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ORIGINAL RESEARCH

Comparative Analysis of Out-of-Hospital Cardiac Arrest Outcomes in Health Clinics, Nursing Homes, and Public Places: Implications for Optimizing Automated External Defibrillator Strategies

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Purpose: Various factors, such as event location and response time, influence the outcomes of out-of-hospital cardiac arrest (OHCA). Very few studies have explored the delivery of basic life support (BLS) to patients having OHCA at health clinics or nursing homes—settings with professional BLS providers. Thus, in this study, we compared prognostic and survival outcomes between health clinics, nursing homes, and other public places (eg, workplaces and sports facilities/recreational areas) to offer insights for optimizing OHCA outcomes.

Patients: This study included adults who had nontraumatic OHCA in Taoyuan City between January 2017 and December 2022.

Methods: We collected data on patient characteristics, emergency medical service parameters, onsite patient management, automated external defibrillator (AED) locations, OHCA prognosis, and survival outcomes. Multivariate analyses were performed to predict survival to discharge (primary outcome) and neurological outcomes at discharge (secondary outcome).

Results: During the study period, the numbers of OHCA events at health clinics, nursing homes, and other public places were 158, 208, and 1986, respectively. The mean age of OHCA in health medical clinics, nursing home and other public places were 63.4, 81.5 and 64.7, respectively (P value<0.001). The proportion of witnessed events, rate of bystander resuscitation, and frequency of AED utilization were the highest for health clinics (53.2% (84/158), 83.4% (132/158), and 13.3% (21/158), respectively, P value<0.001). The average AED–scene distances and response times were the lowest for health clinics (388.8 m and 5.4 min, respectively). In initial shockable rhythm group, the probabilities of survival to discharge at discharge were the highest for health clinics (aOR=1.41, 95% CI=1.04–1.81, P value=0.041)) and lowest for nursing homes (aOR=0.84, 95% CI=0.76–0.93, P value=0.024).

Conclusion: Our research shows that OHCA patients at medical health clinics have higher rates of witnessing and bystander CPR and AED usage than other public places. However, while survival rates for patients with shockable rhythms are slightly better at health clinics, the neurological outcomes are not significantly different. The AED–scene distances are too far to be used effectively.

Keywords: public access defibrillators, geographic information system, out-of-hospital cardiac arrest, automated external defibrillators, emergency medical services

Introduction

Out-of-hospital cardiac arrest (OHCA) is a critical and potentially fatal condition that requires immediate onsite intervention. Recent public health initiatives have been focusing on optimizing each step in the chain of post-OHCA

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survival.[1,2] The corresponding measures include increasing the rates of bystander cardiopulmonary resuscitation[3,4] (CPR and dispatcher-assisted CPR,[5,6] promoting the installation of public access defibrillators (PADs),[7–9] and facilitating the delivery of basic life support (BLS; CPR + AED application).[2,10] In Taiwan, these measures are implemented through proactive promotion by medical directors and through the implementation of effective public health policies. In 2016, considering the indicators recommended by the American Heart Association,[11] dispatcher-assisted CPR and quality surveillance[5,12] were integrated into Taiwan's emergency medical service (EMS) dispatch system. This integration reflects a commitment to enhancing the efficacy and efficiency of the entire OHCA response system, aiming to improve the outcomes of OHCA.[5,10]

In Taoyuan, the rate of bystander intervention increased from 39.57% (763/1928) in 2017 to 64.3% (1135/1765) in 2022.[13] In 2022, 1367 automated external defibrillators (AEDs) were strategically placed across public places, including traffic hub, long-distance transportation, tourist areas, school, Large leisure place, large shopping mall, hotel with room over 100, hot spring and police stations)—approximately 59 AEDs per 100,000 persons—in Taoyuan City. However, the rate of bystander AED application for OHCA increased from 2.32% (45/1928) in 2017 to 3.88% (68/1765) in 2022.[13]

Factors such as the location of the event and the presence of witnesses strongly influence the outcomes of OHCA,[14–16] likely because of the timely delivery of BLS and AED.[4,17] The rate of survival is 12–43% for patients who have an initial shockable rhythm after OHCA at a public place and in the presence of witnesses.[18–20] This finding emphasizes the importance of swift and appropriate interventions, highlighting the need for widespread AED installation, increased bystander engagement, and efficient emergency response systems for enhancing the overall outcomes of OHCA. Therefore, determining optimal locations for PAD installation is imperative.[2,7,16]

Survival outcomes markedly vary across event locations, which can be divided into the following categories on the basis of the Utstein template:[21] residential areas, public places, nursing homes, health clinics, workplaces, institutions, and sports facilities/recreational areas. Owing to the expansion of PAD coverage and the promotion of bystander CPR, the rate of PAD usage at public places in Taoyuan City increased from 1.97% in 2013 to 3.8% in 2022.[5] Cases of OHCA occurring at nursing homes and health clinics are unique because the first responders in these settings have more professional first-aid capabilities. However, for OHCA patients with an initial shockable rhythm in these locations, timely implementation of early defibrillation depends largely on the timely arrival of emergency medical technicians (EMTs), possibly due to the long PAD distance or difficulty in finding the nearest PAD location.

Unlike other public places, Taiwan regulations do not require the installation of PADs in health clinics and nursing homes. Very few studies have focused on first-aid capabilities and the strategies of PAD in specific settings. The content mainly discusses initiating EMS as early as possible if the patient has warning symptoms of cardiac arrest.[22,23] There is less evaluation of the status of AEDs and OHCAs in health clinics and nursing homes. Therefore, we investigated the status of OHCA first-aid capabilities and PAD delivery at health clinics and nursing homes. In addition, we evaluated survival outcomes in patients having OHCA in these settings.

Methods

Study Design and Setting

This retrospective cohort study was conducted between January 2017 and December 2022 in Taoyuan City, northern Taiwan. Relevant data over this period were collected from an OHCA database, which stores data in accordance with the Utstein reporting template. This database contains OHCA data from all emergency departments and EMSs (41 EMSs, including 13 first-aid hospitals) across Taoyuan City. This city has a population of 2,302,465 and an area of 1221 km^2. Taoyuan City's population accounts for approximately 9.83% (2,302,465/23,416,375) of Taiwan's population. Notably, the data used in the present study were devoid of any patient or public information. The AED installation strategy in Taiwan includes places with higher density, higher risk, higher benefit and harder to reach. The relevant policy in Taiwan recommends installing PADs in crowded areas and areas with high OHCA incidence rates, including transportation hubs, large long-distance vehicles, tourist spots, schools, large assembly places, large leisure places, large shopping malls, hotels, large public bath houses, hot springs, and public service buildings such as police stations. However, there was no relevant regulation to mandate health clinics or nursing homes to install AEDs until now.

Patient Selection

This study included adults who had nontraumatic OHCA in Taoyuan City during the study period. We excluded patients with a pre-OHCA do-not-resuscitate directive, those with clear indications of prolonged death or intoxication, and those who drowned. In addition, we excluded patients who had a cardiac arrest in a residential area or in the presence of an EMT. Figure 1 presents the flowchart of patient selection. OHCA events were stratified by location into three categories: health clinics, nursing homes, and other public places (eg, public places, workplaces, institutions, and sports facilities/ recreational areas).

Data Collection

We collected data on patient characteristics (eg, age, sex, event location, witness status, bystander AED application, and bystander CPR), EMS parameters (eg, response time and scene time interval), transport time, onsite patient management by EMTs (eg, intubation, defibrillation, epinephrine use, and amiodarone use), and clinical outcomes (information was collected from both EMS run sheets and hospital medical records). In addition, we obtained AED data (2022) for Taoyuan City from a government-run open-data platform. This city has 1367 registered AEDs. Furthermore, we collected data (in Chinese) on event locations, fire department locations, and AED locations. These data were incorporated into the two-degree Universal Transverse Mercator system and then projected onto the map of Taoyuan City by using a geographic information system (QGIS; version 3.30.2). Next, using QGIS Network Analysis Toolbox, we calculated the shortest "real walking route" from each event location to the fire department and nearest AED locations.

The Taoyuan Fire Department is responsible for data collection and reporting. In Taiwan, we still have not conducted the termination of resuscitation (TOR) protocol by EMTs until now. Hence, OHCA cases would be sent to hospitals after EMS activation unless pronounced dead at the scene. Our data contains all OHCA data in Taoyuan City.

Study Outcomes

The primary outcome was survival to discharge, and the secondary outcome was favorable neurological outcomes (Cerebral Performance Category score 1 or 2) at discharge.

Statistical Analysis

Descriptive statistics are presented as the mean ± standard deviation values for continuous variables and the count and percentage values for categorical variables. One-way analysis of variance was performed for between-group

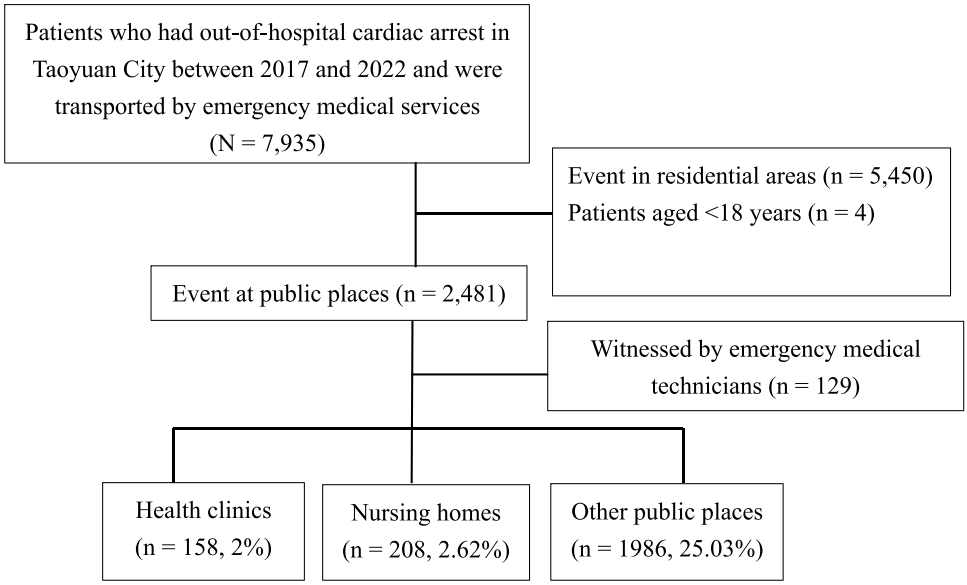

Figure 1 Flowchart of patient selection.

comparisons. The chi-square test was performed to determine between-group proportion disparities. Based on the public OHCA studies, whether the initial rhythm is shockable has a crucial impact on the survival prognosis. Therefore, for the multivariable logistic regression analysis of survival prognosis, we would use the classification into the initial shockable or non-shockable rhythm. Multivariate logistic regression was performed to predict survival to discharge and favorable neurological outcomes at discharge. The multivariate model was adjusted for age, sex, witness status, bystander CPR, intubation, epinephrine use, amiodarone use, response time, scene time interval, and transport time. Statistical analyses were performed using SPSS (version 25.0 [2017]; IBM Corporation, Armonk, NY, USA). A P value of <0.05 indicated statistical significance.

Results

Patient Characteristics

Between 2017 and 2022, 7935 events of nontraumatic OHCA occurred in Taoyuan City; the annual incidence was 57.41 events per 100,000 inhabitants. Of these events, 29.64% (2352/7935) occurred in public areas; 2% (158/7935), 2.62% (208/7935), and 25.03% (1986/7935) occurred at health clinics, nursing homes, and other public places, respectively (Figure 1). As shown in Figure 2, OHCA events at health clinics were further stratified into those occurring at general medicine clinics (67.08% (106/158)), surgical clinics (17.72% (28/158)), and obstetrics and gynecology clinics (15.19% (24/158)). Of the events, 40.51% (64/158) occurred during an invasive procedure (eg, panendoscopy and surgery) or during labor. The proportions of witnessed events at health clinics, nursing homes, and other public places were 53.2% (84/158), 48.1% (100/208), and 37.8% (751/1986), respectively. The rates of bystander CPR and bystander AED application at health clinics, nursing homes, and other public places were 83.4% (132/158), 83.8% (174/208), and 60.3% (1197/1986) and 13.3% (21/158), 9.5% (19/208), and 4.4% (88/1986), respectively. The proportions of patients with an initial shockable rhythm were 22% (35/158), 13% (27/208), and 16% (318/1986) at health clinics, nursing homes, and other public places, respectively. Table 1 presents information on onsite patient management by EMTs and various EMS parameters, such as response time, scene time, and transport time. The rates of prehospital return of spontaneous circulation for OHCA events at health clinics, nursing homes, and other public places were 10.1% (16/158), 9.6% (20/208), and 10% (198/1986), respectively.

Key results

The average distances between PADs and event locations—health clinics, nursing homes, and other public places—were 388.8, 514.4, and 544.9 m, respectively. The average distances between the fire department and event locations—health clinics, nursing homes, and other public places—were 3.99, 5.12, and 4.35 km, respectively (Table 2). Furthermore, the average response times for OHCA events at health clinics, nursing homes, and other public places were 5.4, 5.6, and 5.5 min, respectively (Table 1). The adjusted odds ratios for survival to discharge after OHCA at health clinics and nursing

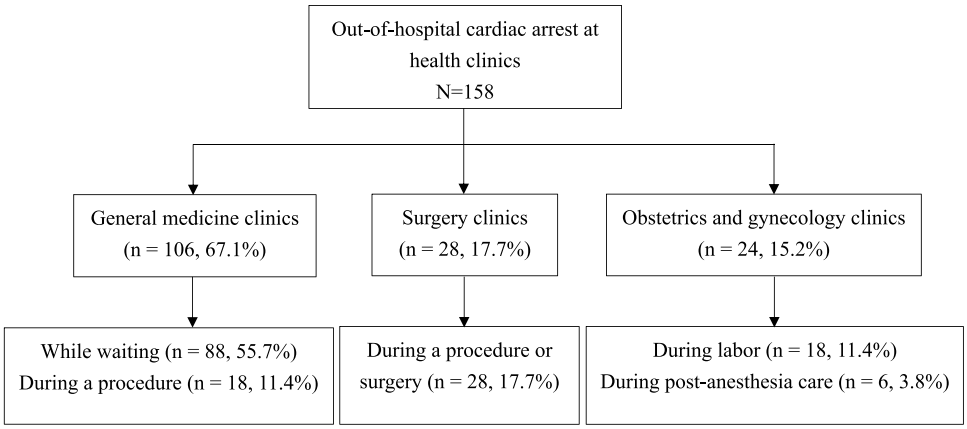

Figure 2 Distribution of out-of-hospital cardiac arrest events across health clinics.

Table 1 Baseline Characteristics of the Study Cohort

Characteristic	Total Number N=2352	Health Medical Clinics N=158	Nursing Home N=208	Other Public Place N=1986	P value
Age, mean (SD)	67.7 (16.8)	63.4 (17.1)	81.5 (14.6)	64.7 (16.5)	<0.001
Male, N (%)	1212 (51.5%)	84 (53.2%)	115 (55.3%)	1013 (51.0%)	0.458
Witnessed, N (%)	935 (39.8%)	84 (53.2%)	100 (48.1%)	751 (37.8%)	<0.001
Bystander CPR, N (%)	1503 (63.9%)	132 (83.4%)	174 (83.8%)	1197 (60.3%)	<0.001
PAD use before EMT, N (%)	128 (5.4%)	21 (13.3%)	19 (9.5%)	88 (4.4%)	<0.001
Initial rhythm					
Shockable, N (%)	380 (16.2%)	35 (22.0%)	27 (13.0%)	318 (16.0%)	0.056
Non-shockable, N (%)	1972 (83.8%)	123 (78.0%)	181 (87.0%)	1668 (84.0%)	
Intubation, N (%)	322 (13.7%)	21 (13.3%)	23 (11.1%)	278 (14.0%)	0.496
Epinephrine, N (%)	1070 (45.5%)	107 (67.7%)	129 (62.0%)	834 (42.0%)	<0.001
Amiodarone, N (%)	127 (5.4%)	13 (8.2%)	15 (7.2%)	99 (5.0%)	0.106
Response time, mean (SD)	5.6 (2.7)	5.4 (3.1)	5.6 (2.6)	5.5 (2.8)	0.467
Scene time interval, mean (SD)	21 (5.6)	18 (5.4)	19 (5.2)	22 (6.1)	0.125
Transport time, mean (SD)	6.1 (5.2)	6.2 (4.7)	5.8 (5.1)	6.2 (5.4)	0.523
Outcome					
Pre-hospital ROSC, N (%)	234 (9.9%)	16 (10.1%)	20 (9.6%)	198 (10.0%)	0.984
Survival for 2 hours, N (%)	766 (32.6%)	53 (33.5%)	58 (27.9%)	655 (33.0%)	0.317
Survival at Discharge, N (%)	233 (9.9%)	20 (12.7%)	16 (7.7%)	197 (9.9%)	0.289
Favor neurological outcome, N (%)	104 (4.4%)	7 (4.4%)	6 (2.9%)	91 (4.6%)	0.526

Table 2 Distances of Public Access Defibrillators and the Fire Department

Variables	Health Medical Clinics	Nursing home	Other Public Place	P value
PAD distance, mean (SD)	388.8 (42.2)	514.4 (53.9)	544.9 (39.4)	<0.001
Fire department distance, mean (SD)	3987 (547.8)	5123 (769.8)	4345 (379.5)	<0.001

homes were respectively 1.41 (95% confidence interval [CI]: 1.04–1.81, P value=0.041) and 0.84 (95% CI: 0.76–0.93, P value=0.024) in patients with an initial shockable rhythm and 1.21 (95% CI: 0.89–1.57, P value=0.147) and 0.9 (95% CI: 0.85–0.96, P value=0.042) in those with an initial nonshockable rhythm (Table 3). Furthermore, the adjusted odds ratios for favorable neurological outcomes at discharge after OHCA at health clinics and nursing homes were respectively 1.18 (95% CI: 0.82–1.58, P value=0.217) and 0.82 (95% CI: 0.73–0.92, P value=0.032) in patients with an initial shockable rhythm and 1.14 (95% CI: 0.74–1.76, P value=0.332) and 0.92 (95% CI: 0.86–0.98, P value=0.047) in those with an initial nonshockable rhythm. Both primary and secondary outcomes were assessed by considering patients with OHCA at public places as the reference group.

Table 3 Results of a Multivariate Analysis for Predicting Survival to Discharge and Favorable Neurological Outcomes at Discharge

Variables	Survival at Discharge		Favor Neurological Outcome	
	aOR (95% CI)	P value	aOR (95% CI)	P value
Shockable				
Health Medical Clinics	1.41 (1.04–1.81)	0.041	1.18 (0.82–1.58)	0.217
Nursing home	0.84 (0.76–0.93)	0.024	0.82 (0.73–0.92)	0.032
Other Public area	Reference group			
Non-shockable				
Health Medical Clinics	1.21 (0.89–1.57)	0.147	1.14 (0.74–1.76)	0.332
Nursing home	0.90 (0.85–0.96)	0.042	0.92 (0.86–0.98)	0.047
Other Public area	Reference group			

Notes: The multivariate model was adjusted for age, sex, witness status, bystander cardiopulmonary resuscitation, intubation, epinephrine use, amiodarone use, response time, scene time interval, and transport time.

Discussion

We explored survival outcomes after OHCA at health clinics, nursing homes, and other public places. The rate of survival to discharge was higher for health clinics than for other public places; notably, the poorest survival and neurological outcomes were observed for nursing homes. Distances between the fire department and PADs were the lowest for health clinics, resulting in the highest rate of PAD utilization.

Evidence[24,25] suggests that early CPR and AED application (within first few minutes after an event) increases the survival rate to >50%. For events at public places, bystanders' willingness to perform CPR and witnesses' awareness regarding the nearest AED location are crucial for improving OHCA prognosis.[4,10,14] We found that the rates of initial shockable rhythm after OHCA at health clinics and nursing homes were 22% and 13%, respectively. Witnesses in these settings are often licensed BLS providers. Despite the presence of relatively proficient responders, improvements in post-OHCA survival outcomes are barely noted in these settings. Thus, future studies should investigate how the time taken to reach an AED and the quality of CPR affect survival outcomes.[3,26]

Thus far, public health policy in Taiwan does not mandate AED installation in health clinics or nursing homes. The incidence of OHCA in health medical clinics accounts for approximately 6% of OHCA in public areas, and its patient characteristics include a higher proportion of young patients, witnessed and bystander CPR, and shockable rhythms. Among the events at health clinics, 40.51% occurred during invasive procedures (panendoscopy, colonoscopy, hemorrhoid surgery, and cesarean section).[22] This is similar to about 35% in past studies. These OHCAs have about 22% of initial shockable rhythms but only 13.3% of PAD usage. It may be that the PAD is too far away to be obtained within the EMS response time. Therefore, as past studies have suggested, AED installation should be equipped at health clinics and staff with well-trained staff as a better strategy.[22]

After reviewing the location of the nearest PAD for each event, we found that the average distances between the nearest PAD and a health clinic and nursing home were 388.8 and 514.4 m, respectively, which hinders PAD application within the optimal response time window. According to the guidelines of the American Heart Association, the distance between the OHCA events and the PAD is within 100 m, which is more likely to be covered by the PAD.[27] Therefore, PAD usage is still not high even at the nearest health medical clinics (388.8 m). The distance makes it difficult for first responders to reach the nearest PAD and administer defibrillation in time.[19] Considering that health clinics and nursing homes are typically located in relatively crowded areas with a high population density, we recommend AED installation in these settings to facilitate early defibrillation. Although bystanders may not necessarily be familiar with PAD locations,

most people are likely to be aware of the nearest health clinics in their neighborhood. Therefore, AEDs should be systematically installed in health clinics and nursing homes to improve the accessibility and utilization of these devices.

Recently, the rates of early bystander CPR and AED application have increased because of the promotion of BLS education, widespread distribution of PADs, and establishment of a national AED network.[4,8,10] The rate of bystander CPR increased from 39.57% in 2017 to 64.3% in 2022, whereas that of bystander AED application increased from 2.32% in 2017 to 3.88% in 2022. Adequate AED utilization is dependent on the availability of these devices and the willingness of bystanders to fetch an AED to the event location.[2,8,28] In this study, we found that the rate of AED application before EMT arrival was better at health clinics (13.3%). However, the probability of survival at discharge is higher than in other public places. The reason is that the staff may have better first-aid capabilities and be well-trained.[29]

Evidence[30,31] suggests that the factors associated with an improved OHCA prognosis include event witness, occurrence at public places, early bystander CPR, initial shockable rhythm, early defibrillation[8,32] in patients with an initial shockable rhythm, and early epinephrine use[33] in patients with an initial nonshockable rhythm. However, we found that the prognosis, in terms of neurological outcomes, was not significantly better in patients who developed OHCA at health clinics—which are locations associated with high rates of event witness, initial shockable rhythm, bystander CPR, and PAD utilization and a high likelihood of patient survival—than in those having OHCA at other public places. Notably, patients who developed OHCA at nursing homes had the worst survival to discharge and neurological outcomes, likely because of old age and the elevated prevalence of comorbidities (eg, cerebrovascular disease, cardiovascular disease, hypertension, diabetes mellitus, and chronic kidney disease) in these individuals. The same findings have been obtained in past studies, mainly because the first responders at the nursing home do not educate pre-arrest support and advance care planning.[34] The poor outcomes after OHCA at nursing homes may also be attributable to the potentially inadequate assessment of the quality of resuscitation. Therefore, CPR education and quality in these settings should be monitored, similar to the monthly video meetings between medical directors and EMTs to review OHCA cases. Furthermore, considering the benefits of early epinephrine use,[33,35] we recommend that first responders at health clinics and nursing homes should establish intravenous routes before the arrival of EMTs due to their inherent first-aid capabilities.

Limitations

This study has some limitations. First, Taoyuan City has a high population density and has numerous PADs and hospitals. We did not consider the effects of traffic and holidays, particularly in rural or low-density areas. Thus, our results should be interpreted with caution. Second, we did not review the patients' anamneses; this might have influenced our results pertaining to OHCA prognosis. However, our objectives were to compare survival outcomes across event locations and to identify factors influencing these outcomes, rather than to evaluate the effects of medical care on survival outcomes. Third, not all AED were registered in Taiwan. Unregistered AEDs may affect actual PAD distance and PAD usage. Unregistered AEDs cannot be used effectively because there is no public information, and they are mostly set up in residential areas for private use. Hence, the impact on the results is limited. Finally, we lacked data on the quality of bystander-delivered BLS. Thus, we could not measure the indicators of bystander-delivered BLS quality—for example, compression position, depth, rate, recoil, and AED placement. Future studies should investigate the benefits of AED installation in health clinics.

Conclusion

Our findings indicate elevated rates of event witness, bystander CPR, and bystander AED application for patients who experienced OHCA at medical health clinics. Furthermore, survival outcomes for OHCA patients with shockable rhythms appear to be a little better at health clinics than in other public places but not neurologically significant. AEDs are installed in medical health clinics and nursing homes, and the access distance is too far to deliver effectively.

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author on reasonable request.

Ethics Approval and Informed Consent

This study was approved by the Human Research Ethics Committee of Chang Gung Medical Foundation (approval number: 202400189B0) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from the study participants before the study commencement. This database has been approved by the Human Research Ethics Committee of Chang Gung Medical Foundation, and the data has been anonymized.

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Disclosure

The authors declare there are no conflicts of interests.

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