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ORIGINAL RESEARCH

Effects of Emergency Medical Service Response Time on Survival Rate of Out-of-Hospital Cardiac Arrest Patients: a 5-Year Retrospective Study

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Abstract: **Introduction:** Emergency medical service (EMS) response time is a critical factor in managements of out-of-hospital cardiac arrest (OHCA) cases. This study aimed to investigate the effects of EMS response time on survival of OHCA patients. **Methods:** This study employed a retrospective cohort design focused on prognosis research. Data was collected from the Erawan EMS Dispatch Center of the Bangkok Metropolitan Administration from January 2019 to December 2023. All OHCA cases visited by dispatched prehospital teams in Bangkok were included. Multivariable logistic regression was used to analyze the effect of response time on survival at scene, survival to emergency department (ED), and survival to hospital discharge of OHCA cases. **Results:** Among the 5,433 OHCA patients included in the study, 29.17% achieved return of spontaneous circulation at the scene, 6.9% survived to ED, and 1% survived to hospital discharge. Each 1-minute increase in response time decreased the likelihood of survival at the scene by 6% (OR: 0.94, $p < 0.001$), survival to ED admission by 4% (OR: 0.96, $p < 0.001$), and survival to hospital discharge by 6% (OR: 0.94, $p = 0.006$). Response times under 8 minutes significantly improved outcomes, with survival at the scene increasing by 2.31 times ($p < 0.001$), survival to ED by 1.76 times ($p < 0.001$), and survival to hospital discharge by 2.09 times ($p = 0.048$). **Conclusion:** A maximum response time of 8 minutes significantly enhances survival outcomes, including survival at the scene, survival to ED, and survival to hospital discharge. Furthermore, each 1-minute increase in response time is associated with a 6% reduction in the likelihood of survival to hospital discharge.

Keywords: Out-of-Hospital Cardiac Arrest; Response Time; Emergency Medical Services; Ambulances; Advanced Cardiac Life Support

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1. Introduction

Out-of-hospital cardiac arrest (OHCA) remains a leading cause of mortality worldwide (1, 2). The incidence of OHCA varies widely, ranging from 40 to over 200 cases per 100,000 individuals annually, depending on the country and degree of urbanization (3). Over the past five years, survival after OHCA has shown a positive trend in many developed countries, increasing from approximately 8–12% to 12–20% (4). A study conducted at Ramathibodi Hospital reported outcomes for in-hospital cardiac arrest (IHCA), with 67.3% of patients achieving return of spontaneous circulation (ROSC), 18.0% surviving to hospital discharge, and 9.6% achieving favorable neurological outcomes. In comparison, among OHCA cases, 29.17% of patients achieved sustained ROSC, and 13.26% survival to hospital discharge (5). Furthermore, an 11-year study of traumatic out-of-hospital cardiac arrest (TOHCA) cases across Thailand reported that 18.45% of patients survived to hospital admission (6).

Previous studies have identified several prognostic factors associated with improved rates of ROSC and survival to hospital discharge in cases of OHCA. Key factors include bystander-initiated cardiopulmonary resuscitation (CPR) and early defibrillation, both of which significantly enhance survival outcomes (7, 8). Additionally, the management provided by emergency medical services (EMS) agencies plays a pivotal role in the treatment of OHCA (9). The initial cardiac rhythm at presentation also substantially influences outcomes. Survival to hospital discharge is notably higher among patients presenting with ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT) compared to those with pulseless electrical activity (PEA) or asystole (5.9% vs. 1.1%) (10).

Studies on CPR duration indicate that prolonged resuscitation efforts yield diminishing rate of ROSC. For EMS-witnessed cardiac arrests, survival rates drop to 1% when CPR exceeds 32 minutes, with no survivors reported beyond 48 minutes for VF and VT, 47 minutes for PEA, and 45 minutes for asystole (11). Additionally, the design of the EMS system

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significantly influences patient outcomes. Multi-tiered EMS systems, which deploy prehospital care providers at various levels of expertise, have been associated with better neurological outcomes compared to single-tier systems (12, 13).
Numerous studies have demonstrated that increased EMS response times are associated with decreased rates of ROSC and survival to hospital discharge (14, 15, 16, 17). The acceptable threshold for response time varies across countries due to differences in EMS systems and infrastructure. A study utilizing a national database in Japan found that for every 1-minute increase in response time, survival and favorable neurological outcomes at one month decreased by 9.3% and 10.7%, respectively. The upper limit for an effective response time was identified as 13 minutes for cases involving bystander CPR with defibrillation and 11 minutes for cases without defibrillation (18). Similarly, research in Taiwan identified an optimal response time of 6.2 minutes (19), while a study conducted in Korea determined the threshold to be 7.5 minutes (20).
A study conducted in Sweden demonstrated that response times exceeding 10 minutes were significantly associated with decreased 30-day survival (21). Similarly, research in Germany found that for every 1-minute increase in response time, the likelihood of survival with favorable neurological outcomes decreased by 5% (14). However, some studies have not identified a clear association between response time and favorable outcomes, indicating variability that may be influenced by study design and regional EMS system characteristics (22).
Thailand's EMS system is regulated by the National Institute for Emergency Medicine (NIEMS) and operates within a hospital and volunteer-based ambulance framework. This multi-tiered system includes EMS teams providing comprehensive life support (CLS), advanced life support (ALS), and basic life support (BLS). According to NIEMS standards, the target response time is 8 minutes for CLS and ALS teams and 4 minutes for BLS teams. For suspected cardiac arrest cases, the dispatch center activates CLS or ALS teams to deliver on-scene care and facilitate patient transfer to the emergency department (ED) as needed. This study aimed to evaluate the impact of EMS response times on critical survival outcomes in patients experiencing OHCA with a particular focus on ROSC at the scene, survival to ED admission, and survival to hospital discharge.

2. Methods

2.1. Study design and setting

This study employed a prognostic research design with a retrospective cohort approach, incorporating an explanatory model to evaluate the impact of response time on survival outcomes of OHCA cases (ROSC at the scene, survival to ED admission, and survival to hospital discharge). The research was conducted at the EMS Center of the Bangkok Metropolitan Administration, which coordinates OHCA cases through its EMS system in Bangkok. The data were obtained from the electronic medical record (EMR) of Erawan Dispatch Center's information system, covering a 5-year period from January 2019 to December 2023.
In Bangkok, the Erawan Dispatch Center coordinates EMS operations across 11 zones, ensuring efficient responses to critical emergencies. For cardiac arrest cases, activation begins with a 1669 medical emergency call directed to the Erawan Dispatch Center. The Emergency Medical Dispatcher (EMD) receives the call, identifies the patient's location, and dispatches the nearest CLS or ALS team. If a BLS team is available, they are also deployed to provide additional support. Furthermore, the EMD provides prearrival instructions for chest compressions to bystanders until the CLS or ALS team arrives (6).
The standard activation time for ALS teams is a maximum of 2 minutes, with a guaranteed response time of no more than 8 minutes. CLS and ALS teams are led by an emergency physician, paramedic, or emergency nurse practitioner. If a BLS team arrives at the scene before the CLS or ALS teams, they initiate chest compressions and utilize an automated external defibrillator (AED) while awaiting the arrival of the CLS or ALS teams.
Prehospital care data provided by the EMS is recorded in the EMR system of the Erawan Dispatch Center by the EMD. Additionally, in-hospital management and patient outcome data is submitted to the Erawan Dispatch Center by the EMS teams of the receiving hospitals and subsequently recorded in the EMR system.
This study was approved by the Faculty of Medicine, Committee on Human Rights Related to Research Involving Human Subjects at Ramathibodi Hospital, Mahidol University on 28 February 2024 (IRB COA. MURA2024/148) and by the Bangkok Metropolitan Administration Institutional Review Board (BMA-IRB) on 22 May 2024 (Approval No. 62/U010hh/67_EXP). Since this was a retrospective observational study, the requirement for informed consent was waived. The study adheres to international research ethics guidelines, including the Declaration of Helsinki and the Belmont Report.

2.2. Participants

The study included all OHCA patients managed by the EMS dispatched by the Erawan Center. Eligibility criteria included patients aged over 18 years. Patients with OHCA who exhibited obvious signs of death or had missing survival outcome records were excluded from the study.

2.3. Data gathering and outcome measures

Baseline prognostic factors, potential confounding factors, and effect modifiers were collected, including gender, age, distance to the scene, activation time, response time, scene time, transport time, total prehospital time, trauma or non-trauma status, operational shift, aggressive intravenous (IV) fluid administration, and whether the initial heart rhythm was shockable or non-shockable.

The data was obtained from the exported EMR program of the Erawan Dispatch Center. Potential sources of selection bias include the exclusion of OHCA cases without documented outcomes.

2.4. Outcomes

The outcomes of interest were survival at the scene, survival to ED admission, and survival to hospital discharge for OHCA patients.

2.5. Definitions

Out-of-hospital cardiac arrest (OHCA) was defined as the abrupt cessation of cardiac function in prehospital setting (23).

Response time was defined as the interval between the dispatch of the EMS team and their arrival at the incident scene. It reflects the efficiency of the EMS system in promptly reaching patients after notification (24).

On-scene time refers to the duration the EMS team spends at the incident location, during which they assess, stabilize, and manage the patient before initiating transport to a hospital or other appropriate facility (25).

Transport time is the interval from when the EMS team departs the incident scene to when they arrive at the receiving hospital or healthcare facility. This measure indicates the time taken to transfer the patient to definitive care(26).

Survival at the scene refers to the restoration of a spontaneous pulse during prehospital care provided by EMS, prior to the patient's arrival at a hospital (27).

Survival to emergency department (ED) admission indicates that the patient arrives at the ED with sustained vital signs following prehospital interventions, such as CPR or defibrillation (27).

Survival to hospital discharge represents a patient's ability to be discharged alive from the hospital (27).

2.6. Statistical analysis

We conducted sensitivity analyses on three survival outcomes: survival at the scene, survival to ED admission, and survival to hospital discharge. Exact probability tests were utilized for categorical variables, which are presented as frequencies and percentages. For quantitative variables, a Student's t-test was used for normally distributed data, which are presented as means with standard deviations (SD). For non-normally distributed data, the rank-sum test was employed, and results are reported as medians with interquartile ranges (IQRs).

Data were analyzed using STATA version 16.0. Multivariable logistic regression was employed to evaluate the prognostic performance for predicting survival at the scene, survival to ED admission, and survival to hospital discharge. Potential confounding factors, including age, type of OHCA, endotracheal intubation, aggressive IV fluid administration, and shockable rhythm, were considered for adjustment in the final multivariable model. Results are presented as odds ratios (ORs) with 95% confidence intervals (CIs) and P-values. A P-value of less than 0.05 was considered statistically significant. Since the data were collected retrospectively, complete case analysis was used to address missing data, without the application of imputation methods. Response time was analyzed in five subgroups: <6 minutes, <7 minutes, <8 minutes, <9 minutes, and <10 minutes, to evaluate its effect on survival outcomes.

For sample size estimation, this study referred to the findings of Huang LH et al.(19), which examined various variables and their impact on survival to hospital discharge in relation to response times. The observed differences between survival groups in that study were used for calculating the sample size. Using Stata version 16.1, a two-sample comparison of means was employed with the following assumptions: alpha (α) = 0.05 (two-sided), power = 0.8, and the ratio of survivors to non-survivors to hospital discharge = 0.03. The mean and standard deviation of the response time variable were used in the calculation. The minimum sample size required to detect a statistically significant difference was estimated to be 1,024 OHCA patients, comprising 30 patients who survived hospital discharge and 994 patients who did not survive to discharge.

3. Results

A total of 11,947 OHCA cases attended by EMS in Bangkok, Thailand, from January 2019 to December 2023 were included in the initial assessment. As shown in Figure 1, exclusions were made based on the following criteria: obvious signs of death upon arrival (n = 6,478) and missing survival outcome records (n = 36). After applying these exclusions, 5,433 patients were included in the final analysis.

At the scene, 70.83% (n = 3,848) of OHCA patients died, while 29.17% (n = 1,585) achieved ROSC. Among those transported to the ED, 76.21% (n = 1,208) died in the ED, while 23.79% (n = 377) survived to ED admission. Of those admitted to the hospital, 86.74% (n = 327) died during hospitalization, and 13.26% (n = 50) survived to hospital discharge.

3.1. Comparing the Baseline characteristics based on the studied outcomes

The analysis categorized patients into three groups: survival versus death at the scene, survival to ED admission versus death before ED admission, and survival to hospital discharge versus death before hospital discharge (as shown in Table 1).

3.1.1 Survival at scene

At the scene, a significantly higher proportion of males survived compared to non-survived (67.77% vs. 62.85%, p < 0.001). Survivors were younger than those who died (61.37 ± 17.41 vs. 64.56 ± 17.60 years, p < 0.001). Key time intervals, such as shorter activation times (5 vs. 6 minutes), response times (15.53±8.09 vs. 18.64±8.95 minutes), scene times (22 vs. 30 minutes), and total prehospital times (46 vs. 60 minutes), were strongly associated with survival (p < 0.001). Non-trauma cases were more frequent among survivors (97.54% vs. 98.62%, p = 0.007). Endotracheal intubation (71.36% vs. 36.38%; P < 0.001) and aggressive IV fluid administration were more common in survivors (95.14% vs. 67.49%; P < 0.001). A shockable rhythm was also more prevalent in survivors (47.89% vs. 42.15%, p < 0.001).

3.1.2 Survival to ED

At the ED, males had higher survival to ED admission compared to those who died (68.08% vs. 63.93%, p = 0.050). Survivors were younger than those who died (59.87 ± 17.56 vs. 63.91 ± 17.57 years, P < 0.001). Survivors had shorter distances to the scene (5 vs. 6 km), shorter activation times (5 vs. 6 minutes), response times (15.05 ± 7.12 vs. 17.93 ± 8.90 minutes), and total prehospital times (47 vs. 57 minutes) (p < 0.001). Admissions during the morning shift were associated with higher survival rates (p = 0.005). Endotracheal intubation (75.60% vs. 44.42%) and aggressive IV fluid administration (95.76% vs. 74.05%) were more frequent among ED survivors (P < 0.001).

3.1.3 Survival to discharge

At the Hospital, survivors to hospital discharge were more likely to be male, though this difference was not statistically significant (76% vs. 64.17%; p = 0.102). Survivors had significantly shorter response times (13.90 ± 5.46 vs. 17.77 ± 8.83 minutes, p=0.002) and total prehospital times (46 vs. 56 minutes, p = 0.001). Endotracheal intubation (76% vs. 46.31%) and aggressive IV fluid administration (98% vs. 75.35%) were significantly more common among survivors (p < 0.001). There was no significant difference in the presence of a shockable rhythm (p = 0.886).

3.2. EMS response time and survival of OHCA cases (multivariate analysis)

The multivariable logistic regression analysis of response time for predicting survival at the scene, survival to ED admission, and survival to hospital discharge, adjusted for age, trauma versus non-trauma status, endotracheal intubation, aggressive IV fluid administration, and shockable rhythm, is presented in Table 2.

Our analysis reveals that for every 1-minute increase in response time, the likelihood of survival at the scene decreases by 6% (OR: 0.94, 95%CI: 0.90–0.98, p < 0.001), survival to ED admission decreases by 4% (OR: 0.96, 95%CI: 0.95–0.98, p < 0.001), and survival to hospital discharge decreases by 6% (OR: 0.94, 95%CI: 0.89–0.98, p = 0.006).

When response times are less than 8 minutes, the chances of survival at the scene increase by 2.31 times (OR: 2.31, 95% CI: 1.89–2.83, p < 0.001), survival to ED admission increases by 1.76 times (OR: 1.76, 95% CI: 1.30–2.38, p < 0.001), and survival to hospital discharge increases by 2.09 times (OR: 2.09, 95% CI: 1.00–4.35, p = 0.048). At a response time of 9 minutes, the likelihood of survival at the scene remains elevated (OR: 2.21, 95% CI: 1.85–2.63, p < 0.001), as does survival to ED admission (OR: 1.67, 95% CI: 1.28–2.19, P < 0.001); however, the association with survival to hospital discharge is not statistically significant (OR: 1.83, 95% CI: 0.93–3.60, p = 0.082). These findings emphasize that maintaining response times below 8 minutes significantly enhances survival outcomes, particularly for survival to hospital discharge, which is the most critical endpoint.

3.3. Probability of survival based on emergency response time

The plot illustrates the significant impact of shorter response times on improving survival rates. In the first 20 minutes, there is a sharp drop in survival probability, emphasizing that delays during this critical window substantially reduce the chances of survival. After 40 minutes, the decline in survival probability becomes less steep, yet the overall trend continues to show a reduction in survival as response times lengthen. Figure 2 demonstrates the probability of survival at the scene, survival to ED, and survival to discharge based on emergency response time. For OHCA patients who received immediate resuscitation from the EMS team, the probability of survival at the scene is approximately 50%. In the first 20 minutes, the probability of survival at the scene declines rapidly, dropping to less than 10% by a response time of approximately 40 minutes.

OHCA patients who received immediate resuscitation from the EMS team have a survival to ED admission probability of around 15%. Within the first 20 minutes, the probability of survival declines quickly, falling below 5% when the response time reaches approximately 20 minutes.

For OHCA patients who received immediate resuscitation from the EMS team, the probability of survival to hospital discharge is less than 3%. Within the first 20 minutes, the probability of survival to hospital discharge drops rapidly.

4. Discussion

Our study demonstrated that standardizing the maximum response time to 8 minutes significantly improved survival outcomes at the scene, survival to ED admission, and survival to hospital discharge. Notably, survival to hospital discharge, which truly reflects the quality of advanced life care, showed a statistically significant improvement with response times under 8 minutes. In contrast, response times exceeding 8 minutes, although associated with increased survival at the scene and ED admission, did not demonstrate a statistically significant impact on survival to hospital discharge. This highlights the importance of minimizing response times to improve the overall quality of emergency medical care and long-term patient outcomes.

Our study utilized five years of retrospective data from the Erawan Center in Bangkok. We found that, when OHCA occurs, only about one-third (29.17%) of cases achieve a ROSC following interventions by EMS teams and are subsequently transported to the ED. Of these, only 6.9% received successful resuscitation in the ED and survived to ED admission. Ultimately, approximately 1% of OHCA patients survived to hospital discharge.

The ROSC rate for OHCA in our study was 29.17%, which is closely aligned with the global average of 29.7% (95% CI: 27.6–31.7%). This rate is higher than the overall average reported for Asia (22.1%) and North America (24.3%) but lower than that of Europe (36.7%) (28). The incidence of survival to admission in our study (average 7%) was notably lower than the global average of 22.0% (95% CI: 20.7–23.4%), as well as the rates reported in Europe (25.7%), North America (20.5%), and other Asian countries (15.6%)(28). The survival to hospital discharge in our study (1%) was significantly lower than the global average of 8.8% (95% CI: 8.2–9.4%) and the rates reported in Europe (11.7%) and North America (7.7%)(28). Survival to hospital discharge aligns more closely with findings from other Asian studies, such as those in Japan (0.6–3%), Singapore (0.9%), and Taiwan (1%)(29), as well as China, where the survival rate is reported to be less than 1% (30). Additionally, the Pan-Asian Resuscitation Outcomes Study (PAROS), which included 4 years of data from 11 EMS agencies in Bangkok and Chiang Mai, reported that 3.4% of OHCA patients were discharged alive after 30 days (31).

In contrast, IHCA tends to have better outcomes. A study conducted at Ramathibodi Hospital, Thailand, reported that 67.3% of IHCA patients achieved ROSC following CPR, 18.0% survived to hospital discharge, and 9.6% survived with favorable neurological outcomes (5). For TOHCA, a review of 11 years of data in Thailand revealed that, upon transfer to the ED, 18.45% of patients survived to ED admission, while 81.55% underwent termination of resuscitation efforts in the ED (6).

Every 1-minute increase in response time decreased the likelihood of survival at the scene, survival to ED admission, and survival to hospital discharge by 6%, 4%, and 6%, respectively. These findings are consistent with previous studies that emphasized the critical importance of shortening response times to improve survival outcomes (12, 14, 15, 18, 21). For instance, the PAROS study highlighted that a 1-minute reduction in response time increases the likelihood of survival to hospital discharge by 1.12 times (31). These results reinforce the need for rapid EMS interventions to optimize outcomes for OHCA patients.

The average response time in our study, conducted within the EMS system of Bangkok's metropolitan area, was 17.73 ± 8.82 minutes. This is significantly longer compared to other studies, such as the PATOS study, where the median response time (IQR) was 9 minutes (4–13) (31). Similarly, the average response times in other regions are shorter: 7.3 minutes in Asia, 8.0 minutes in Oceania, 19 minutes in Africa, and 9 to 11 minutes in America and Europe (24, 32). The prolonged response times in Bangkok's metropolitan area are largely attributed to traffic congestion, particularly during working hours. To address this, measures could include traffic coordination: sharing OHCA data with traffic police to prioritize and guide ambulances directly to the scene. Motorcycle ambulances (Motorlance): deploying motorcycle ambulances to access OHCA patients more quickly in areas with severe traffic congestion (33, 34). Improved location identification: delays caused by difficulties in locating patients can be mitigated by using GPS for precise location tracking and ensuring rapid scene access (35, 36). Community and remote area strategies: inaccessible areas, such as crowded urban slums or remote regions, could benefit from local CPR training programs for community volunteers or family caregivers to provide immediate first-response care (35). Standardizing Dispatcher-Assisted Bystander CPR (DA-CPR) Protocols (37) with real-time audiovisual feedback to enhance chest compression quality before ALS team arrival (38, 39). Additionally, installing AEDs in strategic locations to ensure accessibility within 4 minutes could further enhance survival outcomes (40).

The maximum response time for OHCA in our study was identified as 8 minutes. However, the findings clearly demonstrate that the shorter the response time, the higher the probability of survival. The response time threshold identified in our study aligns with findings from another research. The Korean Cardiac Arrest Research Consortium (KoCARC) reported a threshold of 7.5 minutes, which significantly increased the odds of survival to hospital discharge and favorable neurologic outcomes (OR: 1.54 and 2.01, respectively) (20). Similarly, a study in Taiwan found a response time threshold of 6.2 minutes for survival to hospital discharge (19). In Japan, a response time threshold of ≤6.5 minutes was associated with improved odds of survival to discharge with favorable neurologic outcomes (41). The Resuscitation Outcomes Consortium (US) set a response time threshold at 10 minutes to distinguish "early" versus "late" ALS response, with delays beyond 10 minutes being linked to lower survival rates and worse neurologic outcomes (42).

In our study, only 9.08% (491 out of 4,914) of EMS operations for OHCA met the 8-minute response time threshold, a proportion that remains critically low. To address this, national policy advocacy is essential to establish a standardized response time that all EMS agencies must adhere to. Separating EMS services from ED workloads is another crucial measure to reduce both activation and response times. In many hospitals in Bangkok, EMS personnel are also responsible for ED duties, which can delay both the activation of EMS services and their response times. Implementing a multi-tiered EMS delivery system could further enhance response times. For instance, BLS teams, often composed of volunteers and strategically stationed at key locations across Bangkok, can provide rapid access to OHCA patients, significantly reducing response times (12, 43).

5. Limitations

Several limitations of this study should be acknowledged. First, as a retrospective cohort study, it is inherently susceptible to information bias due to the retrospective nature of data collection from EMR. Selection bias may also be present, as 0.7% of OHCA cases (36 patients) without survival outcome data were excluded, potentially affecting the generalizability of the findings. Additionally, confounding bias may have arisen from the limitations of the EMRs, which might not have captured all relevant confounding variables. Lastly, temporal bias is a potential limitation, as the data were collected over a 5-year period from 2019 to 2023, which may not account for recent advances or changes in EMS practices. Although cases with missing survival outcome records were excluded, unmeasured confounding factors or variables not captured in the EMS database may still influence the results. Additionally, imprecision in response time and outcome data may have occurred due to the export of data from EMRs, which were recorded by EMS providers based on standard guidelines rather than actual operational practices. Furthermore, this study was conducted within a single urban EMS system in Bangkok, which may limit the generalizability of the findings to other regions, particularly rural or less densely populated areas with different EMS infrastructures and operational challenges. Thus, the results may not be directly applicable to rural or other settings with distinct EMS systems.

6. Conclusions

A maximum response time of 8 minutes significantly enhanced survival outcomes, including survival at the scene, survival to ED admission, and survival to hospital discharge. Furthermore, each 1-minute increase in response time was associated with a 6% reduction in the likelihood of survival to hospital discharge.

7. Declarations

7.1. Acknowledgments

The Bangkok Emergency Medical Service Center (Erawan Center).

7.2. Author Contribution

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work. All authors read and approved the final version of the manuscript.

7.3. Ethical considerations

This study was approved by the Faculty of Medicine, Committee on Human Rights Related to Research Involving Human Subjects at Ramathibodi Hospital, Mahidol University on 28 February 2024 (IRB COA. MURA2024/148) and by the Bangkok Metropolitan Administration Institutional Review Board (BMA-IRB) on 21 May 2024 (Approval No. 62/U010hh/67_EXP). Since this was a retrospective observational study, the requirement for informed consent was waived. The study adheres to international research ethics guidelines, including the Declaration of Helsinki and the Belmont Report.

7.4. Availability of data and material

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

7.5. Funding Source

No funding was obtained for this study.

7.6. Competing interests

The authors declare that they have no competing interests.

7.7. Using artificial intelligence chatbots

During the preparation of this work the authors used ChatGPT4.0 and Grammarly's AI in order to check and correct grammatical errors during the manuscript writing process. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Table 1: Comparing the different variables of out-of-hospital cardiac arrest (OHCA) patients between cases with and without survival at scene, survival to emergency department (ED), and survival to hospital discharge

Variables	Survival at Scene		P	Survival to ED		P	Survival to discharge		P
	No (n=3848)	Yes (n=1585)		No (n=5056)	Yes (n=377)		Yes (n=5383)	No (n=50)	
Gender									
Male	2411 (62.85)	1068 (67.77)	<0.001	3221 (63.93)	258 (68.08)	0.050	3441 (64.17)	38 (76.0)	0.102
Age (years)									
Mean ± SD	64.56±17.60	61.37±17.41	<0.001	63.91±17.57	59.87±17.56	<0.001	63.63±17.61	63.4±17.06	0.926
Distance (km)									
Median (IQR)	7 (4,11)	5 (3,8)	<0.001	6 (4,10)	5 (3,8)	<0.001	6 (4,10)	5 (3,7)	0.010
Activation time (minutes)									
Median (IQR)	6 (4,8)	5 (3,7)	<0.001	6 (4,8)	5 (3,7)	<0.001	6 (4,8)	5 (3,7)	0.148
Response time (minutes)									
Mean ± SD	18.64±8.95	15.53±8.09	<0.001	17.93±8.90	15.05±7.12	<0.001	17.77±8.83	13.90±5.46	0.002
Response time									
≤8 minutes	259 (6.77)	232 (14.67)	<0.001	434 (8.63)	57 (15.16)	<0.001	482 (9.0)	9 (18.37)	0.030
Scene time (minutes)									
Median (IQR)	30(15,43)	22(16,32)	<0.001	27(15,40)	24(16,33)	0.002	26(15,40)	24(16,30)	0.137
Total prehospital time (minutes)									
Median (IQR)	60 (46,76)	46 (37,59)	<0.001	57 (43,72)	47 (37,59)	<0.001	56 (42,71)	46 (39,57)	<0.001
Cause									
Non-trauma	3795 (98.62)	1546 (97.54)	0.007	4977 (98.44)	364 (96.55)	0.012	5292 (98.31)	49 (98.0)	0.576
Shift									
Morning	1477 (38.38)	692 (43.22)	<0.001	1994 (39.44)	175 (46.42)	0.005	2145 (39.58)	24 (48.0)	0.538
Evening	1404 (36.49)	587 (37.03)		1855 (36.69)	136 (36.07)		1975 (36.69)	16 (32.0)	
Night	967 (25.13)	306 (19.31)		1207 (23.87)	66 (17.51)		1263 (23.46)	10 (20.0)	
Intervention									
ETT	1400 (36.38)	1131 (71.36)	<0.001	2246 (44.42)	285 (75.60)	<0.001	2493 (46.31)	38 (76.0)	<0.001
Aggressive IV	2597 (67.49)	1508 (95.14)	<0.001	3744 (74.05)	361 (95.76)	<0.001	4056 (75.35)	49 (98.0)	<0.001
Cardiac rhythm									
Shockable	1622 (42.15)	759 (47.89)	<0.001	2207 (43.65)	174 (46.15)	0.361	2360 (43.84)	21 (42.0)	0.886

Data are presented as mean ± standard deviation (SD) or median (interquartile range (IQR)); or number (%). km: kilometer; ETT: endotracheal tube intubation; IV: intravenous fluid administration.

Table 2: Multivariable logistic regression analysis of association between emergency medical service (EMS) response time in out-of-hospital cardiac arrest (OHCA) with at scene survival, survival to emergency department (ED) admission, and survival to hospital discharge

Response time	Survival at Scene		Survival to ED		Survival to discharge	
	Odds (95%CI)	P	Odds (95%CI)	P	Odds (95%CI)	P
Overall	0.94(0.90-0.98)	<0.001	0.96(0.95-0.98)	<0.001	0.94(0.89-0.98)	0.006
≤ 6 minutes	2.31(1.89-2.83)	<0.001	2.20(1.47-3.28)	<0.001	3.04(1.28-7.26)	0.012
≤ 7 minutes	2.53(1.98-3.24)	<0.001	2.15(1.52-3.04)	<0.001	2.95(1.36-6.36)	0.006
≤8 minutes	2.31(1.89-2.83)	<0.001	1.76(1.30-2.38)	<0.001	2.09(1.00-4.35)	0.048
≤ 9 minutes	2.21(1.85-2.63)	<0.001	1.67(1.28-2.19)	<0.001	1.83(0.93-3.60)	0.082
≤ 10 minutes	2.13(1.82-2.50)	<0.001	1.76(1.38-2.25)	<0.001	1.59(0.84-3.01)	0.157

All odds ratios are adjusted for age, trauma vs non-trauma, endotracheal tube insertion, aggressive intravenous (IV) Fluid administration, and shockable cardiac rhythm. CI: confidence interval.

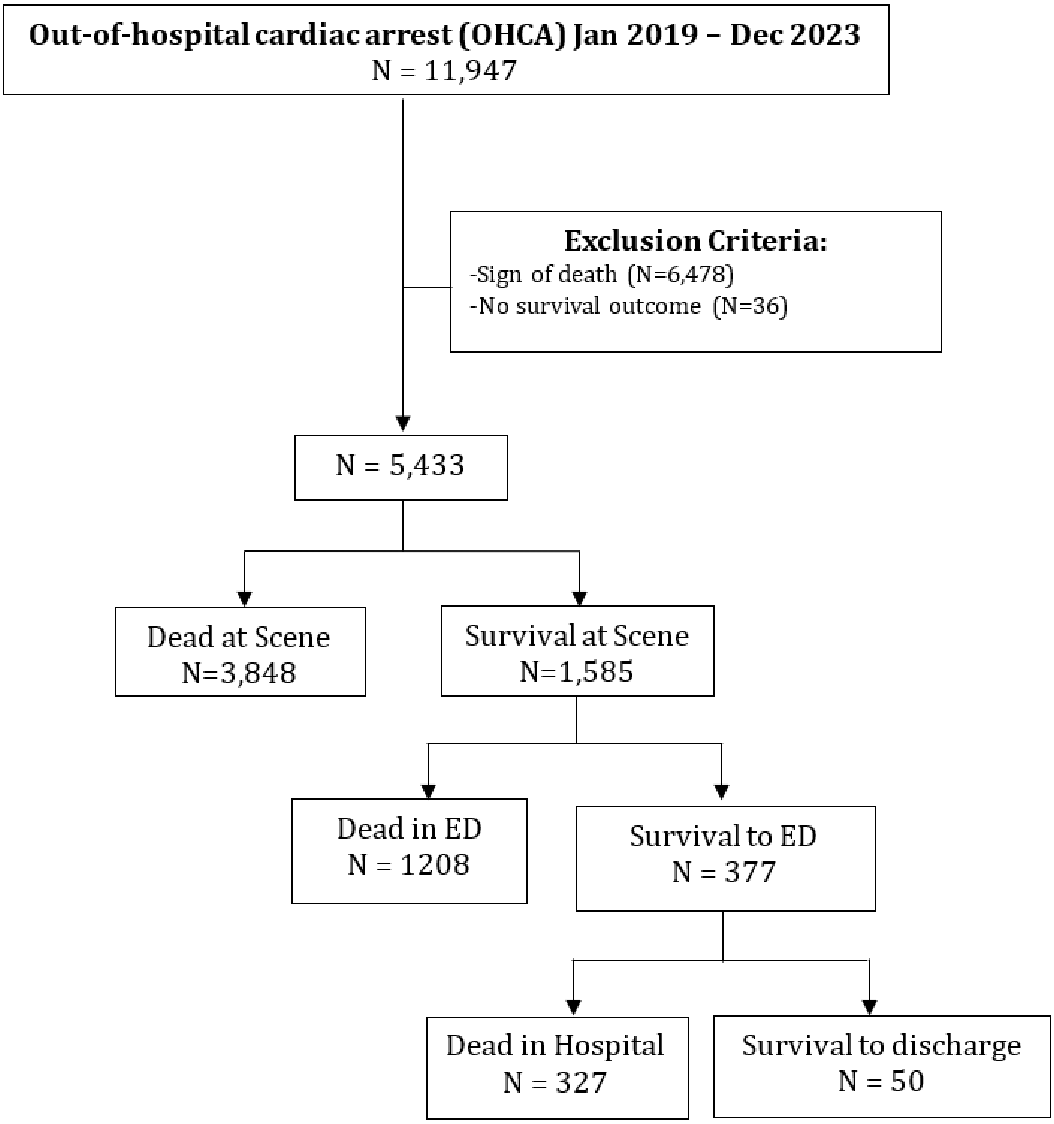

Figure 1: Flow chart of the study population. ED: Emergency department.

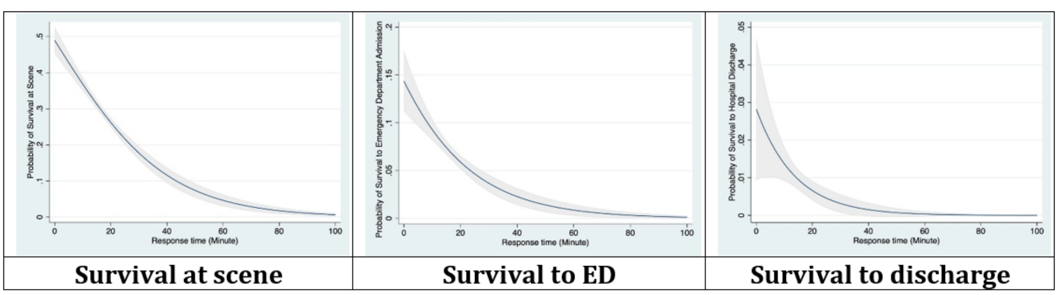

Figure 2: Probability of survival at scene, survival to emergency department (ED), and survival to discharge based on emergency response time.