Out-of-hospital cardiac arrest in the Algarve region of Portugal: a retrospective registry trial with outcome data

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Background and importance **Out-of-hospital cardiac arrest is a leading cause of death in Europe. An understanding of region-specific factors is essential for informing strategies to improve survival.**

Design **This retrospective observational study included all out-of-hospital cardiac arrest patients attended by the Emergency Medical Service of the Algarve in 2019. Outcome data were derived from hospital records.**

Main results **In 2019, there were 850 out-of-hospital cardiac arrests treated with cardiopulmonary resuscitation in the Algarve, representing a population incidence of 189/100 000. Return of spontaneous circulation occurred in 83 patients (9.8%), of whom 17 (2.0%) had survival to hospital discharge and 15 (1.8%) had survival with good neurologic outcome. Among patients in the Utstein comparator group, survival to hospital discharge was 21.4%. Predictors of return of spontaneous circulation were age, witnessed arrest, initial shockable rhythm, time of year, time to cardiopulmonary resuscitation, and time to advanced life support. Predictors of survival to hospital discharge were age, initial shockable rhythm, time to rhythm analysis, and time to advanced life support. Predictors of survival with good neurologic outcome were age, initial shockable rhythm, and time to return of spontaneous circulation.**

Conclusions **The incidence of out-of-hospital cardiac arrest with cardiopulmonary resuscitation in the Algarve was higher than in other jurisdictions while return of spontaneous circulation, survival to hospital discharge, and survival with good neurologic outcome were comparatively low. An aging population, a geographically diverse region, and a low incidence of bystander cardiopulmonary resuscitation may have contributed to these outcomes. These results confirm the importance of early cardiopulmonary resuscitation, early rhythm assessment, and early advanced life support, all of which are potentially modifiable through public education, broadening of the defibrillator network and increased availability of advanced life support teams.** ***European Journal of Emergency Medicine*** **29: 134–139 Copyright © 2021 The Author(s). Published by Wolters Kluwer Health, Inc.**

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Introduction

Out-of-hospital cardiac arrest (OHCA) is a worldwide public health problem due to its unpredictability and low survival [1–3]. In Europe and the USA, the incidence of OHCA with cardiopulmonary resuscitation (OHCA-CPR) was estimated as 56/100 000 and 76/100 000 inhabitants per year, respectively [4–6]. There is considerable variation between jurisdictions, however, ranging from 27 to 91 per 100 000 in the EuReCa Two study of European countries [5]. This is due, at least in part, to varying definitions of OHCA and policies surrounding which patients should receive resuscitation [7].

The initial goal of resuscitation is return of spontaneous circulation (ROSC). Multiple factors influence the likelihood of ROSC including age, whether the OHCA was witnessed, the provision of bystander CPR, and the presence of an initial shockable rhythm [8]. Rates of ROSC vary widely, ranging from 8 to 42% in the EuReCa Two study [6]. However, survival to hospital discharge (SHD) and survival with good neurologic outcome (SGNO) are generally low, ranging from 0 to 18% [9]. Factors associated with SHD include: early CPR, an initial shockable rhythm, and increased used of automated external defibrillators (AEDs) [10].

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To date, there have been no published data on incidence and outcomes of OHCA-CPR in continental Portugal. In this context, we aimed to analyze all OHCA-CPR in the Algarve region of Portugal in 2019. The Algarve is the southern-most region of mainland Portugal, with 450 000 inhabitants [11] spread across 5000 km^2. It comprises a heavily populated coastal zone and a sparsely populated interior. The population is relatively elderly, with 22% of the population over age 65. EMS services are provided by the National Institute of Emergency Medicine (INEM). For high-acuity calls, doctor- or nurse-lead advanced life support (ALS) teams are dispatched along with ambulance crews. For low-acuity calls, only ambulance crews are dispatched. National legislation requires that resuscitation attempts be made in virtually all pulseless patients unless a physician is present and deems the attempt futile [12]. In the present study, we report the characteristics and outcomes of all OHCA-CPR in the Algarve in 2019.

Methods

Study design

The study is a retrospective observational cohort study of all OHCA attended by INEM or its supervised teams in the Algarve between 1 January and 31 December, 2019. The dataset included all of the Utstein elements [13]. INEM records were cross-referenced with hospital records from the University Hospital Centre of the Algarve to determine patient survival and neurologic outcomes [14].

Data collection

Variables analyzed included demographic characteristics (sex and age) and characteristics of the OHCA [probable etiology, location, month, time, presence of a witness, bystander CPR, bystander defibrillation, initial cardiac rhythm, time to EMS arrival, and outcome after OHCA (ROSC or death)]. Outcome variables were derived from hospital and national records and included: 30-d survival, SHD, and neurological outcome at hospital discharge according to the modified Rankin Scale (mRS) [14].

Statistical analysis

Descriptive analyses were performed using frequencies, mean and SD or median and interquartile range (IQR). Comparisons were made using the Student's *t*-test and Kruskal–Wallis tests for continuous variables and the χ^2 test for categorical variables. All tests were 2-tailed with $P < 0.05$ considered statistically significant. In univariate and multivariate terms, a logistic regression model was applied in which ROSC, SHD, and SGNO were considered dependent variables. Variables that were significant ($P < 0.05$) in univariate regression were included in multivariate regression. Colinear variables ($r > 0.8$) were excluded. The final multivariate model was selected through stepwise (backwards and forwards) regression using the Akaike Information Criterion to identify the best-fit model. Statistical analysis was performed in SPSS and R 4.0.3 [15].

Ethics approval

The study was approved by the ethics committees of the National Institute of Medicine (INEM) and the University Hospital Centre of the Algarve.

Results

Incidence of out-of-hospital cardiac arrest

In 2019, 1184 patients with OHCA were attended by EMS in the Algarve. Of these, 850 underwent CPR (OHCA-CPR). With a resident population of 450 000 inhabitants, the incidence of OHCA in the Algarve was, therefore, 258/100 000 inhabitants, and of OHCA-CPR was 189/100 000 inhabitants. For the purposes of this study, only 850 patients with OHCA-CPR were included for further analysis (Fig. 1).

Patient and out-of-hospital cardiac arrest characteristics

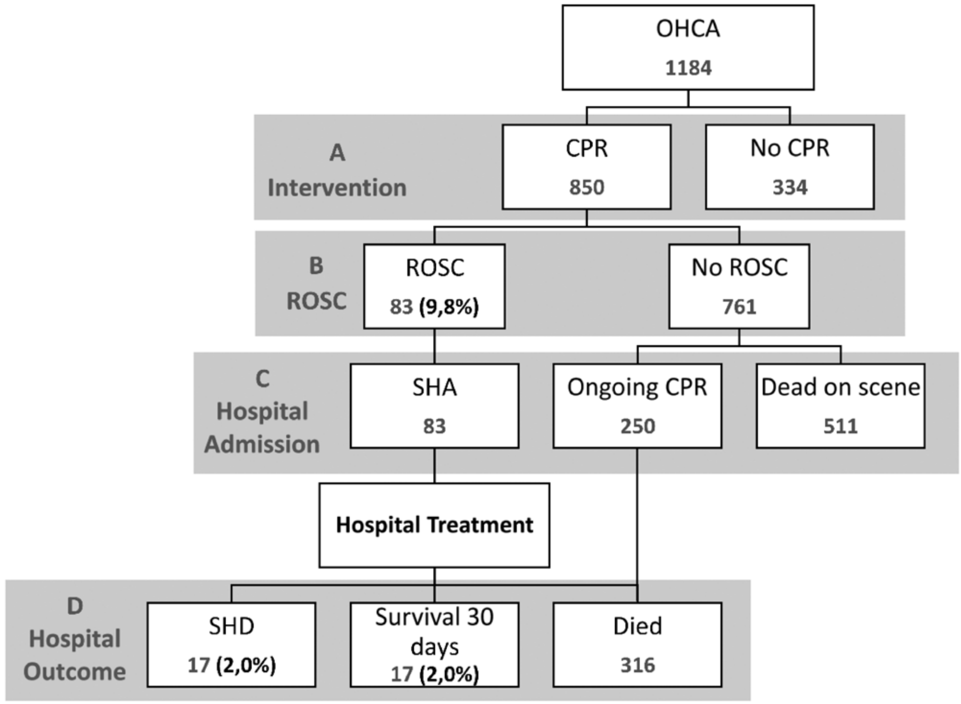
The mean age of OHCA-CPR patients was 74.5 (±17.0) years, with a median of 79 years (IQR 67–87), and a minority were female (38.5%) (Table 1). Most OHCA-CPRs occurred at home (68.1%) and during daytime hours of 8 AM–8 PM (62.2%) (Supplementary Table S1, Supplemental digital content 1, *http://links.lww.com/EJEM/A323*). Most cases were attributed to a medical etiology (92.7%) while 4.6% were attributed to trauma, 1.2% to asphyxia, 1.2% to drowning, and 0.4% to drug overdose. Witnesses were present at 446 (52.5%) OHCA-CPR, with 345 (40.6%) witnessed by a bystander and 101 (11.9%) witnessed by EMS (Table 1). Bystander CPR was provided to 198 patients (23.3%) and 23 patients (2.7%) had an AED applied prior to ALS team arrival (Table 1).

EMS times were recorded. The median response time, the time from calling the emergency number until EMS arrival, was 10 (IQR 6–16) min. The time from OHCA identification to CPR was 13 (IQR 3–23) min. The time to rhythm analysis was 16 (IQR 9–26) min and the time to first shock was 17 (IQR 9–29) min. The median time from OHCA to hospital arrival was 63 (IQR 44–85) min (Table 1).

Likelihood of return of spontaneous circulation

A total of 83 (9.8%) OHCA-CPR patients achieved ROSC. Patients who achieved ROSC were younger (64.9 ± 17.6 years) than those who did not (75.6 ± 16.6 years) [odds ratio (OR) 0.97, 95% confidence interval (CI) 0.96–0.98, $P < 0.001$], but there was no difference between males and females (Supplementary Table S1, Supplemental digital content 1, *http://links.lww.com/EJEM/A323*). The location of OHCA-CPR was significant, with a higher likelihood of ROSC at work (OR 23.7, 95% CI 5.61–119), in the street (OR 3.00, 95% CI 1.56–5.56) or in a public building (OR 5.42, 95% CI 2.14–12.7), relative to at home or in long-term care. The likelihood of ROSC did not vary by time of day but did vary by time of year, with a higher likelihood

Fig. 1



Flow diagram of all patients in the study. CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest; ROSC, return of spontaneous circulation; SHA, survival at hospital admission; SHD, survival at hospital discharge. Adapted from [9] with permission.

in the spring (OR 3.90, 95% CI 1.94–8.40), summer (OR 2.33, 95% CI 1.11–5.15) or fall (OR 2.54, 95% CI 1.24–5.52), relative to winter (Supplementary Table S2, Supplemental digital content 1, *http://links.lww.com/EJEM/A323*). ROSC was significantly more likely when the OHCA-CPR was witnessed (OR 5.6, 95% CI 3.15–10.7, $P < 0.001$), when the patient received immediate CPR (OR 5.60, 95% CI 2.15–10.7) and when there was an initial shockable rhythm (OR 5.07, 95% CI 3.05–10.7, $P < 0.001$) (Supplementary Table S2, Supplemental digital content 1, *http://links.lww.com/EJEM/A323*).

Shorter time intervals to care were universally associated with a higher likelihood of ROSC (Supplementary Table S2, Supplemental digital content 1, *http://links.lww.com/EJEM/A323*). These included time from OHCA to EMS call, time from EMS call to EMS arrival, time from OHCA to initiation of CPR, time from OHCA to rhythm analysis, time from OHCA to first shock, and time from OHCA to ALS team arrival (Supplementary Table S2, Supplemental digital content 1, *http://links.lww.com/EJEM/A323*).

In multivariate analysis (Table 2), the strongest predictors of ROSC were younger age, witnessed OHCA, time of year, shorter time to CPR, and shorter time to ALS team arrival.

Likelihood of survival to hospital discharge

After cross-referencing EMS data with hospital records, it was determined that 42/83 of patients with ROSC were transitioned to a palliative plan of care in the emergency department. Of the 41 (4.8%) patients who received ongoing aggressive care, 17 (2.0% of all OHCA-CPR) survived to 30 days and 17 (2.0%) survived to hospital discharge (n.b.16 patients survived to both 30 days and hospital discharge while one patient survived to 30 days but not hospital discharge and one patient survived to hospital discharge but not 30 days).

Patients who achieved SHD were younger (51.6 ± 16.3) than those who did not (75.0 ± 16.7 years; $P < 0.001$) (Supplementary Table S3, Supplemental digital content 1, *http://links.lww.com/EJEM/A323*), were more likely to have received immediate CPR (OR 8.97, 95% CI 2.90–39.2, $P < 0.001$), and were more likely to have an initial shockable rhythm (OR 35.0, 95% CI 11.2–154, $P < 0.001$) (Supplementary Table S4, Supplemental digital content 1, *http://links.lww.com/EJEM/A323*). The likelihood of SHD did not differ according to time of day or time of year but did differ by location, with those occurring in a public building having a higher likelihood of SHD (OR 8.24, 95% CI 1.73–30.4) than those at home or in long-term care facility ($P = 0.005$). Shorter time intervals to care were strongly associated with SHD: these included time from EMS call to arrival at the victim, time from OHCA to CPR, time from

Table 1 Characteristics of all patients with out-of-hospital cardiac arrest who received resuscitation attempts in the Algarve in 2019

Characteristic	Total (n = 850)
Age (y), mean (SD)	74.5(±17.0)
Median (IQR)	79 (67–87)
Female, n (%)	325 (38.5)
Location, n (%)	
Residence	579 (68.1)
Street	92 (10.8)
Long-term care	114 (13.4)
Public building	29 (3.4)
Work/office	8 (0.9)
Sports	3 (0.4)
Other	25 (2.9)
Etiology, n (%)	
Medical	788 (92.7)
Traumatic	39 (4.6)
Asphyxia	10 (1.2)
Drug overdose	3 (0.4)
Drowning	10 (1.2)
Collapse witnessed by a bystander, n (%)	345 (40.6)
Collapse witnessed by EMS, n (%)	101 (11.9)
Immediate CPR by a bystander, n (%)	198 (23.3)
Immediate CPR by EMS, n (%)	101 (11.9)
Telephone CPR, n (%)	13 (1.5)
Initial shockable rhythm, n (%)	109 (13.2)
EMS time interval, median (IQR)	
From OHCA to EMS call	2 (1–8)
From EMS call to the victim	10 (6–16)
From OHCA to CPR	13 (3–23)
From OHCA to rhythm analysis	16 (9–26)
From OHCA to first shock	17 (9–29)
From OHCA to ALS team arrival	22 (14–35)
From OHCA to hospital	63 (44–85)
Outcome, n (%)	
Return of spontaneous circulation	83 (9.8)
Survival to hospital discharge	17 (2.0)
Survival to 30 d	17 (2.0)
Neurologic condition mRS = 0	13 (1.5)
Neurologic condition mRS = 1	1 (0.1)
Neurologic condition mRS = 2	1 (0.1)
Neurologic condition mRS = 3	0 (0)
Neurologic condition mRS = 4	1 (0.1)
Neurologic condition mRS = 5	1 (0.1)
Neurologic condition mRS = 6	833 (98.0)

ALS, advanced life support; CPR, cardiopulmonary resuscitation; EMS, Emergency Medical Services; IQR, interquartile range; mRS, modified Rankin Score; OHCA, out-of-hospital cardiac arrest.

Table 2 Multivariate analysis of variables associated with return of spontaneous circulation

Characteristic	OR	95% CI	*P* value
Age (y)	0.98	0.97–1.00	**0.016**
Witnessed OHCA	3.92	2.07–7.97	**< 0.001**
Initial shockable rhythm	3.01	1.69–5.32	**< 0.001**
Time of year			**0.002**
January to March			
April to June	3.95	1.81–9.12	
July to September	1.95	0.86–4.62	
October to December	3.42	1.57–7.92	
Time to ALS team arrival (min)	0.96	0.94–0.98	**< 0.001**

ALS, advanced life support; CI, confidence interval; OR, odds ratio.
P-values in bold are those below the pre-determined significance threshold of 0.05.

OHCA to rhythm analysis, time from OHCA to first shock, time from OHCA to arrival of the ALS team, and time to ROSC (Supplementary Table S4, Supplemental digital content 1, *http://links.lww.com/EJEM/A323*).

In multivariate analysis (Table 3), the best predictors of SHD were younger age, an initial shockable rhythm, shorter time to rhythm analysis, and shorter time to ALS team arrival.

Likelihood of survival with good neurologic outcome

Neurologic outcomes at hospital discharge were assessed using hospital records (Supplementary Figure S1, Supplemental digital content 1, *http://links.lww.com/EJEM/A323*). Excellent neurologic outcome, corresponding to a score of 0 on the mRS, was observed in 13 patients. Two patients showed good neurologic outcome, represented by an mRS of 1–3. Finally, 2 patients showed poor neurologic outcome, represented by an mRS of 4–5 (Table 1). Patients with SGNO were younger (53.2 ± 15.2 versus 74.9 ± 16.8 years; $P < 0.001$) (Supplementary Table S5, Supplemental digital content 1, *http://links.lww.com/EJEM/A323*), were more likely to have a witnessed collapse (OR 13.1, 95% CI 2.61–237, $P<0.001$), and were more likely to have received immediate CPR (OR 7.64, 95% CI 2.40–33.7, $P<0.001$) (Supplementary Table S6, Supplemental digital content 1, *http://links.lww.com/EJEM/A323*). They were also more likely to have an initial shockable rhythm (OR 29.4, 95% CI 9.15–131, $P < 0.001$). The likelihood of SGNO did not differ by time of day or time of year but was more likely when the OHCA occurred in a sports facility (OR 35.7, 95% CI 1.57–412) versus at home or in long-term care ($P < 0.001$). Shorter intervals to care were strongly associated with SGNO: these included time from EMS call to arrival at the victim, time from OHCA to CPR initiation, time from OHCA to rhythm analysis, time from OHCA to first shock, time from OHCA to arrival of an ALS team, and time to ROSC (Supplementary Table S6, Supplemental digital content 1, *http://links.lww.com/EJEM/A323*). In multivariate analysis (Table 4), the strongest predictors of SGNO were younger age, an initial shockable rhythm, and shorter time to ROSC.

Outcomes within the utstein comparator group

Among the 850 OHCA-CPR patients, 56 met the four Utstein comparator group criteria: witnessed cardiac arrest, immediate CPR, initial shockable rhythm, and presumed cardiac cause. In this select subgroup, ROSC was achieved in 21 patients (37.5%), SHD was achieved in 12 patients (21.4%), and SGNO (mRS of 0–3) was achieved in 10 patients (17.9%).

Discussion

In 2019, 1189 OHCA were recorded in the Algarve, of which 850 received resuscitative interventions including CPR. This represents a population incidence of 258/100 000 inhabitants for OHCA and 189/100 000 for OHCA-CPR. When compared with the EuReCa Two data, the incidence of OHCA in the Algarve is higher than in any jurisdiction in that registry (range 28–244) [4]. Similarly, the rate of OHCA-CPR was higher than in any jurisdiction in EuReCa One (range 19–104) [4].

The reasons for the high incidence of OHCA-CPR in the Algarve are unclear. Tourism may be a contributing factor since EMS records do not distinguish between residents and non-residents. However, rates of OHCA were highest in the winter months, when tourist numbers are lower. Population aging may be another contributing factor. The population of the Algarve is elderly [16] and the median age of OHCA-CPR patients in this cohort was 79 years, older than any other cohort in EuReCa One or Two [4,9]. The likelihood of cardiac arrest increases with age, so an aging population would be expected to have a higher incidence of OHCA [17]. Finally, Portuguese legislation requires that resuscitation be initiated in virtually all pulseless patients, unless a physician is present and deems it futile [12]. Thus, in the absence of a physician, EMS crews almost always initiate CPR, even when the likelihood of survival is low.

The rate of ROSC in the Algarve in 2019 was 9.8%. In the EuReCa Two study, only Greece (8.0%) and Iran (8.3%) reported comparable results [3,9]. Rates of SHD (2.0%) and SGNO (1.8%) were also comparatively low. A number of factors may have contributed to these outcomes. First, the patients in this cohort were elderly, with a median age of 79 years. Age was a strong negative predictor of ROSC, SHD, SGNO, as in other cohorts [18]. Second, the percentage of patients with an initial shockable rhythm was only 13.2%. A shockable rhythm was strongly associated with ROSC, SHD, and SGNO, as in previous studies [19]. However, the presence of a shockable rhythm is influenced by time to rhythm analysis [20]. Thus, limited AED availability or delayed EMS arrival may have decreased the likelihood of a shockable rhythm. Finally, rates of bystander CPR were low, at only 23.3% of OHCA-CPR. Provision of immediate CPR was strongly associated with ROSC, SHD, and SGNO. Studies have demonstrated that early CPR can double or triple survival after OHCA [21–23]. In this regard, programs that offer basic life support training to the general public might be effective in improving survival [3]. Such programs have shown benefit in other countries but are not widely implemented in Portugal [10,24]. Provision of telephone CPR could also increase the likelihood and quality of bystander CPR [25].

Amongst patients meeting criteria for the Utstein comparator group, SHD was significantly higher at 21.4%. In EuReCa One, average survival for these patients was 29.7% (range 5.3–57.9%), with 7/21 jurisdictions reporting survival below 20%. Thus, outcomes in this selected group were relatively similar to those in other European jurisdictions.

Multiple regression analysis indicated that successful ROSC was predicted by younger age, an initial shockable rhythm, shorter time to CPR, and shorter time to ALS team arrival. A small seasonal effect was also noted, with ROSC being more likely in the spring, summer and fall, relative to winter. To our knowledge, this effect has not been reported in other studies and requires confirmation.

Factors predictive of SHD included younger age, an initial shockable rhythm, time to rhythm analysis, and time to ALS team arrival.

Finally, factors predictive of SGNO were younger age, an initial shockable rhythm, and shorter time to ROSC. Duration of cardiac arrest is a known predictor of neurologic outcome, as prolonged brain ischemia increases the probability of brain injury [26].

Previous studies have shown that increased EMS response times are associated with decreased survival [16,20]. In the present study, the median time from EMS call to arrival at the victim was 10 min. This was longer than reported in the USA and Canada (4–7 min) [27] or Australia (7–10 min) [28] and may reflect the challenges of serving the heavily populated coastal region of the Algarve and the sparsely populated interior with a limited number of EMS crews.

Our results suggest several avenues by which OHCA outcomes could be improved in the Algarve. Increased bystander CPR as well as increased AED availability, including a phone-based AED program [29], could improve ROSC, SHD, and SGNO. These are areas in which public education may be beneficial. In addition, shorter time intervals to ALS team arrival could improve ROSC and SHD. In this respect, it would be helpful to examine geographic variations in outcomes that might be remedied by repositioning of EMS services.

Limitations

The OHCA data used in this study were obtained through EMS registries, which were completed manually and may be subject to recall bias. Automation of data collection would improve dataset quality [30]. In addition, the present study did not consider ALS procedures (e.g. adrenaline administration) and post-CPR care, which may have also impacted survival and neurologic outcomes.

Conclusion

The incidence of reported OHCA, and OHCA with CPR, in the Algarve in 2019 were higher than in other European jurisdictions, while ROSC and SHD were comparatively low. An aging population, a geographically diverse region and national legislation that mandates resuscitation attempts in virtually all cases unless a physician is present and deems it futile may have contributed to these findings. The results of this study confirm the importance of (1) early initiation of CPR, (2) early rhythm assessment, and (3) early ALS team arrival. These risk factors are potentially modifiable through

Table 3 Multivariate analysis of variables associated with survival to hospital discharge

Characteristic	OR	95% CI	*P* value
Age (y)	0.96	0.93–0.99	**0.006**
Initial shockable rhythm	25.4	7.31–124	**< 0.001**
Time to rhythm analysis (min)	0.89	0.79–1.01	0.080
Time to ALS team arrival (min)	0.96	0.86–1.01	0.13

ALS, advanced life support; CI, confidence interval; OR, odds ratio.
P-values in bold are those below the pre-determined significance threshold of 0.05.

Table 4 Multivariate analysis of factors associated with survival with good neurologic outcome

Characteristic	OR	95% CI	*P* value
Age (y)	0.93	0.87–0.98	**0.004**
Initial shockable rhythm	12.0	2.27–87.3	**< 0.001**
Time to ROSC (min)	0.89	0.80–0.95	**< 0.001**

CI, confidence interval; OR, odds ratio; ROSC, return of spontaneous circulation. *P*-values in bold are those below the pre-determined significance threshold of 0.05.

BLS and AED training, broadening of the AED network, and increasing the number and locations of ALS crews.

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Conflicts of interest

There are no conflicts of interest.

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