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Response Time and Patient Outcomes in Prehospital Emergency Medical Services: A Systematic Review Relevant to the Saudi Red Crescent Authority

زمن الاستجابة ونتائج المرضى في خدمات الطوارئ الطبية قبل الوصول إلى المستشفى: مراجعة منهجية ذات صلة بهيئة الهلال الأحمر السعودي

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Emergency Medical Services –Saudi Red Crescent Authority

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Abstract

Background: Ambulance response time is a prominent performance indicator in prehospital emergency medical services (EMS), yet its association with patient-centred outcomes varies according to the condition, the time interval measured, clinical priority, bystander intervention, geography and case-mix. These issues are relevant to the Saudi Red Crescent Authority (SRCA), where rapid access must be balanced with effective triage and equitable regional coverage.

Objective: To examine published evidence linking prehospital EMS response time with survival, return of spontaneous circulation, mortality, neurological outcomes and related patient outcomes, and to consider practical implications for SRCA service improvement.

Methods: Following PRISMA 2020 reporting guidance, the research team reported searching PubMed, Scopus, Web of Science, PsycINFO and CINAHL and identifying 412 records. The team supplied a selection-count sequence (412, 162, 120, 60, 40, 20, 10), ending with 10 included studies; the intermediate numbers were not labeled by PRISMA stage and therefore cannot yet be assigned to duplicate removal, screening, retrieval or eligibility exclusions. Search dates, database-specific yields, decision logs and the definitive ten-study inclusion list were not supplied. A provisional ten-study evidence synthesis and QUIPS-guided risk-of-bias screen are presented without claiming independent reproduction of the original search [1].

Results: Associations were most consistent in out-of-hospital cardiac arrest (OHCA) cohorts and selected trauma studies, while all-emergency cohorts showed uncertain overall mortality effects. A Saudi SRCA OHCA analysis (Alshahrani et al., 2025) found that longer EMS response time was independently associated with lower odds of return of spontaneous circulation (ROSC): adjusted OR 0.981 per additional minute (95% CI 0.970–0.991; $p < 0.001$). This endpoint is ROSC, not survival to discharge, and does not establish causality. Heterogeneity, incomplete search documentation and unresolved appraisal items limit certainty [3].

Conclusion: The response-time–outcome relationship appears most consequential for selected time-critical presentations, but the heterogeneous literature does not justify a single universal response-time threshold. For the SRCA, linked patient-outcome registries, stratified performance targets, dispatch optimization and attention to access inequities are higher-value priorities than response-time averages alone.

Keywords: emergency medical services; ambulance response time; patient outcomes; Saudi Red Crescent Authority; out-of-hospital cardiac arrest; prehospital trauma; systematic review; PRISMA.

الملخص

الخلفية :يُعد زمن استجابة سيارات الإسعاف أحد أبرز مؤشرات الأداء في خدمات الطوارئ الطبية قبل المستشفى (EMS)، إلا أن علاقته بالنتائج الصحية التي تهم المرضى تختلف تبعًا للحالة الطبية، والفترة الزمنية المقاسة، والأولوية السريرية، وتدخل المارة، والعوامل الجغرافية، وطبيعة الحالات .وتكتسب هذه المسائل أهمية خاصة بالنسبة إلى هيئة الهلال الأحمر السعودي (SRCA)، حيث يتعين تحقيق سرعة الوصول مع ضمان فاعلية الفرز الطبي وعدالة التغطية الجغرافية بين المناطق.

الهدف :دراسة الأدلة المنشورة التي تربط بين زمن استجابة خدمات الطوارئ الطبية قبل المستشفى والنجاة، وعودة الدورة الدموية التلقائية (ROSC)، والوفيات، والنتائج العصبية، وغيرها من النتائج الصحية المرتبطة بالمرضى، إلى جانب بحث الآثار العملية لهذه الأدلة على تحسين خدمات هيئة الهلال الأحمر السعودي.

المنهجية :استرشادًا بإرشادات إعداد التقارير وفق بيان PRISMA 2020، أفاد فريق البحث بإجراء عمليات بحث في قواعد بيانات PubMedو Scopusو Web of Scienceو PsycINFOوCINAHL، وتحديد 412سجلًا .وقدّم الفريق تسلسلًا لأعداد

السجلات خلال مراحل الاختيار 412)، 162، 120، 60، 40، 20، (10، انتهى بإدراج 10دراسات؛ إلا أن الأعداد الوسيطة لم تُحدَّد وفق مراحل مخطط PRISMA، ولذلك لا يمكن تصنيفها حتى الآن ضمن إزالة التكرارات أو الفرز أو استرجاع النصوص الكاملة أو استبعاد الدراسات بعد تقييم الأهلية .كما لم تُقدَّم تواريخ البحث، أو نتائج البحث الخاصة بكل قاعدة بيانات، أو سجلات قرارات الاختيار، أو القائمة النهائية للدراسات العشر المشمولة .وعليه، عُرضت مراجعة تركيبية أولية للأدلة المستمدة من عشر دراسات، إلى جانب فحص أولي لمخاطر التحيز استرشادًا بأداة QUIPS، دون الادعاء بإعادة تنفيذ عملية البحث الأصلية بصورة مستقلة .[1]

النتائج :كانت الارتباطات أكثر اتساقًا في الدراسات التي تناولت حالات توقف القلب خارج المستشفى (OHCA)، وفي بعض دراسات الإصابات، في حين ظلت آثار زمن الاستجابة في مجمل حالات الطوارئ على الوفيات غير مؤكدة .وأظهر تحليل سعودي لحالات توقف القلب خارج المستشفى التابعة لهيئة الهلال الأحمر السعودي (Alshahrani et al., 2025)أن زيادة زمن استجابة خدمات الطوارئ الطبية ارتبطت بصورة مستقلة بانخفاض احتمالات عودة الدورة الدموية التلقائية (ROSC)، بنسبة أرجحية معدّلة بلغت 0.981لكل دقيقة إضافية)فاصل الثقة 0.991–0.970 :95%؛ p < 0.001). ويُقاس هذا المؤشر بعودة الدورة الدموية التلقائية، وليس بالبقاء على قيد الحياة حتى الخروج من المستشفى، كما أنه لا يثبت وجود علاقة سببية .وتحدّ أوجه التباين بين الدراسات، ونقص توثيق عمليات البحث، والمسائل التي لم تُحسم في التقييم المنهجي، من درجة اليقين في النتائج .[3]

الخاتمة :تبدو العلاقة بين زمن الاستجابة والنتائج الصحية أكثر أهمية في بعض الحالات الطبية الحرجة التي تتطلب تدخلًا سريعًا، إلا أن تباين الأدبيات العلمية لا يبرر اعتماد حد زمني موحد للاستجابة في جميع الحالات .وبالنسبة إلى هيئة الهلال الأحمر السعودي، تتمثل الأولويات الأكثر أهمية في إنشاء سجلات مترابطة تربط زمن الاستجابة بالنتائج الصحية للمرضى، وتحديد مستهدفات أداء تراعي اختلاف الحالات والمناطق، وتحسين أنظمة توجيه البلاغات وتوزيع الموارد، والاهتمام بأوجه عدم المساواة في الوصول إلى الخدمات، بدلًا من الاعتماد على متوسطات زمن الاستجابة وحدها.

الكلمات المفتاحية :خدمات الطوارئ الطبية؛ زمن استجابة سيارات الإسعاف؛ النتائج الصحية للمرضى؛ هيئة الهلال الأحمر السعودي؛ توقف القلب خارج المستشفى؛ الإصابات قبل المستشفى؛ المراجعة المنهجية؛ PRISMA.

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1. Introduction

1.1. Background

Prehospital EMS systems perform a complex sequence of tasks: receiving a call, identifying the nature and priority of the emergency, dispatching an appropriate resource, navigating to the location, reaching the patient, initiating assessment and treatment, and transporting to definitive care. Response time is routinely monitored because it is easy to quantify and clinically intuitive. Nevertheless, the earliest potentially lifesaving intervention may be delivered by a bystander, an ambulance team, a first responder or a hospital-based specialist, depending on the emergency. Accordingly, an ambulance's arrival time is an important but incomplete measure of the quality of emergency care [1,14].

The importance of minutes is particularly plausible in out-of-hospital cardiac arrest, major haemorrhage and certain other time-sensitive emergencies. In OHCA, delay may increase the interval to defibrillation and advanced resuscitation; in severe injury, prolonged time to essential interventions may influence mortality. For broader ambulance populations, however, faster dispatch is often preferentially assigned to patients who are already more severely ill. This creates confounding by indication: a short response can appear associated with higher mortality when initial illness severity is not adequately addressed [5,7,14].

1.2. Relevance to the Saudi Red Crescent Authority

Saudi Arabia presents distinctive EMS planning challenges, including major urban centres, extensive intercity distances, variable population density and large fluctuations in demand around religious gatherings and travel. The SRCA is a central provider of emergency ambulance response across these settings. Saudi registry reports have described an OHCA response-time median of about 13 minutes in separate cohorts, emphasizing that system-level averages should be interpreted together with case-mix, site and patient outcomes [2,12]. A recent five-region SRCA analysis further highlighted regional variation in urgent responses, supporting the need for equity-focused monitoring [13].

Published Saudi studies supply important local benchmarks; notably, the 2025 SRCA OHCA analysis reports an adjusted response-time association with ROSC, although it cannot establish causality or demonstrate an effect on discharge survival. Other local descriptive registries provide context rather than independent time–outcome effects [2,3,12].

1.3. Study objective and questions

The objective of this review is to summarize evidence regarding the relationship between EMS response time and patient outcomes and to identify implications for the SRCA. The review addresses three questions:

Which emergency groups show the clearest association between response intervals and clinical outcomes?

How do study design, exposure definition and confounding change interpretation?

Which measurement and operational improvements are most defensible in the Saudi prehospital context?

2. Methodology

2.1. Review design and reporting status

This manuscript is organized using PRISMA 2020 reporting domains [1]. The research team identified five databases—PubMed, Scopus, Web of Science, PsycINFO and CINAHL—and reported 412 records retrieved and 10 studies included. Additional figures were supplied in the order 162, 120, 60, 40 and 20, but without descriptions of the corresponding selection stages. These numbers are preserved as a team-supplied, unallocated sequence pending reconciliation with the original screening log (Table 1 and Appendix A). Source-specific yields, executed search strings, dates, duplicate-removal logs, full-text decisions and the definitive ten-study bibliography were not provided. Consequently, the ten traceable publications profiled in this manuscript are a provisional

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analytical set rather than verified matches to the original included studies. Protocol registration and reviewer roles also require confirmation.

2.2. Eligibility framework

The working question was structured using PICOTS: population—patients attended by prehospital EMS, with priority subgroup analyses for OHCA and major trauma; index factor—ambulance dispatch/response or patient-contact time; comparator—shorter versus longer times or an effect per additional minute; outcomes—ROSC, survival, mortality, neurological status, hospitalization or morbidity; timing—prehospital encounter and explicitly reported follow-up; setting—ambulance/prehospital systems, with Saudi relevance. Eligible primary designs comprised registry cohorts, retrospective observational studies, cross-sectional descriptive series and quasi-experimental designs reporting a time measure and clinical outcome. Local descriptive Saudi reports could inform contextual benchmarks even without an adjusted time–outcome estimate. This is an explicit eligibility framework for the revised manuscript, not a claim that the original review team applied identical criteria.

Secondary reviews, commentaries, simulation-only reports, purely dispatch-operational studies without patient outcomes and hospital-only timing analyses were excluded from the principal primary-evidence set. Eligible reports had to describe human EMS encounters and a time interval relevant to the review question. No publication-language restriction, initial search-year filter, peer-review restriction or pre-specified exclusion algorithm can be confirmed from the original records; these require the team's verification. Contextual review and methods references remain in the bibliography, outside the ten-study table.

2.3. Information sources and search approach

The research team identified PubMed, Scopus, Web of Science, PsycINFO and CINAHL as the five sources searched. Across these databases, 412 records were reportedly identified. The exact search date, interface, query, filters and record count for each database remain unprovided; no platform-specific search history can therefore be reproduced. Appendix B supplies source-matched candidate strategies for all five named databases, clearly marked as examples rather than retrospective copies of executed searches. To satisfy PRISMA 2020 items 6–7, the authors should append the actual strings, search dates and exports for each source [1].

2.4. Study selection and data extraction

A PRISMA 2020 selection record should capture database exports, duplicate removal, title/abstract screening, retrieval of full texts, full-text exclusions with reasons and final inclusion, as well as reviewer roles and disagreement resolution. The research team supplied 412, 162, 120, 60, 40, 20 and 10 in sequence, but did not specify whether the intermediate five numbers represent remaining records, exclusions or other stages. This distinction is essential: a decreasing sequence of records retained is not equivalent to a list of stage-specific exclusions. Thus, no intermediate quantity is asserted here as a verified duplicate, screening or retrieval count. The present evidence-mapping exercise separately profiled ten published primary studies and extracted source, design, exposure, outcome, estimates, adjustments and limitations. Appendix D contains the verification worksheet.

2.5. Primary outcomes and definitions

Primary patient-centred endpoints were survival to discharge, 7-day/30-day or in-hospital mortality (where reported); ROSC was retained as an important early resuscitation endpoint, but was never equated with long-term survival. Additional endpoints included favourable neurological outcome, admission and morbidity-related healthcare use. Response time was handled as a study-specific exposure: incident/call time to scene arrival, dispatch to arrival, or dispatch to patient contact. Mean, median, percentile and per-minute associations were not treated as interchangeable. Analyses were grouped narratively by OHCA, trauma and all-emergency populations, and Saudi descriptive versus analytical contributions were separated.

2.6. Quality appraisal and evidence synthesis

Risk-of-bias appraisal was structured around the six domains of the Quality In Prognosis Studies (QUIPS) tool: study participation, attrition, response-time exposure measurement, outcome measurement, confounding, and statistical analysis/reporting [15,16]. A preliminary domain-level concern screen was completed from published methods and results accessible for the profiled studies and from the study information in this manuscript. Ratings L (low), M (moderate), H (high concern) and U (unclear/not verified) appear in Appendix C and are interpreted narratively in Section 3.8. These are provisional, single-pass judgements—not a formal, blinded or two-independent-reviewer QUIPS assessment of all full texts. Because some reports were reviewed at abstract/summary level and the original included-study list remains unconfirmed, no definitive pooled overall judgement or GRADE certainty rating is claimed. Heterogeneity of patients, intervals and outcomes precluded a defensible meta-analysis; a structured narrative synthesis was used.

2.7. Missing-data rules, sensitivity and synthesis decisions

The unit of inclusion is the primary study, not an individual abstract or database record. When a reported denominator is inconsistent across a paper's tables, it is flagged for source-level reconciliation rather than silently harmonized; Table 2 and Appendix D mark an inconsistency in the 2025 SRCA paper. Estimates are transcribed with their effect direction, confidence intervals, endpoint and adjustment status. Descriptive median response times are not compared quantitatively against adjusted odds ratios. Given incomplete verification and substantial design heterogeneity, subgroup comparisons are interpretive only; no funnel plot, statistical heterogeneity measure, subgroup meta-regression or certainty grading was feasible.

2.8. Reporting integrity and unresolved protocol fields

Remaining requirements are the executed search dates and exact strings for the five now-identified databases; per-database record totals and exports; labels and supporting decisions for each intermediate selection figure (162, 120, 60, 40, 20); duplicate-removal method; independent screening roles; numbers and reasons for full-text exclusion; exact identifiers for the ten included papers; finalized QUIPS assessments; and protocol, funding and conflict-of-interest declarations. Appendix E maps these gaps to PRISMA 2020 items. Do not infer search dates or screening-stage labels from the manuscript drafting date or the numeric order alone.

3. Results

3.1. Study identification and selection

The research team reported identifying 412 records in PubMed, Scopus, Web of Science, PsycINFO and CINAHL and including 10 studies in the final analysis. Five intermediate values were also reported, in this order: 162, 120, 60, 40 and 20. Their PRISMA 2020 stage labels have not been supplied; they may represent remaining records at checkpoints, numbers excluded, or a combination. Although $412 - 162 - 120 - 60 - 40 - 20 = 10$, this arithmetic does not establish that the five values are exclusions, nor does it reveal the number of records screened, reports sought, reports retrieved or reasons for ineligibility. Table 1 and Appendix A preserve the reported figures while identifying the missing evidence needed for a valid PRISMA flow diagram.

Table 1. PRISMA 2020 selection accounting: confirmed endpoints and unallocated intermediate figures

Selection stage	Count	Verification status
Records identified: PubMed, Scopus, Web of Science, PsycINFO, CINAHL	412	Reported by research team; database-specific yields not supplied
Intermediate figure 1 (stage not labeled)	162	Reported sequence; duplicate/removal/retention interpretation unknown
Intermediate figure 2 (stage not labeled)	120	Reported sequence; requires screening ledger
Intermediate figure 3 (stage not labeled)	60	Reported sequence; requires screening ledger
Intermediate figure 4 (stage not labeled)	40	Reported sequence; retrieval or exclusion status unknown
Intermediate figure 5 (stage not labeled)	20	Reported sequence; full-text/other status unknown
Studies included in final analysis	10	Reported by research team; definitive source list unprovided

3.2. Characteristics of the ten published studies profiled

Table 2 summarizes ten independently verifiable primary studies identified for this draft. Their publication years span 2021–2026; cohorts reflect Saudi Arabia, Taiwan, Denmark, Thailand, Norway, France, multiple European countries, four Asian countries and the United States. Two Saudi studies provide local resuscitation data, while the remaining studies evaluate time–outcome

associations or response-related variation more directly. The studies were not assumed to be the exact ten originally selected from the 412 records.

Table 2. Characteristics and core findings of ten published primary investigations (*6,012 inferred from totals in the published analysis table)

Study	Setting / design / sample	Reported response-time / clinical finding	Principal caveat
1. Alsofayan et al. (2021) [2]	Saudi Arabia; SRCA retrospective cross-sectional; 1,307 OHCA patients	Median response 13 min; ROSC 8%; no adjusted response–survival effect estimated	Descriptive evidence; outcomes do not establish time causality
2. Alshahrani et al. (2025) [3]	Saudi Arabia; SRCA multiregional OHCA retrospective study; ROSC table denominator n=6,012 (see Appendix D reconciliation note)	ROSC 12.6%; response 11.10 vs 12.45 min (ROSC vs no ROSC); adjusted OR for ROSC per additional minute = 0.981 (95% CI 0.970–0.991; p < 0.001)	Association is observational and for ROSC, not discharge survival; table denominators require reconciliation
3. Huang et al. (2021) [4]	Taiwan; retrospective medical OHCA; 6,742 patients	Modelled survival-to-discharge cut-off 6.2 min; adjusted OR 1.99 for <6.2 min	Locally derived ROC threshold, not a universal standard
4. Mills et al. (2024) [5]	Denmark; registry cohort, all urgent ambulance activations; 182,895 people	No adjusted overall 30-day mortality association (OR ~1.00 per minute); OHCA exception	Strong confounding by dispatch priority in crude comparisons
5. Damdin et al. (2025) [6]	Thailand; retrospective OHCA cohort; 5,433 patients	Adjusted OR 0.94 for discharge survival per extra response minute; <8 min favoured	Very low discharge survival; single metropolitan setting
6. Asheim et al. (2025) [7]	Norway; natural-experiment cohort; 239,320 acute incidents	5-minute capacity-related delay: 7-day death RD 0.10 percentage points (95% CI −0.17 to 0.36)	Mixed clinical priorities; estimate imprecise for rare conditions
7. Heidet et al. (2025) [8]	France; Paris OHCA cohort; 4,082 patients	EMS contact interval >8 min linked to worse mortality and neurological outcome	Urban setting; SES and building access complicate times
8. Gräsner et al. (2026) [9]	28 European countries;	Mean response 12.2 min; overall survival 7.5%;	Major between-country system

	prospective OHCA registry; 32,033 treated cases	association with survival reported	and case-mix differences
9. Usawasuraiin et al. (2026) [10]	Taiwan/Malaysia/ Korea/Thailand; trauma cohort; 8,968 patients	Longer response time associated with in-hospital mortality (aOR 1.03, 95% CI 1.01–1.04)	Possibility of residual injury-severity confounding
10. Biswas et al. (2026) [11]	Florida, USA; crash/EMS linked records; 7,187 severe crash cases	Early delay windows associated with fatality risk; associations non-linear	Road-crash-specific; triage bias despite modelling

3.3. Out-of-hospital cardiac arrest: response time and survival

The strongest recurring positive associations came from cardiac-arrest populations. Huang et al. studied 6,742 adult OHCA cases in Taiwan and used receiver-operating-characteristic analysis to estimate a 6.2-minute response threshold for survival to discharge; shorter responses also retained an adjusted association with improved survival. The authors' cut-off changed according to whether the arrest was witnessed, CPR was delivered by a bystander and other resuscitation factors, indicating that a single numeric benchmark is sensitive to context [4].

In Bangkok, Damdin et al. evaluated 5,433 OHCA cases from 2019–2023. Each additional minute of EMS response time was associated with lower odds of survival to hospital discharge (adjusted OR 0.94, $p = 0.006$), and an interval below eight minutes was associated with better survival-related endpoints. However, the low absolute discharge-survival proportion (1%) requires caution when transferring threshold estimates to different healthcare systems [6].

The Paris MEDIC study linked an EMS dispatch-to-patient-contact time above eight minutes to higher mortality and poorer neurological outcome following multivariable adjustment in 4,082 OHCA cases. Crucially, the study measured time to reaching the patient rather than simply parking the vehicle, and highlighted additional delays linked to building access and social geography [8]. The EuReCa-THREE registry collected EMS-treated OHCA cases across 28 European countries (n=32,033), finding considerable between-country variation and an association between response time and survival; the average response was 12.2 minutes and reported overall survival was 7.5% [9].

3.4. Trauma and transport-related time intervals

Prehospital trauma evidence was less uniform than cardiac-arrest evidence, in part because trauma outcomes depend on injury pattern, availability of haemorrhage control, airway management and the location of definitive care. In the Pan-Asian Trauma Outcomes Study, Usawasuraiin et al. analysed 8,968 EMS-transported trauma patients. Longer response time was associated with greater in-hospital mortality (adjusted OR 1.03; 95% CI 1.01–1.04), and longer on-scene time was also associated with mortality; transport time did not show the same adjusted mortality association. The investigators warned that longer times may partly reflect greater underlying severity and complexity [10].

Biswas et al. used linked crash and EMS data for 7,187 seriously injured Florida crash victims across 2014–2024. Adjusted regression and other modelling methods suggested non-linear effects,

with the largest potential gains from reducing early delays, although the observed timing effects varied with injury severity and age. The study does not establish that these windows should be adopted unchanged for all prehospital trauma settings [11].

3.5. All-comer emergencies and evidence against a universal threshold

Results from broad ambulance cohorts challenge the assumption that every extra minute produces a uniform mortality increase. Mills et al. studied 182,895 people receiving emergency ambulance dispatches in Denmark. In crude data, the shortest-response groups had the highest mortality—a pattern plausibly explained by preferential allocation to patients with more urgent and severe conditions. Following adjustment, response time was not independently associated with 30-day mortality across the overall population, although OHCA represented an important exception [5].

Asheim et al. examined 239,320 acute out-of-hospital incidents in Norway and attempted to reduce confounding by using ambulance busyness as a source of response-time variation. A five-minute capacity-related delay corresponded to a 0.10-percentage-point difference in seven-day death risk (95% CI −0.17 to 0.36), an estimate compatible with little overall mortality change. Hospitalization and subsequent healthcare costs nevertheless rose, suggesting that outcomes beyond mortality should be considered [7].

3.6. Saudi Red Crescent Authority evidence

Alsofayan et al. examined 1,307 OHCA incidents recorded by the SRCA during April–June 2021. Median response time was 13 minutes, only 11% of cases had responses within six minutes, and ROSC was documented in approximately 8% of patients. These data indicate potential scope for resuscitation-system improvement but did not isolate an adjusted causal effect of response time [2].

Alshahrani et al. analysed SRCA OHCA records from January–June 2024 across 13 Saudi regions. The paper reports bystander CPR in 12.0% and ROSC in 12.6% of cases, and mean response times of 11.10 minutes in the ROSC group versus 12.45 minutes in the non-ROSC group. Crucially, Table VI reports an adjusted odds ratio of 0.981 for ROSC per additional minute of response time (95% CI 0.970–0.991; $p < 0.001$). The direction is consistent with lower ROSC odds for longer response, after adjustment for variables including witnessed arrest and mechanical CPR; bystander CPR itself was not independently significant in that model (aOR 1.005; 95% CI 0.802–1.260; $p = 0.965$). The exposure was recorded as incident time to reach time, not necessarily time to first intervention. The source's tabulated denominators also merit checking: ROSC totals sum to 6,012 whereas a bystander CPR row lists 5,920 non-recipients plus 722 recipients (6,642). These observations do not establish that shortening response time will causally improve survival to discharge, which was not measured [3].

A separate Saudi prospective OHCA registry (SOHAR) reported a median call-to-arrival response of 13 minutes and survival to hospital discharge in 2.9% of 3,671 patients, providing additional context rather than a directly comparable response-time effect estimate [12]. A 2026 SRCA registry analysis of 3,398 critical cases across five regions documented regional response-time inequities but, without a reported patient-level time-to-outcome effect in the accessible abstract, it was kept outside the principal ten-study analytic table [13].

3.7. Evidence quality and limitations of the findings

The ten profiled studies were predominantly observational and used different data systems, exposure clocks, eligibility restrictions and outcomes. Registry-based time measures and large

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cohorts are strengths, but confounding by dispatch priority, illness severity, bystander CPR, initial rhythm, injury severity and service access remains possible. The Saudi descriptive series [2] cannot estimate an adjusted response-time effect, whereas the second Saudi study [3] does report an adjusted association with ROSC. Appendix C provides a preliminary QUIPS-domain map, with uncertain items explicitly labelled U; it should not be mistaken for a consensus formal appraisal. The overall certainty of a universal response-time threshold is not established.

3.8. Preliminary risk-of-bias findings

Table 3 highlights the principal sources of possible bias identified during the evidence-mapping appraisal. For all ten studies, several domains cannot be fully judged without complete article-level, independently verified assessment. Descriptive study [2] is particularly limited for causal time–outcome inference, while study [3] adjusts several predictors but is still vulnerable to omitted CPR-quality variables and internally inconsistent tabulations. Registry cohorts [4–11] offer larger denominators or adjusted models, but cannot remove all residual confounding. The Norwegian analysis [7] provides a stronger design for addressing dispatch-priority confounding yet its assumptions and applicability still require independent checking.

Table 3. Main study-specific risk-of-bias concerns (provisional evidence-mapping screen)

Study	Key concern	Interpretation
Alsofayan 2021 [2]	Descriptive cross-sectional OHCA; missing bystander/AED variables; no adjusted time–ROSC effect.	High concern for causal association; useful descriptive context
Alshahrani 2025 [3]	Observed association adjusted for some predictors; no CPR quality or long-term survival; conflicting source-table denominators.	Moderate concern; verify denominators and residual confounding
Huang 2021 [4]	Retrospective registry; outcome-derived threshold may be optimism-prone; residual differences in witness/defibrillation.	Moderate concern; do not generalize 6.2-minute cut-off
Mills 2024 [5]	Adjusted registry mortality model, but dispatch priority and initial severity can influence both response and mortality.	Moderate concern for confounding by indication
Damdin 2025 [6]	Exclusions before analysis; 1% survival to discharge; observational confounding and precision concerns.	Moderate concern; interpret discharge findings cautiously
Asheim 2025 [7]	Natural-experiment strategy reduces priority confounding but relies on ambulance-busyness assumptions.	Moderate concern; causal assumptions require scrutiny
Heidet 2025 [8]	Patient-contact intervals and socioeconomic context; urban-specific exposure misclassification and access differences.	Moderate/unclear until complete domain review
Gräsner 2026 [9]	Across-country variation in case mix, registry completeness and resuscitation systems.	Moderate/unclear; check harmonization and missingness

Study	Key concern	Interpretation
Usawasurairin 2026 [10]	Trauma severity, procedure need and multi-system timing definitions may confound mortality associations.	Moderate/unclear; verify injury adjustment
Biswas 2026 [11]	Severe-crash selected cohort, triage-related bias and modelling assumptions.	Moderate/unclear; external validity limited to crashes

4. Discussion

4.1. Interpretation of the main findings

Across the profiled evidence, response delays were more consistently associated with poorer outcomes in OHCA and selected serious-trauma cohorts than in undifferentiated ambulance incidents. Importantly, the 2025 Saudi SRCA study adds locally relevant adjusted evidence: each additional response minute was associated with lower odds of ROSC (aOR 0.981, 95% CI 0.970–0.991), but not with an observed discharge-survival endpoint. This supports careful examination of response performance without establishing a universally causal minute-by-minute benefit. Differences in acuity, dispatcher prioritization, exposure clocks and interventions complicate cross-study comparison [3–11].

The apparent reversal seen in unadjusted studies deserves particular attention. Dispatchers deliberately direct faster resources towards the most seriously ill patients, so higher mortality can coexist with shorter responses even when fast arrival is beneficial. The Copenhagen and Norway findings caution against evaluating EMS performance by simple comparisons of average minutes and deaths without accounting for priority, clinical acuity, resource availability and case-mix [5,7].

4.2. Comparison with the wider evidence base

A 2025 systematic review by Hansen et al., pooling a much wider literature, found high heterogeneity and very low certainty for a general association between ambulance/helicopter response time and survival. The authors cautioned against strong universal inferences, particularly outside selected time-critical presentations [14]. The findings profiled here are consistent with that caution: direct time–outcome associations in specific cohorts coexist with null or uncertain effects in mixed populations. These findings do not invalidate time-critical EMS goals but argue for indication-specific metrics and stronger research designs.

4.3. Practical implications for the SRCA

For the Saudi Red Crescent Authority, the most defensible response is to pursue both rapid access and measurable clinical effectiveness. A useful performance dashboard would separate call answering and triage, dispatch interval, travel to scene, scene-to-patient contact, time to first CPR/defibrillation, on-scene time and transport time. These intervals should be stratified by OHCA, severe trauma, suspected stroke, other high-priority emergencies, region, urbanicity, hour and dispatch priority. Reporting the median alongside the 90th percentile would expose delayed tails that are hidden by averages.

Operational action should also extend beyond ambulance travel time. Early recognition of arrest, telephone-assisted CPR, public access to defibrillators, first-responder activation, traffic-aware deployment, ambulance location optimization and reliable hospital handovers could influence

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outcomes. Comparative evaluation should focus on patient-centred endpoints (ROSC, discharge survival, neurological status, trauma mortality), not merely faster dispatch statistics [2,3,8,12].

4.4. Equity and regional variation

Saudi regional comparisons must consider distance, road access, call volume, facility distribution and staffing. The recently published multiregional SRCA study provides a rationale for monitoring regional variation rather than treating a single national mean as sufficient [13]. Resource deployment should prioritize communities with persistent high-percentile delays while maintaining fair coverage of lower-volume rural districts. Where time to actual patient contact is materially longer than vehicle arrival, improvements in caller location accuracy and building access may be as valuable as driving faster [8].

4.5. Implications for research design

Future Saudi studies should link SRCA electronic dispatch timestamps with hospital diagnosis and disposition records through secure identifiers; use consistent definitions of call receipt, dispatch, arrival and patient contact; and capture initial rhythm, witnessed status, bystander CPR, severity, geography, shift, traffic conditions and ambulance availability. Multilevel adjustment or quasi-experimental analyses could make estimates less vulnerable to confounding. Outcomes should extend beyond ROSC to hospital discharge, 30-day survival and neurological function wherever feasible.

4.6. Strengths and limitations of this manuscript

Strengths include preservation of the original team-provided screening totals; a source-checked correction to the Saudi adjusted ROSC result; explicit definitions of response-time exposure and patient outcomes; a structured provisional QUIPS bias map; and appendices supporting a reproducible search, extraction and PRISMA audit. The chief limitation remains provenance: original exports and the definitive ten-study inclusion log were not supplied. Accordingly, the publications profiled in Table 2 are not yet demonstrably the ten articles selected from the reported 412 records. Incomplete search dates, reviewer counts, screening flow, formal risk-of-bias consensus and some source-level ambiguities also limit reproducibility.

The evidence base contains mixed clinical populations, response-time definitions, outcome horizons and geographic systems. The preliminary domain ratings cannot replace independently verified, full-text QUIPS assessment or an outcome-specific certainty review. The article should not be represented as a completed, fully auditable systematic review until the source records are reconciled, PRISMA flow fields are verified, study eligibility is confirmed and final quality assessments are signed off.

5. Conclusion

Published evidence does not justify a single response-time target as a universal predictor of patient survival. Shorter responses are commonly associated with better OHCA and selected trauma outcomes, but broad emergency cohorts show mixed findings. In Saudi SRCA OHCA data, a longer response was independently associated with lower odds of ROSC (aOR 0.981 per minute; 95% CI 0.970–0.991), not proven improved survival at discharge. Improvements should combine prioritization, earlier patient contact, bystander support, fair geographic access and linked hospital outcomes. The research team’s 412 identified and 10 accepted studies remain aggregate reported counts; full PRISMA reconstruction and verification of the actual included studies are still required.

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Appendix A. PRISMA 2020 evidence-flow reconciliation

Status: the five database identities and the seven-number sequence (412, 162, 120, 60, 40, 20, 10) were supplied by the research team. The first value is labeled records identified and the last studies included. The intermediate five values were not assigned to standard PRISMA 2020 boxes and must not be silently treated as duplicates, exclusions or retained records. Actual search exports, screening decisions and full-text exclusion reasons remain necessary.

Stage	Count	Source/evidence needed
Records identified in five named databases	412 (reported)	Five exports and per-database totals needed
Duplicate and other pre-screen removals	Unlabeled	Check original ledger; 162 is not confirmed duplicates
Unique records screened	Unlabeled	Check original ledger
Records excluded at screening	Unlabeled	Check original ledger
Reports sought / not retrieved	Unlabeled	Check retrieval decisions
Full-text reports assessed	Unlabeled	Check full-text list
Full-text reports excluded (reasons)	Unlabeled	Check full-text eligibility reasons
Studies included	10 (reported)	Crosswalk to original ten study IDs
Research-team intermediate figures	162; 120; 60; 40; 20	Sequence supplied; stage descriptions missing

Reconciliation rule. Record the number identified within each named database; pre-screen removals (duplicates and any automation/other reasons); unique records screened; records excluded; reports sought and not retrieved; reports assessed; reports excluded with reasons; and studies included. Use source logs to ensure all conservation equations balance. The numeric identity 412 − 162 − 120 −

60 − 40 − 20 = 10 is not a sufficient substitute for stage labels or original decisions; alternative allocations of these figures can produce very different PRISMA flow diagrams.

Appendix A1. Reported selection figures and assignment status

Position in reported sequence	Number	PRISMA 2020 role
1	412	Identified records (labeled by the team)
2	162	Not labeled: requires author confirmation
3	120	Not labeled: requires author confirmation
4	60	Not labeled: requires author confirmation
5	40	Not labeled: requires author confirmation
6	20	Not labeled: requires author confirmation
7	10	Included studies (labeled by the team)

Author verification: please identify whether 162, 120, 60, 40 and 20 are counts remaining or numbers excluded, and specify the corresponding PRISMA decision for each. Only then can the official 2020 flow diagram be finalized.

Appendix B. Candidate search strategies for the five reported databases (execution unverified)

The five reported sources were PubMed, Scopus, Web of Science, PsycINFO and CINAHL. The following syntax is an illustrative, unexecuted reconstruction aid—not the verified historical search strategy. Retrieve and replace these examples with the actual query history, interface, execution date, limits and yield for each database. In particular, PsycINFO field syntax depends on the interface (e.g., Ovid vs EBSCOhost).

B1. MEDLINE via PubMed (candidate)

(("Emergency Medical Services"[Mesh] OR "Ambulances"[Mesh] OR prehospital[tiab] OR pre-hospital[tiab] OR ambulance*[tiab] OR "emergency medical service*"[tiab]) AND ("response time"[tiab] OR "response times"[tiab] OR "dispatch time"[tiab] OR "time to scene"[tiab] OR "time to patient"[tiab]) AND (mortality[tiab] OR surviv*[tiab] OR "return of spontaneous circulation"[tiab] OR ROSC[tiab] OR "neurologic* outcome*"[tiab] OR outcome*[tiab]))

B2. PsycINFO (candidate; interface and subject terms to verify)

(prehospital OR "pre-hospital" OR ambulance* OR "emergency medical services") AND ("response time" OR "response times" OR "dispatch time" OR "time to scene" OR "time to patient") AND (mortality OR surviv* OR ROSC OR "return of spontaneous circulation" OR "neurological outcome*" OR "patient outcome*"). This generic keyword string is NOT an executed PsycINFO search: map keywords to PsycINFO subject headings and fields in the actual interface before use.

B3. Scopus (candidate)

TITLE-ABS-KEY((prehospital OR "pre-hospital" OR ambulance* OR "emergency medical services") AND ("response time" OR "dispatch time" OR "time to patient" OR "time to scene") AND (mortality OR surviv* OR ROSC OR "patient outcome*"))

B4. Web of Science Core Collection (candidate)

TS=((prehospital OR "pre-hospital" OR ambulance* OR "emergency medical services") AND ("response time" OR "dispatch time" OR "time to patient" OR "time to scene") AND (mortality OR surviv* OR ROSC OR "patient outcome*"))

B5. CINAHL via EBSCOhost (candidate)

(MH "Emergency Medical Services+" OR TI (prehospital OR ambulance* OR "emergency medical services") OR AB (prehospital OR ambulance* OR "emergency medical services")) AND (TI ("response time" OR "dispatch time" OR "time to scene") OR AB ("response time" OR "dispatch time" OR "time to scene")) AND (TI (mortality OR surviv* OR ROSC OR outcomes) OR AB (mortality OR surviv* OR ROSC OR outcomes))

Search audit fields required for each of the five reported sources: database; actual interface; date last searched; date limits; exact executed syntax; language/document filters; records returned; export filename; searcher; deduplication software and settings. Also supply the original screening ledger mapping each of the five intermediate figures 162, 120, 60, 40 and 20 to a precisely labeled stage. Supplementary citation chasing or grey literature should only be described if actually performed.

Appendix C. QUIPS-guided provisional study-level bias map

Six domains: P = study participation/representativeness; A = attrition or missing outcome data; T = response-time (prognostic factor) measurement; O = clinical outcome measurement; C = confounding; S = statistical analysis/reporting. L = low concern apparent from accessible reporting; M = moderate concern; H = high concern for response-time–outcome inference; U = insufficient source detail to judge. This single-pass evidence-map is NOT a finalized consensus appraisal, and a numerical sum across domains is inappropriate [15,16].

Study	P	A	T	O	C	S
Alsofayan 2021 [2]	L	U	M	M	H	M
Alshahrani 2025 [3]	M	U	M	L	M	M
Huang 2021 [4]	M	U	L	L	M	M
Mills 2024 [5]	L	U	L	L	M	L
Damdin 2025 [6]	M	L	L	L	M	M
Asheim 2025 [7]	M	U	L	L	M	L
Heidet 2025 [8]	M	U	M	M	M	U
Gräsner 2026 [9]	M	U	M	M	M	U
Usawasuraiin 2026 [10]	M	U	M	M	M	U
Biswas 2026 [11]	M	U	M	L	M	M

Interpretation: The greatest recurring concern is residual confounding from acuity, dispatch priority, early bystander action or injury severity. U signals lack of independently verified information, not evidence of low risk. Descriptive study [2] is contextual; rating its confounding domain H means it should not be interpreted as an adjusted time–ROSC effect. The apparent low-concern domains above are not substitutes for reading and independently checking each full report.

C1. Domain-specific prompts for final reviewer assessment

- P (participation): Was the catchment population clearly defined? Were no-CPR / dead-on-arrival / non-transported cases excluded? Does selection depend on response time or outcome?
- A (attrition): What proportion had complete dispatch timestamps and linked survival outcomes? Were missing cases and excluded records described? Was missingness associated with severity?
- T (exposure): What exact events start and stop the response clock? Were automatic timestamps and outliers validated? Was scene arrival incorrectly used as patient contact?
- (outcome): Was ROSC consistently defined and measured? Was hospital survival ascertainment complete? Were neurological scores validated and at a consistent follow-up?
- C (confounding): Did analyses account for dispatch priority, witnessed arrest, initial rhythm, bystander CPR, severity, geography, time of day and ambulance availability when applicable?
- S (analysis/reporting): Were effect measures and confidence intervals reported correctly, missing data handled, thresholds validated, model assumptions evaluated and subgroup claims interpreted cautiously?
- Reviewer completion fields: Reviewer 1 initials/date: _____ ; Reviewer 2 initials/date: _____ ; Reconciliation date: _____ ; Changes to any provisional rating and supporting article page/table: _____

Appendix D. Extraction verification and source-level correction log

Minimum fields for each included study: study ID and DOI; country and registry; recruitment years; design; inclusion/exclusion criteria; final cohort denominator; exact response-time start/stop; primary endpoint and follow-up; adjusted effect and precision; covariates; missing-data handling; exposure and outcome limitations; QUIPS domain rationale; reviewer names; eligibility decision; exact citation. This worksheet should be applied to the ten original included studies after source reconciliation.

Issue / source	Verified manuscript correction	Remaining verification
Alshahrani et al. 2025 [3]	Table VI: adjusted OR for ROSC per extra minute = 0.981 (95% CI 0.970–0.991; p < 0.001). Crude OR = 0.981 (95% CI 0.971–0.991).	Check exact denominator and timing; do not relabel ROSC as discharge survival.

Issue / source	Verified manuscript correction	Remaining verification
Alshahrani et al. 2025 [3]	Table II ROSC cells: 5,252 without ROSC + 760 with ROSC = 6,012. Table II bystander cells printed as 5,920 + 722 = 6,642.	Source-internal discrepancy; obtain authors' clarification or erratum before treating n=6,012 as fully confirmed.
Alsofayan et al. 2021 [2]	Retrospective cross-sectional source describes 1,307 OHCA patients and ROSC ≈8%, but does not provide an adjusted response-time causal estimate.	Keep descriptive evidence separate from adjusted association studies.
Review-wide screening	412 identified and 10 accepted are research-team-supplied aggregate counts.	Obtain exact included-study IDs; verify all ten rows in Table 2 against original screening decisions.

Appendix E. PRISMA 2020 manuscript audit / remaining actions

Selected PRISMA items are mapped below. "Partial" means manuscript text exists but the underlying audit evidence has not been supplied; "Pending" means substantive completion is still needed. This is a transparent completion tracker, not a declaration of full compliance [1].

PRISMA item	Status	Document location / next requirement
1–4 Title, abstract, rationale, objectives	Substantially present	Title/abstract, Sections 1.1–1.3
5 Eligibility criteria	Partial	Section 2.2; verify versus original pre-specified eligibility rules
6–7 Sources and executed strategies	Partially resolved	Section 2.3 / Appendix B: all five names supplied; actual dates, strings, exports and per-source totals pending
8–9 Screening and extraction procedures	Partial	Section 2.4; supply actual reviewer counts, roles and decisions
10 Outcomes, effect measures	Substantially present	Section 2.5; extract exact endpoint for every study
11 Risk-of-bias methods	Provisional	Section 2.6 / Appendix C; two-reviewer full-text consensus pending
12–13 Synthesis methods	Present with limits	Sections 2.5–2.7; narrative synthesis, no meta-analysis

PRISMA item	Status	Document location / next requirement
16a Study flow; 16b exclusions	Partially resolved	Section 3.1 / Appendix A: 412 and 10 labeled, additional 162/120/60/40/20 reported without stage labels; exclusions and reasons pending
17–19 Included-study data and bias	Provisional	Tables 2–3 / Appendix C; exact ten-study matching pending
20–22 Synthesis and certainty	Partial	Narrative results; no formal certainty or meta-analysis
23–27 Registration, support, interests, data	Pending confirmation	Add review registration/protocol status, funder declaration, competing interests and availability statements from the actual authors

Academic submission boundary: database identities and the numerical sequence are now reported; however, a definitive PRISMA flowchart and fully reproducible systematic-review claim still require labeled screening-stage counts, retrieval/exclusion reasons, the five actual search exports, the definitive ten-study list and finalized independent risk-of-bias forms.

Appendix F. Administrative statements requiring author confirmation

- Protocol registration: No registration identifier was provided; authors should confirm whether a protocol existed and if/where it was registered.
- Ethics approval: This manuscript reviews published literature and does not describe collection of new patient-level data; institutional rules should nevertheless be checked and an appropriate declaration approved by the authors.
- Funding: Funding details were not supplied and should not be guessed.
- Competing interests: Author declarations were not supplied and must be completed by each author.
- Data and materials availability: The authors supplied the five database names and a seven-number selection sequence. Underlying database exports, date-stamped search strings, stage-labeled selection records and completed appraisal worksheets were not made available for this revision.
- Author contributions and corresponding author: Contributions, corresponding email and approval of the final manuscript must be confirmed by the named authors.