Resuscitation 120 (2017) 26–30

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical paper

Modeling a novel hypothetical use of postal collection boxes as automated external defibrillator access points☆

Sanjana Srinivasan [a], Jessica Salerno [a], Hadi Hajari [b], Lenny S. Weiss [a], David D. Salcido [a],*

[a] *University of Pittsburgh School of Medicine, Pittsburgh, PA, United States*
[b] *University of Pittsburgh School of Computing and Information, Pittsburgh, PA, United States*

ARTICLE INFO

Article history:
Received 3 April 2017
Received in revised form 20 July 2017
Accepted 21 August 2017

Keywords:
AED
Defibrillator
Cardiac arrest
Map

ABSTRACT

Introduction: Optimizing placement of Automated External Defibrillators (AED) can increase survival after an out-of-hospital cardiac arrest (OHCA). Using postal collection boxes (PCB) as locations for AEDs could potentially enhance accessibility and streamline maintenance. In this study, we modeled the hypothetical effects of deploying AEDs at PCB locations.
Hypothesis: We hypothesized that PCB-AEDs would increase AED coverage overall and in residential areas, and reduce the distance from OHCA to an AED.
Methods: AEDs in Pittsburgh, PA were identified by the University of Pittsburgh Resuscitation Logistics and Informatics Venture (n = 747). PCB locations were obtained from the United States Postal Service (n = 479). OHCA locations from 2009 to 2014 were obtained from the Pittsburgh site of the Resuscitation Outcomes Consortium. AED coverage assuming a ¼ mile radius around each AED was estimated for known AEDs, PCB-AEDs (hypothetical AED locations), and known AEDs augmented by PCB-AEDs, both overall and for residential and non-residential zones. Linear distance from each OHCA to the nearest AED was calculated and compared between the sets.
Results: The set of known AEDs augmented with PCB-AEDs covered more of the city overall (55% vs 30%), as well as greater proportions of residential (62% vs 27%) and non-residential areas (45% vs 30%). The median distance from OHCA to AED was significantly shorter when known AEDs were augmented with PCB-AEDs (0.12 mi vs 0.32 mi; p = 0.001).
Conclusion: Augmenting existing publicly accessible AEDs with AEDs deployed at PCBs can increase AED spatial coverage in both residential and non-residential areas, and reduce the distance from AED to OHCA.

Introduction

More than 350,000 OHCAs occur annually in the United States and survival rates are generally low, though there is indication that rates are improving over time [1]. The use of automated external defibrillators (AED) and bystander-initiated cardiopulmonary resuscitation (CPR) can improve survival rates and neurological outcomes [2,3]. AED accessibility and awareness of locations is not always optimal [4]. AEDs are not necessarily placed uniformly and tend to be geographically clustered, potentially increasing bystander AED retrieval times and subsequent arrival times at an OHCA [5]. Strategies for deploying public AEDs should ideally provide a wide and equitable coverage area while facilitating rapid access, maintenance, and location recognition.

Postal collection boxes (PCBs), or public mailboxes, are part of the infrastructure of national postal systems in the United States and elsewhere. PCBs serve as collection points for letters and small packages and can be located indoors or outdoors, as well as in commercial zones or residential zones. PCBs are prevalent in most cities and are intended to be easily accessible and readily recognizable. Moreover, by virtue of their role in national postal systems, PCBs are part of vast, comprehensive logistics networks that include transportation and delivery systems. Taken altogether, these features suggest a potential role for PCBs as AED locations.

To our knowledge, no study has considered the utility or effects of using PCBs as public AED locations. Therefore, we conducted a preliminary study to investigate the impact of a hypothetical PCB-based AED deployment strategy in the City of Pittsburgh, Pennsylvania. We hypothesized that integrating PCB-located AEDs into an existing network of AEDs would result in greater AED coverage

☆ A Spanish translated version of the abstract of this article appears as Appendixi n the final online version at http://dx.doi.org/10.1016/j.resuscitation.2017.08.220.

* Corresponding author at: 3600 Forbes Ave, Iroquois Building, Suite 400A, Pittsburgh, PA 15261, United States.
E-mail address: salcidodd@upmc.edu (D.D. Salcido).

http://dx.doi.org/10.1016/j.resuscitation.2017.08.220
0300-9572/

throughout the City, as well as shorter distances between AEDs and historical OHCA events.

Methods

This study was conducted under an existing protocol approved by the University of Pittsburgh Institutional Review Board for analysis of OHCA incidence and outcomes in the City of Pittsburgh.

AED coverage estimates

Locations of AEDs within the incorporated limits of the City of Pittsburgh, PA (n = 747) were collected by the University of Pittsburgh's Resuscitation Logistics and Informatics Venture (ReLIVe) and associated partner programs. Mechanisms for locating AEDs included crowdsourcing through the HeartMap Challenge [6], direct contact with AED distribution programs, and active searching throughout the city by study personnel. AED locations were first recorded as street addresses and then geocoded to latitude/longitude coordinates using the publically available Quantum Geographic Information Systems (QGIS, ver. 2.12.1, QGIS Development Team) software suite. The final location data set of "known AEDs" included all AEDs located by March 20, 2017.

PCB locations (n = 479) within the city limits were obtained from the United States Postal Service as street addresses and geocoded to latitude/longitude coordinates using QGIS [7]. PCB locations included only public use PCBs (blue boxes), not feeder locations (green boxes) used only by mail carriers. The geocoded locations of all qualifying PCBs were taken as the location data set for the hypothetical PCB-AEDs throughout this study.

We estimated AED coverage with and without inclusion of PCB-AEDs using three different methods. In the first method we determined the percentage of census tracts containing at least one AED with and without augmentation by PCB-AEDs. This method provided a general picture of the availability of AEDs in different areas of the City, but little spatial resolution for knowing whether the AEDs would be accessible equitably to the population in each census tract when needed. In the second method we determined the proportion of the total spatial area of the City covered by known AEDs with and without augmentation by PCB-AEDs, assuming that each AED was reasonably accessible in a ¼ mile radius around its base location. This method would afford a sense of the effect of PCB locations on accessibility using a distance limitation that corresponds to approximately 3 min of walking time at a brisk walking pace of 5 miles per hour. In the third method, we determined the proportion of the total residential area of the city covered, with the same ¼ mile access assumption. This method was intended to understand the added value of PCB-AEDs in reaching OHCA events in residential areas, since it is known that most AEDs tend to be located in public buildings while most OHCA events tend to occur in private locations. Proportions were reported in percentages. For comparison, and to reflect geographic regions or case circumstances in which a ¼ mile radius might be infeasible, we repeated the above analyses with an alternative 1/8 mile radius assumption.

AED – OHCA distance estimates

Case data for all EMS-assessed OHCA from 2007 to 2014 were obtained from the Pittsburgh Site for Resuscitation Outcomes Consortium (n = 2765). The Resuscitation Outcomes Consortium consisted of 10 regional clinical centers conducting research on out-of-hospital cardiac arrest and major trauma from 2005 to 2016 [8]. The street address of each OHCA event was retrieved from the electronic patient care report using a custom MATLAB (The Mathworks, Natick, MA) script and geocoded into latitude/longitude coordinates with QGIS.

To assess the distance between AEDs and OHCAs during the capture period of this cohort, we restricted our known AED data set to just those AEDs that were in our database as of December 31, 2014. We then separately calculated the direct linear ("as the crow flies") distance from each OHCA to the nearest known AED, the nearest PCB-AED, and the nearest of either, using the QGIS Hub Lines tool. Linear distance was chosen to avoid making assumptions about the probable path of responders retrieving the devices, as well as to provide an analogy to electronic bystander dispatch systems that alert volunteers to nearby cardiac arrests and AEDs, generally by linear proximity. (See Supplement for a preliminary treatment using a street distance approach.) The distance was initially calculated in arc degrees and then converted into feet. Mean (SD) distance from OHCA to AED was calculated for each set. To determine the net benefit of including PCB-AEDs, we calculated the average difference in distance from AED to OHCA using known AEDs only and known AEDs augmented by PCB-AED sets, as well as the proportion of OHCA cases with a reduced distance to AED after addition of PCB-AEDs. Distances from OHCA to AED were compared between sets with the Wilcoxon Signed-Rank test due to non-normally distributed data. An alpha level of 0.05 was used as the criterion of statistical significance, and all statistical calculations were performed in Stata 14 (StataCorp, College Station, Tx).

Results

Fig. 1 shows a map of the distribution of known AEDs and PCBs throughout the City of Pittsburgh, against the backdrop of residential zoning space. The City is divided into a total of 138 census tracts overlapping 90 individual neighborhoods of mixed zoning. Of the total spatial area of the City, 43% is zoned residential, where the category residential collapses several non-commercial categories that include Residential Single-Unit Detached (Very-Low Density), Residential Single-Unit Detached (Very-Low Density), Residential Two Unit (Very Low Density), Residential Single-Unit Attached (Moderate Density), Residential Three Unit Attached (Moderate Density), Residential Multi-Unit (Moderate Density), Residential Multi-Unit (High Density), and Residential Multi-Unit (Very-High Density). The remaining zoning codes were combined into a single non-residential category.

Known AEDs are present in 58% of census tracts, with a median (IQR) of 1 (0–3) AEDs per tract and a range of 0–236. PCBs are present in 71% of census tracts, with a median (IQR) of 2 (0–5) PCBs per tract and a range of 0–62. Overall, 8% of all known AEDs and 33% of PCBs fall within residential zoning areas. Assuming a ¼ mile accessibility radius, 30% of the City overall is currently covered by known AEDs, while 47% would be covered by PCB-AEDs alone and 55.44% would be covered by known AEDs augmented with PCB-AEDs. Assuming a 1/8 mile radius, these change to 12%, 21% and 27%, respectively. Of the area zoned residential throughout the City, 27% are covered by known AEDs, 53% would be covered by PCB-AEDs, and 62% would be covered by known AEDs augmented with PCB-AEDs. Under a 1/8 mile radius constraint, these change to 26%, 41% and 44%, respectively. In area zoned non-residential, 30% was covered by known AEDs and 45% was covered by known AEDs augmented by PCB-AEDs, or 15% and 25% assuming a 1/8 mile radius. Fig. 2 shows a map of coverage areas by each method under the ¼ mile assumption.

The median distance to OHCA was 0.32 mi (IQR = 0.17–0.53) for known AEDs, 0.16 mi (IQR = 0.09–0.33) for PCB-AEDs alone, and 0.12 mi (IQR = 0.06–0.25) for known AEDs augmented by PCB-AEDs (AEDs vs AEDs augmented by PCB-AEDs; $p < 0.001$). Among all OHCAs, the distance from OHCA to AED was shorter in 57% of cases when augmenting known AEDs with PCB-AEDs.