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

Running title: Malta Hansen et al.; AED accessibility and coverage of cardiac arrests

Carolina Malta Hansen, MD1; Mads Wissenberg, MD1; Peter Weeke, MD1; Martin Huth Ruwald, MD1; Morten Lamberts, MD1; Freddy Lippert, MD2; Gunnar Hilmar Gislason, MD, PhD1,3; Søren Loumann Nielsen, MD2; Lars Køber, MD, DSc4; Christian Torp-Pedersen, MD, DSc1,5; Fredrik Folke, MD, PhD1

1Dept of Cardiology, Copenhagen University Hospital Gentofte, Hellerup; 2Emergency Medicine and EMS, Head Office, Capital Region of Denmark, Copenhagen; 3National Institute of Public Health, University of Southern Denmark, Copenhagen; 4The Heart Centre, Copenhagen University Hospital Rigshospitalet, Copenhagen; 5Institute of Health, Science and Technology, Aalborg University, Aalborg, Denmark

Address for Correspondence:
Carolina Malta Hansen, MD
Department of Cardiology
Copenhagen University Hospital Gentofte, Denmark
Niels Andersens vej 65, post 635
DK 2900 Hellerup, Denmark
Tel: (+45) 60 12 61 27
Fax: (+45) 39 77 76 42
E-mail: cmh@heart.dk

Abstract

**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 these 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 100m (109.4yd) of an AED: 1) irrespective of AED accessibility, and 2) 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. 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) during daytime, all weekdays. Irrespective of AED accessibility, 28.8% (537/1864) of all cardiac arrests were covered by an AED. Limited AED accessibility decreased coverage of cardiac arrests by 4.1% (9/217) during daytime on weekdays, and by 53.4% (171/320) 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 warrants attention if public access defibrillation is to improve survival after out-of-hospital cardiac arrest.

**Key words:** cardiopulmonary resuscitation, defibrillation, cardiac arrest, automated external defibrillator, resuscitation
Introduction

Automated external defibrillators (AEDs) have been widely disseminated in the western world, with more than 1 million AEDs sold in the United States alone.\textsuperscript{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.\textsuperscript{3-9} Despite this large dissemination, AED use in the community setting remains limited; the reasons for this are not completely understood.\textsuperscript{2, 3, 9-14} Thus, improved strategies to increase AED use in community settings are warranted.\textsuperscript{1, 4, 6, 15-18}

For AEDs to be used and fulfill their lifesaving potential, they need to be close to the victim and accessible at the time of cardiac arrest.\textsuperscript{19-23} 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, accessibility and bystanders’ knowledge of these. Such conditions pose obvious challenges to AED use and not overcoming these challenges may be the main limitation to the lifesaving potential of AEDs in community settings.\textsuperscript{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.\textsuperscript{4, 8, 13-15, 22-26} 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.\textsuperscript{8, 20, 22, 23, 26, 27} However, it is unknown what proportion of AEDs deployed in ‘real life’ community settings is actually accessible at the time of nearby cardiac arrest.\textsuperscript{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 time and location of all cardiac arrests in public locations during 1994–2011 and 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 irrespective of AED accessibility was determined and was reassessed including AED accessibility at the time of cardiac arrest. Further, 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 square kilometers (60 square miles) and has a resident population of approximately 600,000. The Emergency Medical Service of Copenhagen is a two-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.28

Study Population

We identified 8125 cases with out-of-hospital cardiac arrest confirmed by the absence of signs of circulation, in Copenhagen, Denmark, during January 1, 1994–December 31, 2011.28 Due to incomplete data registration, we did not identify cases with 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 due to unregistered location of arrest and 866 due to non-compliance with Utstein guidelines (cardiac arrests resulting from suicide, poisoning, drowning, trauma, 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 and 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 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, though 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 six 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, Denmark
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. An AED was considered to cover an area with a radius of 100m (109.4yd), based on the estimate that an AED within that range could be transported by bystanders to the victim within 1½-minute, in accordance with the American Heart Association recommendations. It was assumed that one AED could provide coverage for all historical cardiac arrests within a radius of 100m (109.4yd). If more than one AED was within 100m (109.4yd) of a cardiac arrest, the nearest AED was chosen as 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 1994–2011, 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 two 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 100m (109.4yd) of an AED irrespective 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 08:00–15:59, 16:00–23:59 and 0:00–07:59,
respectively. Weekend was defined as Saturday–Sunday and weekdays as Monday–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 (IQR), except for the variable “response time”, which is presented as means with standard deviations (SD). Binary variables were compared using the Chi-square test.

For all analyses, a two-sided p-value <0.05 was considered statistically significant. All analyses were done using the SAS statistical software package, version 9.2 (SAS Institute Inc., Cary, NC, USA) and R version 2.15.1 (R Core Team (2012). R: A language and environment for statistical computing, R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL 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; and have read and agreed to the manuscript as written.

**Ethics**

No ethical approval is required for retrospective registry studies in Denmark. The study was approved by the Danish Data Protection Agency (No. 2008-41-2685.).

**Results**

**Cardiac Arrests**

Baseline characteristics of the 1864 cardiac arrest cases in public locations during 1994–2011 are shown in **Table 1**. Cardiac arrests occurring on weekends, in the evenings, or at nighttime comprised 61.8% (n=1,152) of all cardiac arrests. This proportion did not change significantly
Loss of AED Potential through Limited AED Accessibility

Irrespective of AED accessibility and time of cardiac arrest, 28.8% (n=537) of all cardiac arrests occurred within 100m (109.4yd) 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% (217/712) of the cardiac arrests occurring during the daytime on weekdays, and 27.8% (320/1,152) of those occurring during the evening, nighttime or weekends were within 100m (109.4yd) 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% (208/712) for those occurring during the daytime on weekdays, but only 12.9% (149/1,152) for cardiac arrests occurring during the evening, nighttime or weekends.

Of the 537 cardiac arrests occurring within 100m (109.4yd) 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% (180/537). The corresponding figures were 4.1% (9/217) for cardiac arrests...
during the daytime, and 53.4% (171/320) for those during the evening, nighttime or weekends.

**AED Coverage by Period of Day and Type of Location**

The majority of cardiac arrests (n=237) was covered by AEDs in offices; 80.6% (112/139) of those occurring during the daytime had access to the AED the time of cardiac arrest (Supplemental Table 1). The corresponding figures were 18.1% (15/83) and 11.4% (4/35) 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 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/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 100m (109.4yd) of an AED during the daytime, on weekdays, could have access to it. 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 to AEDs’ potential 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.\textsuperscript{3, 8, 12, 22, 23, 25, 31}

Since 2005, the number of AEDs available for public access defibrillation in Copenhagen, Denmark, has increased more than 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.\textsuperscript{25} Notably, our results show that AEDs were within 100m (109.4yd) of nearly 1/3 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.\textsuperscript{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.\textsuperscript{2, 3, 9, 11-14, 19, 33} As in our study, a recent Canadian study reported the majority of AEDs were placed in offices and schools. This study also reported low AED use but did not include information on AED accessibility.\textsuperscript{13} Our findings 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.\textsuperscript{1, 24}

Different approaches could be considered to promote an increase in AED accessibility and thereby facilitate AED use. Multi media campaigns have previously succeeded in increasing
AED awareness and campaigns targeted at increasing public awareness of how low AED accessibility limits an AED’s potential to save additional lives may encourage AED owners to render their AED more accessible.\textsuperscript{34,35} 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 more than 8000 AEDs over the past 6 years.\textsuperscript{36} The adherence to the AED network confirms that increasing public awareness can highly contribute to AED implementation. Accordingly, a continuous emphasis on the importance of 24-hour AED accessibility by key organs 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.\textsuperscript{5} However, the Danish 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. Since 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 new legislation required these 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’.\textsuperscript{14,25} Authorities could then use these findings as guidance to complement already deployed AEDs, increasing accessibility where it is needed, and thus,
intelligently utilize public resources to complement privately deployed AEDs.14

Other ways to improve AED accessibility in public locations could be through placing of 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. In Japan, vending machines containing an AED have successfully been employed 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.37, 38

The main strengths of this study are 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.1, 4, 15, 17, 18 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 regarding cardiac arrests were uniformly collected throughout the study by anesthesiologists using a standard form based on the Utstein criteria.28 Furthermore, our population characteristics mimic those of other similar studies, where 25.9% of cardiac arrests occurred in public locations and baseline characteristics of the population such as age are comparable with previous reports.10, 12-14, 19, 20, 39-41

Limitations

This study has several limitations. Although the information regarding cardiac arrests was prospectively collected over a 17 year period, AED location and accessibility are from December
31, 2011. Hence, location and time of historical cardiac arrests (1994–2011) were compared to 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, 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.2, 4, 13-15, 24, 25, 29, 39, 41-45 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 as well (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, as well as not readily locatable to all persons who witness a cardiac arrest and call the Emergency Dispatch Center. Since 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 as these 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 emergency teams to an AED, whether the AED was used, whether it worked, and if bystanders used it, what their reactions were. Since deployment of most AEDs and linkage to the Emergency Dispatch Center occurred within the last two years of the study, it would be premature to expect an effect of AED use on overall survival. Nevertheless, in future investigations it is 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.

Conclusion

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 warrants 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 regarding automated external defibrillators registered with the network.

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Conflict of Interest 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 have no conflicts of interest.

References:


22. Page RL, Joglar JA, Kowal RC, Zagrodzky JD, Nelson LL, Ramaswamy K, Barbera SJ,


43. Warden CR, Daya M, LeGrady LA. Using geographic information systems to evaluate...


**Table 1.** Baseline Characteristics of Subjects with Out-of-hospital Cardiac Arrest in Public during 1994–2011

<table>
<thead>
<tr>
<th>Baseline characteristics</th>
<th>Cardiac Arrests in Public (n=1737)*</th>
<th>Total</th>
<th>Daytime†</th>
<th>Evening†</th>
<th>Nighttime†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age, y (IQR)</td>
<td></td>
<td>63 (24)</td>
<td>66 (23)</td>
<td>62 (25)</td>
<td>55 (25)</td>
</tr>
<tr>
<td>Men, n (%)</td>
<td></td>
<td>1315 (75.7)</td>
<td>680 (74.9)</td>
<td>457 (75.8)</td>
<td>178 (78.8)</td>
</tr>
<tr>
<td>Mean response time, min ± SD‡</td>
<td></td>
<td>5.0±2.4</td>
<td>4.9±2.8</td>
<td>4.8±2.2</td>
<td>5.6±2.9</td>
</tr>
<tr>
<td>VF/pVT§</td>
<td></td>
<td>684 (39.4)</td>
<td>401 (44.2)</td>
<td>229 (38.0)</td>
<td>54 (23.9)</td>
</tr>
<tr>
<td>Asystole</td>
<td></td>
<td>646 (37.2)</td>
<td>306 (33.7)</td>
<td>229 (38.0)</td>
<td>111 (49.1)</td>
</tr>
<tr>
<td>Pulseless Electric Activity</td>
<td></td>
<td>229 (13.2)</td>
<td>119 (13.1)</td>
<td>85 (14.1)</td>
<td>25 (11.1)</td>
</tr>
<tr>
<td>Other/unknown rhythm¶</td>
<td></td>
<td>178 (10.3)</td>
<td>82 (9.0)</td>
<td>60 (10.0)</td>
<td>36 (15.9)</td>
</tr>
<tr>
<td>Survival after 30 days, n (%)</td>
<td></td>
<td>324 (18.7)</td>
<td>171 (18.8)</td>
<td>127 (21.1)</td>
<td>26 (11.5)</td>
</tr>
</tbody>
</table>

*Abbreviations: SD, standard deviation. IQR, interquartile ranges.*

*127 cases had an invalid identification number, mainly due to foreign resident status. Baseline characteristics were not available for these cases.

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

‡Interval between call to Emergency Medical Service and ambulance arrival.

§VF/pVT is ventricular fibrillation or pulseless ventricular tachycardia.

¶Other/unknown rhythm includes pace rhythms, atrioventricular blocks and unknown rhythm.
Table 2. Loss of AED Potential through Limited Accessibility from Type of Location

<table>
<thead>
<tr>
<th>Location of AEDs</th>
<th>Number of AEDs, n (%)</th>
<th>Cardiac arrests ≤ 100m (109.4yd) of an AED*, (number of arrests per AED)</th>
<th>Cardiac arrests ≤ 100m (109.4yd) of an accessible AED, (number of 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>

Abbreviations: AED, automated external defibrillator.

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

†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, then another (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 originally shown under * (> 100.0%).

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

**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.** AED Accessibility by Hour of Day and Day of Week. Abbreviations: AED, automated external defibrillator. 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–Friday and weekends as Saturday–Sunday.

**Figure 3.** Coverage of Cardiac Arrests According to Time of Arrest and Accessibility of Nearby AED. Abbreviations: AED, automated external defibrillator. Coverage of cardiac arrests irrespective of AED accessibility and according to time of arrest and accessibility of nearby AED, for weekdays and weekends. Error bars show confidence intervals based on the assumption that the incidence of cardiac arrests in public locations followed the Poisson distribution.
Cardiac arrests during daytime on weekdays

Percentage of all cardiac arrests

Year

Arrow bars indicate confidence intervals
Figure 2
Figure 3

- Percentage of cardiac arrests ≤ 100m (109.4yd) of an AED irrespective of AED accessibility
- Percentage of cardiac arrests ≤ 100m (109.4yd) of an accessible AED at time of arrest
Automated External Defibrillators Inaccessible to More than Half of Nearby Cardiac Arrests in Public Locations during Evening, Nighttime and Weekends

Carolina Malta Hansen, Mads Wissenberg, Peter Weeke, Martin Huth Ruwald, Morten Lamberts, Freddy Lippert, Gunnar Hilmar Gislason, Søren Loumann Nielsen, Lars Køber, Christian Torp-Pedersen and Fredrik Folke

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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>14</td>
<td>7</td>
<td>5</td>
<td>2</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>
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<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>
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<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
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<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.

\(^{1}\)Regardless of whether the AED was accessible at the time of cardiac arrest.

\(^{1}\)Daytime, evening and nighttime were defined as 08:00–15:59, 16:00–23:59, and 00:00–07:59, respectively.

\(^{2}\)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 \(^{1}\) 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

Weekdays

Weekends
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.