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Short paper

Walking time to nearest public automated external defibrillator for out-of-hospital cardiac arrest in a major U.S. city

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Abstract

Background: How frequently out-of-hospital cardiac arrest (OHCA) occurs within a reasonable walking distance to the nearest public automated external defibrillator (AED) has not been well studied.

Methods: As Kansas City, Missouri has a comprehensive city-wide public AED registry, we identified adults with an OHCA in Kansas City during 2019–2022 in the Cardiac Arrest Registry to Enhance Survival. Using AED location data from the registry, we computed walking times between OHCAs and the nearest registered AED using the Haversine formula, a mapping algorithm to calculate walking distance in miles from one location to another. Results were stratified by OHCA location (home vs. public) and by whether the patient received bystander cardiopulmonary resuscitation (CPR).

Results: Of 1,522 OHCAs, 1,291 (84.8%) occurred at home and 231 (15.2%) in public. Among at-home OHCAs, 634 (49.1%) received bystander CPR and no patients had an AED applied even as 297 (23.0%) were within a 4-minute walk to the closest public AED. Among OHCAs in public, 108 (46.8%) were within a 4-minute walk to the closest public AED. For public OHCAs within a 4-minute walk, bystanders applied an AED in 13 (12.0%) of these cases and in 24.5% (13/53) of those who received bystander CPR.

Conclusion: In one U.S. city with a publicly available AED registry, there were no instances in which a bystander accessed a public AED for an OHCA at home. For OHCAs in public, nearly half occurred within a 4-minute walk to the closest AED but bystander use of an AED was low.

Keywords: Out-of-Hospital Cardiac Arrest, Automated external defibrillators, Cardiopulmonary Resuscitation, Public Health

Introduction

Out-of-hospital cardiac arrest (OHCA) is a life-threatening medical emergency requiring immediate intervention.[1,2] Of the 350,000 estimated OHCAs that occur annually in the U.S., approximately 10% survive to hospital discharge.[3] Early cardiopulmonary resuscitation (CPR) and automated external defibrillator (AED) use improves OHCA survival; thus, bystander initiation of these interventions are critical links in the Chain of Survival.[1–6] Defibrillation within 3–5 min of arrest can yield survival rates as high as 50–70%.[7] To reduce time to first defibrillation, guidelines have promoted the deployment and use of public AEDs in settings with a high likelihood of OHCA.[5,7–10] Despite this, bystander AED use rates remain low.[9]

Some cities in the United States have developed a public AED registry to facilitate access to an AED during an OHCA.[10] In a Seattle-based public access AED program coupled with voluntary community responder training in 1999–2002, the public AED use rate was 1.3% (50/3754 OHCAs).[11] A Los Angeles public access AED program reported that a public AED was deployed in 42 of 59

Abbreviations: AED, automated external defibrillator, CARES, Cardiac Arrest Registry to Enhance Survival, CPR, cardiopulmonary resuscitation, OHCA, out-of-hospital cardiac arrest

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https://doi.org/10.1016/j.resplu.2024.100698

Received 30 May 2024; Received in revised form 6 June 2024; Accepted 11 June 2024

OHCAs at an airport.[12] To assess contemporary resuscitation practices in a large U.S. city with a public AED registry, we examined the proportion of OHCA events within a reasonable walking time of an AED and the extent to which AEDs were accessed in the public and home settings when the OHCA was within a reasonable walking distance.

Methods

We identified adults 18 years of age or older with a non-traumatic OHCA and had CPR initiated in Kansas City, Missouri (population 509,207; area 319 mi^2) from 01/01/2019-12/31/2022 in the Cardiac Arrest Registry to Enhance Survival (CARES). We excluded OHCAs that occurred in healthcare facilities or nursing homes and those witnessed by 911 personnel.

AED location information was obtained from the Kansas City public AED registry acquired from OpenDataKC (data.kcmo.org) and the Kansas City Fire Department. This city-wide AED registry is maintained by the Office of the Emergency Medical Services Medical Director and has been present in Kansas City since 2014 and contained 1,167 public access AEDs in 2019 and 1,422 as of 2022. Those within the city limits are encouraged to register their AEDs in the program, although this is not legally mandated and there is no penalty for non-participation.[13] The AED registry includes location name, address, latitude and longitude, and device information. During the study period, 9-1-1 dispatchers did not have knowledge of the nearest accessible public AED to provide as this information was not embedded within the city's emergency medical dispatch system. Thus, life support instruction provided by the dispatcher often centered on CPR alone.

We quantified one-way walking distance from each OHCA event to the nearest public AED. To do this, staff at CARES geocoded each OHCA event's location and calculated the one-way straight-line walking distance using the Haversine formula and estimated walking time between each geocoded OHCA event to surrounding AEDs in the city-wide registry. This technique involves a basic mapping algorithm to calculate the linear distance between two points.[14,15] Some OHCA events were near multiple publicly registered AEDs, and, in these cases, we selected the nearest public AED for analysis. One-way walking distance intervals were categorized at the minute level to the nearest AED. Within each walking time interval (e.g., 1, 2, 3, 4 min), we quantified the number of OHCA events within walking distance and how often bystander CPR and AED application was performed. For the primary analysis, we quantified the proportion of OHCAs within a 4-minute (8-minute round trip) walking distance to the closest AED in the city-wide registry, as the average response time from a 9-1-1 call to first responder arrival on the scene was approximately 8 min. Results were stratified by location of arrest as at-home and public arrests.

Methods and results are reported using the Strengthening the Reporting of Observational Studies in Epidemiology checklist.[16] Summary statistics are reported using median and interquartile range (IQR). Analyses were performed using R version 4.3.2.[17] This study was designated exempt by the Saint Luke's Institutional Review Board given the use of publicly available information and use of deidentified OHCA data in CARES.

Results

Between 2019 and 2022, 1,522 OHCAs occurred in non-medical settings and were not witnessed by a 9-1-1 responder. Of these, 1,291 (84.8%) occurred at home and 231 (15.2%) in public. Median age was 62 years (IQR: 51–73), 541 (35.5%) were women, and 27 (1.8%) involved use of a public AED (Table 1).

As shown in Table 2, among the 1,291 OHCAs occurring at home, 634 (49.1%) received bystander CPR and no patients had an AED applied by a bystander even as 297 (23.0%) were within a 4-minute one-way walk to the closest public AED. If a shorter walking distance threshold was used, 177 (13.7%) home OHCAs were within a 3-minute walking distance, 91 (7.0%) were within a 2-minute walking distance, and 20 (1.4%) were within a 1-minute walking distance.

Among the 231 OHCAs occurring in public, 119 (51.5%) received bystander CPR and an AED was applied by a bystander in 19 (8.2%) of instances. A total of 108 (46.8%) were within a 4-minute one-way walk to the closest public AED and bystanders used an AED in 13 (12.0%) of these cases. Of OHCA cases within a 4-minute walking distance of a public AED and in which bystander CPR was performed, bystander AED use was 24.5% (13/53). If a shorter walking distance threshold was used, 83 (35.9%) of public OHCAs were within a 3-minute walking distance, 54 (23.4%) were within a 2-minute walking distance, and 20 (8.7%) were within a 1-minute walking distance.

Discussion

We quantified the proportion of OHCA events in close proximity to the nearest public AED in a large U.S. city with a city-wide AED registry and assessed the extent to which AEDs were accessed in the public and home settings. We found that almost half of public OHCAs and a quarter of OHCAs at home occurred within a 4-minute walk of a publicly registered AED. The majority of OHCAs occurred at home, for which there were no instances of bystander AED use, even for arrests occurring within a 1-minute walk to a public AED. Bystander rates of AED application were only 12% for public OHCAs within a 4-minute walking distance to the closest AED. Our findings indicate that AED rates for OHCA remain low in Kansas City, Missouri, despite the existence of a city-wide AED registry.

In a prior study from Denmark, fewer than 5% of OHCAs were within 100 m, which is approximately a 1–1.5-minute brisk walk of an accessible AED.[18] Beyond 100 m, there was a rapid decline in the probability of bystander defibrillation for a public OHCA. That study also found low use of public AEDs for residential arrests, with only a 1.5% probability of bystander AED use for an OHCA within 100 m of the nearest accessible AED.[18] Another Danish study found that the chance of bystander defibrillation and 30-day survival were 3-fold and 2-fold higher, respectively, for publicly accessible AEDs compared to when AEDs were inaccessible at the time of OHCA.[19] These findings underscore the critical role that timely access to an AED plays in improving patient outcomes following OHCA.

In our study, we found that 7.0% and 23.7% of all OHCAs occurring at home were within a 2-minute and 4-minute walking distance, respectively, to the closest AED, underscoring the potential opportunity to leverage the city-wide AED registry for OHCAs occurring at

Table 1 – Characteristics of non-traumatic out-of-hospital cardiac arrests in Kansas City, Missouri from 2019 to 2022.

Characteristic	Overall, *N* = 1,522[1]	Home/Residence, *N* = 1,291[1]	Public, *N* = 231[1]
Age	62 (51, 73)	63 (51, 74)	58 (47, 66)
Female sex	541 (36%)	498 (39%)	43 (19%)
Race/Ethnicity			
Black/African-American	644 (42%)	573 (44%)	71 (31%)
Hispanic/Latino	78 (5.1%)	67 (5.2%)	11 (4.8%)
White	767 (50%)	621 (48%)	146 (63%)
Other	33 (2.2%)	30 (2.3%)	3 (1.3%)
Bystander CPR Performed	753 (49%)	634 (49%)	119 (52%)
Who first applied AED			
Bystander	19 (3.9%)	0 (0%)	19 (20%)
Family Member	1 (0.2%)	0 (0%)	1 (1.1%)
Healthcare Provider (non-911 Responder)	7 (1.4%)	0 (0%)	7 (7.4%)
Law Enforcement First Responder	12 (2.4%)	3 (0.8%)	9 (9.6%)
Non-Law Enforcement First Responder	453 (92%)	395 (99%)	58 (62%)
Public AED use	27 (1.8%)	0 (0%)	27 (12%)
Who first defibrillated the patient			
Bystander	8 (0.5%)	0 (0%)	8 (3.5%)
EMS Responder (transport EMS)	329 (22%)	264 (20%)	65 (28%)
Family Member	1 (<0.1%)	0 (0%)	1 (0.4%)
Healthcare Provider (non-911 Responder)	0 (0%)	0 (0%)	0 (0%)
Law Enforcement First Responder	5 (0.3%)	4 (0.3%)	1 (0.4%)
Non-Law Enforcement First Responder	127 (8.3%)	93 (7.2%)	34 (15%)
Not Applicable	1,052 (69%)	930 (72%)	122 (53%)

[1] Median (Interquartile Range); *n* (%).

Table 2 – Proportion OHCA within different one-way walking distance intervals to the closest public AED. Results are presented overall and among those receiving bystander CPR. Shaded row at 4-minutes reflects time threshold used for the main study results.

Walking time to AED (min)	OHCA, *n* (%)	Overall bystander AED, *n* (%)	Overall bystander Bystander CPR, *n* (%)	Bystander AED in bCPR cohort, *n* (%)
HOME				
1	20 (1.5%)	0/20 (0.0%)	9/20 (45.0%)	0/9 (0.0%)
2	91 (7.0%)	0/91 (0.0%)	38/91 (41.8%)	0/38 (0.0%)
3	177 (13.7%)	0/177 (0.0%)	75/177 (42.4%)	0/75 (0.0%)
4	297 (23.0%)	0/297 (0.0%)	130/297 (43.8%)	0/130 (0.0%)
5	434 (33.6%)	0/434 (0.0%)	193/434 (44.5%)	0/193 (0.0%)
6	570 (44.2%)	0/570 (0.0%)	258/570 (45.3%)	0/258 (0.0%)
>6	721 (55.8%)	0/721 (0.0%)	376/721 (52.1%)	0/376 (0.0%)
Overall	1291 (100%)	0/1291 (0.0%)	634/1291 (49.1%)	0/634 (0.0%)
PUBLIC				
1	20 (8.7%)	4/20 (20.0%)	12/20 (60.0%)	4/12 (33.3%)
2	54 (23.4%)	8/54 (14.8%)	26/54 (48.1%)	8/26 (30.8%)
3	83 (35.9%)	9/83 (10.8%)	38/83 (45.8%)	9/38 (23.7%)
4	108 (46.8%)	13/108 (12.0%)	53/108 (49.1%)	13/53 (24.5%)
5	125 (54.1%)	14/125 (11.2%)	59/125 (47.2%)	14/59 (23.7%)
6	146 (63.2%)	15/146 (10.3%)	70/146 (47.9%)	15/70 (21.4%)
>6	85 (36.8%)	4/85 (4.7%)	49/85 (57.6%)	4/49 (8.2%)
Overall	231 (100%)	19/231 (8.2%)	119/231 (51.5%)	19/119 (16.0%)
Rates are cumulative at each minute level				

Abbreviations: AED – automated external defibrillator; OHCA – out-of-hospital cardiac arrest; CPR – cardiopulmonary resuscitation; bCPR – bystander cardiopulmonary resuscitation.

home if multiple bystanders are present and can administer bystander CPR and retrieve the AED. For public OHCAs, only 133 (47.8%) were within a 4-minute walking distance, highlighting that the majority of public OHCAs are still outside of a reasonable retrieval distance despite the fact that the city-wide AED registry lists 1,422 AEDs. Our findings underscore both the opportunity and the chal-

lenges of AED placement in a city-wide registry to potentially reach the maximum number of individuals with OHCA.

The low rate of AED application for OHCA is likely attributable to several factors. These may include lack of awareness of the city-wide AED registry among residents and emergency telecommunicators, difficulty accessing AED location data during an OHCA, poor deployment planning in urban settings, lack of education on AED usage, bystander reluctance to use public-access defibrillators, medical-legal concerns, inadequate maintenance of existing systems, and insufficient funding.[20] To address these, the Centers for Disease Control and Prevention recommends targeted AED placement in high-risk settings, responder training, coordination with emergency medical services, development and implementation of emergency response planning, routine AED maintenance and testing, quality improvement monitoring, and civil immunity for lay rescuers. Our findings suggest that simply maintaining a city-wide AED registry may be insufficient, as overall rates of AED application for public OHCAs was only 6.8%, which is similar to rates nationally.[3] This work may be extended to identify OHCA hotspots and inform strategic AED deployment and accessibility efforts and support local initiatives, including community volunteer responders, telecommunicator assistance, or mobile applications to help identify and access the nearest AED.

Our findings should be interpreted in the context of potential limitations. First, we only examined one large U.S. city, and it is unclear how generalizable these results may be to other cities with an AED registry. However, the rates of bystander CPR and AED use in public arrests were generally consistent with national statistics (40% bystander CPR, 3–7% bystander AED use).[3] Second, we used a public AED registry that only lists registered AEDs and it is possible that this list of public AEDs may be incomplete. Thus, our findings represent a conservative estimate of the proportion of OHCAs within each stratum of walking distance. Third, we used geolocation data to compute straight-line distance and walking time, which can be less exact than walking-route based measures and does not factor in time to access AEDs, such as buildings with multiple floors.[21] Fourth, the presence of a public AED may not ensure accessibility (e.g., public AED is at a location that is not open 24-hours).[22] Fifth, the available data only indicate if a public AED was used and do not allow us to determine if it was a registered or unregistered public AED. Sixth, the stress of the COVID-19 pandemic on healthcare resources and infrastructure may have exacerbated existing barriers to healthcare access for individuals with an OHCA in KCMO, including limited public funding, public health staffing shortages, and heightened public scrutiny and distrust.[23]

Conclusion

In a large U.S. city with a publicly available AED registry, there were no instances in which a bystander accessed a public AED for an OHCA at home. For OHCAs in public, nearly half occurred within a 4-minute walk to the closest AED but bystander use of an AED was low.

Funding

- Dr. Khan is supported by the National Heart, Lung, and Blood Institutes of Health (T32HL110837).
- Dr. Chan receives research funding from the National Heart, Lung, and Blood Institute (R01HL160734).
- None of the above funders had any role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation,

Access to data and data sharing

Dr. Chan had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Data sharing statement

The present study analyzed data using the CARES registry. Qualified and interested researchers may request access to these data from the CARES registry.

CRediT authorship contribution statement

Mirza S. Khan: Writing – original draft, Visualization, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Kayla Riel:** Writing – review & editing, Resources. **Julie A. Stilley:** Writing – review & editing, Resources. **Erica Carney:** Resources. **Ryan B. Koehler:** Resources. **Rabab Al-Araji:** Writing – review & editing, Software, Resources, Methodology, Investigation, Formal analysis, Data curation. **Paul S. Chan:** Writing – review & editing, Visualization, Supervision, Methodology, Conceptualization.

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.

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