Automated External Defibrillators Inaccessible to More Than Half of Nearby Cardiac Arrests in Public Locations During Evening, Nighttime, and Weekends

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**Background**—Despite wide dissemination, use of automated external defibrillators (AEDs) in community settings is limited. We assessed how AED accessibility affected coverage of cardiac arrests in public locations.

**Methods and Results**—We identified cardiac arrests in public locations (1994–2011) in terms of location and time and viewed them in relation to the location and accessibility of all AEDs linked to the emergency dispatch center as of December 31, 2011, in Copenhagen, Denmark. AED coverage of cardiac arrests was defined as cardiac arrests within 100 m (109.4 yd) of an AED and further categorized according to AED accessibility at the time of cardiac arrest. Daytime, evening, and nighttime were defined as 8 AM to 3:59 PM, 4 to 11:59 PM, and midnight to 7:59 AM, respectively. Of 1864 cardiac arrests in public locations, 61.8% (n=1152) occurred during the evening, nighttime, or weekends. Of 552 registered AEDs, 9.1% (n=50) were accessible at all hours, and 96.4% (n=532) were accessible during the daytime on all weekdays. Regardless of AED accessibility, 28.8% (537 of 1864) of all cardiac arrests were covered by an AED. Limited AED accessibility decreased coverage of cardiac arrests by 4.1% (9 of 217) during the daytime on weekdays and by 53.4% (171 of 320) during the evening, nighttime, and weekends.

**Conclusions**—Limited AED accessibility at the time of cardiac arrest decreased AED coverage by 53.4% during the evening, nighttime, and weekends, which is when 61.8% of all cardiac arrests in public locations occurred. Thus, not only strategic placement but also uninterrupted AED accessibility warrant attention if public-access defibrillation is to improve survival after out-of-hospital cardiac arrest. *(Circulation. 2013;128:2224-2231.)*

**Key Words:** cardiopulmonary resuscitation • defibrillators • heart arrest • resuscitation

Automated external defibrillators (AEDs) have been widely disseminated in the Western world, with >1 million AEDs sold in the United States alone.¹⁻³ Several countries have implemented national public-access defibrillation programs, and in North America, several states have made it mandatory to deploy an AED at defined locations.³⁻⁹ Despite this large dissemination, AED use in the community setting remains limited; the reasons for this are not completely understood.¹³⁻⁶,¹⁴ Thus, improved strategies to increase AED use in community settings are warranted.¹⁵⁻¹⁸

**Clinical Perspective on p 2231**

For AEDs to be used and to fulfill their lifesaving potential, they need to be close to the victim and accessible at the time of cardiac arrest.¹⁹⁻²¹ Moreover, within minutes of cardiac arrest, bystanders must be able to locate and bring the AED to the victim. Accordingly, the potential of an AED depends entirely on its placement and accessibility and on bystanders’ knowledge of these factors. Such conditions pose obvious challenges to AED use, and failure to overcome these challenges may be the main limitation to the lifesaving potential of AEDs in community settings.¹⁻³,⁷,⁹⁻¹²

One strategy to increase AED use is to place the devices in areas with a high incidence of cardiac arrest, as encouraged by the current guidelines.⁴⁻¹¹,¹⁵⁻²²,²⁶⁻²⁸ However, once deployed, AEDs need to be accessible at the right time. Several public-access defibrillation studies have been conducted in environments with 24-hour AED accessibility.²⁻³,¹⁰,²²,²₃,²₆,²⁷ However, it is unknown...
what proportion of AEDs deployed in real-life community settings are actually accessible at the time of nearby cardiac arrest.1 Furthermore, current guidelines do not mention how AED accessibility should be approached, despite limited accessibility impeding AED use even when a cardiac arrest occurs nearby.

To increase insight into how AED accessibility affects AED coverage of cardiac arrests in public locations, we conducted a retrospective analysis of the time and location of all cardiac arrests in public locations during 1994 through 2011 and of the location and accessibility of all AEDs linked to the emergency dispatch center as of December 31, 2011, in Copenhagen, Denmark. AED coverage of cardiac arrests regardless of AED accessibility was determined and was reassessed, including AED accessibility at the time of cardiac arrest. Furthermore, we examined how coverage of cardiac arrests changed depending on the time of day, the day of the week, and the type of AED location.

Methods

Study Setting

The city of Copenhagen covers 97 km² (60 square miles) and has a resident population of ≈600,000. The emergency medical service of Copenhagen is a 2-tiered system comprising advanced life support provided by physician-staffed ambulances and basic life support provided by ambulances equipped with defibrillators. In the event of cardiac arrest, both tiers of response are activated simultaneously. Data from each cardiac arrest were systematically recorded by the physician at the scene, who adhered to the Utstein guidelines for reporting out-of-hospital cardiac arrests.

Study Population

We identified 8125 cases of out-of-hospital cardiac arrest confirmed by the absence of signs of circulation in Copenhagen from January 1, 1994, to December 31, 2011.2 Because of incomplete data registration, we did not identify cases of out-of-hospital cardiac arrest from 1999. Only patients who were eligible for an on-site resuscitation attempt by the physician were included in the study.

We excluded 924 cardiac arrests: 58 because of unregistered location of arrest and 866 because of noncompliance with Utstein guidelines (cardiac arrests resulting from suicide, poisoning, drowning, trauma, and exsanguination and in patients judged to be terminally ill by the doctor on location). Of the remaining 7201 cardiac arrests, 1864 (25.9%) occurred in public locations, defined as all areas accessible to the general public, including all outdoor locations, public transportation sites, schools, outpatient clinics, and commercial and civic establishments, and were included in the study. Information on patients' survival status (dead or alive) at least 30 days after the date of cardiac arrest was obtained from the Central Population Registry through Statistics Denmark.

Danish AED Network

Since 2007, AEDs available for public-access defibrillation have been registered online in a Danish AED network (the Heart Start Network, www.hjertestarter.dk), managed by the private foundation TrygFonden. Registration with the network is entirely voluntary but strongly recommended by the Danish National Board of Health and most AED vendors. The network is nationwide and has been accessible to all emergency dispatch centers since May 2010, providing information on AED location, type of establishment, date of inauguration, and exact days and hours of AED accessibility. This information is validated through a call center every 6 months. The technology enables the emergency dispatch center to identify the nearest accessible AED in the event of a cardiac arrest. If the AED is not on site and it is not possible for a bystander at the location of the cardiac arrest to fetch the AED, the dispatcher can contact the AED location and request that the AED be delivered to the location of the cardiac arrest. All AEDs registered with the Danish AED network by December 31, 2011, in Copenhagen were included in the study (n=552).

Study Design

The exact locations of cardiac arrests and AEDs were determined by a geographic information system (Geomatic) and marked on a digital city map, a method used previously.25,29,30 An AED was considered to cover an area with a radius of 100 m (109.4 yd) based on the estimate that an AED within that range could be transported by bystanders to the victim within 1½ minutes, in accordance with the American Heart Association recommendations.2 It was assumed that 1 AED could provide coverage for all historical cardiac arrests within a radius of 100 m (109.4 yd). If >1 AED was within 100 m (109.4 yd) of a cardiac arrest, the nearest AED was chosen to be the one to cover the cardiac arrest.

Analysis of AED Coverage of Cardiac Arrests

Analysis of AED coverage of cardiac arrests was performed using time and location of all cardiac arrests in public locations during 1994 through 2011 in relation to location and accessibility of all AEDs linked to the emergency dispatch center as of December 31, 2011. The AED coverage of historical cardiac arrests was assessed on 2 levels. First, we assessed the AED coverage of historical cardiac arrests regardless of AED accessibility. Second, we reassessed the AED coverage of historical cardiac arrests taking time of cardiac arrest and AED accessibility into consideration. It was assumed that the incidence of cardiac arrests in public locations followed the Poisson distribution, and confidence intervals for coverage of cardiac arrests were calculated accordingly. The loss of AED potential was calculated as the difference between the number of cardiac arrests within 100 m (109.4 yd) of an AED regardless of accessibility and the number of cardiac arrests occurring within the radius of an AED accessible at the time of the event. Daytime, evening, and nighttime were defined as 8 AM to 3:59 PM, 4 to 11:59 PM, and midnight to 7:59 AM, respectively. Weekends were defined as Saturday and Sunday and weekdays as Monday through Friday.

Statistical Analysis

Binary variables are presented in tables and figures as absolute numbers and percentages. Continuous variables are presented as medians with interquartile range, except for the variable response time, which is presented as means with standard deviations (SD). Binary variables were compared by use of the χ² test.

For all analyses, a 2-sided value of P<0.05 was considered statistically significant. All analyses were done with the SAS statistical software package version 9.2 (SAS Institute Inc, Cary, NC) and R version 2.15.1 (R Core Team; R: A Language and Environment for Statistical Computing; R Foundation for Statistical Computing; Vienna, Austria; 2012; ISBN 3-900051-07-0; http://www.R-project.org/).

All authors had full access to all data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. All authors have read and agreed to the manuscript as written.

No ethics approval is required for retrospective registry studies in Denmark. The study was approved by the Danish Data Protection Agency (No. 2008-41-2685).
Automated External Defibrillators
A total of 552 AEDs were registered in the study area as of December 31, 2011 (5.7 AEDs per km² [9.2 per square mile] on average). Of those, 49.8% (n=275) were placed in government or municipal buildings. The proportions of AEDs accessible for public-access defibrillation by hour of day and day of week are shown in Figure 2 and Figure I in the online-only Data Supplement. Most AEDs were accessible during the daytime on all weekdays. Only 9.1% (n=50) of all AEDs were accessible 24 hours a day, 7 days a week.

Loss of AED Potential Through Limited AED Accessibility
Regardless of AED accessibility and time of cardiac arrest, 28.8% (n=537) of all cardiac arrests occurred within 100 m (109.4 yd) of an AED, and this proportion did not vary significantly with hour of day or day of week (P=0.42; Figure 3).

A total of 30.5% (217 of 712) of the cardiac arrests occurring during the daytime on weekdays and 27.8% (320 of 1152) of those occurring during the evening, nighttime, or weekends were within 100 m (109.4 yd) of an AED. Thus, assuming all AEDs were accessible 24 hours a day, 7 days a week, nearly 30% of all cardiac arrests in public locations could be reached by an AED within a few minutes on weekdays and weekends.

When AED accessibility and time of cardiac arrest were taken into account, AED coverage of cardiac arrests was 29.5% (208 of 712) for those occurring during the daytime on weekdays but only 12.9% (149 of 1152) for cardiac arrests occurring during the evening, nighttime, or weekends.

Of the 537 cardiac arrests occurring within 100 m (109.4 yd) of an AED, there was no access to the AED at the time of the cardiac arrest in 180 cases. Thus, the overall loss of AED potential was 33.5% (180 of 537). The corresponding figures were 4.1% (9 of 217) for cardiac arrests during the daytime.

Table 1. Baseline Characteristics of Subjects With Out-of-Hospital Cardiac Arrest in Public From 1994 Through 2011

<table>
<thead>
<tr>
<th>Baseline Characteristics</th>
<th>Cardiac Arrests in Public (n=1737)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>Median age (IQR), y</td>
<td>63 (24)</td>
</tr>
<tr>
<td>Men, n (%)</td>
<td>1315 (75.7)</td>
</tr>
<tr>
<td>Mean±SD response time, min‡</td>
<td>5.0±2.4</td>
</tr>
<tr>
<td>VF/pVT, n (%)</td>
<td>684 (39.4)</td>
</tr>
<tr>
<td>Asystole, n (%)</td>
<td>646 (37.2)</td>
</tr>
<tr>
<td>Pulseless electric activity, n (%)</td>
<td>229 (13.2)</td>
</tr>
<tr>
<td>Other/unknown rhythm, n (%)§</td>
<td>178 (10.3)</td>
</tr>
<tr>
<td>Survival after 30 d, n (%)</td>
<td>324 (18.7)</td>
</tr>
</tbody>
</table>

IQR indicates interquartile range; pVT, pulseless ventricular tachycardia; and VF, ventricular fibrillation.
*127 cases had an invalid identification number, mainly because of foreign resident status. Baseline characteristics were not available for these cases.
†Daytime, evening, and nighttime were defined as 8 AM to 3:59 PM, 4 to 11:59 PM, and midnight to 7:59 AM, respectively.
‡Interval between call to emergency medical services and ambulance arrival.
§Other/unknown rhythm includes pace rhythms, atrioventricular blocks, and unknown rhythm.

Figure 1. Cardiac arrests in public locations during the daytime on weekdays according to year. Incidence of cardiac arrests in public locations during the daytime on weekdays in Copenhagen, Denmark (1994–2011). Error bars show confidence intervals based on the assumption that the incidence of cardiac arrests in public locations followed the Poisson distribution.

Figure 2. Automated external defibrillator (AED) accessibility by hour of day and day of week. AED accessibility is based on all AEDs registered with the Danish AED network in Copenhagen, Denmark, by December 31, 2011. Weekdays were defined as Monday through Friday and weekends as Saturday and Sunday.
and 53.4% (171 of 320) for those during the evening, night-time, or weekends.

AED Coverage by Period of Day and Type of Location

The majority of cardiac arrests (n=237) were covered by AEDs in offices; 80.6% (112 of 139) of those occurring during the daytime had access to the AED at the time of cardiac arrest (Table I in the online-only Data Supplement). The corresponding figures were 18.1% (15 of 83) and 11.4% (4 of 35) for cardiac arrests during the evening and nighttime, respectively. Cardiac arrests covered by AEDs at train stations, hotels, and police stations/fire departments had access to AEDs regardless of the time of cardiac arrest.

Loss of AED Potential Through Limited Accessibility From Type of Location

The loss of AED potential according to type of location is shown in Table 2. The largest loss in potential was observed for AEDs in banks (69.2%), offices (49.0%), and private medical or dental practices (47.6%). AEDs at train stations, hotels, and police stations/fire departments had no loss in potential.

Discussion

Our results show that AEDs were highly accessible during the daytime on weekdays but considerably inaccessible during the evening, nighttime, and weekends, which was when most cardiac arrests occurred. Consequently, nearly all cardiac arrests within 100 m (109.4 yd) of an AED during the daytime on weekdays could have access to the AED. Conversely, more than half of cardiac arrests during the evening, nighttime, or weekends could not have access to a nearby AED. These findings indicate that limited AED accessibility is a major limitation of the potential of AEDs in community settings.

Previous studies have suggested that for AEDs to be used, they need to be widely disseminated, strategically placed, and linked to the emergency dispatch center.3,8,12,22,23,25,31 Since 2005, the number of AEDs available for public-access defibrillation in Copenhagen has increased >5-fold (from 104 in 2005 to 552 in 2011), and a national network has been established with exact AED location and accessibility linked to the Emergency Dispatch Center.25 Notably, our results show that AEDs were within 100 m (109.4 yd) of nearly one third of all cardiac arrests in public locations, regardless of hour of day or day of week. Furthermore, AEDs near cardiac arrests during the daytime on weekdays were virtually always accessible to bystanders. However, if bystanders witnessed a cardiac arrest during the evening, nighttime, or weekends, a nearby AED would have been inaccessible in more than half of those cases (53.4%), even though it was within walking distance of the cardiac arrest. The importance of AED accessibility and how it can limit AED use in community settings has not previously been assessed, and studies with the highest effect on survival were conducted in settings with 24-hour AED accessibility.2,3,8,19,22,23,26,32 Our findings underline that not only the location but also the time of cardiac arrest should be taken into consideration and that 24-hour AED accessibility...
should be encouraged in future guidelines for public-access defibrillation programs.

AED deployment in our study, as in many other communities, was driven by public and private initiatives. 2,3,9,11–14,19,33 As in our study, a recent Canadian study reported the major- ity of AEDs were placed in offices and schools. This study also reported low AED use but did not include information on AED accessibility. 13 Our finding that limited AED accessibility is a major limitation to AED potential in community settings can be valuable to guide other communities trying to identify factors restricting AED use. 1,24

Different approaches could be considered to promote an increase in AED accessibility and thereby facilitate AED use. Multimedia campaigns have previously succeeded in increasing AED awareness, and campaigns targeted at increasing public awareness of how low AED accessibility limits the potential of an AED to save additional lives may encourage AED owners to render their AEDs more accessible. 24 In Denmark, TrygFonden, the foundation that founded the AED network, along with the Danish Resuscitation Council, the Danish Heart Foundation, the Danish National Board of Health, and AED vendors, have continuously emphasized the importance of AED registration with the network, which has led to voluntary registration of >8000 AEDs over the past 6 years. 36 The adherence to the AED network confirms that increasing public awareness can contribute greatly to AED implementation. Accordingly, a continuous emphasis on the importance of 24-hour AED accessibility by key organizations in the community could contribute to improving AED accessibility.

Policymakers could also develop new legislation or revise existing legislation to help increase AED accessibility. Unlike several states in the United States, it is not mandatory to install AEDs at certain locations or buildings in Denmark. It is also not mandatory to provide 24-hour AED accessibility. 5 However, the Danish National Board of Health issued national AED recommendations in 2011 stating that all AEDs placed in municipal or government buildings should be accessible 24 hours a day. Because 49.8% (n=275) of all registered AEDs in our study were placed in municipal or government buildings, AED accessibility could improve greatly if these recommendations were followed strictly or if new legislation required these buildings to have 24-hour accessibility.

Another approach to increase AED accessibility would be to use mathematical optimization techniques to identify high-incidence cardiac arrest locations lacking 24-hour accessibility, or temporal “hot spots.” 14,25 Authorities could then use these findings as guidance to complement already deployed AEDs, increasing accessibility where it is needed and thus intelligently use public resources to complement privately deployed AEDs. 14

Other ways to improve AED accessibility in public locations could be through placing the AEDs in vending machines or protective cabinets at strategic locations. Protective outdoor AED cabinets with first-aid instructions and direct connection to the emergency medical services are available for purchase.

### Table 2. Loss of AED Potential Through Limited Accessibility From Type of Location

<table>
<thead>
<tr>
<th>Location of AEDs</th>
<th>AEDs, n (%)</th>
<th>Cardiac Arrests ≤100 m (109.4 yd) of an AED, n (arrests per AED)</th>
<th>Cardiac arrests ≤100 m (109.4 yd) of an Accessible AED, n (arrests per AED)</th>
<th>Loss of AED Potential, %†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>314 (56.9)</td>
<td>257 (0.8)</td>
<td>131 (0.4)</td>
<td>49.0</td>
</tr>
<tr>
<td>School, kindergarten, university</td>
<td>73 (13.2)</td>
<td>49 (0.7)</td>
<td>29 (0.4)</td>
<td>40.8</td>
</tr>
<tr>
<td>Sports facility</td>
<td>59 (10.7)</td>
<td>64 (1.1)</td>
<td>56 (1.0)</td>
<td>12.5</td>
</tr>
<tr>
<td>Theater, museum, library, zoo</td>
<td>26 (4.7)</td>
<td>26 (1.0)</td>
<td>16 (0.6)</td>
<td>38.5</td>
</tr>
<tr>
<td>Bank</td>
<td>17 (3.1)</td>
<td>13 (0.8)</td>
<td>4 (0.2)</td>
<td>69.2</td>
</tr>
<tr>
<td>Hotel</td>
<td>14 (2.5)</td>
<td>10 (0.7)‡</td>
<td>14 (1.0)‡</td>
<td>No loss</td>
</tr>
<tr>
<td>Store, shopping mall</td>
<td>13 (2.4)</td>
<td>20 (1.5)</td>
<td>18 (1.4)</td>
<td>10.0</td>
</tr>
<tr>
<td>Private medical practice/dental practice</td>
<td>12 (2.2)</td>
<td>21 (1.8)</td>
<td>11 (0.9)</td>
<td>47.6</td>
</tr>
<tr>
<td>Public shelter, addiction center</td>
<td>10 (1.8)</td>
<td>16 (1.6)</td>
<td>15 (1.5)</td>
<td>6.3</td>
</tr>
<tr>
<td>Police station/fire department</td>
<td>5 (0.9)</td>
<td>14 (2.8)</td>
<td>14 (2.8)</td>
<td>No loss</td>
</tr>
<tr>
<td>Other</td>
<td>4 (0.7)</td>
<td>2 (0.5)</td>
<td>1 (0.3)</td>
<td>50.0</td>
</tr>
<tr>
<td>Church</td>
<td>2 (0.4)</td>
<td>2 (1.0)</td>
<td>2 (1.0)</td>
<td>No loss</td>
</tr>
<tr>
<td>Train station</td>
<td>2 (0.4)</td>
<td>42 (21)‡</td>
<td>44 (22)‡</td>
<td>No loss</td>
</tr>
<tr>
<td>Marina, harbor</td>
<td>1 (0.02)</td>
<td>1 (1.0)</td>
<td>1 (1.0)</td>
<td>No loss</td>
</tr>
<tr>
<td>Total</td>
<td>552 (100.0)</td>
<td>537 (1.0)</td>
<td>357 (0.7)</td>
<td>33.5</td>
</tr>
</tbody>
</table>

AED indicates automated external defibrillator.

†The loss of AED potential was calculated as the number of cardiac arrests ≤100 m (109.4 yd) of an AED, minus the number of cardiac arrests ≤100 m (109.4 yd) of an accessible AED, divided by number of cardiac arrests ≤100 m (109.4 yd) of an AED.

‡The nearest AED within 100 m (109.4 yd) of cardiac arrest was identified. When taking accessibility into account, if an AED was nearest but not accessible at time of arrest, then another (the nearest accessible) AED within 100 m (109.4 yd) was identified. Thus, AEDs with 24-hour accessibility such as at train stations and hotels covered a higher number of cardiac arrests than originally shown under * (>100%).
In Japan, vending machines containing an AED have successfully been used to place AEDs with 24-hour accessibility in public locations. The costs could be divided between the provider of the vending machine/outdoor cabinet and the AED distributor or by paid advertising on a display panel above the AED, an approach also used in South Korea. The main strength of this study is that we report results from a volunteer-based AED registry linked to the emergency dispatch center, which holds accurate and validated information on AED location and accessibility. The AED registry with linkage to the emergency dispatch center described in this study has been envisioned and warranted in the literature. The 17-year study period included cardiac arrests from an entire city, yielding a large population of cardiac arrests in public locations, minimizing the natural variability in the number of cardiac arrests occurring at a given time or site. Data on cardiac arrests were uniformly collected throughout the study by anesthesiologists using a standard form based on the Utstein criteria. Furthermore, our population characteristics mimic those of other similar studies in which 25.9% of cardiac arrests occurred in public locations, and baseline characteristics of the population such as age are comparable to those in previous reports.

Limitations
This study has several limitations. Although the information on cardiac arrests was prospectively collected over a 17-year period, AED location and accessibility are from December 31, 2011. Hence, the location and time of historical cardiac arrests (1994–2011) were compared with AED location and accessibility as of December 31, 2011. Accordingly, interpretation of our data is based on several underlying assumptions. We assumed that the time and location of cardiac arrests in public locations are related to the moving patterns and underlying geographic epidemiology of the population and thus are not simply random events. Numerous previous studies have found this to be plausible in terms of location of cardiac arrests in public locations, and current guidelines for AED placement are based on this notion. Importantly, we identified a stable, long-term (17 years) trend of time of cardiac arrests and find this assumption to be plausible in our study population also (Figure 1). In terms of optimizing AED use in urban settings, our data support the use of trends of time and location of cardiac arrests to guide AED placement and accessibility. We also assumed that AED location and accessibility were constant over time and will continue to be so, which might not be the case for all AEDs. However, registration with the AED network requires permanent AED location, and accessibility reflects opening hours of the establishment where the AED is placed, which is unlikely to change frequently.

We report only AEDs registered with the Danish AED network. However, the unregistered AEDs are not validated in terms of location, accessibility, and maintenance status, and they are not readily locatable to all persons who witness a cardiac arrest and call the emergency dispatch center. Because our primary objective was to examine how AED accessibility in community settings affects public-access defibrillation programs, we did not include traditional factors that influence outcome such as witnessed arrest and bystander cardiopulmonary resuscitation because they are irrelevant for AED coverage of cardiac arrests. An additional limitation is the observational nature of the data.

Future AED evaluation should consider relevant points such as how often the emergency dispatch center referred to an AED, whether the AED was used, whether it worked, and what the reactions were of the bystanders who used it. Because deployment of most AEDs and linkage to the emergency dispatch center occurred within the last 2 years of the study, it would be premature to expect an effect of AED use on overall survival. Nevertheless, in future investigations, it will be of major relevance to assess how the improved AED dissemination has affected 30-day and long-term survival or neurological status of patients with out-of-hospital cardiac arrest treated with an AED.

Conclusions
Our results provide strong evidence that limited AED accessibility at the time of cardiac arrest decreased AED coverage by 53.4% during the evening, nighttime, and weekends, which is when 61.8% of all cardiac arrests in public locations occurred. These findings underline that not only strategic placement but also uninterrupted AED accessibility warrant attention if public-access defibrillation is to improve survival after out-of-hospital cardiac arrest.

Acknowledgments
We thank the Mobile Emergency Care Unit personnel who completed the case report forms and the Danish AED network (http://www.hjertestarter.dk) for sharing information on AEDs registered with the network.

Sources of Funding
This study was funded by TrygFonden and the Health Insurance Foundation, Denmark. Dr Gislason is supported by an independent research scholarship from the Novo Nordisk Foundation. None of these institutions had any influence on the design and conduct of the study; collection, management, analysis, and interpretation of the data; and preparation, review, or approval of the manuscript.

Disclosures
The AED network (http://www.hjertestarter.dk) is fully supported by TrygFonden with no commercial interests in the field of cardiac arrest. The authors report no conflicts.

References


Out-of-hospital cardiac arrest is a major public health concern and is associated with a poor prognosis. Automated external defibrillators (AEDs) can increase survival markedly after out-of-hospital cardiac arrest and can be used safely and effectively by laypersons. During the past years, there has been increasing focus on community-based AED deployment to establish grounds for public-access defibrillation. To increase survival, AEDs need to be used within minutes and thus must be close to the victim, locatable, and accessible to bystanders. Despite widespread AED dissemination, AED use and effect on survival in community settings have remained limited, and the reasons for this are not completely understood. So far, efforts to increase AED use have focused on widespread AED dissemination, optimizing AED placement and establishing linkage to emergency dispatch centers. Our study shows that AEDs were highly accessible during the daytime on weekdays but considerably inaccessible during the evening, nighttime, and weekends, when most cardiac arrests occurred. Thus, limited AED accessibility greatly reduced the potential for the AED to be used. The results provide insight into how AED accessibility affects AED coverage of cardiac arrests in public locations and serve as guidance for other communities seeking to optimize AED use. These findings underline that not only strategic placement but also uninterrupted AED accessibility warrant attention if public-access defibrillation is to improve survival after out-of-hospital cardiac arrest.

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Circulation. 2013;128:2224-2231; originally published online September 13, 2013; doi: 10.1161/CIRCULATIONAHA.113.003066

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

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Supplemental Material:

The supplemental material intended for publication as an online data supplement.
### Supplemental Table 1: AED Coverage by Period of Day and Type of Location

<table>
<thead>
<tr>
<th>Location of AEDs, (n)</th>
<th>Total</th>
<th>Daytime</th>
<th>Evening</th>
<th>Nighttime</th>
<th>Total</th>
<th>Daytime</th>
<th>Evening</th>
<th>Nighttime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office (314)</td>
<td>257</td>
<td>139</td>
<td>83</td>
<td>35</td>
<td>131</td>
<td>112</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>School, kindergarten, university (73)</td>
<td>49</td>
<td>27</td>
<td>17</td>
<td>5</td>
<td>30</td>
<td>23</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Sports facility (59)</td>
<td>64</td>
<td>36</td>
<td>25</td>
<td>3</td>
<td>56</td>
<td>36</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Theater, museum, library, zoo (26)</td>
<td>26</td>
<td>10</td>
<td>11</td>
<td>5</td>
<td>16</td>
<td>8</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Bank (17)</td>
<td>13</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Hotel (14)</td>
<td>10</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Store, shopping mall (13)</td>
<td>20</td>
<td>13</td>
<td>6</td>
<td>1</td>
<td>18</td>
<td>12</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Private medical practice/ dental practice (12)</td>
<td>21</td>
<td>13</td>
<td>7</td>
<td>1</td>
<td>11</td>
<td>10</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Public shelter, addiction center (10)</td>
<td>16</td>
<td>8</td>
<td>7</td>
<td>1</td>
<td>15</td>
<td>8</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Police station/fire department (5)</td>
<td>14</td>
<td>4</td>
<td>6</td>
<td>4</td>
<td>14</td>
<td>4</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Other (4)</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Church (2)</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Train station (2)</td>
<td>42</td>
<td>17</td>
<td>20</td>
<td>5</td>
<td>44</td>
<td>17</td>
<td>21</td>
<td>6</td>
</tr>
<tr>
<td>Marina, harbor (1)</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total, (552)</td>
<td>537</td>
<td>283</td>
<td>188</td>
<td>66</td>
<td>357</td>
<td>242</td>
<td>97</td>
<td>18</td>
</tr>
</tbody>
</table>
Abbreviations: AED, automated external defibrillator.

*Regardless of whether the AED was accessible at the time of cardiac arrest.

†Daytime, evening and nighttime were defined as 08:00–15:59, 16:00–23:59, and 00:00–07:59, respectively.

‡The nearest AED within 100m (109.4yd) of cardiac arrest was identified. When taking accessibility into account, if an AED was the nearest but not accessible at time of arrest, another AED, the nearest accessible AED within 100m (109.4yd) was identified. Thus, AEDs with 24-hour accessibility, such as at train stations and hotels, covered a higher number of cardiac arrests than shown under † which is why they covered > 100.0% of cardiac arrests that occurred during evening and nighttime.
Supplemental Figure 1: AED Accessibility According to Hour of Day
Supplemental figure 1: AED Accessibility According to Hour of Day

Legend:

Abbreviations: AED, automated external defibrillator.

AED accessibility during weekdays and weekends is shown for the 552 AEDs registered in the study area, by December 31, 2011. Weekdays were defined as Monday–Friday and weekends as Saturday–Sunday. Weekdays were defined as Monday–Friday and weekends as Saturday–Sunday.