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Clinical paper

Epidemiology and outcomes of out-of-hospital cardiac arrest in Zhejiang, China based on Electronic Medical Record Surveillance

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Abstract

Background: Out-of-hospital cardiac arrest (OHCA) is a critical challenge for public health, with wide variation in epidemiology and outcomes in different countries and regions. We aimed to describe the epidemiology and outcomes for OHCA in Zhejiang, China based on Electronic Medical Record Surveillance.

Methods: This retrospective study using the Zhejiang Emergency Command Center Electronic Medical Record System in Zhejiang Province, China. We included OHCA cases with non-traumatic, aged 18 years and above and had resuscitation attempted by emergency medical services (EMS). All data were collected and reported using the Utstein template. The primary outcomes were survival to discharge or 30th day, the secondary outcomes were survival with favorable neurological outcomes.

Results: 6923 non-traumatic OHCA patients with aged 18 and above were identified. The OHCA incidence assessed by EMS was 37.6 per 100,000 population. The median age was 68 (54–79) years, with more than half of patients aged 65 or older. 4860 (70.2%) were male, 5033 (72.7%) had cardiac arrest at home. 2889 (41.7%) patients had bystander cardiopulmonary resuscitation (CPR). Among 6923 non-traumatic, 608 (8.8%) patients had shockable rhythm, 497 (7.2%) patients achieved return of spontaneous circulation (ROSC), 82 (1.2%) patients survived to hospital discharge. Under 65 years of age who received bystander CPR, 173 (12.1%) patients achieved ROSC, 43 (3.0%) patients survived to hospital discharge.

Conclusion: The survival after OHCA in Zhejiang Province is unsatisfactory, especially for those above 65 years patients. Electronic Medical Record Surveillance can assist the implementation of the chain of survival to improve outcomes.

Keywords: Out-of-hospital cardiac arrest, Epidemiology, Outcomes, Utstein template, Chain of survival

Introduction

Out-of-hospital cardiac arrest (OHCA) is a major public health issue, rates with large variations in survival and neurological outcomes around the world.[1] Early attempts at bystander cardiopulmonary resuscitation (CPR) attempts a crucial role in the chain of survival for OHCA.[2] In China, bystander CPR and use of public Automated External Defibrillators (AEDs) is relatively low. The incidence and mortality rate from OHCA is projected to increase due to the rapid ageing of the population in China.[3]

According to the 2020 report of the International Liaison Committee on Resuscitation (ILCOR), survival to hospital discharge vary between 3.1% and 20.4% across the world.[4] However, the survival to discharge of OHCA was only 1.2% in China.[5] Numerous countries have made national efforts to improve pre-hospital resuscitative attempt, including CPR training, which has increased CPR rates and a concomitant increase in survival.[6–8] The rates of bystander CPR for OHCA vary significantly across different countries, ranging from 19.1 to 79.0%.[4] For optimal patient outcomes, it is essential to implement an effective chain of survival and proper management of OHCA. Reports of the outcomes of OHCA in China are scarce and limited to single cities.[9]

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https://doi.org/10.1016/j.resplu.2025.100962
Received 12 February 2025; Received in revised form 14 April 2025; Accepted 16 April 2025

Zhejiang as one of the economically developed provinces in China, and has recently invested in developing a province wide electronic medical record system for pre-hospital emergency care. Therefore, we aimed to describe the epidemiology and outcomes for OHCA in Zhejiang, China based on Electronic Medical Record Surveillance.

In this observational study, we used the Utstein template[10] to collect and analyze the data on OHCA from the Zhejiang Emergency Command Center Electronic Medical Record System to systematically describe the epidemiology and outcomes of OHCA in Zhejiang, China.

Methods

Study design, population and EMS system

The total population of Zhejiang Province is approximately 6577 million, and its area is about 105,500 square kilometers. The overall population density of Zhejiang Province is approximately over 400 people per square kilometer. Major cities such as Hangzhou, Ningbo and Wenzhou have a higher population density, typically exceeding 6,000 people per square kilometer. The population density in towns ranges between 1,000 and 3,000 people per square kilometer. These figures reflect the characteristics of population distribution and urbanization in Zhejiang Province.

One-click dialing 120 opens a connected channel for emergency assistance. In mainland China, each ambulance typically includes a caregiver driver who can provide basic life support (BLS), as well as at least one physician and one nurse, all of whom are well-trained and familiar with the latest international guidelines for CPR. Ambulance personal are capable of performing CPR, administering intravenous fluids, and intubating patients. Furthermore, doctors are authorized to initiate and terminate resuscitation efforts on-site and issue death certificates at the scene.

The treatment was performed in accordance with the European Resuscitation Council and the American Heart Association guidelines for basic and advanced cardiac life support and post-resuscitation care.[11,12] OHCA was defined as loss of functional cardiac mechanical activity associated with an absence of signs of circulation that occurred outside the hospital setting.

This study was approved by the Ethics Committee of Zhejiang Provincial People's Hospital, exempting patients from the requirement for written informed consent because the study involved research conducted during the emergency setting of life-threatening cardiac arrest.

Data collection and key variables

This retrospective observational study included 6923 non-traumatic OHCA collected the Zhejiang Emergency Command Center Electronic Medical Record System between October 2023 to September 2024. We included 6923 OHCA cases which were identified non-traumatic etiology, aged 18 and above and received resuscitation attempted by EMS. We used the 2015 Utstein template for collecting and reporting OHCA data elements and definitions,[10] which incorporates core elements of resuscitation performance. All participating physicians have received training on using the Utstein registry form to document events. Resuscitation attempted was defined as number of cardiac arrests attended (defined by absence of signs of circulation as assessed or confirmed by EMS, including patients with ROSC after confirmed defibrillation before EMS arrival). Witnessed arrest was defined as a cardiac arrest that is seen or heard by another person or is monitored. Bystander CPR was defined as CPR performed by a bystander before EMS arrival. Bystander CPR may be compression only or compression with ventilation.

The following variables were obtained: age and sex of patients, location and etiology of cardiac arrest of OHCA, whether resuscitation was attempted by EMS personal, status of witnessed cardiac arrest (bystander witnessed, EMS witnessed, unwitnessed, or unknown), relationship of bystander to patients (family member or non-family bystander), whether bystander initiates CPR, whether bystander CPR was assisted by EMS dispatcher, whether public access defibrillation was performed by bystander, first recorded cardiac arrest rhythm (ventricular fibrillation [VF], pulseless ventricular tachycardia [VT], asystole, pulseless electrical activity [PEA] or other), whether epinephrine was administered, whether advanced airway management was performed, return of spontaneous circulation status of the patient until arrival at hospital, survival to discharge or 30-day survival and Cerebral Performance Category (CPC) score.

Outcomes

The primary outcome of this study was survival to discharge or 30th days after-arrest, the secondary outcome was favorable neurological outcomes, defined as a cerebral performance category (CPC) score of 1(indicating good cerebral performance) or 2 (indicating moderate cerebral disability) in patients at 30 days after an OHCA.[13,14] The secondary outcomes were return of spontaneous circulation (ROSC) with OHCA. Survival to discharge or 30 days was defined as alive at the point of hospital discharge/30 days. Any ROSC was defined as ROSC at any point during the resuscitation attempt.

Statistical analysis

Data was analyzed using SPSS (version 26.0, IBM, NY) and R (version 4.2.0, Vienna, Austria). Data from the one-year period spanning Oct 1, 2023 to Sep 30, 2024, were used to analyze patient characteristics, incidence and outcomes. Data was descriptively analyzed as median and IQRs for continuous variables and as frequency and proportions for categorical variables. Clinical outcomes including survival at discharge, good neurological and ROSC were compared between subgroups of participants with different clinical characteristics with the use of chi-square test, or Fisher's exact, as appropriate. Univariate and multivariate logistic regressions were further perform to evaluate the association of some of the clinical characteristics with the outcomes. A two-sided p value of less than 0.05 was considered to indicate statistical significance.

Results

Study population

During the one-year study period, a total of 24,963 OHCA cases were recorded on the emergency command center platform in Zhejiang Province. The selection process for the included cases is shown in Fig. 1. Of 24,963 OHCA cases collected between Oct 1, 2023 and Sep 30, 2024, we included 6923 OHCA cases aged 18 years old and above, of non-traumatic and with resuscitation attempted by EMS.

In Zhejiang Province, the EMS-assessed incidence of OHCA was 37.6 cases per 100,000 population per year. Among 6923 OHCA patients, 3867 (55.9%) cases of cardiac arrest were witnessed by bystanders, 2889 (41.7%) received bystander CPR. Patients with bystander CPR were more likely to have their OHCA in public loca-

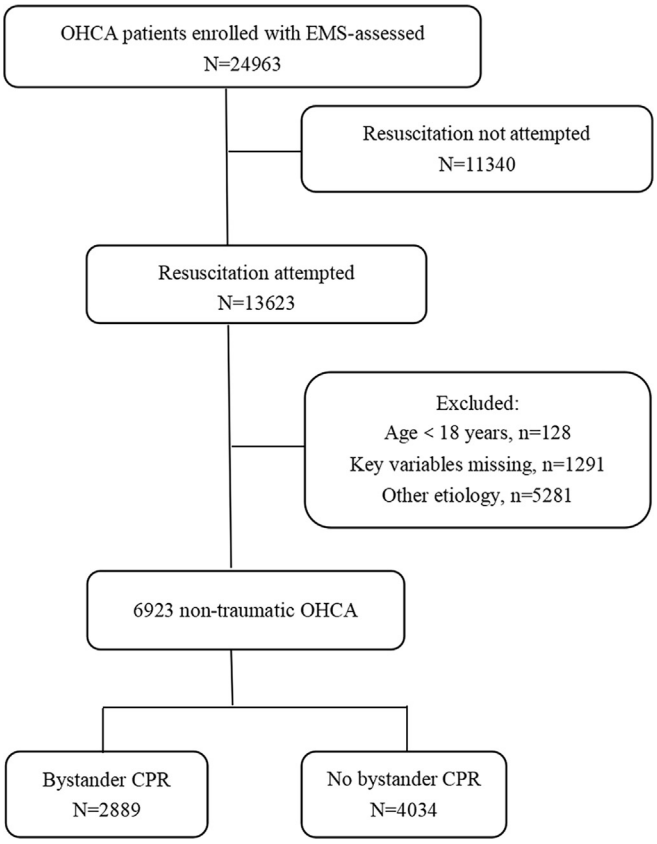

Fig. 1 – The flow chart of the OHCA population. OHCA, out-of-hospital cardiac arrest; CPR, cardiopulmonary resuscitation;

tions, have a witnessed arrest, and have an initially detected cardiac arrest rhythm that was ventricular fibrillation (VF), the proportion was higher than that in the non-bystander CPR group (VF:13.4% vs 4.7%).

Baseline characteristics

Among 6923 OHCA patients, the median age was 68 years (range 54–79), with ages spanning from 18 to 107 years. Over half of the patients were aged 65 or older. Patients in the bystander CPR group were younger. 4870 (70.3%) patients were male, and 5033 (70.3%) experienced cardiac arrest at home. Meanwhile, 1670 (24.1%) occurred in public locations, including sports and recreational venues, schools and public facilities, industrial and construction sites, commercial and service locations, as well as roads and streets (Table 1).

608 (8.8%) had an initial shockable rhythm. The proportion of initial shockable rhythms was higher in the bystander CPR group (13.7% vs 5.2%) (Table 1). In the group of patients under 65 years old who received CPR, 286 (19.9%) had an initial shockable rhythm, only 4.3% compared to the group aged above 65 years who not received bystander CPR (Table 2). A total of 2770 (40.0%) patients received medicine treatment before arriving at the emergency department, including epinephrine, amiodarone, physiological saline. 2857 (41.3%) had a prehospital airway established, and 121 (1.7%) had an AED applied by bystander.

Outcomes

For OHCA patients who received EMS treatment, 497 (7.2%) achieved ROSC at scene or before arrival at the emergency department, 82 (1.2%) survived to hospital discharge or 30 days, and 62 (0.9%) survived with favorable neurological outcomes (CPC1-2). In the bystander CPR group, 295 (10.2%) achieved ROSC, 55 (1.9%) survived to hospital discharge or 30 days, and 46 (1.6%) survived with favorable neurological outcomes (Table 1). In the group aged under 65 years who received bystander CPR, 43 (3.0%) survived to hospital discharge, and 40 (2.8%) survived with favorable neurological outcomes. In the group aged above 65 years who not received CPR, survival to hospital discharge and favorable neurological outcomes were only 0.5% and 0.2%, respectively (Table 2).

Our multivariate logistic regression adjusted for prognostic confounding factors (Table 3). Age (OR = 0.98, 95%CI: 0.96–0.99, $P = 0.004$), Location (OR = 1.90, 95%CI: 1.14–3.17, $P = 0.02$), Witnessed (OR = 18.86, 95%CI: 4.58–77.67, $P < 0.001$), initial rhythm (OR = 0.27, 95%CI: 0.18–0.42, $P < 0.001$) were statistically associated with survival to discharge of OHCA. For favorable neurological outcome, Age (OR = 0.97, 95%CI: 0.95–0.99, $P < 0.001$), Location (OR = 2.32, 95%CI: 1.25–4.30, $P = 0.007$), Witnessed (OR = 23.76, 95%CI: 3.25–173.67, $P = 0.002$), initial rhythm (OR = 0.22, 95%CI: 0.13–0.37, $P < 0.001$) were independently associated with OHCA.

Table 1 – Characteristics and Outcomes of out-of-hospital cardiac arrest with non-traumatic etiology.

Variables	All N = 6923	Bystander CPR N = 2889	No bystander CPR N = 4034	P value
Age (years)	68(54–79)	65(52–76)	70(56–80)	< 0.001
Sex	< 0.001			
Male	4870(70.3%)	2097(72.6%)	2773(68.7%)	
Female	2053(29.7%)	792(27.4%)	1261(31.3%)	
Location	< 0.001			
Home/Residence	5033(72.7%)	1965(68.0%)	3068(76.1%)	
Public	1670(24.1%)	839(29.0%)	831(20.6%)	
Witnessed	< 0.001			
Bystander witnessed	3867(55.9%)	1952(67.6%)	1915(47.5%)	
No witnessed	3056 (44.1%)	937(32.4%)	2119(52.5%)	
Initial Rhythm	< 0.001			
Shockable rhythm	608(8.8%)	397(13.7%)	211(5.2%)	
Non-shockable rhythm	4317(62.4%)	1919(66.4%)	2398(59.4%)	
Bystander AED	121(1.7%)	112(3.9%)	9(0.2%)	< 0.001
Prehospital advanced airway	2857(41.3%)	1394(48.3%)	1463(36.3%)	< 0.001
Prehospital medicine treatment	2770(40.0%)	1380(47.8%)	1390(34.5%)	< 0.001
Prehospital ROSC	497(7.2%)	295(10.2%)	202(5.0%)	< 0.001
Survival to discharge	82(1.2%)	55(1.9%)	27(0.7%)	< 0.001
Favorable neurological outcomes	62(0.9%)	46(1.6%)	16(0.4%)	< 0.001

Values are displayed as frequency (percent), or median interquartile range; CPR, Cardiopulmonary resuscitation; AED, Automated external defibrillator; ROSC, Return of spontaneous circulation; Favorable neurological outcomes, Cerebral performance category 1 or 2 at the hospital discharge or 30 days after the event;

Table 2 – Characteristics of out-of-hospital cardiac arrest according to bystander cardiopulmonary resuscitation in different age groups.

	Age < 65 N = 2985			Age ≥ 65 N = 3938		
	Bystander CPR (N = 1434)	No bystander CPR (N = 1551)	P value	Bystander CPR (N = 1455)	No bystander CPR (N = 2483)	P value
Age, years	52(43–58)	52(45–58)	0.11	76(71–83)	78(72–85)	0.02
Sex			0.23			0.18
Male	1154(80.5%)	1219(78.6%)		943(64.8%)	1554(62.6%)	
Female	280(19.5%)	332(21.4%)		512(35.2%)	929(37.4%)	
Location			< 0.001			0.0001
Home/Residence	830(57.9%)	1022(65.9%)		1135(78.0%)	2046(82.4%)	
Public	563(39.3%)	447(28.8%)		276(19.0%)	354(14.3%)	
Witnessed			< 0.001			< 0.001
Bystander witnessed	1011(70.5%)	733(47.3%)		941(64.7%)	1182(47.6%)	
No witnessed	423(29.5%)	818(52.7%)		514(35.3%)	1301(52.4%)	
Initial Rhythm			< 0.001			0.001
Shockable rhythm	286(19.9%)	104(6.7%)		111(7.6%)	107(4.3%)	
Non-shockable rhythm	893(62.3%)	942(60.7%)		1026(70.5%)	1456(58.6%)	
Bystander AED	66(4.6%)	4(0.3%)	< 0.001	46(3.2%)	5(0.2%)	< 0.001
Prehospital advanced airway	679(47.4%)	574(37.0%)	< 0.001	715(49.1%)	889(35.8%)	< 0.001
Prehospital medicine treatment	689(48.0%)	568(36.6%)	< 0.001	691(47.5%)	822(33.1%)	< 0.001
Prehospital ROSC	173(12.1%)	85(5.5%)	< 0.001	122(8.4%)	117(4.7%)	< 0.001
Survival to discharge	43(3.0%)	15(1.0%)	0.0001	12(0.8%)	12(0.5)	0.26
Favorable neurological outcomes	40(2.8%)	10(0.6%)	< 0.001	6(0.4%)	6(0.2)	0.52

Values are displayed as frequency (percent), or median interquartile range; CPR, Cardiopulmonary resuscitation; AED, Automated external defibrillator; ROSC, Return of spontaneous circulation; Favorable neurological outcomes, Cerebral performance category 1 or 2 at the hospital discharge or 30 days after the event;

Table 3 – Adjusted odds ratios for outcomes of out-of-hospital cardiac arrest with non-traumatic.

	Survival to hospital discharge		Favorable neurological outcome	
	OR (95% CI)	P	OR (95% CI)	P
Age, (years)	0.98(0.96–0.99)	0.004	0.97(0.95–0.99)	< 0.001
Sex	1.10(0.65–1.88)	0.715	1.23(0.65–2.31)	0.526
Location	1.90(1.14–3.17)	0.014	2.32(1.25–4.30)	0.007
Witnessed	18.86(4.58–77.67)	< 0.001	23.76(3.25–173.67)	0.002
Bystander CPR	1.24(0.73–2.09)	0.433	1.50(0.77–2.92)	0.237
AED	1.66(0.53–5.21)	0.390	1.87(0.68–5.14)	0.227
Initial rhythm	0.27(0.18–0.42)	< 0.001	0.22(0.13–0.37)	< 0.001

Sex, Representing male patients, for males were calculated using a mixed-effects logistic regression model; Location, Representing public; Witnessed, Representing Bystander witnessed; CPR, Cardiopulmonary resuscitation; AED, Automated external defibrillator; ROSC, Return of spontaneous circulation; Favorable neurological outcomes, Cerebral performance category 1 or 2 at the hospital discharge or 30 days after the event; OR, Odds ratio; 95% CI, 95% confidence interval;

Discussion

This is the first report evaluating the outcomes of OHCA and bystander CPR in Zhejiang Province based on the Utstein template. The outcomes for OHCA patients of non-traumatic treated by EMS are unsatisfactory, with 1.2% surviving to discharge or 30 days and 0.9% surviving with good neurological outcomes (CPC 1–2). Bystander CPR can potentially improve survival rates and neurological recovery in OHCA patients, particularly among younger patients, with a survival to discharge or 30-day of 3.0% and 2.8% surviving with good neurological outcomes.

The construction of the Zhejiang Emergency Command Center platform has achieved province-wide sharing and interconnection of pre-hospital data, breaking down information silos. Real-time data collection and analysis optimize the deployment of medical resources, reduce response times, and improve the efficiency of pre-hospital emergency services. Secondly, the platform facilitates dispatcher-assisted CPR guidance, increasing the likelihood of successful resuscitation, and encourages better participation from citizens and volunteers through digital tools. Furthermore, by analyzing large volumes of emergency data, the platform provides valuable insights for policymaking, resource planning, and system improvements, enabling continuous adaptation and enhancement of healthcare and emergency response needs. The platform also incorporates electronic health records and follow-up systems, allowing real-time data access and enabling the connection of pre-hospital EMS data with hospital data across different regions. This integration enhances the efficiency of the healthcare system and improves the treatment outcomes for critically patients.

In this study, the incidence of OHCA evaluated by EMS in Zhejiang Province was lower than that reported in North American, Europe and other Asian countries (67–170 cases per 100,000 population).[15–17] Witnessed or family members may seek medical care by private car or other methods after cardiac arrest, even abandon medical treatment. Therefore, the overall OHCA incidence in China may be underestimated, as a substantial proportion of OHCA patients are not evaluated or transported by EMS.[18]

This could be attributed to the fact that many patients were already dead prior to resuscitation efforts, exhibiting signs such as rigor mortis, livor mortis or decomposition, or were cardiac arrest occurring in elderly individuals or those with advanced chronic diseases. Additionally, a significant proportion of patients' relatives refused or requested termination of resuscitation attempts for OHCA patients. In China, a common reason for family calling EMS is so that EMS physicians can declare death and issue a death certificate, this phenomenon had also been discussed in other studies.[19] To effectively achieve the rational utilization of EMS resources and improve emergency response efficiency, we propose further initiatives. First, public education on EMS response should be promoted through awareness campaigns and educational programs to optimize resource allocation and utilization. Secondly, public education, CPR and AED training should be conducted, with more AED devices installed in public locations and residential to improve the success rate of OHCA resuscitation. Additionally, regular skills training for emergency individuals should be conducted, and more community volunteers should be trained. A highly efficient and close cooperation mechanism should be established between firefighters, police and EMS to ensure effective bystander CPR or AED use before EMS arrival. Another potential solution is promoting the use of information technology systems by developing emergency response applications that quality direct nearby volunteers to the scene, thereby improving community response time. These measures will have a positive impact on improving the outcomes of OHCA.

Age is associated with outcomes after OHCA,[20–22] and older age may be a factor contributing to poor prognosis. In our study, more than half of the OHCA patients was aged 65 years or older. The median age of OHCA patients was 68 years (range 54–79), with a higher proportion of male patients (70.3%). The majority of cardiac arrest occurred at home, consistent with findings from previous studies in other countries.[4] Pareek et al. found that compared to patients under 60 years old, the odds ratio (OR) for poor neurological outcomes in the 60–80 years group and above 80 years group were 1.97(95%CI:1.27–3.08) and 8.97(95%CI:3.66–27.06), respectively.[21] Our study is consistent with these findings. We observed that younger patients in the bystander CPR group had better survival and neurological outcomes. The OR for survival to discharge and favorable neurological outcomes in younger patients were 0.98(95%CI:0.96–0.99, $P = 0.004$) and 0.97 (95%CI:0.95–0.99, $P < 0.001$), respectively.

In this study, the rate of initial shockable rhythm among OHCA patients was significantly lower than reported in North American, Europe and Oceania (17.1–37.8%).[4] However, in younger patients with non-traumatic OHCA who received bystander CPR, the initial shockable rhythm was comparable to those reports[4] (4). This discrepancy may be due to factors such as the patients' advanced

age, delays in response and suboptimal rates of bystander CPR. In addition, the defibrillation rate was significantly higher in the younger patients group compared to the older patients group. Winther-Jensen et al. reported that the incidence of cardiac etiology OHCA was higher in younger patients than in older patients[23] and that the prognosis for OHCA of cardiac etiology appeared to be better.[24] In our study, we found that younger patients in the bystander CPR group had better survival and neurological outcomes. Early defibrillation is an effective treatment for VF, which is a common manifestation of OHCA of cardiac etiology.[25]

In this study, we were unable to show a positive correlation between bystander CPR and outcomes after OHCA. Poor quality of bystander CPR could play a role, potentially influenced by factors, such as the bystander's age, gender and whether they have received training. Second, patients' age and community differences may also affect the impact of bystander CPR on OHCA outcomes. We found that younger patients in the bystander CPR group had higher survival rates and better neurological outcomes compared to older patients. Additionally, the time interval between cardiac arrest and the initiation of CPR might influence the outcomes. In our study, most bystanders performed chest compressions only, without ventilation, and did not maintain continuous CPR. Only approximately 20% patients received both compressions and ventilations. Moreover, the rate of bystander AED defibrillation was low. Therefore, efforts should be made to strengthen public education, volunteer training, dispatcher-assisted CPR implementation, and widespread training programs in Zhejiang Province. The "Everyone Saves" project initiated by the Zhejiang Emergency Command Center had trained a large number of volunteers. The government activity should be encouraged citizens and medical professionals to participate in public emergency services and provides legal protections. On the other hand, the main factors hindering bystander CPR, are social, culture, and psychological factors. Challenges remain in dispatcher-assisted CPR, such as bystanders felling too nervous or afraid to perform CPR, failure to callback, inability to move patients, and excessive distraction preventing proper completion of CPR. Therefore, the government still needs to further support, along with the development and implementation of relevant policies and standardized procedures.

This study has some limitations. First, this study cannot avoid the inherent limitations of retrospective observational analysis, the data was collected based on the Utstein style, and we efforts were made to reduce potential biases through quality control. Additionally, other factors (including the quality of CPR, age of the rescuer, and whether they had received training) may influence the outcomes. Second, our study did not include long-term survival data, and we lack information to explore patients' long-term outcomes and quality of life. Third, this study included all OHCA patients in Zhejiang Province and the differences in EMS systems across regions and countries make it uncertain whether the results are generalizable to other regions or countries. Fourth, unmeasured confounding factors may exist, which could introduce bias to this study results.

In conclusion, the survival rate after OHCA in Zhejiang Province is unsatisfactory, especially for elderly patients. Electronic Medical Record Surveillance can assist the implementation of the chain of survival to improve outcomes.

Author statement

Shanshan Chen: Clinical studies, data analysis and Manuscript preparation

Pin Pin Pek, Senjun Jin, Hengjie Li: Literature search and Data collect;

Marcus Eng Hock Ong, Wenwei Cai: Manuscript review.

CRediT authorship contribution statement

Shanshan Chen: Writing – original draft. **Hengjie Li:** Data curation. **Pin Pin Pek:** Methodology. **Senjun Jin:** Data curation. **Marcus Eng Hock Ong:** Writing – review & editing. **Wenwei Cai:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This study was supported by the Research and Development Plan for Leading Wild Goose in Zhejiang Province (No.2023C03195) and S.J. Received Funding from Youth Talents Project of Health Commission of Zhejiang Province (No. 2019RC103).

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