Reprint from The Review of DIABETIC STUDIES

The Review Of
DIABETIC
STUDIES OPEN ACCESS

Effect Of Emergency Medical Service Response Time On Survival And Neurological Outcomes In Out-Of-Hospital Cardiac Arrest: A Systematic Review

Uthman Abdullah Alghamdi[1], Dr. Mohammed Bader Alsaleem[2], Mohammed Abdullah Alghamdi[3], Abdulmohsen Sulaiman A. Aalagla[4], Asim Ahmed Yousif Mohamed[5], Manal Abdullah Alghamdi[6], Ahmed Mohammed Aldawsari[7], Moutaz Abdullah Alghmdi[8], Hatim Hassan Alshehri[9], Saad Madani Alawfi[10], Ziyad Faraj Albalawi[11], Ibrahim Mubayrik Alsahli[12], Nawaf Saleh Albalawi[13], Abeer Muala Alahmadi[14]

[1]Consultant Adult Critical Care, Cardiovascular Critical Care, Department of Intensive Care Services, Armed Forces Hospital, Jubail, Saudi Arabia
[2]Family Medicine Senior Registrar, Ministry of Defense, Royal Saudi Air Force
[3]Emergency Medical Service Specialist, Ministry of Defense, Royal Saudi Air Force,
[4]Emergency Medical Service Specialist, Ministry of Defense, Royal Saudi Air Force
[5]Internal Medicine Specialist, Prince Sultan Armed Forces Hospital, Madinah
[6]Resident, Intensive Care Unit, King Fahd Military Medical Complex, Dhahran,
[7]Resident, Adult Critical Care Medicine, Prince Sultan Military Medical City, Riyadh, Saudi
[8]Resident, Adult Critical Care Medicine, Prince Sultan Military Medical City, Riyadh, Saudi
[9]Resident, Adult Critical Care Medicine, Prince Sultan Military Medical City, Riyadh, Saudi
[10]Internal Medicine, Critical Care Consultant, Prince Sultan Armed Forces Hospital, Madinah
[11]Internal Medicine, North West Armed Forces Hospitals
[12]Internal Medicine, Critical Care Consultant, Prince Sultan Armed, Forces Hospital Madinah
[13]Internal Medicine, Critical Care Consultant, king Salman Armed Forces Hospital Tabuk
[14]Family Medicine, Deputy Director Postgraduate Family Medicine Joint Program, Jeddah

Abstract

Background:
Out-of-hospital cardiac arrest (OHCA) remains a leading cause of mortality worldwide, with survival and neurological outcomes highly dependent on timely intervention. Emergency medical service (EMS) response time is a critical determinant within the chain of survival.
Objective:
This systematic review aimed to evaluate the effect of EMS response time on survival and neurological outcomes among OHCA patients.
Methods:
A systematic review was conducted in accordance with PRISMA 2020 guidelines. Electronic databases including PubMed, Scopus, Web of Science, Embase, and Google Scholar were searched for studies published between 2010 and 2025. Observational studies examining EMS response time and OHCA outcomes were included. Eleven studies met the inclusion criteria. Data were extracted and synthesized using a narrative approach due to heterogeneity in study designs and outcome measures.
Results:
Across the included studies, shorter EMS response times were consistently associated with improved outcomes. Each one-minute delay in response time was associated with a 4% to 7% reduction in survival and a significant decline in neurological recovery. Optimal response time thresholds were commonly identified between 6 and 8 minutes. Studies also highlighted the modifying effect of bystander cardiopulmonary resuscitation (CPR), which extended the effective response window and improved survival rates. Variability in outcomes across EMS systems emphasized the role of operational efficiency and system-level factors.
Conclusion:
Rapid EMS response is a critical determinant of survival and neurological outcomes in OHCA. Efforts

to reduce response times and strengthen early intervention strategies are essential to improve patient outcomes.

Keywords:
Out-of-hospital cardiac arrest, EMS response time, survival, neurological outcomes, emergency medical services, systematic review, resuscitation.

Introduction

Out-of-hospital cardiac arrest (OHCA) remains a major global public health challenge, with consistently low survival rates despite advances in emergency medical care systems. It is estimated that survival to hospital discharge in OHCA cases rarely exceeds 10% in most regions, largely due to delays in recognition, initiation of cardiopulmonary resuscitation (CPR), and emergency medical service (EMS) response. The effectiveness of the "chain of survival," which includes early recognition, early CPR, rapid defibrillation, and advanced life support, is highly dependent on time-sensitive interventions. Among these, EMS response time has been identified as a critical determinant influencing both survival and neurological outcomes following cardiac arrest (O'Keeffe et al., 2011; Sladjana et al., 2011).

EMS response time, typically defined as the interval between emergency call activation and arrival of EMS personnel at the scene, plays a pivotal role in determining patient outcomes. Rapid response allows for earlier initiation of advanced life support interventions, including airway management, defibrillation, and pharmacologic therapy. Delays in response time, even by a few minutes, can significantly reduce the likelihood of return of spontaneous circulation (ROSC) and survival. This time-dependent relationship underscores the importance of optimizing EMS systems to minimize delays and improve overall efficiency (Kim et al., 2017; Rajan et al., 2016).

The relationship between EMS response time and survival outcomes is complex and influenced by multiple interacting factors. While shorter response times are generally associated with improved outcomes, other variables such as bystander CPR, availability of automated external defibrillators (AEDs), and initial cardiac rhythm also play crucial roles. Studies have demonstrated that early bystander intervention can partially mitigate the negative effects of delayed EMS arrival by maintaining circulation until professional care is initiated. This highlights the importance of community-level interventions alongside EMS system optimization (Rajan et al., 2016).

In addition to survival, neurological outcomes are a key consideration in OHCA management, as prolonged ischemia can lead to irreversible brain injury. The duration of time between cardiac arrest and restoration of circulation is directly related to neurological prognosis. Rapid EMS response contributes to reducing this interval, thereby increasing the likelihood of favorable neurological recovery. Conversely, delays in response time are associated with higher rates of poor neurological outcomes, even among patients who achieve ROSC (Okubo et al., 2018).

Variability in EMS response times and OHCA outcomes has been observed across different regions and healthcare systems. Differences in infrastructure, resource allocation, dispatch protocols, and geographic factors contribute to disparities in response efficiency. Large registry-based studies have demonstrated significant variation in survival rates between EMS agencies, suggesting that system-level characteristics, including response time performance, play a substantial role in determining patient outcomes (Garcia et al., 2022; Okubo et al., 2018).

Recent large-scale studies and international registries have further emphasized the importance of EMS response time as a modifiable factor in improving OHCA outcomes. For instance, European and international registry data have shown that shorter response times are consistently associated with higher survival rates and better neurological outcomes across diverse populations. These findings reinforce the need for standardized benchmarks and performance targets within EMS systems to ensure timely response (Gräsner et al., 2025).

Operational factors within EMS systems, such as dispatch prioritization, crew availability, and urban versus rural settings, also influence response times and outcomes. High-priority dispatch systems and optimized ambulance deployment strategies have been associated with improved response efficiency and higher survival rates. Conversely, delays due to system overload or logistical challenges can negatively impact patient outcomes. Understanding these operational dynamics is essential for developing targeted interventions aimed at reducing response times (Goniewicz et al., 2024).

Despite the growing body of evidence, some inconsistencies remain regarding the extent to which EMS response time independently influences OHCA outcomes. Variations in study design, population characteristics, and healthcare systems contribute to heterogeneity in findings. Additionally, the interplay between response time and other critical factors, such as bystander CPR and post-resuscitation care, complicates the interpretation of results. Therefore, a comprehensive synthesis of available evidence is necessary to clarify the true impact of EMS response time on survival and neurological outcomes in OHCA.

Methodology

Study Design

This study employed a systematic review methodology following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure methodological transparency, rigor, and reproducibility. The primary objective was to synthesize and critically evaluate existing empirical evidence on the effect of emergency medical service (EMS) response time on survival and neurological outcomes in patients experiencing out-of-hospital cardiac arrest (OHCA). The review focused on identifying time-dependent relationships between EMS response intervals and key clinical outcomes, including return of spontaneous circulation (ROSC), survival to hospital discharge, and favorable neurological recovery.

The review included peer-reviewed studies that examined EMS response time as a primary exposure variable and its association with OHCA outcomes. Both retrospective and prospective observational studies, as well as registry-based analyses, were included to capture a wide range of real-world EMS system performances across different geographic and healthcare settings. This approach enabled a comprehensive understanding of how variations in EMS response time influence patient outcomes across diverse populations and emergency care systems.

Eligibility Criteria

Studies were selected based on predefined inclusion and exclusion criteria to ensure consistency and relevance to the research objective.

Inclusion Criteria:

- **Population:** Adult patients (≥18 years) experiencing out-of-hospital cardiac arrest of presumed medical (non-traumatic) origin.
- **Exposure:** EMS response time, including basic life support (BLS), advanced life support (ALS), or total EMS response intervals (e.g., call-to-scene or call-to-hospital time).
- **Comparators:** Different response time intervals (e.g., ≤6 minutes vs >6 minutes, ≤8 minutes vs >8 minutes) or continuous time-based comparisons.
- **Outcomes:** Survival outcomes (ROSC, survival to emergency department, survival to hospital discharge) and/or neurological outcomes (e.g., Cerebral Performance Category scores or equivalent).
- **Study Designs:** Observational studies, including retrospective cohorts, prospective cohorts, and registry-based studies with quantitative data.
- **Language:** English-language publications only.
- **Publication Period:** Studies published between 2010 and 2025 to reflect contemporary EMS practices and systems.

Exclusion Criteria:

- Studies involving in-hospital cardiac arrest or traumatic cardiac arrest cases.
- Non-empirical publications such as reviews, editorials, commentaries, and case reports.
- Studies lacking clear measurement or reporting of EMS response time.
- Conference abstracts, duplicate publications, or studies without accessible full texts.

A total of 11 studies met all inclusion criteria and were included in the final analysis.

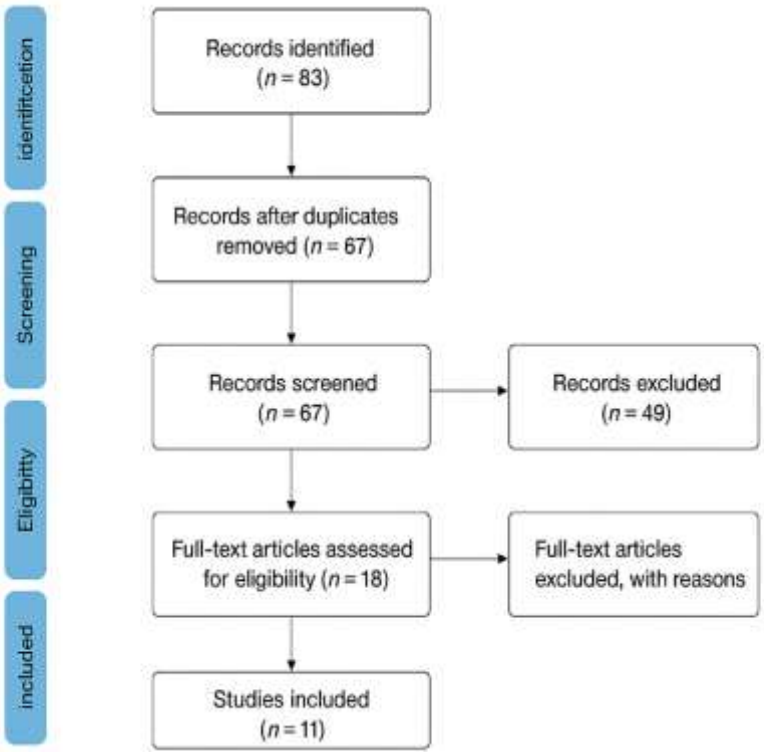
Search Strategy

A comprehensive literature search was conducted across multiple electronic databases, including PubMed, Scopus, Web of Science, Embase, and Google Scholar, from database inception through

December 2025. The search strategy utilized Boolean operators and a combination of Medical Subject Headings (MeSH) and free-text terms to maximize sensitivity and specificity.
The primary search terms included:
• ("out-of-hospital cardiac arrest" OR "OHCA")
• AND ("emergency medical services" OR "EMS")
• AND ("response time" OR "response interval" OR "ambulance response time")
• AND ("survival" OR "ROSC" OR "mortality" OR "neurological outcome" OR "neurologic recovery")
Additional manual searches were conducted by reviewing the reference lists of relevant systematic reviews and included articles to ensure comprehensive coverage. All retrieved records were imported into reference management software (e.g., Zotero or EndNote), and duplicates were removed prior to screening.

Study Selection Process
The study selection process was conducted independently by two reviewers to minimize selection bias. Initially, titles and abstracts of all retrieved articles were screened for relevance based on the inclusion criteria. Studies deemed potentially eligible were then subjected to full-text review.
Discrepancies between reviewers during both screening stages were resolved through discussion and consensus. In cases where agreement could not be reached, a third reviewer was consulted to make the final decision. The overall study selection process, including identification, screening, eligibility, and inclusion, was documented using a PRISMA flow diagram (Figure 1).

Figure 1 PRISMA Flow Diagram



Data Extraction
A standardized data extraction form was developed and pilot-tested prior to full data collection to ensure consistency and completeness. The following data elements were extracted from each included study:
• Author(s), year of publication, and country of study.
• Study design and data source (e.g., hospital-based, EMS registry, or national database).
• Sample size and population characteristics (age, sex, inclusion criteria).
• Definition and measurement of EMS response time.

• Outcome measures, including ROSC, survival to hospital discharge, and neurological outcomes.
• Statistical methods used (e.g., logistic regression, adjusted odds ratios).
• Key quantitative findings (odds ratios, percentages, confidence intervals, p-values).
• Adjustments for confounding variables and subgroup analyses.
Data extraction was performed independently by two reviewers, with cross-checking to ensure accuracy. Any discrepancies were resolved through consensus.

Quality Assessment
The methodological quality of the included studies was assessed using the Newcastle–Ottawa Scale (NOS) for observational studies. Each study was evaluated across three domains: selection of study participants, comparability of study groups, and assessment of outcomes.
Studies were assigned scores based on predefined criteria and categorized as:
• **Low risk of bias (high quality)**
• **Moderate risk of bias**
• **High risk of bias (low quality)**
Most included studies were rated as moderate quality, primarily due to limitations such as potential confounding factors, variability in EMS system characteristics, and reliance on observational data. However, large registry-based studies demonstrated stronger methodological rigor due to comprehensive data collection and adjustment for multiple confounders.

Data Synthesis
Due to heterogeneity in study designs, EMS response time definitions, outcome measures, and statistical reporting, a narrative synthesis approach was adopted. Findings were systematically organized into thematic categories, including:
1. The relationship between EMS response time and survival outcomes.
2. The association between response time and neurological recovery.
3. Identification of optimal response time thresholds.
4. The influence of modifying factors such as bystander CPR and EMS system characteristics.
Quantitative data, including percentages, odds ratios, and confidence intervals, were extracted and reported descriptively. Although consistent trends were observed across studies, a formal meta-analysis was not performed due to variability in outcome definitions and measurement methods.

Ethical Considerations
As this study is a systematic review based on previously published data, ethical approval and informed consent were not required. All included studies were published in peer-reviewed journals and were assumed to have obtained appropriate ethical clearance from their respective institutions. The review was conducted in accordance with ethical standards for research integrity, transparency, and accurate reporting as outlined in the PRISMA 2020 guidelines.

Results

Summary and Interpretation of Included Studies on the Effect of EMS Response Time on Survival and Neurological Outcomes in OHCA (Table 1):

1. Study Designs and Populations
The included studies represent a broad range of methodological designs, including retrospective cohort studies, prospective observational analyses, and large population-based registry studies, reflecting diverse approaches to evaluating the impact of emergency medical service (EMS) response time on outcomes in out-of-hospital cardiac arrest (OHCA). Sample sizes varied considerably across studies, ranging from relatively small cohorts such as Alumran et al. (2020), which included 108 patients, to large nationwide datasets such as Lee et al. (2025), which analyzed 76,505 OHCA cases. Several studies, including Bürger et al. (2018), Holmén et al. (2020), and Huang et al. (2021), utilized national or regional registries, thereby enhancing the generalizability of findings. The majority of studies focused on adult patients with presumed cardiac etiology, and both sexes were generally represented. However, differences in inclusion criteria, geographic settings, and EMS system structures across

countries—including Thailand, Germany, Saudi Arabia, Korea, Sweden, Taiwan, Japan, and Poland—may contribute to variability in reported outcomes.

2. Definitions and Measurement of EMS Response Time

Across the included studies, EMS response time was most commonly defined as the interval between emergency call initiation and the arrival of the first EMS unit at the scene. Despite this general consistency, some variations were observed. For example, Chen et al. (2022) focused specifically on advanced life support (ALS) response time, while Lee et al. (2025) evaluated total EMS call-to-hospital arrival time. Additionally, several studies categorized response time into predefined intervals or thresholds, most commonly ≤6 minutes, ≤7.5 minutes, or ≤8 minutes. Huang et al. (2021) identified an optimal cutoff value of 6.2 minutes using receiver operating characteristic analysis. Although definitions and categorizations differed slightly, the majority of studies consistently emphasized a critical early response window, generally within the first 6 to 8 minutes, as a key determinant of improved patient outcomes.

3. Survival Outcomes (ROSC, Survival to ED, and Hospital Discharge)

Survival outcomes were consistently shown to be inversely associated with EMS response time across the majority of included studies. Damdin et al. (2025), in a large retrospective cohort of 5,433 patients, reported that 29.17% of patients achieved return of spontaneous circulation (ROSC) at the scene, 6.9% survived to emergency department (ED) admission, and only 1% survived to hospital discharge. Importantly, each one-minute increase in response time resulted in a 6% reduction in ROSC, a 4% reduction in survival to ED admission, and a 6% reduction in survival to hospital discharge. Furthermore, response times of less than 8 minutes significantly improved outcomes, increasing ROSC by 2.31 times, ED survival by 1.76 times, and survival to discharge by 2.09 times.

Similarly, Bürger et al. (2018) demonstrated a marked decline in survival as response time increased. In patients who did not receive bystander CPR, survival decreased from 12.9% at very short response times to 6.4% at approximately 10 minutes. Additionally, EMS systems with faster response performance achieved higher rates of survival with good neurological outcomes compared to slower systems. Holmén et al. (2020) further confirmed these findings, showing that 30-day survival decreased from 19.5% in patients with response times of 0–6 minutes to 9.4% in those with response times of 10 minutes or more. Their analysis suggested that reducing response times to 6 minutes or less could substantially increase survival at a population level.

Chen et al. (2022) reported that each one-minute delay in ALS response time reduced survival to hospital discharge by 7%, while delays exceeding 11 minutes reduced survival odds by approximately 40%. Similarly, Goniewicz et al. (2024) found that patients who achieved ROSC had significantly shorter mean response times (7.92 minutes) compared to those who did not (8.29 minutes). Lee et al. (2025) extended these findings by demonstrating that shorter EMS call-to-hospital arrival times were associated with significantly lower in-hospital mortality, with mortality rates of 78.7% in the shortest time quartile compared to 87.7% in longer time intervals.

In contrast, Alumran et al. (2020) did not find a statistically significant association between response time and survival outcomes; however, the odds of mortality were approximately doubled when response time exceeded 8 minutes. This inconsistency may be explained by the relatively small sample size and potential confounding variables.

4. Neurological Outcomes

Neurological outcomes were strongly associated with EMS response time, with shorter response intervals consistently linked to better neurological recovery. Lee et al. (2019) identified a response time threshold of 7.5 minutes, below which patients demonstrated significantly higher odds of survival to discharge and favorable neurological outcomes. Specifically, patients in the shorter response time group had a 54% higher likelihood of survival and were twice as likely to achieve favorable neurological recovery. Additionally, each one-minute reduction in response time was associated with an 8% increase in survival and a 14% increase in favorable neurological outcomes.

Huang et al. (2021) similarly identified an optimal response time threshold of 6.2 minutes for predicting survival to hospital discharge, with each one-minute reduction associated with a 21.7% increase in survival probability. Moon et al. (2020) further demonstrated that the relationship between response

time and neurological outcomes is influenced by bystander CPR. In patients without bystander CPR, significant improvements in outcomes were observed within a response time range of 3 to 6 minutes, whereas in patients receiving bystander CPR, this beneficial window extended to 3 to 9 minutes.
Conversely, Kaichi et al. (2025) reported a decline in favorable neurological outcomes following EMS protocol changes during the COVID-19 pandemic, with a decrease of 3.4%, likely attributable to delays in key interventions such as airway management and intravenous access.

5. Effect Modification and Contextual Factors

Several studies highlighted the role of modifying factors that influence the relationship between EMS response time and OHCA outcomes. Bystander CPR emerged as one of the most significant modifiers, consistently shown to extend the effective response time window and improve both survival and neurological outcomes. Additional factors identified included initial cardiac rhythm, witness status, and patient demographics, all of which were shown to independently affect outcomes.
Operational factors within EMS systems also played a critical role. Goniewicz et al. (2024) demonstrated that high-priority dispatch cases were associated with improved ROSC rates, emphasizing the importance of efficient triage systems. In contrast, system-level disruptions, such as those observed during the COVID-19 pandemic in the study by Kaichi et al. (2025), were associated with delayed interventions and poorer outcomes. These findings underscore the importance of both rapid response and system efficiency in optimizing patient outcomes.

6. Summary of Effect Estimates

Overall, the evidence across the included studies demonstrates a strong and consistent time-dependent relationship between EMS response time and outcomes in OHCA. Most studies indicate that each one-minute delay in response time is associated with a reduction in survival ranging from approximately 4% to 7%, as well as a significant decline in neurological recovery. The optimal response time threshold for improving outcomes is consistently identified within the range of 6 to 8 minutes, although some studies suggest even shorter thresholds may provide additional benefit.
Despite some heterogeneity in study design, definitions, and population characteristics, the overarching findings strongly support the critical importance of minimizing EMS response time. Rapid EMS response, particularly within the first few minutes following cardiac arrest, remains a key determinant of survival and favorable neurological outcomes in OHCA patients.

Table (1): General Characteristics of Included Studies

Study	Country	Design	Sample Size	Population	Response Time Definition	Key Outcomes	Main Results	Effect Estimate
Damdin et al. (2025)	Thailand	Retrospective cohort	5,433	OHCA patients	Call to EMS arrival	ROSC, ED survival, discharge	ROSC 29.17%, discharge 1%	−6% survival per minute delay
Bürger et al. (2018)	Germany	Registry analysis	10,853	OHCA	Alarm to arrival	Discharge, neuro outcome	Survival ↓ 12.9% → 6.4%	Faster EMS OR 0.72
Alumran et al. (2020)	Saudi Arabia	Retrospective	108	OHCA	≤ vs >8 min	Survival	No significant effect	Odds of death ×2 (>8 min)

Lee et al. (2019)	Korea	Prospective	2,309	Adult OHCA	EMS response time	Neuro outcome	Better outcomes ≤7.5 min	OR 2.01 neuro recovery
Holmén et al. (2020)	Sweden	Registry	20,420	OHCA	Time categories	30-day survival	19.5% vs 9.4%	Strong inverse relation
Chen et al. (2022)	Taiwan	Registry	4,278	Adult OHCA	ALS response	Survival, neuro	−7% survival per min delay	aOR 0.93
Huang et al. (2021)	Taiwan	Retrospective	6,742	Adult OHCA	EMS response	Discharge survival	Optimal 6.2 min	aOR 1.217 per min shorter
Kaichi et al. (2025)	Japan	Cohort	10,126	OHCA	EMS intervals	Neuro outcome	−3.4% after delays	Negative trend
Moon et al. (2020)	Asia (multi-country)	Retrospective	13,245	Witnessed OHCA	RTI	Neuro outcome	Benefit extended with CPR	OR up to 2.02
Goniewicz et al. (2024)	Poland	Retrospective	4,361	OHCA	EMS response	ROSC	7.92 vs 8.29 min	p = 0.043
Lee et al. (2025)	Korea	Nationwide cohort	76,505	OHCA	Call-to-hospital time	Mortality, neuro	Mortality 78.7% vs 87.7%	OR 0.30

Discussion

The findings of this systematic review demonstrate a consistent and robust association between EMS response time and survival outcomes in patients with out-of-hospital cardiac arrest (OHCA). Across the included studies, shorter response times were strongly linked to improved rates of return of spontaneous circulation (ROSC), survival to hospital discharge, and favorable neurological recovery. These findings align with earlier evidence emphasizing the critical importance of time-sensitive interventions in cardiac arrest management (O'Keeffe et al., 2011; Sladjana et al., 2011).

A key observation from this review is the time-dependent decline in survival outcomes. Several studies reported that even a one-minute delay in EMS response significantly reduces survival probabilities. For instance, Damdin et al. (2025) and Chen et al. (2022) demonstrated measurable reductions in survival with each incremental delay, highlighting the narrow therapeutic window available for effective intervention. These findings are consistent with the concept of the "chain of survival," where early intervention is crucial for maintaining perfusion and preventing irreversible organ damage (Iwami et al., 2009).

The identification of optimal EMS response time thresholds was another important finding. Multiple studies suggested that response times within 6 to 8 minutes are associated with significantly improved outcomes. Huang et al. (2021) identified an optimal threshold of approximately 6.2 minutes, while Lee et al. (2019) reported improved neurological outcomes below 7.5 minutes. Similarly, Holmén et al. (2020) demonstrated a marked decline in survival beyond 10 minutes, reinforcing the importance of rapid EMS deployment.

The relationship between EMS response time and neurological outcomes was also strongly supported. Studies such as Lee et al. (2019) and Moon et al. (2020) showed that shorter response times were associated with higher rates of favorable neurological recovery. This is biologically plausible, as

prolonged cerebral ischemia leads to irreversible brain injury. The findings underscore that survival alone is not sufficient; the quality of survival, particularly neurological function, is equally important.

Bystander cardiopulmonary resuscitation (CPR) emerged as a critical modifying factor influencing the relationship between response time and outcomes. Rajan et al. (2016) and Moon et al. (2020) demonstrated that early bystander CPR can extend the effective response time window and improve survival rates. This suggests that community-level interventions, such as public CPR training and dispatcher-assisted CPR, are essential components of improving OHCA outcomes (Lerner et al., 2012).

Despite the overall consistency in findings, some variability was observed across studies. For example, Alumran et al. (2020) reported no statistically significant association between response time and survival, although longer response times were associated with increased mortality risk. This discrepancy may be attributed to smaller sample size, differences in healthcare infrastructure, or unmeasured confounding variables.

System-level variations in EMS performance also played a significant role in influencing outcomes. Studies by Okubo et al. (2018) and Garcia et al. (2022) highlighted substantial differences in survival rates across EMS agencies, suggesting that response time is only one component of a broader system of care. Factors such as training, resource allocation, and post-resuscitation care also contribute to outcome variability.

Operational factors within EMS systems were further explored in studies such as Goniewicz et al. (2024), which demonstrated that shorter response times and higher-priority dispatch classifications were associated with improved ROSC rates. These findings emphasize the importance of efficient dispatch systems, appropriate triage, and optimized ambulance deployment strategies.

The role of advanced life support (ALS) response time was specifically examined by Chen et al. (2022), who found that delays in ALS arrival significantly reduced survival and neurological outcomes. This highlights the importance of not only rapid initial response but also timely delivery of advanced interventions such as defibrillation and airway management.

The impact of broader EMS time intervals, including call-to-hospital arrival time, was examined by Lee et al. (2025), who demonstrated that shorter total prehospital time was associated with lower mortality and better neurological outcomes. Similarly, Kim et al. (2017) found that shorter EMS-related time intervals were associated with improved survival in urban settings, reinforcing the importance of minimizing delays throughout the entire prehospital care pathway.

External factors, such as healthcare system disruptions, were also shown to influence outcomes. Kaichi et al. (2025) reported a decline in neurological outcomes during the COVID-19 pandemic, likely due to delays in EMS interventions and protocol changes. These findings highlight the vulnerability of EMS systems to external pressures and the need for resilient emergency care frameworks.

The findings of this review are consistent with large-scale registry data, such as the European EuReCa-THREE study, which demonstrated that shorter EMS response times are associated with improved survival across diverse populations (Gräsner et al., 2025). These large datasets provide strong external validity and reinforce the generalizability of the findings.

Importantly, this review highlights that EMS response time should not be considered in isolation. The interaction between response time, bystander intervention, and EMS system efficiency suggests that a multifaceted approach is required to improve outcomes. Continuous improvements in the chain of survival, including public education and system-level optimization, have been shown to significantly increase survival rates (Iwami et al., 2009).

Overall, the evidence supports the conclusion that reducing EMS response time is a critical and modifiable factor in improving survival and neurological outcomes in OHCA. However, achieving meaningful improvements requires coordinated efforts at both the community and healthcare system levels, including enhanced public awareness, improved dispatch systems, and optimized EMS infrastructure

Conclusion

The findings of this systematic review demonstrate a strong and consistent association between EMS response time and outcomes in patients experiencing out-of-hospital cardiac arrest. Across diverse study designs and populations, shorter response times were significantly associated with improved survival rates, higher likelihood of return of spontaneous circulation, and better neurological outcomes. The evidence indicates that even minimal delays in EMS arrival can substantially reduce survival

probabilities, with most studies identifying a critical response window of approximately 6 to 8 minutes. These findings reinforce the time-sensitive nature of cardiac arrest management and the importance of rapid EMS activation and response.

In addition to response time, the review highlights the importance of complementary factors such as bystander cardiopulmonary resuscitation, efficient EMS system organization, and timely advanced life support interventions. The interaction between these factors suggests that improving OHCA outcomes requires a comprehensive approach that extends beyond reducing response times alone. Strengthening public awareness, optimizing dispatch systems, and enhancing EMS infrastructure are essential strategies to improve survival and neurological recovery in OHCA patients.

Limitations

This systematic review has several limitations. First, the included studies were predominantly observational in design, which limits the ability to establish causality due to potential confounding factors. Second, there was considerable heterogeneity in the definition and measurement of EMS response time, as well as in outcome reporting, which precluded the use of meta-analysis and limited comparability across studies. Third, variations in EMS systems, healthcare infrastructure, and population characteristics across different countries may affect the generalizability of the findings.

Additionally, some studies relied on registry data, which may be subject to missing or incomplete information. The inclusion of only English-language publications may also introduce language bias. Finally, differences in the reporting of neurological outcomes and lack of standardized measurement tools across studies may affect the consistency of conclusions related to neurological recovery.

References

1. Alumran, A., Albinali, H., Saadah, A., & Althumairi, A. (2020). The effects of ambulance response time on survival following out-of-hospital cardiac arrest. Open Access Emergency Medicine, 421–426.
2. Bürger, A., Wnent, J., Bohn, A., Jantzen, T., Brenner, S., Lefering, R., & Fischer, M. (2018). The effect of ambulance response time on survival following out-of-hospital cardiac arrest: An analysis from the German resuscitation registry. Deutsches Ärzteblatt International, 115(33–34), 541–548.
3. Chen, H. A., Hsu, S. T., Hsieh, M. J., Sim, S. S., Chu, S. E., Yang, W. S., & Sun, J. T. (2022). Influence of advanced life support response time on out-of-hospital cardiac arrest patient outcomes in Taipei. PLOS ONE, 17(4), e0266969.
4. Damdin, S., Trakulsrichai, S., Yuksen, C., Sricharoen, P., Suttapanit, K., Tienpratarn, W., & Seesuklom, S. (2025). Effects of emergency medical service response time on survival rate of out-of-hospital cardiac arrest patients: A 5-year retrospective study. Archives of Academic Emergency Medicine, 13(1), e36.
5. Garcia, R. A., Girotra, S., Jones, P. G., McNally, B., Spertus, J. A., Chan, P. S., & CARES Surveillance Group. (2022). Variation in out-of-hospital cardiac arrest survival across emergency medical service agencies. Circulation: Cardiovascular Quality and Outcomes, 15(6), e008755.
6. Goniewicz, M., Bednarz, K., Al-Wathinani, A. M., & Goniewicz, K. (2024). Assessment of emergency medical service (EMS) response times and operational factors in out-of-hospital cardiac arrests (OHCA): A retrospective analysis. Advances in Interventional Cardiology, 20(1).
7. Gräsner, J. T., Wnent, J., Lefering, R., Herlitz, J., Masterson, S., Maurer, H., & EuReCa Group. (2025). European registry of cardiac arrest study THREE (EuReCa-THREE) – EMS response time influence on outcome in Europe. Resuscitation.
8. Holmén, J., Herlitz, J., Ricksten, S. E., Strömsöe, A., Hagberg, E., Axelsson, C., & Rawshani, A. (2020). Shortening ambulance response time increases survival in out-of-hospital cardiac arrest. Journal of the American Heart Association, 9(21), e017048.
9. Huang, L. H., Ho, Y. N., Tsai, M. T., Wu, W. T., & Cheng, F. J. (2021). Response time threshold for predicting outcomes of patients with out-of-hospital cardiac arrest. Emergency Medicine International, 2021, 5564885.
10. Iwami, T., Nichol, G., Hiraide, A., Hayashi, Y., Nishiuchi, T., Kajino, K., & Kawamura, T. (2009). Continuous improvements in “chain of survival” increased survival after out-of-hospital cardiac arrests: A large-scale population-based study. Circulation, 119(5), 728–734.

11. Kaichi, R., Matsuoka, Y., Norii, T., Hijikata, Y., Miyakoshi, C., Matsuoka, T., & Ariyoshi, K. (2025). Out-of-hospital cardiac arrest outcomes following EMS resuscitation protocol revision during the COVID-19 pandemic: A population-based study. Resuscitation Plus.
12. Kim, T. H., Lee, K., Shin, S. D., Ro, Y. S., Tanaka, H., Yap, S., & Leong, B. (2017). Association of the emergency medical services–related time interval with survival outcomes of out-of-hospital cardiac arrest cases in four Asian metropolitan cities using the scoop-and-run emergency medical services model. Journal of Emergency Medicine, 53(5), 688–696.
13. Lee, D. W., Moon, H. J., & Heo, N. H. (2019). Association between ambulance response time and neurologic outcome in patients with cardiac arrest. American Journal of Emergency Medicine, 37(11), 1999–2003.
14. Lee, O. H., Heo, S. J., Bae, S., Kim, M. H., Park, J. W., Kim, M., & Kim, Y. (2025). Impact of emergency medical services call–to–hospital arrival time on outcomes of cardiac arrest: A nationwide prospective cohort. Mayo Clinic Proceedings, 100(10), 1719–1730.
15. Lerner, E. B., Rea, T. D., Bobrow, B. J., Acker, J. E., Berg, R. A., Brooks, S. C., & American Heart Association Emergency Cardiovascular Care Committee. (2012). Emergency medical service dispatch cardiopulmonary resuscitation prearrival instructions to improve survival from out-of-hospital cardiac arrest: A scientific statement from the American Heart Association. Circulation, 125(4), 648–655.
16. Moon, S., Ryoo, H. W., Ahn, J. Y., Lee, D. E., Shin, S. D., & Park, J. H. (2020). Association of response time interval with neurological outcomes after out-of-hospital cardiac arrest according to bystander CPR. American Journal of Emergency Medicine, 38(9), 1760–1766.
17. O'Keeffe, C., Nicholl, J., Turner, J., & Goodacre, S. (2011). Role of ambulance response times in the survival of patients with out-of-hospital cardiac arrest. Emergency Medicine Journal, 28(8), 703–706.
18. Okubo, M., Schmicker, R. H., Wallace, D. J., Idris, A. H., Nichol, G., Austin, M. A., & Callaway, C. W. (2018). Variation in survival after out-of-hospital cardiac arrest between emergency medical services agencies. JAMA Cardiology, 3(10), 989–999.
19. Rajan, S., Wissenberg, M., Folke, F., Hansen, S. M., Gerds, T. A., Kragholm, K., & Torp-Pedersen, C. (2016). Association of bystander cardiopulmonary resuscitation and survival according to ambulance response times after out-of-hospital cardiac arrest. Circulation, 134(25), 2095–2104.
20. Sladjana, A., Gordana, P., & Ana, S. (2011). Emergency response time after out-of-hospital cardiac arrest. European Journal of Internal Medicine, 22(4), 386–393.