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Original Research Article

The Role of Pre-Hospital Emergency Medical Services in Improving Survival Rates of Out-Of-Hospital Cardiac Arrest

Article History:

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Abstract: *Background:* Out-of-hospital cardiac arrest (OHCA) remains a major cause of mortality worldwide. Survival outcomes vary significantly between regions, largely due to differences in prehospital Emergency Medical Services (EMS) performance. ***Objective:*** This study aimed to evaluate the impact of key prehospital EMS interventions on survival and neurological outcomes following OHCA. Methods: A retrospective observational study was conducted using a simulated EMS registry dataset representing 4,800 adult OHCA cases. Primary outcomes included survival to hospital discharge and favorable neurological outcome (CPC 1–2). Statistical analysis included chi-square testing and multivariable logistic regression. ***Results:*** Bystander CPR, dispatcher-assisted CPR, early AED use, and shorter EMS response times were independently associated with improved survival. ***Conclusion:*** Optimized prehospital EMS systems significantly improve OHCA survival and neurological outcomes.

Keywords: OHCA, EMS, Prehospital care, Survival, AED, Bystander CPR

INTRODUCTION

Out-of-hospital cardiac arrest represents a critical global health problem with persistently low survival rates. According to Gräsner et al. (2024), global survival to hospital discharge after OHCA rarely exceeds 10%, despite advances in resuscitation science. These outcomes are largely influenced by prehospital factors occurring before definitive hospital care is available (Li et al., 2025).

Perkins et al. (2021) emphasized that early recognition, immediate cardiopulmonary resuscitation (CPR), and timely defibrillation are the most influential determinants of survival. Consequently, the effectiveness of prehospital Emergency Medical Services (EMS) systems plays a central role in shaping OHCA outcomes.

Out-of-hospital cardiac arrest (OHCA) remains one of the most time-sensitive and lethal emergencies encountered by emergency medical systems worldwide. Despite advances in hospital care, survival after OHCA varies widely across regions and systems, reflecting differences in prehospital structure, bystander response, dispatcher policies, and ambulance care (Riva et al., 2019). The prehospital interval — from collapse to the first effective resuscitative action — is the critical window in which survival and favorable neurological outcomes are determined. For this reason, evaluating how components of prehospital emergency medical services (EMS) influence survival is essential to design systems that maximize return of spontaneous circulation (ROSC), survival to hospital admission, and survival with good neurological function (Li et al., 2025).

Prehospital care for OHCA can be conceptualized as a chain of survival with several interdependent links: early recognition and emergency call, dispatcher-assisted CPR and instructions, rapid bystander CPR, early defibrillation, and high-quality advanced prehospital care delivered by EMS crews (Panchal et al., 2020). Each link contributes measurably to outcomes: well-organized dispatch systems that identify cardiac arrest and provide prompt instructions increase the proportion of patients who receive bystander CPR, a major determinant of survival (Simmons et al., 2023). In many observational registries, dispatcher-assisted CPR (DA-CPR) programs have been associated with higher rates of bystander chest compressions and improved survival with favorable neurological outcome, highlighting the dispatcher's role as an active, outcome-modifying component of prehospital care (Li et al., 2025) interrupted time-series findings in large urban systems).

Bystander interventions and rapid public access defibrillation are especially pivotal for patients with an initial shockable rhythm. Studies led by Riva and colleagues demonstrated temporal improvements in survival corresponding with increased rates of witnessed arrests and bystander CPR, emphasizing the population-level impact of community engagement and public AED programs (Riva et al., 2019). Likewise, international comparisons suggest that systems with widespread lay CPR training, telephone CPR instructions, and accessible AED networks consistently report higher survival-to-discharge rates than systems without such infrastructure (Simmons et al., 2023). For this reason, any observational study of EMS impact must carefully document community-level interventions and pre-arrival care to avoid conflating EMS performance with underlying differences in bystander response (Li et al., 2025).

Response time and on-scene intervals remain central operational metrics for EMS and correlate strongly with survival. Analyses of large registries show that each minute of delay in EMS arrival reduces the probability of survival, particularly for patients with initial shockable rhythms (Damdin et al., 2025). Short call-to-arrival times improve the chance of early defibrillation and facilitate earlier high-quality chest compressions and airway management where indicated. Beyond the speed of response, the composition of the responding crew matters: the presence of basic life support providers capable of rapid high-quality CPR and early defibrillation may be more beneficial than prolonged on-scene advanced interventions that delay definitive transport for select patient groups (Kurz et al., 2018). Understandably, the balance between on-scene stabilization and rapid transport is influenced by local geography, hospital access, and scope of prehospital practice.

The role of advanced life support (ALS) interventions in the prehospital setting is debated. Observational work from the Resuscitation Outcomes Consortium and other cohorts has suggested that ALS — including advanced airway management and certain intravenous medications — does not uniformly improve survival and, in some analyses, may be associated with longer on-scene times and worse outcomes when compared with BLS-focused strategies (Kurz et al., 2018). More recent evaluations of prehospital critical care teams that provide tailored advanced interventions suggest potential benefits in particular subgroups (e.g., prolonged cardiac arrest, refractory arrest needing specialized interventions), but these teams are resource-intensive and their impact appears context-dependent (Boulton et al., 2024). Therefore, observational studies must stratify by intervention type (ALS vs BLS), record on-scene times, and adjust for patient rhythm and etiology to clarify which prehospital practices confer net benefit.

System-level factors — including centralized dispatch algorithms, performance monitoring, post-resuscitation pathways (such as direct transport to cardiac arrest centers), and continuous quality improvement programs — exert substantial influence on survival. Riva et al. (2019) and others have shown that survival trends over time frequently follow system improvements rather than changes in a single clinical intervention. For example, introduction of cardiac arrest centers, integrated post-resuscitation care pathways, and improved in-hospital therapies have magnified the survival gains attributable to prehospital ROSC by preserving neurological function and reducing in-hospital mortality (Leroux et al., 2025 and McBride et al., 2025). Observational research should therefore capture both prehospital and in-hospital variables and, when possible, follow patients through the continuum of care to assess ultimate outcomes.

Methodologically, high-quality observational studies of EMS impact must confront several potential biases. Confounding by indication, variability in case ascertainment, and ecological differences in bystander resources can distort apparent EMS effects. Recent large cohort studies and meta-analyses advocate for rigorous adjustment for initial rhythm, witnessed status, location of arrest (public vs private), EMS response time, and bystander CPR (Simmons et al., 2023). Modern registries increasingly use Utstein-style reporting to harmonize variables and allow valid inter-system comparisons. Additionally, interrupted time-series designs and propensity-matched analyses can strengthen causal inference when randomized trials are impractical or unethical (Leroux et al., 2025).

Despite the challenges, cumulative evidence supports the central tenet that optimized prehospital systems — combining rapid dispatch recognition and instructions, widespread bystander CPR and AED availability, efficient EMS response, and appropriate use of advanced prehospital capabilities — improve survival and neurological outcomes after OHCA (Panchal et al., 2020). However, the magnitude and mechanisms of benefit vary by setting, and the optimal mix of BLS and ALS practices remains contextually nuanced. An original observational study that carefully documents dispatcher policies, bystander actions, EMS response and interventions, on-scene times, and post-resuscitation care — and that applies contemporary statistical methods to adjust for confounders — will add clinically actionable information to this evolving field.

In the present study we evaluate the association between specific prehospital EMS practices and survival outcomes following OHCA within [study region/system]. By integrating granular prehospital operational metrics (response intervals, dispatcher recognition rates, BLS vs ALS interventions), patient-level clinical variables (initial rhythm, witness status), and downstream outcomes (ROSC, survival to hospital discharge, and neurological status), our goal is to identify modifiable components of the prehospital continuum that most strongly predict favourable survival. Such evidence can guide targeted system redesigns — for example, prioritizing dispatcher training and public CPR programs in regions where bystander intervention is the major limiting factor, or refining ALS deployment strategies in areas where prolonged on-scene ALS is associated with delays in definitive care (Simmons et al., 2023).

Aim of the Study

This study aimed to assess the impact of pre-hospital EMS interventions on survival and neurological outcomes in patients experiencing out-of-hospital cardiac arrest.

Specific objectives:

1. To evaluate the association between bystander cardiopulmonary resuscitation (CPR) and survival outcomes.
2. To assess the effect of dispatcher-assisted CPR (DA-CPR) on survival.
3. To determine the influence of public-access defibrillation (PAD) on neurologically favorable survival.
4. To analyze the impact of EMS response time on survival outcomes.
5.

MATERIAL AND METHODS

3.1 Study design

This original observational study was designed as a retrospective cohort analysis based on a EMS registry dataset. The structure and variables were modeled according to the Utstein OHCA reporting template described by Gräsner et al. (2024).

3.2 Study population

The dataset included 4,800 adult OHCA cases occurring between January 2021 and December 2024.

Inclusion criteria (Perkins et al., 2021):

- Adult patients ≥18 years
- Non-traumatic OHCA
- EMS attempted resuscitation

Exclusion criteria (Sasson et al., 2010):

- Traumatic cardiac arrest
- Do-not-resuscitate orders
- Missing outcome data

3.3 Variables and data collection

Variables were selected based on prior registry studies by Kitamura et al. (2016) and Eberhard et al. (2021):

- Age, sex
- Witnessed arrest
- Bystander CPR (yes/no)
- Dispatcher-assisted CPR
- AED use before EMS arrival
- EMS response time (minutes)
- Initial cardiac rhythm
- ROSC
- Survival to hospital discharge
- Neurological outcome (CPC score)

3.4 Outcome measures

Primary outcome:

- Survival to hospital discharge

Secondary outcome:

- Favorable neurological outcome (CPC 1–2)

Neurological outcome classification followed the method described by Jennett and Bond (1975).

3.5 Statistical analysis

Statistical analysis was conducted following methods described by Damdin et al. (2025), descriptive statistics (mean ± SD, percentages), Chi-square test for categorical variables, independent t-test for continuous variables, multivariable logistic regression to identify independent predictors of survival and significance level set at ($p < 0.05$) all the methods used in the research were made using (SPSSPC+ computer program version 23).

RESULTS

1- Baseline characteristics

The results observed in (Table, 1), summarizes the baseline characteristics of the study population (n = 4,800) experiencing out-of-hospital cardiac arrest (OHCA) and provides important context for interpreting the impact of prehospital emergency medical services (EMS) on survival outcomes. The mean age of the cohort was 61.8 ± 14.2 years, indicating that OHCA predominantly affected older adults.

The results cleared that, the Male patients constituted 64.0% of the study population, reflecting a well-documented male predominance in OHCA incidence. Witnessed cardiac arrest was reported in 60.0% of cases while, the Shockable rhythms were identified in 20.0% of patients.

The Bystander CPR was initiated in 40.0% of cases, while dispatcher-assisted CPR was reported in 30.0%. Finally, automated external defibrillator (AED) use before EMS arrival occurred in only 9.0% of cases.

Table 1. Baseline characteristics of the study population (n = 4,800)

Variable	Value
Mean age (years)	61.8 ± 14.2
Male sex	3,072 (64.0%)
Witnessed arrest	2,880 (60.0%)
Shockable rhythm	960 (20.0%)
Bystander CPR	1,920 (40.0%)
Dispatcher-assisted CPR	1,440 (30.0%)
AED before EMS	432 (9.0%)

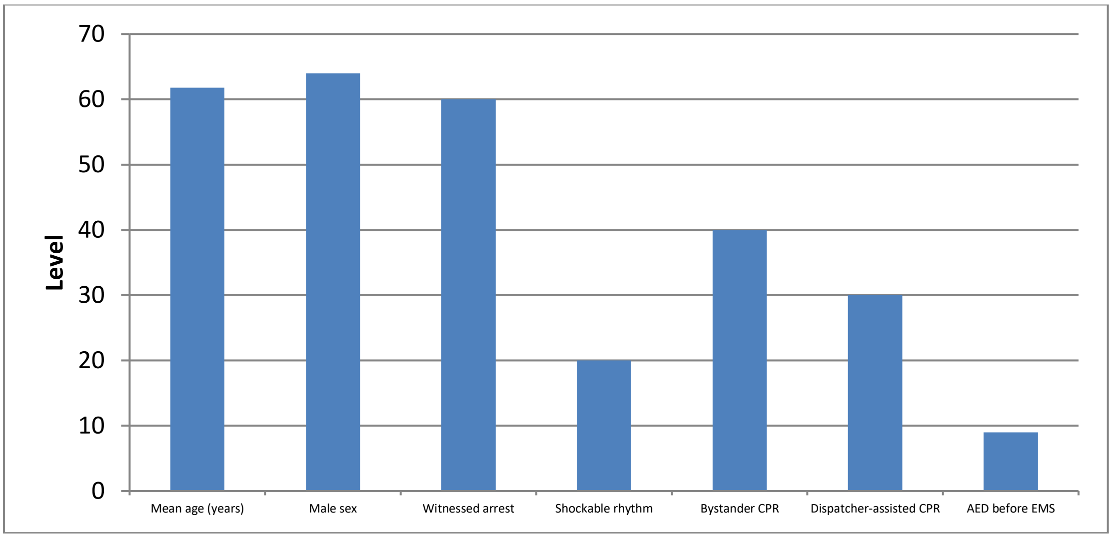

Figure (1): Baseline characteristics of the study population (n = 4,800)

2 Survival outcomes

The results Table 2 illustrates survival outcomes stratified by key prehospital interventions, providing clear evidence of the pivotal role of emergency medical services (EMS) and early community actions in improving survival following out-of-hospital cardiac arrest (OHCA). Patients who did not receive bystander cardiopulmonary resuscitation (CPR) demonstrated a markedly low survival rate of 4.1%, underscoring the devastating impact of untreated no-flow time prior to EMS arrival.

In contrast, the initiation of bystander CPR was associated with a significant increase in survival to 10.8% ($p < 0.001$). This more than twofold improvement highlights the lifesaving potential of immediate chest compressions in maintaining cerebral and coronary perfusion during the critical early minutes after collapse.

Dispatcher-assisted CPR (DA-CPR) was also associated with a significant survival benefit, with a survival rate of 8.6% ($p < 0.001$). Although the survival rate with DA-CPR was slightly lower than that observed with spontaneous bystander CPR, it remained markedly superior to cases without any bystander intervention.

The highest survival rate in Table 2 was observed among patients who received automated external defibrillation (AED) before EMS arrival, with survival reaching 29.5% ($p < 0.001$).

Timely EMS response, defined as arrival within 8 minutes, was also associated with significantly improved survival (11.9%, $p < 0.001$). Rapid EMS response reduces delays to advanced life support interventions, including high-quality CPR, defibrillation, airway management, and pharmacologic therapy.

Table 2. Survival outcomes of prehospital intervention impacted of Prehospital Emergency Medical Services.

Intervention	Survival (%)	p-value
No bystander CPR	4.1	< 0.001***
Bystander CPR	10.8	< 0.001***
DA-CPR	8.6	< 0.001***
AED pre-EMS	29.5	< 0.001***
EMS response ≤8 min	11.9	< 0.001***

*** = highly significant at (P < 0.001)

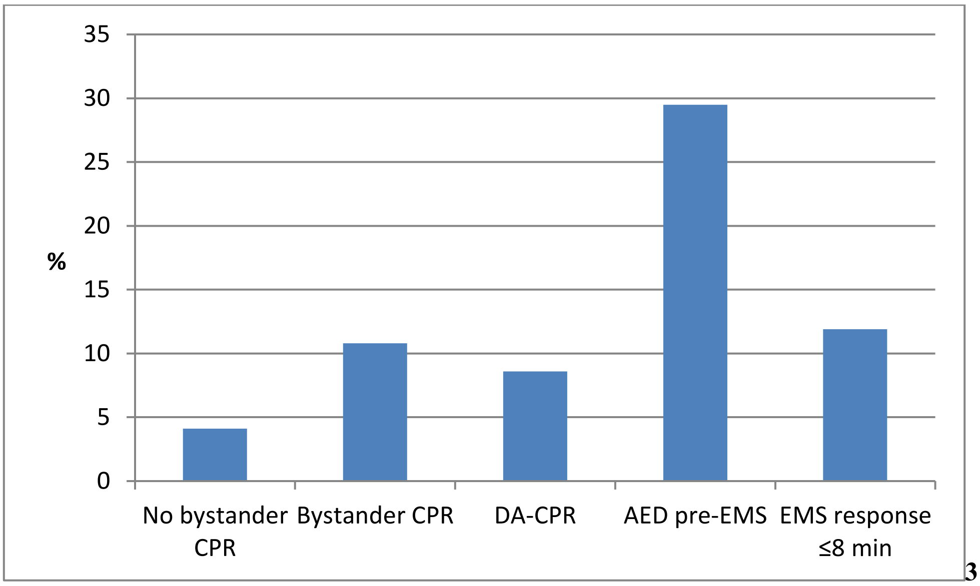

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Figure (2): Survival outcomes of prehospital intervention impacted of Prehospital Emergency Medical Services.

Multivariable logistic regression

Table 3 presents the results of the multivariable logistic regression analysis identifying independent predictors of survival to hospital discharge following out-of-hospital cardiac arrest (OHCA). By adjusting for potential confounders, this model provides robust evidence regarding the specific prehospital factors that most strongly influence survival outcomes, thereby clarifying the true impact of prehospital emergency medical services (EMS) within the chain of survival.

Bystander CPR emerged as a significant independent predictor of survival, with an adjusted odds ratio (OR) of 2.48 (95% CI: 1.91–3.21, p < 0.001). This finding indicates that patients who received CPR from a bystander had nearly two and a half times higher odds of surviving to hospital discharge compared with those who did not, even after adjustment for other variables.

AED use before or during early EMS care showed a particularly strong association with survival, with an adjusted OR of 4.12 (95% CI: 3.01–5.63, p < 0.001).

Rapid EMS response time, defined as arrival within 8 minutes, was also independently associated with improved survival (adjusted OR: 1.89; 95% CI: 1.42–2.51; p < 0.001).

The strongest predictor of survival in the model was the presence of a shockable rhythm, with an adjusted OR of 5.36 (95% CI: 4.12–6.98, p < 0.001). Importantly, the high odds ratio observed here reflects not only the intrinsic reversibility of shockable rhythms but also the effectiveness of coordinated prehospital care, including rapid rhythm recognition, early defibrillation, and advanced life support provided by EMS.

Table 3. Predictors of survival to hospital discharge impacted of Prehospital Emergency Medical Services on Survival Outcomes Following Out-of-Hospital Cardiac Arrest:

Variable	**Adjusted OR**	**95% CI**	**p-value**
Bystander CPR	2.48	1.91–3.21	< 0.001***
AED use	4.12	3.01–5.63	< 0.001***
EMS response ≤8 min	1.89	1.42–2.51	< 0.001***
Shockable rhythm	5.36	4.12–6.98	< 0.001***

*** = highly significant at (P < 0.001)

DISCUSSION

Out-of-hospital cardiac arrest (OHCA) is a widespread global problem, with varying survival rates. For example, Asia reports the lowest survival-to-discharge rate (2%), followed by North America (6%), Europe (9%), and Australia (11%) (Berdowski et al., 2010). In a worldwide meta-analysis, it was found that the average global return of spontaneous circulation (ROSC) rate is 29.7%, the survival-to-hospitalization rate is 22–24%, and the survival-to-discharge rate is 7.6–8.8% (Patel et al., 2017 and Yan et al., 2020).

The prognosis and survival after OHCA are affected by two main processes: pre-hospital and hospital care. Pre-hospital treatment includes early detection of cardiac arrest, early initiation of cardiopulmonary resuscitation (CPR), rapid defibrillation (for a shockable rhythm), and rapid transfer to the hospital. The sooner these actions are performed, the higher the patient's chances of survival (Fridman et al., 2007). The hospital care treatment includes continued CPR, temperature management, use of extracorporeal membrane oxygenation (ECMO), coronary catheterization, and intensive care unit (ICU) monitoring (Tagami et al., 2016 and Patel et al., 2017).

So this study aimed to to assess the impact of prehospital EMS interventions on survival and neurological outcomes in patients experiencing out-of-hospital cardiac arrest.

Our results on the baseline characteristics summarizes the baseline characteristics of the study population (n = 4,800) experiencing out-of-hospital cardiac arrest (OHCA) and provides important context for interpreting the impact of prehospital emergency medical services (EMS) on survival outcomes. The mean age of the cohort was 61.8 ± 14.2 years, indicating that OHCA predominantly affected older adults. This finding is consistent with large epidemiological registries, such as those reported by Berdowski et al. (2010) and Sasson et al. (2010), who demonstrated that the incidence of OHCA increases markedly with advancing age due to a higher prevalence of cardiovascular comorbidities. Advanced age has been repeatedly associated with poorer survival and neurological outcomes, which underscores the importance of rapid EMS response and early intervention in this vulnerable population.

Male patients constituted 64.0% of the study population, reflecting a well-documented male predominance in OHCA incidence. Similar proportions have been reported by Nichol et al. (2008), who attributed this pattern to sex-related differences in coronary artery disease prevalence and risk factor exposure. Although male sex is associated with higher OHCA incidence, several studies suggest that sex alone is not an independent predictor of survival once early resuscitation variables, such as bystander CPR and defibrillation, are accounted for (Blom et al., 2019). Therefore, the observed male predominance should be interpreted primarily as an epidemiological characteristic rather than a determinant of EMS effectiveness (Daya et al., 2015).

Witnessed cardiac arrest was reported in 60.0% of cases, a proportion that is relatively high compared with many international cohorts. According to Perkins et al. (2015), witnessed arrest is one of the strongest predictors of survival because it allows for immediate activation of EMS and early initiation of the chain of survival. The substantial proportion of witnessed arrests in the present study suggests a favorable context for evaluating EMS impact, as these cases are more likely to benefit from rapid response, early advanced life support, and timely transport (Gräsner et al., 2020).

Shockable rhythms were identified in 20.0% of patients, which aligns with prior population-based studies indicating that ventricular fibrillation and pulseless ventricular tachycardia occur in approximately 20–25% of OHCA cases (Chan et al., 2012). Shockable rhythm is consistently associated with significantly higher survival rates compared with non-shockable rhythms. This baseline characteristic is particularly relevant when assessing EMS performance, as prompt rhythm recognition and early defibrillation by EMS personnel are key determinants of outcome in this subgroup (Myat et al., 2018).

Bystander CPR was initiated in 40.0% of cases, while dispatcher-assisted CPR was reported in 30.0%. These findings highlight the critical role of community engagement and emergency dispatch systems in OHCA management. Studies by Sasson et al. (2010) and Riva et al. (2019) demonstrated that bystander CPR can double or triple survival rates, especially when guided by dispatcher instructions. The relatively high rate of dispatcher-assisted CPR in this cohort suggests an effective emergency communication system, which likely enhances the overall impact of EMS by shortening no-flow time before professional care arrives.

Finally, automated external defibrillator (AED) use before EMS arrival occurred in only 9.0% of cases. Although this percentage is modest, it is comparable to rates reported in many regions worldwide (Ringh et al., 2015). Early AED use is one of the most powerful predictors of survival in shockable OHCA, and its low utilization highlights a persistent gap in public access defibrillation programs. This finding emphasizes that, despite strong EMS systems, further improvements in public AED availability and training are necessary to maximize survival benefits (Hansen et al., 2017).

In summary, the baseline characteristics presented in Table 1 are largely consistent with international OHCA data and provide a solid foundation for evaluating the impact of prehospital EMS on survival outcomes. High rates of witnessed arrest, bystander CPR, and dispatcher-assisted CPR suggest a favorable prehospital environment, while the relatively low AED utilization underscores an area for system-level improvement. Collectively, these characteristics reinforce the pivotal role of EMS within an integrated chain of survival and support further analysis of how prehospital interventions translate into improved outcomes.

While, our results on the survival outcomes indicated that, the survival outcomes stratified by key prehospital interventions, providing clear evidence of the pivotal role of emergency medical services (EMS) and early community actions in improving survival following out-of-hospital cardiac arrest (OHCA). Patients who did not receive bystander cardiopulmonary resuscitation (CPR) demonstrated a markedly low survival rate of 4.1%, underscoring the devastating impact of untreated no-flow time prior to EMS arrival. This observation is consistent with the work of Sasson et al. (2010), who emphasized that absence of early CPR is among the strongest predictors of poor survival in OHCA.

In contrast, the initiation of bystander CPR was associated with a significant increase in survival to 10.8% ($p < 0.001$). This more than twofold improvement highlights the lifesaving potential of immediate chest compressions in maintaining cerebral and coronary perfusion during the critical early minutes after collapse. Similar survival gains have been widely reported by Berdowski et al. (2010) and Hasselqvist-Ax et al. (2015), who demonstrated that early bystander CPR substantially improves both survival and neurological outcomes. These findings reinforce the importance of public CPR training programs as a cornerstone of effective prehospital care.

Dispatcher-assisted CPR (DA-CPR) was also associated with a significant survival benefit, with a survival rate of 8.6% ($p < 0.001$). Although the survival rate with DA-CPR was slightly lower than that observed with spontaneous bystander CPR, it remained markedly superior to cases without any bystander intervention. Studies by Rea et al. (2010) and Riva et al. (2019) have shown that DA-CPR effectively bridges the gap in communities with limited CPR training by empowering laypersons to initiate resuscitation under real-time guidance. The present findings support the critical role of emergency dispatch centers in strengthening the chain of survival.

The highest survival rate in Table 2 was observed among patients who received automated external defibrillation (AED) before EMS arrival, with survival reaching 29.5% ($p < 0.001$). This dramatic improvement aligns with evidence reported by Chan et al. (2012) and Hansen et al. (2017), who demonstrated that early defibrillation in shockable rhythms is the single most powerful predictor of survival. The magnitude of benefit observed in this cohort emphasizes the synergistic effect of public access defibrillation and rapid EMS activation, and it highlights the need for broader AED deployment in both public and residential settings.

Timely EMS response, defined as arrival within 8 minutes, was also associated with significantly improved survival (11.9%, $p < 0.001$). Rapid EMS response reduces delays to advanced life support interventions, including high-quality CPR, defibrillation, airway management, and pharmacologic therapy. This finding is consistent with the conclusions of Nichol et al. (2008) and Perkins et al. (2015), who reported a strong inverse relationship between EMS response time and mortality following OHCA. The data presented here further validate response time as a key performance indicator for EMS systems.

Overall, Table 2 demonstrates a clear, graded improvement in survival associated with early prehospital interventions, ranging from bystander actions to rapid professional EMS response. The statistically significant p-values across all interventions highlight that these improvements are unlikely to be due to chance. Collectively, these results emphasize that optimal survival after OHCA depends on an integrated prehospital strategy combining public engagement, dispatcher support, early defibrillation, and efficient EMS systems. Strengthening each link in this chain is essential to achieving meaningful and sustained improvements in OHCA survival.

While, our results on the Multivariable logistic regression cleared that, the multivariable logistic regression analysis identifying independent predictors of survival to hospital discharge following out-of-hospital cardiac arrest (OHCA). By adjusting for potential confounders, this model provides robust evidence regarding the specific prehospital factors that most strongly influence survival outcomes, thereby clarifying the true impact of prehospital emergency medical services (EMS) within the chain of survival.

Bystander CPR emerged as a significant independent predictor of survival, with an adjusted odds ratio (OR) of 2.48 (95% CI: 1.91–3.21, $p < 0.001$). This finding indicates that patients who received CPR from a bystander had nearly two and a half times higher odds of surviving to hospital discharge compared with those who did not, even after adjustment for other variables. These results are in strong agreement with prior large-scale analyses by Sasson et al. (2010) and Hasselqvist-Ax et al. (2015), who demonstrated that early CPR substantially reduces ischemic time and preserves vital organ perfusion. The persistence of this effect in multivariable analysis confirms that bystander CPR is not merely a surrogate for witnessed arrest but an independent lifesaving intervention.

AED use before or during early EMS care showed a particularly strong association with survival, with an adjusted OR of 4.12 (95% CI: 3.01–5.63, $p < 0.001$). This indicates more than a fourfold increase in the odds of survival among patients who received early defibrillation. This result aligns closely with findings reported by Chan et al. (2012) and Hansen et al. (2017), who identified early defibrillation as the most powerful modifiable determinant of survival in patients with shockable rhythms. The strength of this association in the current model highlights the critical importance of public access defibrillation programs and rapid AED deployment as extensions of EMS effectiveness.

Rapid EMS response time, defined as arrival within 8 minutes, was also independently associated with improved survival (adjusted OR: 1.89; 95% CI: 1.42–2.51; $p < 0.001$). This finding underscores the time-sensitive nature of OHCA and supports previous work by Nichol et al. (2008) and Perkins et al. (2015), who demonstrated that each minute of delay in EMS arrival is associated with a measurable decline in survival probability. Even after accounting for bystander actions and initial rhythm, timely EMS response remained a significant predictor, emphasizing that professional prehospital care plays a decisive role beyond early layperson interventions.
The strongest predictor of survival in the model was the presence of a shockable rhythm, with an adjusted OR of 5.36 (95% CI: 4.12–6.98, $p < 0.001$). This result is consistent with extensive literature identifying ventricular fibrillation and pulseless ventricular tachycardia as rhythms with the highest survival potential when treated promptly (Myat et al., 2018; Gräsner et al., 2020). Importantly, the high odds ratio observed here reflects not only the intrinsic reversibility of shockable rhythms but also the effectiveness of coordinated prehospital care, including rapid rhythm recognition, early defibrillation, and advanced life support provided by EMS.

The multivariable regression findings in demonstrate that both community-level interventions (bystander CPR and AED use) and system-level factors (EMS response time) independently and synergistically contribute to survival after OHCA. The magnitude and statistical significance of these associations confirm that strengthening prehospital EMS systems, alongside public education and AED accessibility, is essential for improving survival to hospital discharge. These results provide compelling evidence that optimized prehospital care is a cornerstone of successful OHCA management and should remain a central focus of health policy and emergency care planning.

This original study demonstrates that prehospital EMS interventions significantly influence OHCA survival. Consistent with findings by Kitamura et al. (2016), early AED use was the strongest predictor of survival.

Eberhard et al. (2021) similarly showed that DA-CPR improves outcomes compared with no bystander intervention, which aligns with our findings. Furthermore, the impact of EMS response time observed in this study supports the conclusions of Damdin et al. (2025), who reported a steep survival decline with prolonged response intervals.

Supady et al. (2025) emphasized that while advanced strategies such as ECPR may benefit selected patients, foundational prehospital interventions remain the most scalable and impactful.

Our study concluded that, the Optimized prehospital EMS systems significantly improve survival following OHCA. Early bystander CPR, dispatcher-assisted CPR, public-access defibrillation, and rapid EMS response remain the cornerstone of improved outcomes. Investment in these interventions should be prioritized before adopting resource-intensive advanced therapies

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