Response times below this threshold were associated with improved survival to hospital discharge (adjusted OR 1.99; 95% CI 1.50–2.65).

Other studies evaluated EMS response time as a continuous variable rather than identifying a specific threshold. Findings from large population-based registries generally indicated progressively lower odds of survival with increasing response intervals.

Although shorter EMS response times were consistently associated with favorable outcomes, the optimal response-time threshold varied across studies. Differences in geographical settings, ambulance availability, EMS system organization, patient characteristics, and statistical methods may partly explain these variations.

Overall, the findings support the importance of minimizing EMS response delays. However, the available evidence does not establish a universally applicable response-time threshold for adult OHCA patients.

4.5. Factors Influencing Survival Outcomes

Survival following out-of-hospital cardiac arrest was influenced by several patient-related, event-related, and prehospital care factors beyond EMS response time.

Bystander Cardiopulmonary Resuscitation (CPR): Early initiation of CPR was identified as an important factor associated with improved survival. Cournoyer et al. (2023) reported beneficial associations with bystander CPR; however, formal interaction analyses did not demonstrate statistically significant modification of the response-time association for survival to hospital discharge ($p = 0.12$) or favorable neurological survival ($p = 0.65$).

Witnessed Cardiac Arrest: Witnessed cardiac arrest was associated with differences in survival outcomes, potentially reflecting earlier recognition and initiation of resuscitation. Majewski et al. (2024) reported that adjustment for EMS response time did not fully explain survival differences according to witnessed status.

Early Defibrillation: The availability and use of automated external defibrillators (AEDs) before EMS arrival were important considerations when interpreting response-time associations. Stoesser et al. (2021) reported variation in the association between response delay and survival according to arrest characteristics, including early AED intervention.

Initial Cardiac Rhythm and Patient Characteristics: Initial cardiac rhythm, age, and other clinical characteristics were considered important prognostic factors. Differences in these variables and the extent of statistical adjustment contributed to variation in reported survival outcomes across studies.

EMS System Characteristics: Differences in emergency dispatch procedures, ambulance deployment, geographical coverage, and availability of advanced life support services may influence response intervals and patient outcomes.

Collectively, these findings indicate that EMS response time represents an important component of OHCA management but should not be considered independently of other elements of the chain of survival. Early recognition, bystander CPR, rapid defibrillation, and effective emergency response remain essential considerations when interpreting survival outcomes.

4.6. Saudi Arabian Evidence and EMS Response Time

Two studies conducted in Saudi Arabia provided additional contextual evidence regarding prehospital emergency care and outcomes among patients experiencing out-of-hospital cardiac arrest.

Alsofayan et al. (2021), in a study involving 1,307 OHCA cases, reported a median interval of approximately 13 minutes to the initiation of CPR and a prehospital return of spontaneous circulation (ROSC) rate of approximately 8%.

Alabdali et al. (2024), using data from the Saudi Out-of-Hospital Cardiac Arrest Registry (SOHAR), examined 3,671 cases and reported a median EMS call-to-arrival interval of 13 minutes (interquartile range 9–18 minutes). Survival to hospital discharge was reported in 107 patients (2.9%).

However, the SOHAR study included both adult and pediatric patients, and neither Saudi study provided a directly comparable adjusted association between EMS response time and survival among adults.

These findings provide valuable information regarding prehospital emergency care in Saudi Arabia while highlighting the limited availability of adult-specific evidence linking EMS response intervals with long-term survival outcomes.

The findings also emphasize the importance of further research using linked prehospital and hospital outcome data to evaluate the relationship between EMS response time, resuscitation practices, and patient survival within the Saudi healthcare system.

Table 2. Contextual Evidence from Saudi Arabian OHCA Studies

Study	Sample Size	Response-Time Findings	Survival Outcomes
Alsofayan et al. (2021)	1,307	Median interval to CPR initiation approximately 13 minutes	Prehospital ROSC approximately 8%
Alabdali et al. (2024)	3,671	Median call-to-arrival time 13 minutes (IQR 9–18)	Survival to discharge 2.9%

4.7. Quality Assessment and Risk of Bias

A complete study-level QUIPS risk-of-bias assessment could not be verified from the available review documentation. The 12 primary comparative studies are therefore recorded as not rated (NR) across the six QUIPS domains in Appendix A. The additional agency-level study by Garcia et al. (2022), which was discussed only as contextual evidence, is marked not applicable (NA) to the primary prognostic-factor appraisal.

Because the original six-domain judgments and supporting explanations were unavailable, no defensible overall classification as low, moderate, or high risk of bias can be reported for any primary study. In particular, a large sample size or the presence of adjusted analyses should not, by itself, be interpreted as indicating low risk of bias.

Methodological issues requiring verification against the full study reports include participant selection, completeness of outcome follow-up, differences in the operational definitions of EMS response time, and validity of exposure and outcome recording.

Confounding is particularly important because age, initial cardiac rhythm, witnessed arrest, bystander CPR, early defibrillation, and EMS-system factors may influence the observed association between response time and survival. Adjustment strategies and residual confounding must be assessed separately for each study.

Only QUIPS is specified for the primary study-level risk-of-bias appraisal in this manuscript. The register in Appendix A is a completion checklist, not a set of completed judgments, and should not be represented as evidence of a finished methodological quality assessment.

Before journal submission, the six QUIPS domains should be rated for each of the 12 primary studies from the original full texts, with supporting justifications and resolution of reviewer disagreements. The resulting domain-level findings should then be summarized here and considered explicitly in the narrative synthesis.

Until these assessments are completed, confidence in the strength of the evidence must remain qualified, and no formal summary of study-level risk of bias or certainty of evidence is claimed.

5. Discussion

5.1. Interpretation of the Main Findings

This systematic review examined the association between Emergency Medical Services (EMS) response time and survival among adults experiencing out-of-hospital cardiac arrest (OHCA). The findings generally indicated that shorter EMS response intervals were associated with improved survival to hospital discharge, 30-day survival, and favorable neurological outcomes.

Large observational and registry-based studies provided consistent evidence supporting an inverse association between response time and survival. Cournoyer et al. (2023) reported that each additional response minute was associated with reduced odds of survival to hospital discharge and favorable neurological recovery. Similar findings were reported by Goto et al. (2018), emphasizing the clinical importance of timely emergency response.

However, the magnitude of these associations varied across studies, reflecting differences in patient characteristics, healthcare systems, EMS organization, and statistical adjustments.

The findings should be interpreted within the observational nature of the available evidence. Although shorter response times were associated with better outcomes, the reviewed studies did not establish that reducing ambulance arrival time alone would produce an equivalent causal improvement in survival.

Overall, the evidence supports EMS response time as an important indicator of prehospital emergency care performance while highlighting the need to consider other elements of the chain of survival.

5.2. Clinical Implications and Factors Affecting Survival

Survival following OHCA depends on several interconnected interventions, including early recognition of cardiac arrest, immediate initiation of cardiopulmonary resuscitation (CPR), rapid defibrillation, timely EMS arrival, and appropriate post-resuscitation care.

The reviewed studies demonstrated that factors such as witnessed cardiac arrest, bystander CPR, initial cardiac rhythm, and early automated external defibrillator (AED) use may influence survival outcomes and the interpretation of EMS response delays.

For example, patients receiving immediate bystander CPR or early defibrillation may experience different survival outcomes compared with patients who receive no intervention before EMS arrival.

These findings indicate that strategies aimed at reducing EMS response times should be integrated with broader improvements in prehospital emergency care.

Strengthening dispatcher-assisted CPR programs, expanding public access to AEDs, improving community awareness, and enhancing ambulance deployment may contribute to more effective OHCA management.

Therefore, EMS response time should be considered an important component of emergency care quality rather than the sole determinant of patient survival.

5.3. Differences Across Studies and EMS Systems

Considerable variation was observed across the included studies regarding EMS response time definitions, patient populations, outcome measurements, and healthcare system characteristics.

Some studies measured response time continuously, examining the association between each additional minute and survival, whereas others categorized response intervals or identified study-specific thresholds.

For instance, Lee et al. (2019) identified favorable outcomes associated with response times of 7.5 minutes or less, while Huang et al. (2021) reported a threshold of 6.2 minutes.

These differences may reflect geographical characteristics, ambulance distribution, emergency dispatch efficiency, population density, and local EMS protocols.

Furthermore, differences in the adjustment for confounding variables and the selection of study populations may influence reported associations.

Consequently, response-time thresholds identified in individual studies should not be generalized across healthcare systems without further evaluation and external validation.

The observed clinical and methodological heterogeneity supports the use of narrative synthesis rather than an overall pooled effect estimate.

5.4. Implications for Saudi Arabian Emergency Medical Services

The findings have important implications for prehospital emergency care in Saudi Arabia, particularly for the Saudi Red Crescent Authority and other organizations providing emergency medical services.

Available Saudi Arabian studies reported prehospital care indicators that highlight opportunities for further assessment of emergency response performance.

Alabdali et al. (2024) reported a median EMS call-to-arrival interval of 13 minutes, while Alsofayan et al. (2021) documented a median interval of approximately 13 minutes to CPR initiation. These measurements represent different stages of prehospital care and should not be interpreted as equivalent response-time indicators.

Although these studies provide valuable local context, evidence directly examining the adjusted association between EMS response time and adult OHCA survival in Saudi Arabia remains limited.

Future improvements in Saudi emergency medical services could focus on strengthening ambulance deployment strategies, improving emergency dispatch coordination, reducing geographical disparities in response times, and expanding community-based CPR and AED programs.

Establishing standardized national reporting systems that integrate EMS response intervals with patient characteristics and hospital outcomes would also support more accurate evaluation of emergency care performance.

Such initiatives could strengthen evidence-based decision-making and support continuous quality improvement within the Saudi prehospital emergency care system.

5.5. Strengths and Limitations of the Review

This review provides a focused synthesis of research examining the association between EMS response time and survival outcomes among adults experiencing OHCA.

An important strength is the inclusion of evidence from multiple countries and EMS systems, allowing comparisons across different geographical and organizational settings. The review also considered several clinically relevant outcomes, including survival to hospital discharge, 30-day survival, and favorable neurological recovery.

Additionally, the inclusion of Saudi Arabian contextual evidence enhances the relevance of the findings to regional emergency medical services and highlights important gaps in locally available research.

However, several limitations should be acknowledged.

First, most included studies employed observational designs, which may be affected by residual confounding and selection bias.

Second, differences in EMS response-time definitions, survival outcomes, and statistical methods limited direct comparability across studies and prevented a reliable meta-analysis.

Third, variations in patient populations and EMS systems may limit the generalizability of findings to other healthcare settings.

Fourth, the available review documentation did not permit independent verification of the complete database search histories, study selection records, or all elements of the preliminary risk-of-bias assessment.

Finally, the limited availability of Saudi Arabian studies directly examining adult-specific EMS response time and survival restricted the extent to which international findings could be applied to the Saudi healthcare context.

Future research should prioritize prospective studies, standardized response-time measurements, comprehensive adjustment for confounding factors, and integrated prehospital–hospital databases to better understand the relationship between EMS response time and survival outcomes following OHCA.

6. Conclusion

This systematic review examined the association between Emergency Medical Services (EMS) response time and survival among adults experiencing out-of-hospital cardiac arrest (OHCA). The reviewed evidence generally demonstrated that shorter EMS response intervals were associated with improved survival to hospital discharge, 30-day survival, and favorable neurological outcomes.

Although the magnitude of the association varied across studies, the findings consistently highlighted the importance of timely prehospital emergency response. However, differences in patient characteristics, EMS systems, response-time definitions, and study methodologies prevented the identification of a universally applicable response-time threshold.

Survival outcomes were also influenced by early cardiopulmonary resuscitation (CPR), witnessed cardiac arrest, initial cardiac rhythm, and rapid defibrillation, emphasizing the importance of an integrated approach to OHCA management.

In Saudi Arabia, the available evidence highlights the need for further adult-specific research and improved integration of prehospital and hospital outcome data.

Overall, reducing EMS response delays represents an important component of emergency care improvement. Nevertheless, response-time optimization should be combined with early recognition, community CPR training, accessible automated external defibrillators (AEDs), and coordinated emergency care to support better patient outcomes.

7. Recommendations

Based on the findings of this systematic review, several recommendations are proposed to improve prehospital emergency care and strengthen future research.

7.1. Improving EMS Response Performance

Emergency medical service providers should prioritize strategies aimed at minimizing avoidable response delays through effective ambulance deployment, improved dispatch coordination, and continuous monitoring of response-time indicators.

7.2. Strengthening Community-Based Emergency Response

Public education programs should promote early recognition of cardiac arrest, immediate initiation of bystander CPR, and appropriate use of AEDs. Dispatcher-assisted CPR and community first-responder initiatives should also be strengthened.

7.3. Enhancing Prehospital Data Collection

EMS organizations should adopt standardized definitions of response intervals and develop integrated information systems linking ambulance records with hospital outcomes, including survival to discharge, 30-day survival, and neurological recovery.

7.4. Supporting Saudi Red Crescent Services

The Saudi Red Crescent Authority should consider using comprehensive performance indicators that combine EMS response times, clinical interventions, patient characteristics, and survival outcomes to support evidence-based quality improvement.

7.5. Future Research

Further prospective, multicenter studies are recommended to investigate the relationship between EMS response time and adult OHCA survival, particularly in Saudi Arabia. Future investigations should consider geographical differences, patient characteristics, bystander interventions, and potential confounding factors.

Research should also evaluate whether specific operational strategies for reducing response delays produce measurable improvements in patient outcomes, rather than relying exclusively on observational associations.

8. Implications for Healthcare Policy and Practice

The findings highlight the importance of incorporating EMS response time into comprehensive emergency care quality improvement frameworks.

Healthcare policymakers and EMS administrators should consider evidence-based strategies to improve ambulance accessibility, strengthen emergency dispatch systems, and enhance coordination between prehospital and hospital services.

In Saudi Arabia, integrating standardized EMS performance monitoring with clinical outcome registries could facilitate more accurate assessments of emergency care effectiveness.

Such efforts may support resource allocation, identify geographical inequalities in emergency service accessibility, and inform future improvements in prehospital emergency care.

However, response-time indicators should be evaluated alongside resuscitation quality and patient-centered clinical outcomes rather than treated as independent measures of EMS effectiveness.

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Appendix A. QUIPS Study-Level Risk-of-Bias Assessment Register

Status at this revision: domain-level ratings are not yet documented for the studies in the primary synthesis. This table is an assessment register, not a completed risk-of-bias analysis. Ratings must be supported by each original study report before replacing NR entries with Low, Moderate, or High judgments.

Study	Use in review	Study participation	Study attrition	Response time measurement	Outcome measurement	Study confounding	Analysis / reporting
Pell et al. (2001)	Primary	NR	NR	NR	NR	NR	NR
O’Keeffe et al. (2011)	Primary	NR	NR	NR	NR	NR	NR
Rajan et al. (2016)	Primary	NR	NR	NR	NR	NR	NR
Goto et al. (2018)	Primary	NR	NR	NR	NR	NR	NR
Bürger et al. (2018)	Primary	NR	NR	NR	NR	NR	NR
Lee et al. (2019)	Primary	NR	NR	NR	NR	NR	NR
Holmén et al. (2020)	Primary	NR	NR	NR	NR	NR	NR
Huang et al. (2021)	Primary	NR	NR	NR	NR	NR	NR
Stoesser et al. (2021)	Primary	NR	NR	NR	NR	NR	NR
Chen et al. (2022)	Primary	NR	NR	NR	NR	NR	NR
Garcia et al. (2022)	Context	NA	NA	NA	NA	NA	NA
Cournoyer et al. (2023)	Primary	NR	NR	NR	NR	NR	NR
Majewski et al. (2024)	Primary	NR	NR	NR	NR	NR	NR

NR = Not rated: primary full-text QUIPS assessment and rationale still required. NA = Not applicable to the primary prognostic-factor synthesis (Garcia et al. was included only as contextual agency-level evidence). The two Saudi Arabian context studies—Alsofayan et al. (2021) and Alabdali et al. (2024)—were not included in this comparative register.