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ORIGINAL RESEARCH

Associated Factors of Patients' Survival in Out of Hospital Cardiac Arrest; a Cross-sectional Study

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Abstract: **Introduction:** Chinese populations have an increasingly high prevalence of cardiac arrest. This study aimed to investigate the prehospital associated factors of survival to hospital admission and discharge among out-of-hospital cardiac arrest (OHCA) adult cases in Macao Special Administrative Region (SAR), China. **Methods:** Baseline characteristics as well as prehospital factors of OHCA patients were collected from publicly accessible medical records and Macao Fire Services Bureau, China. Demographic and other prehospital OHCA characteristics of patients who survived to hospital admission and discharge were analyzed using multivariate logistic regression analysis. **Results:** A total of 904 cases with a mean age of 74.2±17.3 (range: 18-106) years were included (78%>65 years, 62% male). Initial shockable cardiac rhythm was the strongest predictor for survival to both hospital admission (OR=3.57, 95% CI: 2.26-5.63; p<0.001) and discharge (OR=12.40, 95% CI: 5.70-26.96; p<0.001). Being male (OR=1.63, 95% CI:1.08-2.46; p =0.021) and the lower emergency medical service (EMS) response time (OR=1.62, 95% CI: 1.12-2.34; p =0.010) were also associated with a 2-fold association with survival to hospital admission. In addition, access to prehospital defibrillation (OR=4.25, 95% CI: 1.78-10.12; p <0.001) had a 4-fold association with survival to hospital discharge. None of these associations substantively increased with age. **Conclusion:** The major OHCA predictors of survival were initial shockable cardiac rhythm, being male, lower EMS response time, and access to prehospital defibrillation. These findings indicate a need for increased public awareness and more education.

Keywords: Bystander Cardiopulmonary Resuscitation; Out-of-Hospital Cardiac Arrest; Survival to Hospital Admission; Survival to Hospital Discharge; Emergency Medical Service Response Times, Age

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1. Introduction

Out-of-hospital cardiac arrest (OHCA) is a significant health problem and a leading cause of global mortality in older adults [1-5]. In China, it is estimated that more than 230 million people have cardiovascular disease (CVD) [6]. OHCA incidence in China was reported to be 97.1 per 100,000 person-years. Approximately 750,000 individuals encounter OHCA every year [7]. Recently, a large-scale China national registry study (the Baseline Investigation of Out-of-Hospital Cardiac Arrest [BASIC-OHCA] study) [7] reported a comprehensive overview of the incidence, process of care, and outcomes of out-of-hospital cardiac arrest (OHCA) in China. Regrettably, EMS-treated non-traumatic OHCA survival rates for hospital discharge in China are low at 1.2% [7, 8], which is much lower compared to developed countries such as the United States which has a survival rate of 12% [9]. It is hypothesized that at older ages (≥ 60 years), OHCA survival rates could be much lower, given their vulnerability to cardiovascular disease [10-12]. It has also been reported that the risk can be higher with lower OHCA treatment readiness [13, 14]. A majority of related studies regarding OHCA have been conducted in European, North American, or Japanese populations [5, 12, 15-19].

Macao is one of the Special Administrative Regions (SAR) in China. It is an urbanized city with an aging population, and as such OHCA is a significant health problem. However, associations between hospital admission and discharge and prehospital factors such as initial shockable cardiac rhythm, emergency medical service (EMS) response times, and prehospital defibrillation are less well known, specifically with

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respect to the age of the population. Therefore, the present study aimed to explore the relationship between prehospital factors and OHCA survival to admission and discharge.

2. Methods

2.1. Study design and setting

This cross-sectional study investigated potential risk factors related to survival odds of OHCA patients between 2017 and 2021. The OHCA cases were identified from publicly accessible medical records of patients who were admitted to the Government Hospital Centro Hospitalar Conde de São Januário, Macao SAR, China. Patients who survived to hospital admission and hospital discharge were investigated in terms of demographic and prehospital characteristics. The OHCA variables were reported based on the Macao Fire Services Bureau standardized official records.

This study was approved by the Macao Health Bureau Centro Hospitalar Conde de São Januário, Macao SAR, China (03/CHCSJ-HMEC-C-0013-20114). Participant consent was collected via ethical procedures.

2.2. Participants

Non-trauma OHCA cases who were treated by EMS between the years 2017 and 2021 were provided by the Fire Services Bureau based on the official registry data system. The inclusion criteria for the present study were OHCA adults equal to or above 18 years, who received prehospital treatment by EMS. The exclusion criteria were patients transferred to private hospitals and those who never registered with the Macao SAR government hospital medical system. In addition, individuals with missing prehospital and demographic characteristics data were also excluded, but noted, from the study.

2.3. Data collection and measurements

The selected OHCA individual patient medical records including their baseline characteristics were collected from the hospital's central data system and merged with prehospital records by using unique patient identification information.

The OHCA variables were recorded by the first EMS who arrived at the incident location following the standardized questionnaire format from the Macao Fire Services guidelines. Variables related to OHCA included: cardiac arrest location (outdoor, indoor); if the cardiac arrest was witnessed (yes, no); if bystander CPR was performed (yes, no); if CPR and automated external defibrillator (AED) was performed and used by EMS as prehospital defibrillation (yes, no); what initial cardiac arrest rhythm was detected (shockable, non-shockable); and EMS response time in minutes and seconds. The response time was calculated by the time interval in minutes from the incident request received by the EMS call center until the EMS arrived at the OHCA patient's location and reported back to the call center.

The dependent variables were "survival to hospital admission" and "survival to hospital discharge". Mortality was defined as those who died before admission or did not survive during the hospitalization period.

2.4. Statistical Analysis

Statistical analysis was performed by the Statistical Package for the Social Sciences (Windows version 26.0; SPSS Inc, Chicago [IL], US).

Patients who survived at the hospital admission and hospital discharge were investigated in terms of patient demography and prehospital medical interventions. Continuous variables were described as the mean ± standard deviation and tested using the independent t-test. Categorical variables were presented as percentage values and compared by Chi-square. Multivariate logistic regression was employed to assess predictors of both survival to hospital admission and discharge with respect to their OHCA factors. Findings were reported as odds ratios (OR) with 95% confidence intervals (CI). P values of <0.05 were considered statistically significant.

3. Results

3.1. Baseline characteristics of studied cases

1532 non-trauma OHCA cases who were treated by EMS between the years 2017 and 2021 were studied. Figure 1 shows the flowchart of patients' inclusion in the study. A total of 904 cases with a mean age of 74.2±17.3 (range: 18-106) years were included (78%>65 years, 62% male). 167 (18.5%) cases reached survival to hospital admission and 38 (4.2%) cases were discharged. Figure 2 shows the age trends of OHCA cases for survival to hospital admission and discharge.

3.2. Survival to hospital admission and discharge

Table 1 compares the baseline as well as out-of-hospital characteristics of cardiac arrest patients between cases with and without survival to hospital admission and discharge. Based on the univariate analysis, the age of those cases with survival to hospital admission (67.6±17.0 vs. 75.6±17.1 years; p<0.001) and hospital discharge (55.8±18.3 vs. 75.0±16.8 years; p<0.001) were lower. Males had higher percentages of survival to hospital admission (22.6% vs. 11.7%; p<0.001) and discharge (6.0% vs. 1.2%; p<0.001) compared to females. OHCA patients with initial shockable cardiac rhythm had a significantly higher rate of hospital admission (44.8% vs. 15.0%; p<0.001). and EMS response times were shorter for those who survived to hospital admission (3.07 vs. 3.24 minutes; p<0.05).

3.3. Prehospital Associated factors of survival based on multivariate analysis

Table 2 presents the multivariate logistic regression analyses of prehospital associated factors for survival to hospital admission and hospital discharge. On multivariate logistic regression, initial shockable cardiac rhythm (OR=3.57, 95% CI: 2.26-5.63; p<0.001), shorter EMS response time (OR=1.62,

95% CI: 1.12-2.34; p =0.010), age (OR = 0.98, 95% CI:0.97-0.99; p=0.001), and gender (being male) (OR=1.63, 95% CI:1.08-2.46; p =0.021) were the strongest associated factors of survival to hospital admission.

Age (OR = 0.95, 95% CI:0.94-0.97; p<0.001), initial shockable cardiac rhythm (OR=12.40, 95% CI: 5.70-26.96; p<0.001), and prehospital defibrillation (OR=4.25, 95% CI: 1.78-10.12; p =0.001) were also the strongest associated factors of survival to hospital discharge.

3.4. Association of OHCA variable with survival based on patients' age

In the multivariate logistic regression initial shockable cardiac rhythm had a three-fold association with survival to hospital admission for the older (age ≥60 years) population (OR=2.70, 95% CI: 1.48-4.92; p<0.001) compared to the total population of three-fold (OR=3.57, 95% CI: 2.26-5.63; p<0.001) (figure 3). Regarding survival to hospital discharge, initial shockable cardiac rhythm had a nine-fold association with survival (OR=8.80, 95% CI: 3.12-24.82; p<0.001) for those aged greater than 60 years old compared to the total population (OR=12.40, 95% CI: 5.70-26.96; p<0.001). There were no significant interactions between initial shockable cardiac rhythm and age groups in terms of survival to hospital admission (p=0.348) or discharge (p=0.112).

Shorter EMS response time (OR=1.74, 95% CI: 1.13-2.66; p<0.001) and being male (OR=2.25, 95% CI: 1.43-3.52; p<0.001) were associated with better survival to hospital admission outcomes for those aged over 60, this being very or even a little stronger to the total population (shorter EMS response time OR=1.62, 95% CI: 1.12-2.34; p=0.010 and being male OR=1.63, 95% CI: 1.08-2.46; p=0.021) (Figures 3). The effects of shorter EMS response time (p=0.699) and being male (p=0.845) on survival to hospital admission did not vary between age groups. In addition, prehospital defibrillation was associated with similar survival to hospital discharge for those aged greater than 60 (OR=4.51, 95%CI: 1.38-14.75; p=0.013) compared to the total population (OR=4.25, 95%CI: 1.78-10.12; p=0.001).

4. Discussion

The results of this study show that the Macao SAR OHCA survival rates to hospital admission and discharge were 18.5% and 4.2%, slightly lower than the average global rates (22%; 9%) and similar to other Asia contexts (16%; 5%) [20]. Age of cases remained a significant predictor for both survival outcomes which was consistent with previous studies from Japan, South Korea, and France [21-23]. However, in these data when investigated by specific older age groups there was very little difference in outcome due to age specifically.

The rate of initial shockable cardiac rhythm was 11.6% in Macao which was lower than international studies [24, 25] but similar to Taiwan data (11.3%) [26] and higher than studies from Beijing (6.1%) [25], and Hong Kong SAR (8.7%) [27]. This factor has been reported as the most valuable predictor for OHCA survival [5] and as can be seen from the present study its association with outcome remains strong over different age groups.

The benefits of witnessing cardiac arrest with CPR initiation by a bystander have been widely considered as one of the most important predictive factors in OHCA survival outcomes with a possible maximum of 40% increased survival to hospital discharge [28, 29]. In our data, the vast majority of cases in the present study were found in indoor areas with very low witness rates (5.8%) compared with Hong Kong (39.5%) [27] and Beijing (38.6%) [30]. Only less than 13% of OHCA patients had bystander CPR before EMS arrival which lower compared with several studies reported in other Asian countries which varied from 10.5% to 40.9% [31]. Unlike previous studies [20, 30, 32] that reported a positive association between bystander CPR and OHCA survival to hospital discharge, bystander CPR in Macao SAR was not associated with OHCA survival outcomes. Public knowledge and attitudes towards bystander CPR in Macao SAR are not clear and these need to be further investigated thus improving bystander cardiopulmonary resuscitation rates, especially in older adults in Macao SAR.

Immediate CPR initiation and AED deployment are known to increase the probability of survival after OHCA [33, 34]. The likelihood of survival from cardiac arrest drops rapidly for every minute that defibrillation is delayed [28, 35, 36]. Compared with major countries and cities, the prehospital defibrillation rate by EMS in Macao SAR was found to be in the high range (39%) compared with countries in Asia such as Japan (10.2%), Korea (22.9%), Malaysia (2.6%), Singapore (23.4%), Thailand (9.2%), Taiwan (11.8%), Beijing (13.5%) and Hong Kong SAR China (26.1%), except UAE which reported similar result with 35.8% [25, 31].

In addition, the present study showed that patients were 1.6 times more likely to have survival to hospital admission when response time was less than 3.2 minutes by EMS. The local EMS average response time (time between call receipt and reaching the patient) of 3.2 minutes was quicker in our study than most of the major Asian countries/cities: 6 minutes in Japan and Korea, 17.4 minutes in Malaysia, 7.9 minutes in Singapore, 11.5 minutes in Thailand, 5.2 minutes in Taiwan, 10.0 minutes in UAE, 15 minutes in Beijing and 9 minutes in Hong Kong SAR China [27, 31]. It should be noted that the recent outbreak of novel coronavirus disease-2019 (COVID-19) has provided challenges for EMS globally, especially in managing time-dependent response cases such as OHCA [37-40]. Many countries have adapted their guidelines [39, 41] and changed their management regimes [39, 41, 42]. As a result of the pandemic lower survival to admission has been reported in various studies due to longer EMS response time [43, 44]. In this context, this current study includes EMS response times before and after the initial pandemic period. The average EMS response time in Macao SAR was found not to be significantly different before and after the COVID-19 pandemic occurred (3 minutes 21 seconds vs. 3 minutes 20

seconds). In addition to the Macao SAR geographical characteristics, which is smaller (33.3 square kilometers) than most other cities. Thus, the positive associations between prehospital defibrillation and lower EMS response time and survival to hospital admission and discharge in the current study reflect the effort made by the Macao Fire Bureau ambulance services for OHCA patients.

4.1. Limitations

There are several limitations of this study. First, this was a retrospective cross-sectional study into the odds of survival and discharge following OHCA by prehospital factors. As such, the results would not allow any explanations of causal relationships. Second, the survival to hospital admission and discharge analysis was limited because of a lack of data on patients' baseline health-related characteristics and post-resuscitation care. If data were available, this would enable further exploration of the interactions between the measured prehospital factors reported in this study. Third, the present study only investigated patients admitted to the government hospital and did not include the private hospitals, which may make it difficult to generalize to the overall situation in Macao SAR. Moreover, we utilized registry data, and these would exclude cases not captured by the registry. Further investigations with larger sample sizes and more variables are warranted to find out the associated factors that influence OHCA survival outcomes.

5. Conclusions

The major OHCA predictors of survival to hospital admission were initial shockable cardiac rhythm, being male and lower EMS times, and access to prehospital defibrillation for survival to hospital discharge. These findings indicate a need for increased public awareness and more education around response times, prehospital defibrillation, and initial shockable cardiac rhythm for reducing excess mortality from OHCA in adults in Macao SAR China.

6. Declarations

6.1. Acknowledgments

The authors would like to thank the Macao Fire Services Bureau for data collection support.

6.2. Conflict of interest

The authors report no conflict of interest.

6.3. Funding

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6.4. Authors' contribution

- Liang KE: Conceptualization, Methodology, Formal analysis, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision, Project administration, Funding acquisition
- Pui I IEONG: Conceptualization, Methodology Data Curation, Aid interpreting the results
- Kaye E Brock: Investigation, Writing - Review & Editing, Visualization.
- Elias Mpofu: Investigation, Writing - Review & Editing, Visualization
- Xiuhua FENG: Methodology Data Curation, Aid interpreting the results
- Pou Kuan KOU: Methodology Data Curation, Aid interpreting the results
- Chi Kun MOK: Methodology Data Curation, Aid interpreting the results
- Ka Ieng CHAO: Methodology Data Curation, Aid interpreting the results
- Wai Seng LEI: Conceptualization, Visualization, Supervision, Project administration

All above-mentioned authors discussed the results and contributed to the final manuscript.

6.5. Data availability

Data are held by the Macao Fire Services Bureau and authors agree to make data and materials supporting the results or analyses on reasonable request.

6.6. Using artificial intelligence chatbots

The authors declare no use of artificial intelligence chatbots

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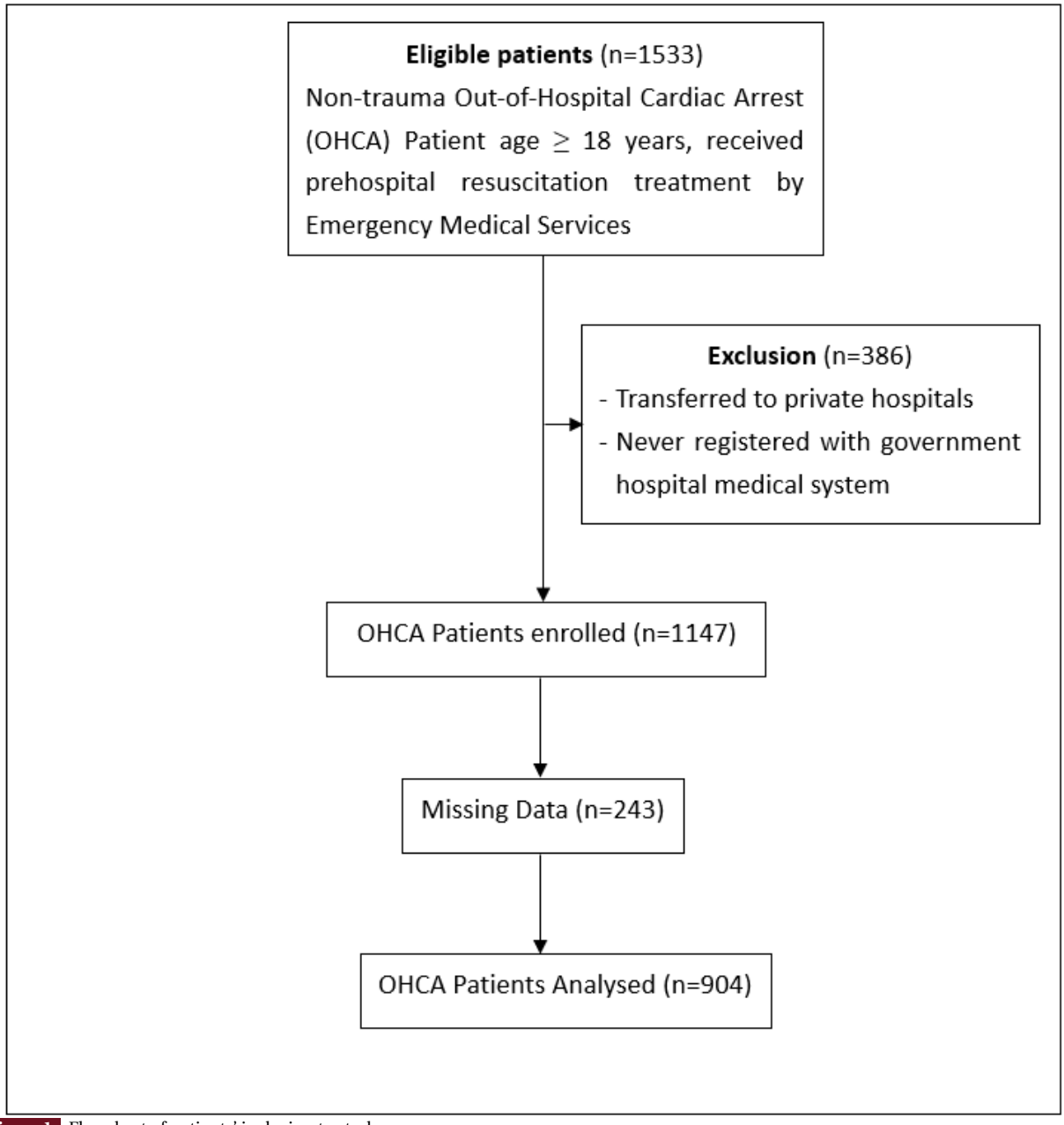

Figure 1: Flowchart of patients' inclusion to study.

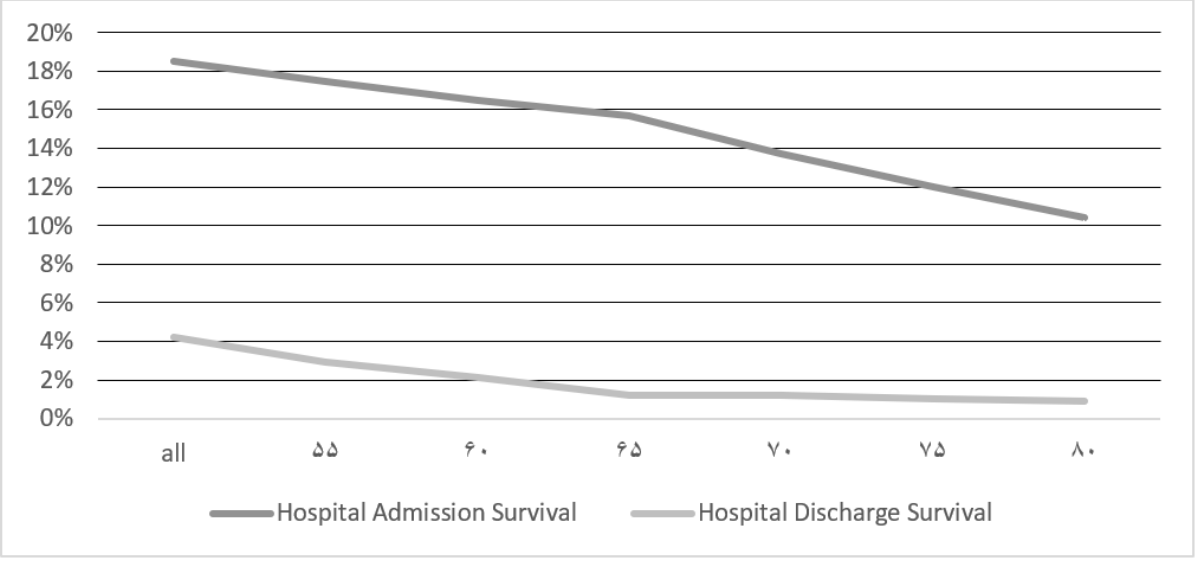

Figure 2: Age trends of out of hospital cardiac arrest cases for survival to hospital admission and discharge.

Table 1: Comparing the baseline and prehospital characteristics of out of hospital cardiac arrest patients attended by Emergency Medical Service in Macao 2017-2021 between cases with and without survival to hospital admission and discharge (n=904)

Variables	Total (n = 904)	Hospital admission		p value	Hospital discharge		P value
		Survival (n=167)	Mortality (n=737)		Survival (n=38)	Mortality (n=866)	
Age, years							
Mean ± SD	74.2 ± 17.3	67.6 ± 17.0	75.6 ± 17.1	<0.001	55.8 ± 18.3	75.0 ± 16.8	<0.001
Sex							
Female	341 (37.7)	40 (11.7)	301 (88.3)	<0.001	4 (1.2)	337 (98.8)	<0.001
Male	563 (62.3)	127 (22.6)	436 (77.4)		34 (6.0)	529 (94.0)	
Location							
Indoor	861 (95.2)	159 (18.5)	702 (81.5)	0.982	35 (4.1)	826 (95.9)	0.353
Outdoor	43 (4.8)	8 (18.6)	35 (81.4)		3 (7.0)	40 (93.0)	
Witnessed							
No	852 (94.2)	155 (18.2)	697 (81.8)	0.378	35 (4.1)	817 (95.9)	0.562
Yes	52 (5.8)	12 (23.1)	40 (76.9)		3 (5.8)	49 (94.2)	
Bystander cardiopulmonary resuscitation							
No	782 (86.5)	145 (18.5)	637 (81.5)	0.893	33 (4.2)	749 (95.8)	0.950
Yes	122 (13.5)	22 (18.0)	100 (82.0)		5 (4.1)	117 (95.9)	
Prehospital defibrillation							
No	554 (61.3)	103 (18.6)	451 (81.4)	0.908	15 (2.7)	539 (97.3)	0.005
Yes	350 (38.7)	64 (18.3)	286 (81.7)		23 (6.6)	327 (93.4)	
Initial cardiac rhythm							
Non-shockable	799 (88.4)	120 (15.0)	679 (85.0)	<0.001	14 (1.8)	785 (98.2)	<0.001
Shockable	105 (11.6)	47 (44.8)	58 (55.2)		24 (22.9)	81 (77.1)	
EMS response time (minutes. secs)							
Mean ± SD	3.20 ± 1.46	3.07 ± 1.25	3.24 ± 1.50	<0.05	3.10±1.18	3.21 ± 1.47	0.38

Data are presented as mean ± standard deviation (SD) or frequency (%). EMS: Emergency medical service.

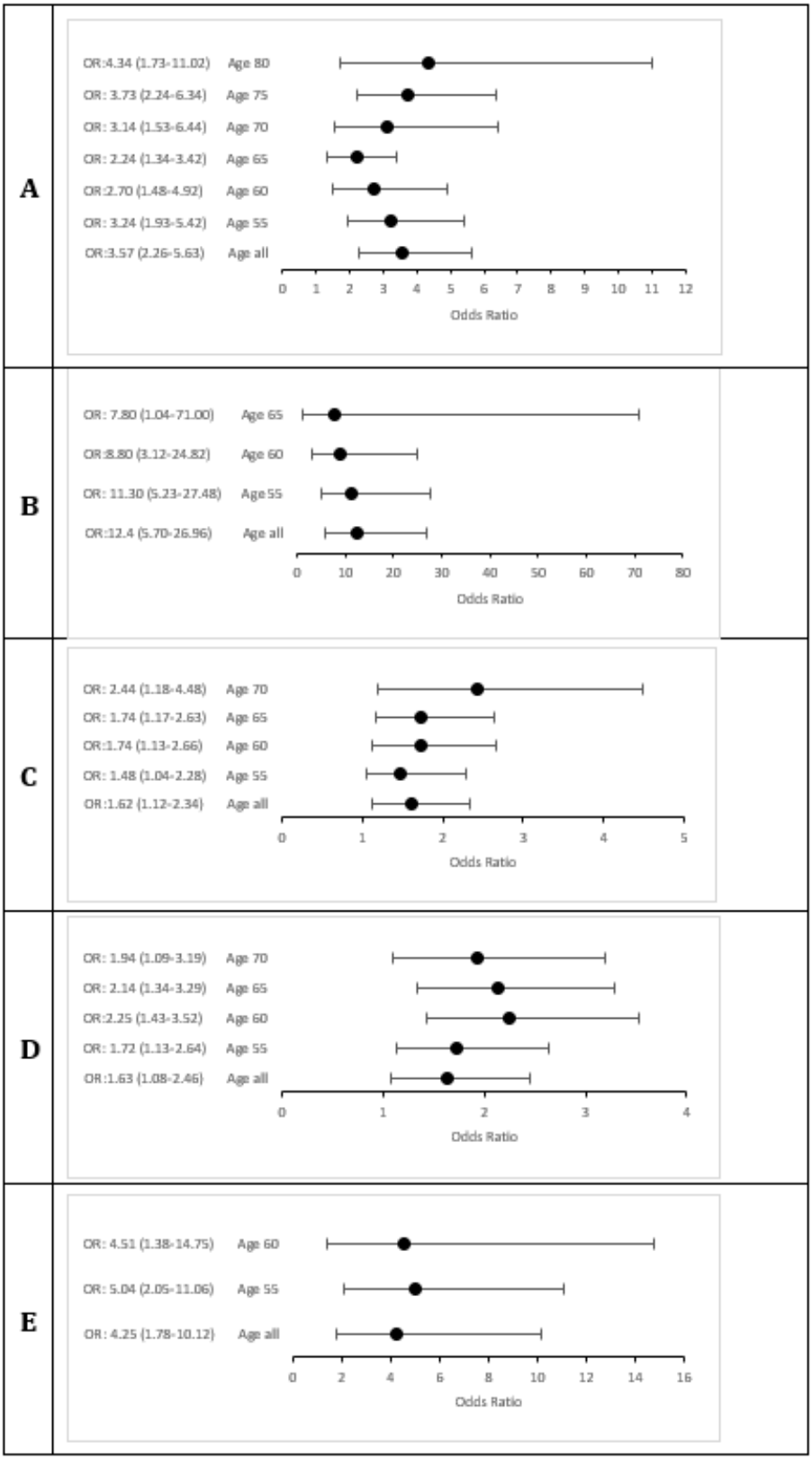

Figure 3: Relationship between out-of-hospital cardiac arrest patients' initial shockable cardiac rhythm and survival to admission (A) and survival to discharge (B); between response time and survival to hospital admission (C); between being male and survival to admission (D); and between prehospital defibrillation and survival to hospital discharge (E) based on patients' age.

Table 2: Prehospital associated factors of survival in out of hospital cardiac arrest patients (n=904) based on multivariate logistic regression analysis of out of hospital variables

	Survival to hospital admission		Survival to Hospital Discharge	
Variables	**Odds Ratio (95% CI)**	**P value**	**Odds Ratio (95% CI)**	**P value**
Age	0.98 (0.97-0.99)	0.001	0.95 (0.94-0.97)	0.000
Sex				
Female	1.0	0.021	1.0	0.157
Male	1.63 (1.08-2.46)		2.22 (0.73-6.77)	
Location				
Indoor	1.0	0.804	1.0	0.662
Outdoor	1.12 (0.47-2.67)		1.42 (0.33-6.03)	
Witnessed				
No	1.0	0.107	1.0	0.242
Yes	2.29 (0.84-6.21)		3.85 (0.45-32.64)	
Bystander cardiopulmonary resuscitation				
No	1.0	0.169	1.0	0.594
Yes	0.59 (0.28-1.25)		0.61 (0.11-3.43)	
Prehospital defibrillation				
No	1.0	0.957	1.0	0.001
Yes	1.01 (0.68-1.50)		4.25 (1.78-10.12)	
Initial cardiac arrest rhythm				
Non-shockable	1.0	0.000	1.0	0.000
Shockable	3.57 (2.26-5.63)		12.40 (5.70-26.96)	
Emergency medical service response time (minutes. secs)				
≥3:20	1.0	0.010	1.0	0.524
<3:20	1.62 (1.12-2.34)		1.12 (0.53-2.35)	

CI: confidence interval.