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Clinical paper

Where are lifesaving automated external defibrillators located and how hard is it to find them in a large urban city?☆

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ABSTRACT

Objectives: Automated external defibrillators (AEDs) are lifesaving, but little is known about where they are located or how to find them. We sought to locate AEDs in high employment areas of Philadelphia and characterize the process of door-to-door surveying to identify these devices.

Methods: Block groups representing approximately the top 3rd of total primary jobs in Philadelphia were identified using the US Census Local Employment Dynamics database. All buildings within these block groups were surveyed during regular working hours over six weeks during July–August 2011. Buildings were characterized as publically accessible or inaccessible. For accessible buildings, address, location type, and AED presence were collected. Total devices, location description and prior use were gathered in locations with AEDs. Process information (total people contacted, survey duration) was collected for all buildings.

Results: Of 1420 buildings in 17 block groups, 949 (67%) were accessible, but most 834 (88%) did not have an AED. 283 AEDs were reported in 115 buildings (12%). 81 (29%) were validated through visualization and 68 (24%) through photo because employees often refused access. In buildings with AEDs, several employees (median 2; range 1–8) were contacted to ascertain information, which required several minutes (mean 4; range 1–55).

Conclusions: Door-to-door surveying is a feasible, but time-consuming method for identifying AEDs in high employment areas. Few buildings reported having AEDs and few permitted visualization, which raises concerns about AED access. To improve cardiac arrest outcomes, efforts are needed to improve the availability of AEDs, awareness of their location and access to them.

1. Introduction

Every year approximately 500,000 cardiac arrests occur in the US[1,2] Automated external defibrillators (AEDs) are small portable emergency devices that are intended to shock ventricular fibrillation so as to restore a normal perfusing rhythm to help cardiac arrest victims. Despite the lifesaving value of AEDs, these devices are rarely used in community, non-clinical settings.[3] People often cannot locate them in an emergency—either because no AED is nearby, or because nearby AEDs may be hidden, unnoticed, or unavailable for use. Public maps with locations of AEDs are largely incomplete or unavailable when needed and no comprehensive methodology for determining the location of AEDs exists. Knowledge of AED locations may facilitate their AED retrieval and usage as well as reduce the time to defibrillation and poor outcomes given that the chance of survival decreases 7–10% each minute in cardiac arrest.[4–6]

The American Heart Association (AHA) recommends that AEDs be placed in large variety of targeted public areas, such as sports arenas, gated communities, office complexes, doctor's offices, and shopping malls, based on the anticipated frequency of events and timeliness of response.[7,8] The Cardiac Arrest Survival Act of 2000

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encouraged the placement of AEDs within federal buildings and created guidelines for public access defibrillation.[9,10] Some states require AEDs to be placed in schools but in general AED availability is minimally regulated.[11]

Even when an AED is present in a building, its location within the building is generally not regulated, making placement inconsistent.[12,13] AEDs are also easy to ignore: people walk by them every day without awareness of their existence. The presence or absence of AEDs in a building is rarely publicized with external signage, online or in brochures.

Although many studies have shown the effectiveness of public access defibrillation and the location of cardiac arrests in communities, little is known about how to actually find existing placed AEDs.[10,14–16] While others have selectively confirmed the presence of known AEDs or within a particular type of building, to the best of our knowledge no study has attempted to comprehensively survey all buildings within a geographic area for AEDs.[17,18] Effective methods of finding currently placed AEDs can potentially lead to comprehensive maps of AEDs to be used by dispatchers and first responders.[13] We used door-to-door surveying to locate AEDs in high-density employment areas and to identify the efficacy and barriers of such approach.

2. Methods

We surveyed regions of high employment density as AEDs are designed to be used by the lay public. We chose regions based on employment density (number of primary jobs per block group) with the assumption that these regions are more likely to have publically accessible, commercial buildings. Alternatively, surveying regions with the highest employed population would likely include high public traffic areas and some residential neighborhoods. Candidate sites for surveying were identified as the top 1% of block groups ($n = 17$) in Philadelphia County based on the absolute number of workers as reported in the 2009 Local Employment Dynamics (LED) data from the US Census Bureau.[19] The US Census Bureau divides census tracts into block groups, which are small clusters of blocks containing between 600 and 3000 people.[20] Block groups are formed by streets, roads, railroads, bodies of water, other visible physical and cultural features, and the legal boundaries shown on US Census Bureau maps.[21]

Four research staff (ACL, KNL, OBS, JMA) were assigned to go door-to-door looking for AEDs in each block group. These were divided into teams of two and each team surveyed separate sides of the street. Research staff were trained prior to survey collection. All research staff used a standardized script, stating their affiliation and purpose, and asked the first available employee at the front desk or entrance if the building had AED(s). If the employee(s) did not know what an AED was, research staff explained the purpose of an AED and showed the employee(s) pictures of AEDs. If the first individual queried was unsure about the presence or absence of an AED, they were asked to identify another person who may know this information. In some cases, follow up in person and/or via email or phone was required after the initial visit to query a person of authority such as the director of safety or security for the building. Every attempt was made to ensure that the person most likely to have information about AEDs was queried.

Surveying occurred for six weeks Monday to Friday between 9 am and 5 pm during July–August of 2011. Visits were attempted at every building, and information was collected about the building, the presence or absence of AEDs, and the process of obtaining this information.

2.1. Building level data

All buildings within each block group were systematically visited to determine if AEDs were present or absent during standard daytime business hours. Some buildings had multiple businesses at a given address.

The number of buildings in each block group was recorded and coded as publically accessible or inaccessible based on the status at the time of surveying. Publically inaccessible buildings were categorized into the following groups: (1) closed, the building was not active during the time of surveying; (2) locked, the building was not open to the public; (3) vacant, the building was not operational; (4) unsafe, research staff did not feel comfortable entering the building. The name, address and location type for buildings was also recorded.

2.2. AED data

For identified AEDs, information regarding: manufacturer name, known prior use of the AED, the number of AEDs at the location, and detailed location of AED (i.e. 2nd floor, next to the elevator) was also obtained through visualization by research staff and querying employees.

In some cases an employee reported that a building had one or more AEDs but the research staff were not allowed to see them. For visualized AEDs, the working condition and visibility of the AED was recorded. Visibility was classified into the following categories: (1) not readily visible, AED is not in plain sight for employees and/or patrons [i.e. AED is kept in a desk drawer or closet]; (2) partially obstructed, AED is partially in plain sight, but somewhat blocked; (3) visible from all angles, AED is in plain sight. The working condition of the AED was determined using indicators unique to the AED manufacturer and model. When permitted, AEDs were photographed using a smartphone with GPS capabilities to document for location analysis.

2.3. Process information

In publically accessible buildings, the time required to locate an AED and the number of people engaged to determine this information was recorded.

2.4. Data analysis

Summary statistics characterized buildings surveyed, AED density of the study geographic region, and AED characteristics. Number of AEDs and number of buildings with AEDs per 10,000 primary jobs was calculated for each of the 17 block groups. We used linear regression to determine if there was an association between the total number of jobs per block group and number of AEDs/buildings with AEDs. Additionally, process measures (e.g. number of people accessed to collect study data and time spent surveying) were reported as medians with ranges.

All statistical analyses were performed using SAS statistical software (Version 9.3, SAS Institute, Cary, NC). This study was approved by the Institutional Review Board at the University of Pennsylvania.

3. Results

3.1. Building level results

We identified 1420 buildings in 17 block groups; 949 (67%) were publically accessible and the remaining 471 (33%) buildings were identified as closed, locked, unsafe, or vacant during the study time frame and hours of surveying (Fig. 1). There were 283 AEDs reported in 115 buildings (12% of publically accessible buildings in

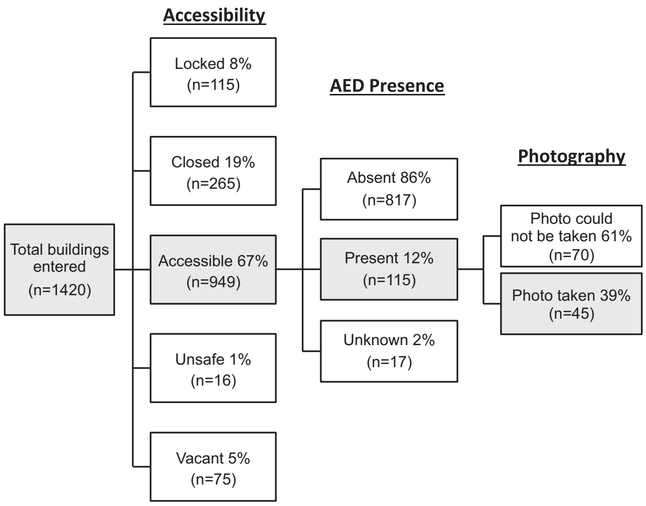

Fig. 1. Public accessibility, presence and ability to photograph AEDs by building.

Table 1
AED access, maintenance, and visibility.

	Reported AEDs	
	Frequency	Percent
Permitted to see AED (n = 283)		
Yes	81	29%
No	202	71%
Permitted to photograph (n = 283)		
Yes	68	24%
No	215	76%
Prior use (n = 283)		
Yes	10	4%
No	69	24%
I do not know	204	72%
Working condition (n = 81)		
Yes, working	49	61%
No, not working	1	1%
Unknown	31	38%
Visibility (n = 81)		
Not readily visible	28	35%
Partially obstructed	17	21%
Visible from all angels	36	44%

AED: automated external defibrillator.

the catchment area). The median number of AEDs per building was 1 (range 1–35). Employees in 817 publically accessible buildings (86%) reported not having an AED. Employees in 17 buildings (2%) did not know if their building of employment had an AED.

Of buildings with AEDs, 36 (31%) were in office buildings, 12 (10%) in medical centers, 11 (10%) in schools, 10 (9%) in hotels and 10 (9%) in government buildings. The majority of retail locations 445 (98%) and restaurants 214 (99%) did not report having AEDs whereas 67% of gyms and theaters/concert halls and 56% of government buildings did report having AEDs (6/9,4/6 and 10/18, respectively (Fig. 2)).

3.2. AED data

Research staff directly visualized 81 (29%) and photographed 68 (24%) of reported AEDs. Of the 81 AEDs visualized, 28 (35%) were not in locations that were easily visible, 17 (21%) were in locations that were partially obstructed, and 36 (44%) were visible from all angles. Functionality was determined in 50 (62%) of visualized AEDs. Ten AEDs (4%) were noted to have been previously used (Table 1).

3.3. Block group data

The 17 block groups comprised 38% (219,981/579,523) of the total primary jobs in Philadelphia County. We standardized comparisons of the numbers of AEDs per block group by the number of primary jobs per block group, which varied from 5952 to 43,655. The median number of AEDs per 10,000 jobs per block group was 10 (range: 0–25). The median number of buildings with an AED per 10,000 jobs per block group was 5 (range: 0–12). There was no relationship between jobs per block group and the number AEDs or number of buildings with AEDs (p = .14 and .82, respectively, Fig. 3).

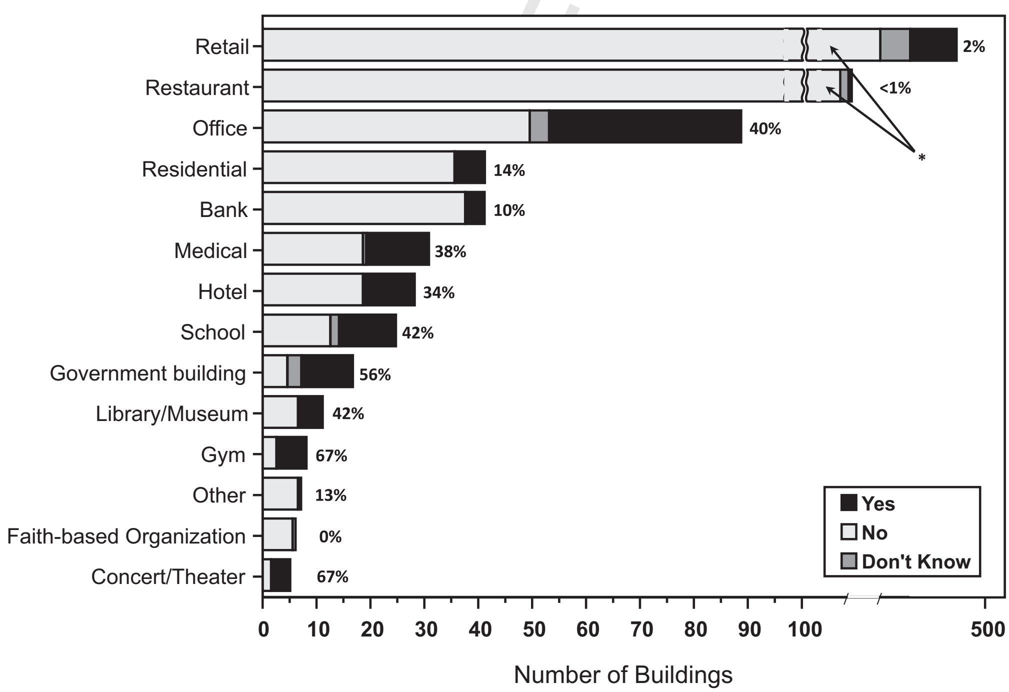

Fig. 2. Reported presence or absence of AEDs by building type.

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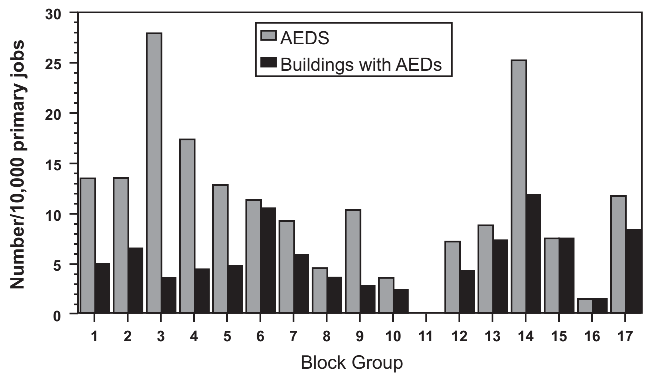

Fig. 3. Proportion of AEDs and buildings with AEDs per 10,000 primary jobs.

3.4. Process information

Ascertaining information about AEDs was often challenging. Workers in buildings with and without AEDs frequently did not know what an AED was, who might know where to locate one, or if the building where they were employed had a device. The person most likely to provide information about the presence or absence of an AED was usually a security guard (17%), receptionist (7%), building manager (3%) or other employee (73%). More people were contacted in buildings with AEDs (median = 2) compared with buildings without AEDs (median = 1). Research staff contacted more than 2 people (range: 1–8) in 200 (21%) of publically accessible buildings. The mean time spent surveying per building was 4 min, with a wide range (1–55 min).

4. Discussion

This paper has three main findings. First, door-to-door surveying is a feasible, but limited method to locate AEDs. Of 1420 buildings visited over six weeks, 283 AEDs were reported and 81(29%) were visually verified. The door-to-door surveying technique attempted to encompass all buildings within a geographic area. Other studies have selectively verified specific locations. Cacko et al. verified locations thought to have AEDs by phone and visited random locations and found 115 AEDs in 83 locations in Warsaw, Poland.[17] This differs from our study, which verified AED availability in all buildings without any previous knowledge of device presence.

Second, although door-to-door surveying is feasible, it is time-consuming, as 12% of 949 publically accessible buildings had AEDs. Furthermore, in buildings with AEDs, several employees (median 2; range 1–8) had to be contacted to ascertain information about AED locations and characteristics, which required considerable time (mean 4 min; range 1–55 min) and sometimes multiple visits. The number of people contacted and time required to find AEDs may reflect lack of AED awareness. In a phone survey performed by Barnhart et al. in the New York City Area, only half of the participants were aware of the existence and capabilities of AEDs.[22] Similarly, Schober et al. surveyed more than a thousand people in a busy station in Amsterdam, Netherlands and found that 53% were unable to recognize an AED.[23] Improvements in AED awareness may facilitate use during an emergency.

Additionally, queried individuals were often hesitant about providing information regarding the availability of an AED in their building, which also made surveying more challenging. This is evident from the small percentage of AEDs research staff were permitted to see (29%) and photograph (24%). However, further research is necessary as to why businesses are protective of this information.

Third, the location of AEDs within buildings that had them varied considerably. Of the 81 AEDs research staff were able to visualize, the majority (56%) were in locations that were either partially obstructed or not easily visible. AEDs were often in boxes with alarms and so RAs were not able to remove the AED for a more thorough determination of functionality. This limited visibility made it difficult to determine the functionality of AEDs as functionality was determined in 62% of visualized AEDs. Prior work by Folke et al. analyzing public cardiac arrest locations showed that the strategic placement of AEDs near high incidence areas is crucial for public access defibrillation.[24] Regulations standardizing the placement of AEDs may lead to more consistent AED placement, thereby making AEDs easier to find and maintain functionality.[10] A comprehensive map of publically accessible AEDs can potentially help bystanders locate the nearest device in the event of a cardiac arrest. If this map was widely distributed, bystanders could either call a 911 dispatcher or use a mobile device to determine the location of the nearest AED.[13] By quickly determining the closest AED, bystanders could retrieve the device more rapidly and possibly improve cardiac arrest outcomes. Further supportive efforts could include legislation to support AED registries and incorporation of AED maintenance and assessment into annual commercial building inspections by fire marshals. This approach could also be leveraged by advocacy groups and undertaken in collaboration with municipalities to further promote the importance of this public health issue regarding emergency resources.

5. Limitations

This study has several limitations. We surveyed 17 block groups, which encompassed 38% of the total jobs in Philadelphia. Other, less employment dense, geographic regions may exhibit different patterns of AED distribution. Further, our approach may have missed high AED dense areas such as stadiums and other venues with large public crowds.

Surveying occurred during standard business hours so the number of publically accessible building was limited (67%). Building access however, likely reflects that which would be publically accessible to a cardiac arrest responder during standard daytime business hours.

Some buildings may have AEDs, but their employees might not have known about them. While this could understate the number of AEDs, this may reflect the challenges of bystanders looking for AEDs during actual emergencies.

Classification of visibility and building type were subjective, but reflects best determination by research staff.

The main strengths of this study were buildings were surveyed without prior knowledge of AED presence, entry was attempted in all buildings within a designated geographic area and a variety of building types were accessed. Most importantly, the information collected from the block groups surveyed could be provided to the public and 911 dispatchers to use in the event of a sudden cardiac arrest. Further, this canvassing approach could be used to establish a baseline AED database which could be periodically updated via contact with identified device owners or contact with the public via crowdsourcing.

6. Conclusions

Door-to-door surveying is a feasible, but time-consuming method for identifying AEDs in high employment areas. Few buildings reported having AEDs and many could not be visualized. This raises concerns about access to these devices in an emergency. To improve cardiac arrest outcomes, continued efforts are needed to

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improve AED awareness, availability, visibility, accessibility, and use.

Conflict of interest statement

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