Use and Coverage of Automated External Defibrillators According to Location in Out-of-Hospital Cardiac Arrest

Laura Sarkisian, M.D.¹,², Laura.Sarkisian2@rsyd.dk
Hans Mickley, M.D., DMSc³, Hans.Mickley@rsyd.dk
Henrik Schakow, EMT³, schakow@pc.dk
Oke Gerke, MSc, PhD⁴,⁵, Oke.Gerke@rsyd.dk
Simon Michael Starck, M.D.¹, simon.michael.starck@rsyd.dk
Jonas Junghans Jensen, M.D.¹, JonasJunghansJensen@gmail.com
Jacob Eifer Møller, M.D., DMSc¹, Jacob.Moeller1@rsyd.dk
Gitte Jørgensen, M.D.³, Gitte.Jorgensen@rsyd.dk
Finn Lund Henriksen, M.D., PhD¹, Finn.L.Henriksen@rsyd.dk


¹Research Unit of Cardiology, Department of Cardiology, Odense University Hospital, J.B. Winsløws Vej 4, 5000 Odense C, Denmark (primary site of research).

²OPEN, Odense Patient data Explorative Network, Odense University Hospital, Odense, Denmark (affiliation).

³Emergency Medical Services, Region of Southern Denmark, Damhaven 12, 7100 Vejle, Denmark

⁴Department of Nuclear Medicine, Odense University Hospital, J.B. Winsløws Vej 4, 5000 Odense C, Denmark.

⁵Research Unit of Clinical Physiology and Nuclear Medicine, Department of Clinical Research, University of Southern Denmark, J.B. Winsløws Vej 19, 5000 Odense C, Denmark.

* Corresponding author: Laura Sarkisian, phone no. +45 27 85 94 44, fax no. +45 65 41 30 02.
Abstract:

**Aims:** To evaluate 1) the relative use of automated external defibrillators (AEDs) at different types of AED locations 2) the percentage of AEDs crossing location types during OHCA before use 3) the AED coverage distance at different types of AED locations, and 4) the 30-day-survival in different subgroups.

**Methods:** From 2014-2018, AEDs used by bystanders during out-of-hospital cardiac arrest (OHCA) in the Region of Southern Denmark were collected. Data regarding registered AEDs was retrieved from the national AED-network. The OHCA site and AED placement was categorized into; 1) Residential; 2) Public; 3) Nursing home, 4) Company/workplace; 5) Institution; 6) Health clinic and 7) Sports facility/recreational. To evaluate 30-day-survival, groups 4-7 were pooled into one Mixed group.

**Results:** In total 509 OHCAs were included. There was high relative usage of AEDs from public places, nursing homes, health clinics and sports facilities, and low relative usage from companies/workplaces, residential areas and institutions. Of AEDs used during residential OHCAs 39% were collected from public places. AEDs placed in residential areas and public places had a coverage of 575 meters (IQR 130-1300) and 270 meters (IQR5-550), respectively. Thirty-day- survival in public, residential and mixed groups were 49%, 14% and 67%, respectively.

**Conclusion:** The relative use of AEDs from public places, nursing homes, sports facilities and health clinics was high, and AEDs used during OHCA in residential areas were most frequently collected from public places. AEDs placed in both residential areas and public places may have a wider coverage area than proposed in current literature.
Introduction

Cardiac arrest means abrupt cessation of cardiac activity and will inevitably lead to death if not treated immediately. Out-of-hospital cardiac arrest (OHCA) is a major public health concern and annually strikes approximately 700,000 people in Northern America and Europe combined (1). Early cardiopulmonary resuscitation (CPR) and defibrillation within the first minutes with an automated external defibrillator (AED) may increase survival to more than 50% (2, 3). In recent years, AEDs have gained widespread dissemination in many communities (4, 5) and in Denmark several national initiatives have been undertaken to increase bystander AED use, including the establishment of a national AED-network (6). Bystander defibrillation, however, remains low ranging from 1-5% (5-8). Prior studies have indicated that to increase AED use, AEDs must be placed in close proximity to the site of cardiac arrest (8-10), they must be available at all times (10-12) and bystanders must be aware of AED locations and be willing to use them (13). Also, the most optimal AED placement appears to be in public places with high pedestrian traffic (12, 14). Indeed, AEDs are recommended to be placed in public places with high likelihood of OHCA that can be reached within 1 to 1.5 minutes of brisk walking or approximately 100 meters (15-17). However, international recommendations regarding specific AED placement are scarce, resulting in unguided AED placement in most cases (6, 7, 18). So far, AED use from specific locations remains largely unknown. Also, data addressing the actual distances AEDs are carried to OHCA sites is limited, making it difficult to assess the coverage of AEDs placed at different locations.

The aim of this study was three-fold: 1) to assess the relative use of AEDs placed at different types of locations; 2) to assess whether AEDs are carried across different location types before they are used; and 3) to assess the AED coverage distances at different AED locations.

Methods

Settings and study design

This is a retrospective cohort study with prospectively collected data from AEDs used by bystanders in the Region of Southern Denmark from January 1st 2014 to December 31st 2018. The region is mixed rural-urban and covers an area of 12,191 km². It has 39 Emergency Medical Service (EMS) stations and one emergency
medical dispatch centre (EMDC). The region has 1.2 million inhabitants. During the years 2009-2014, a total of 4,350 OHCAs occurred in the region, resulting in 42.4 OHCAs per 100,000 inhabitants per year (19). Of these, 52.9% received bystander CPR and 3.5% were defibrillated prior to EMS arrival.

**Data collection**

Data was collected following the Utstein-recommendations for reporting resuscitation outcomes (16).

**AED-centre and the Danish AED-network**

Information regarding AEDs was collected from the AED-centre at Odense University Hospital. In cases where the AED-centre received an AED from an unknown site/owner, the serial number was used to track additional information from the Danish AED-network. The AED-centre collects both registered and unregistered AEDs used during OHCA. Upon receiving an AED, data is retracted, analysed and stored in each patient’s electronic medical record.

In 2010 a national AED-network was established. In 2011 the AED-network became integrated with the five Danish EMDCs. The network gives AED-owners the opportunity to electronically register AED address, location type, availability, serial number and model. The information is available for the public via a homepage and a smartphone application.

**Emergency medical dispatch centre in the region of Southern Denmark**

When the EMDC receives a call and suspects OHCA, the dispatcher phone-assists the bystander in performing CPR. If more than one bystander is present, the dispatcher can refer to a nearby AED via the AED-network, in accordance with international guidelines (17). Also, a two-tiered EMS system is activated followed by the dispatch of an ambulance and a physician-staffed emergency vehicle both equipped with a defibrillator.

**Adjudication of location types**
We used the Utstein-template location types (16): 1) Residential; 2) Public; 3) Nursing home; 4) Company/workplace; 5) Institution; 6) Health clinic and 7) Sports facility/recreational (Table S1 in the Supplement). When presenting the demographic and prognostic results and AED coverage, groups 4-7 will be pooled into one ‘Mixed’ group.

To adjudicate AED location type, a random sample of 150 registered AEDs was reviewed by three authors (LS, HM and FLH) to reach consensus. The remaining 4,209 AEDs were systematically evaluated by one author (LS), and HM and FLH were consulted in cases of ambiguity.

**Study population**

Patients with OHCA were included if 1) an AED was used before the arrival of EMS, 2) the AED was subsequently transported to the AED-centre and 3) information regarding the site of OHCA was available. Data addressing previous medical history and in-hospital treatment was collected from medical records using each patient’s personal identification number (20). Patients with obvious signs of prolonged death were excluded. Cause of cardiac arrest was defined according to the Utstein-guidelines (16). The Cerebral Performance Category (CPC) score at hospital discharge was used to report neurologic outcomes (16).

**Definition of AED coverage and retrieval distances**

AED coverage distance according to AED location type was defined and measured as the shortest one-way walking distance from AED location to OHCA site.

AED retrieval distance according to OHCA location was defined and measured as the shortest one-way walking distance from OHCA site to AED location.

Distance calculations were done using Google Maps.

**Outcomes**

The main outcomes were: 1) the relative use of AEDs at different types of AED locations 2) the percentage of AEDs crossing location types during OHCA before use; and 3) the AED coverage distance at different types of AED locations.
The secondary outcomes were: 1) AED retrieval distance according to OHCA location; 2) CPC score at discharge; and 3) 30-day survival.

When evaluating primary outcomes 2) and 3), and secondary outcome 1) information regarding both registered and unregistered AEDs was used.

**Statistics**

Categorical variables were presented as frequencies and percentages. When comparing categorical variables, Pearson’s chi-square test or Fisher’s exact test were used, depending on sample size. Continuous variables were visually inspected for normal distribution. Normally distributed continuous variables were presented as means with standard deviations (SD), and non-normally distributed variables as medians with interquartile ranges (IQR). In group comparisons, two or more normally distributed variables were compared using Student’s t-test or one-way analysis of variance, respectively. Non-normally distributed variables were compared using the non-parametric Mann-Whitney U-test and the non-parametric Kruskall-Wallis test in cases of two or more group comparisons, respectively.

A scatter plot was used to graphically display the association between percentage of registered AEDs at specific locations and the percentage of AEDs used from the same locations. An upward shift in the scatter plot will suggest increased AED use at that specific location. A box-and-whisker plot was used to visually compare AED coverage distances.

The statistical significance level was at 5%. All analyses were performed by use of STATA version 15 (StataCorp LP, College Station, Texas).

**Ethics and data protection**

The study was approved by The Danish Data Protection Agency (Journal no. 17/32047) and the Danish Patient Safety Authority under the administration of Danish Health Authority (no. 3-3013-2319/1 and 3-3013-2848/1).

**Results**
Baseline characteristics and outcomes

During the study period, the AED-centre collected 621 AEDs. As illustrated in Fig. 1, 509 OHCA-patients fulfilled the inclusion criteria. Table 1 shows the demographic and prognostic results. OHCAs in public places and in the ‘Mixed’ group were more often male and more frequently had a witnessed cardiac arrest. Shockable first AED rhythm was less frequent in OHCAs in residential areas and nursing homes. Survival after OHCA in public places and the ‘Mixed’ group was three to four times higher than in residential areas. Survivors in all groups demonstrated a high proportion of favourable neurological outcomes.

Use of AEDs at different location types

From 2014-2018 the number of registered AEDs increased from 2,288 to 4,359 (Fig. S1 in the Supplement). Twenty-four hour AED availability was highest in residential areas followed by nursing homes and public places (Table S2 in the Supplement). Forty percent of all AEDs did not have 24 h availability. In 416 of the 509 OHCAs (82%), the AED location was available for distance measurements. Fig. 2 shows a relatively high use of AEDs in public areas, nursing homes, sports facilities/recreational areas and health clinics, as opposed to a relatively low use of AEDs from companies/workplaces, residential areas and institutions.

Table 2 shows that during OHCA in public places, nursing homes, companies/workplaces, institutions, health clinics and sports facilities, the AEDs were most commonly retrieved from the same type of area. During OHCA in residential areas the most commonly used AEDs were retrieved from public places.

AED coverage and AED retrieval distances according to different location types

The widest AED coverage distances were observed in residential areas and public places (575 meters (IQR 130-1100) and 250 meters (IQR 5-550), respectively) (Fig. 3). AED retrieval distances in residential areas were significantly higher compared to the other groups (Table 3). In 212 of the 416 OHCA cases (51%), the retrieval distance was ≤100 meters.

Discussion
This study presents novel data addressing real life use of AEDs in patients with OHCA from a mixed rural-urban area. A relative high use was observed of AEDs placed in public places and nursing homes, whereas a low use was observed in residential areas. The majority of AEDs were placed and used in the same type of location. Thirty-nine percent of AEDs used in residential areas were retrieved from public places. AEDs placed in residential areas and at public places had a median coverage distance of more than 500 and 250 meters, respectively, indicating that AEDs may have wider coverage than expected.

In recent years, there has been a wide dissemination of AEDs across communities. Approximately 75% of all OHCAs occur in residential areas, where bystander defibrillation consistently has remained low, compared with public places (6, 21-23). Several factors reduce the chance of survival and bystander defibrillation during residential OHCAs, including older age, higher comorbidity, more frequent unwitnessed arrests and a higher proportion of non-shockable rhythms (22, 24). It has also been shown that bystanders at residential OHCAs more often are alone compared with bystanders in public places, reducing the possibility of AED use (25). Contrary to previous studies (22, 24), we found that patients with OHCA in residential areas and public places were comparable in age and comorbidity (Table 1). This attenuates that OHCAs in residential areas where an AED is applied differ from those where an AED is not applied. Younger age in these OHCA patients makes it more likely that other relatives share the same residence that may put efforts into AED retrieval. It may also imply younger bystanders, who are physically capable of locating and retrieving an AED, compared to their older counterparts. Furthermore, some studies categorize cardiac arrest in nursing homes as residential OHCAs, which may explain the higher age and poorer survival observed in these (9, 21). In a large registry study it was shown that AED application, irrespective of first rhythm, defibrillation status, location and age resulted in an overall increased survival compared to those where an AED was not applied (5). Perhaps, AED applications itself indicates other unseen opportune factors, such as more efficient resuscitation efforts due to voice prompts resulting in fewer CPR breaks, or more aggressive in-hospital treatment. This, however, remains speculative.

According to international guidelines, an AED should be placed where there has been an OHCA every 5 years (16), and “in public locations where there is a relatively high likelihood of witnessed cardiac arrest”
In these settings, an AED is expected to cover a radius of approximately 100 meter walking range ($\approx 0.03 \text{ km}^2$) (15-17). Some studies have opted for mathematical optimization of AED placement based on prior OHCA sites (7, 12, 26, 27). These strategies, however, were based on geographically confined, densely populated urban areas, making it difficult to extrapolate to suburban and rural areas. Moreover, OHCA in residential areas were excluded (7, 12, 26, 27). So far, no recommendations regarding AED placement in residential areas exist. Also, the actual AED coverage at different locations remains unknown, resulting in an arbitrarily based assumption of coverage limited to a 100 meters walking distance. In the present study, AEDs placed in residential areas were carried a median distance of 575 meters, corresponding to a coverage area of $\approx 1 \text{ km}^2$. Furthermore, the observed median retrieval distance of 550 meters in residential OHCA indicates that bystanders were willing to move greater distances to retrieve AEDs than previously proposed in the literature (9, 15, 18, 21). A study in urban Toronto found a median distance of 281 meters between historic OHCA and the closest AED (7). This is potentially within the walking range presented here.

However, only public OHCA were included, and distances were measured using straight line calculations, a method known to underestimate actual walking distances (28). Regarding publicly placed AEDs, the present study showed shorter coverage distances compared with residential AEDs (250 vs. 575 meters), but still longer than the 100 meters proposed (9, 12, 15, 18, 21). The reason for the observed difference is most likely multifactorial; perhaps during public OHCA, bystanders are less prone to walk longer distances, in unfamiliar surroundings with unknown AED locations, or they may retrieve an AED, but find that the EMS arrived first due to shorter EMS response times (7, 22). Conversely, bystanders at residential OHCA are likely residents themselves, potentially making them more inclined to seek out an AED in familiar surroundings despite longer distances.

In both the present and earlier studies (6, 29, 30), the placement of AEDs was consistently skewed in favour of public places. Correspondingly, the present study showed a relatively higher AED use in public places, and found that AEDs were frequently transported from public places to other locations as well, including residential areas. In another study from urban Toronto, the likelihood of OHCA in different building and location types was assessed (30). Here, a large number of AEDs were placed at public schools where OHCA incidences were very low, and the authors concluded that AED placement in these public buildings was
improper. This conclusion is in contrast with our observations, which demonstrated frequent deployment of publically placed AEDs to other cardiac arrest sites. Therefore, we suggest that future AED placement should not only take into account the risk of “on-site” cardiac arrest, but also consider AED placements, that are known and accessed by the public, as these may have wider coverage distances than previously assumed. Despite great 24 h availability (Table S2 in the Supplement), AEDs placed in residential areas were seldom used (Fig. 2). An explanation could be that residential areas are less congested and AEDs therefore less visual for the general public. Low use of AEDs from residential areas was also found in a previous study (5), despite residential AEDs comprising surprisingly four out of ten of total registered AEDs. Perhaps other methods are needed to improve AED use in residential areas.

**Strengths and limitations**

The study has some limitations. First, we do not know the number of AEDs not brought to the AED-centre after being used. Second, we have not taken into account multiple AEDs registered at the same location. The extent of this and its impact is unknown. Third, we assume that unregistered AEDs in the region are dispersed in the same way as registered AEDs, however, this also remains unknown. Fourth, the organizational and logistical settings in Denmark can make it difficult to extrapolate the results to other countries. A final limitation is the observational nature of this study. The strength of this study is the prospectively collected AED data, which provides information about both registered and unregistered AEDs. By cross-linking AED data to the national AED-network, we were able to collect additional information regarding unidentified AEDs, adding to the extensive data completeness. Also, this study is the first to measure and report en-route distances between AED locations and OHCA sites and to thereby evaluate the actual AED coverage distances at various locations.

**Conclusion**

By collecting data from AEDs that were used during OHCAs in a mixed rural-urban area, we observed high AED use from public places, nursing homes, sports facilities/recreational areas and health clinics, and low use from companies/workplaces, residential areas and institutions. The majority of AEDs were placed and
used in the same type of location, except for residential OHCA sites, where AEDs more frequently were retrieved from public places. By measuring en-route distances from AED location to OHCA site, we found that AEDs placed in residential areas and public places had wider coverage than proposed in the current literature. These observations impose new aspects that may be considered in future guidelines addressing AED placement.
Conflicts of interest:

Doctor Møller has received grants and personal fees from Abiomed, and personal fees from Orion Pharma and Novartis. All other authors declared no conflict of interests.

Acknowledgements

We thank the health care professionals at the EMDC for the assistance in data acquisition and collaboration with the AED-centre. Also, we thank the AED-network for sharing data for the purpose of this study.


**Manuscript Title:** Use and Coverage of Automated External Defibrillators According to Location in Out-of-Hospital Cardiac Arrest

**Table 1:** Demographic and prognostic results

<table>
<thead>
<tr>
<th>Location of OHCA</th>
<th>Residential (N=173)</th>
<th>Public place (N=131)</th>
<th>Nursing home (N=96)</th>
<th>Mixed (N=109)</th>
<th>P value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, year, mean (SD)</td>
<td>68 (14)</td>
<td>69 (13)</td>
<td>79 (11)</td>
<td>61 (12)</td>
<td>0.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Male sex, no. (%)</td>
<td>122 (70.5)</td>
<td>102 (81.0)</td>
<td>50 (55.6)</td>
<td>96 (91.4)</td>
<td>0.04</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>- Data missing, no. (%)</td>
<td>0 (0.0)</td>
<td>5 (3.8)</td>
<td>6 (6.3)</td>
<td>4 (3.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cause of cardiac arrest, no. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.04</td>
<td>0.09</td>
</tr>
<tr>
<td>- Cardiac*</td>
<td>155 (89.6)</td>
<td>121 (97.8)</td>
<td>81 (84.4)</td>
<td>98 (89.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Non-cardiac</td>
<td>18 (10.4)</td>
<td>7 (5.4)</td>
<td>14 (14.6)</td>
<td>10 (9.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Trauma/suicide/accident</td>
<td>0 (0.0)</td>
<td>3 (2.3)</td>
<td>1 (1.0)</td>
<td>1 (0.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Data missing, no. (%)</td>
<td>0 (0.0)</td>
<td>2 (1.5)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AED registered at AED-network, no. (%)</td>
<td>129 (75.9)</td>
<td>94 (74.0)</td>
<td>78 (82.1)</td>
<td>83 (76.9)</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>- Data missing, no. (%)</td>
<td>3 (1.7)</td>
<td>4 (3.1)</td>
<td>1 (1.0)</td>
<td>1 (0.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Witnessed cardiac arrest</td>
<td>91 (54.5)</td>
<td>100 (84.0)</td>
<td>46 (51.7)</td>
<td>88 (83.0)</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>- Data missing, no. (%)</td>
<td>6 (3.5)</td>
<td>12 (9.2)</td>
<td>7 (7.3)</td>
<td>3 (2.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AED with shockable first rhythm, n. (%)</td>
<td>50 (34.0)</td>
<td>82 (70.1)</td>
<td>8 (8.8)</td>
<td>79 (79.0)</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>- First rhythm unknown, no. (%)</td>
<td>26 (15.0)</td>
<td>14 (10.7)</td>
<td>5 (5.2)</td>
<td>9 (8.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AED shock and ROSC before EMS arrival, n. (%)</td>
<td>11 (6.5)</td>
<td>30 (25.4)</td>
<td>4 (4.5)</td>
<td>48 (46.6)</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>- Data missing, no. (%)</td>
<td>4 (2.3)</td>
<td>13 (9.9)</td>
<td>7 (7.3)</td>
<td>6 (5.5)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Manuscript Title:** Use and Coverage of Automated External Defibrillators According to Location in Out-of-Hospital Cardiac Arrest

### Comorbidity

<table>
<thead>
<tr>
<th>Comorbidity</th>
<th>Data missing, no. (%)</th>
<th>Known ischemic heart disease</th>
<th>Congestive heart failure</th>
<th>Prior stroke</th>
<th>Diabetes</th>
<th>COPD</th>
<th>Malignancy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>32 (22.4)</td>
<td>33 (31.4)</td>
<td>15 (18.3)</td>
<td>15 (15.2)</td>
<td>0.1(^4)</td>
<td>0.03(^4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19 (13.3)</td>
<td>16 (15.2)</td>
<td>13 (15.9)</td>
<td>10 (10.1)</td>
<td>0.6(^4)</td>
<td>0.6(^4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17 (11.9)</td>
<td>10 (9.5)</td>
<td>21 (25.6)</td>
<td>7 (7.1)</td>
<td>0.6(^4)</td>
<td>0.001(^4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30 (21.0)</td>
<td>23 (21.9)</td>
<td>15 (18.3)</td>
<td>13 (13.1)</td>
<td>0.8(^4)</td>
<td>0.4(^4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26 (18.2)</td>
<td>10 (9.5)</td>
<td>14 (17.1)</td>
<td>14 (14.1)</td>
<td>0.07(^4)</td>
<td>0.3(^4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 (10.5)</td>
<td>11 (10.4)</td>
<td>7 (8.5)</td>
<td>0 (0.0)</td>
<td>0.9(^4)</td>
<td>0.001(^7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Data missing, no. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>30 (17.3)</td>
<td>26 (19.8)</td>
<td>14 (14.6)</td>
<td>10 (9.2)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### ROSC at hospital arrival, no. (%)

<table>
<thead>
<tr>
<th>ROSC at hospital arrival, no. (%)</th>
<th>Data missing, no. (%)</th>
<th>38 (22.6)</th>
<th>68 (55.3)</th>
<th>18 (19.8)</th>
<th>76 (73.1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>5 (2.9)</td>
<td>8 (6.1)</td>
<td>5 (5.2)</td>
<td>5 (4.6)</td>
</tr>
</tbody>
</table>

### 30-day survival

<table>
<thead>
<tr>
<th>30-day survival</th>
<th>Data missing, no. (%)</th>
<th>24 (14.3)</th>
<th>59 (48.8)</th>
<th>2 (2.2)</th>
<th>70 (66.7)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>5 (2.9)</td>
<td>10 (7.6)</td>
<td>6 (6.3)</td>
<td>4 (3.7)</td>
</tr>
</tbody>
</table>

### Cerebral Performance Category Score 1-2 at discharge

<table>
<thead>
<tr>
<th>Cerebral Performance Category Score 1-2 at discharge</th>
<th>Data missing, no. (%)</th>
<th>23/24 (95.8)</th>
<th>57/58 (98.3)</th>
<th>2/2 (100.0)</th>
<th>69/70 (98.6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0 (0.0)</td>
<td>1 (0.8)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
</tr>
</tbody>
</table>

1 Company/workplace, institutions, health clinic and sports facility/recreational. 2 Student’s t-test. 3 One-way ANOVA. 4 Pearson’s chi-square test. 5 Mann-Whitney U-test. 6 Kruskall-Wallis test. 7 Fisher’s exact test. *Deceased with late signs of death, cases of epileptic seizures/syncope etc.

* Includes OHCA with presumed, confirmed and unknown cause of cardiac arrest.

**Manuscript Title:** Use and Coverage of Automated External Defibrillators According to Location in Out-of-Hospital Cardiac Arrest

Table 2. Cross-table showing wherefrom automated external defibrillators (AEDs) were retrieved and carried to during out-of-hospital cardiac arrest (OHCA).

<table>
<thead>
<tr>
<th>Location of OHCA</th>
<th>Residential (N=173)</th>
<th>Public places (N=131)</th>
<th>Nursing homes (N=96)</th>
<th>Companies/ workplaces (N=25)</th>
<th>Institutions (N=22)</th>
<th>Health clinics (N=12)</th>
<th>Sports facilities (N=50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>19 (11.0)</td>
<td>5 (3.8)</td>
<td>4 (4.2)</td>
<td>3 (12.0)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Public places</td>
<td>66 (38.2)</td>
<td>71 (54.2)</td>
<td>8 (8.3)</td>
<td>2 (8.0)</td>
<td>4 (18.2)</td>
<td>1 (8.3)</td>
<td>9 (18.0)</td>
</tr>
<tr>
<td>Nursing homes</td>
<td>4 (2.3)</td>
<td>3 (2.3)</td>
<td>66 (68.8)</td>
<td>1 (4.0)</td>
<td>6 (27.3)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Companies/ workplaces</td>
<td>16 (9.2)</td>
<td>5 (3.8)</td>
<td>2 (2.1)</td>
<td>11 (44.0)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>1 (2.0)</td>
</tr>
<tr>
<td>Institutions</td>
<td>7 (4.1)</td>
<td>4 (3.1)</td>
<td>2 (2.1)</td>
<td>2 (8.0)</td>
<td>6 (27.3)</td>
<td>0 (0.0)</td>
<td>2 (4.0)</td>
</tr>
<tr>
<td>Health clinics</td>
<td>1 (0.6)</td>
<td>5 (3.8)</td>
<td>4 (4.2)</td>
<td>0 (0.0)</td>
<td>2 (9.1)</td>
<td>10 (83.3)</td>
<td>1 (2.0)</td>
</tr>
<tr>
<td>Sports facilities</td>
<td>17 (9.8)</td>
<td>10 (7.6)</td>
<td>1 (1.0)</td>
<td>2 (8.0)</td>
<td>1 (4.6)</td>
<td>0 (0.0)</td>
<td>32 (64.0)</td>
</tr>
<tr>
<td>Unknown AED location</td>
<td>43 (24.9)</td>
<td>28 (21.4)</td>
<td>9 (9.4)</td>
<td>4 (16.0)</td>
<td>3 (13.6)</td>
<td>1 (8.3)</td>
<td>5 (10.0)</td>
</tr>
</tbody>
</table>

25.0 % or higher: Frequent AED use from other locations
25.0 % or higher: Frequent AED use from same location
Table 3: Automated external defibrillator (AED) coverage and retrieval distances in meters (N=416).

<table>
<thead>
<tr>
<th></th>
<th>Residential</th>
<th>Public place</th>
<th>Nursing home</th>
<th>Mixed¹</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AED coverage distance, median (IQR)</td>
<td>575 (130-1100)</td>
<td>250 (5-550)</td>
<td>5 (5-5)</td>
<td>36 (5-450)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>- Total no. (%)</td>
<td>31 (7.5)</td>
<td>159 (38.2)</td>
<td>80 (19.2)</td>
<td>146 (35.1)</td>
<td></td>
</tr>
<tr>
<td>AED retrieval distance, median (IQR)</td>
<td>550 (280-1200)</td>
<td>40 (5-230)</td>
<td>5 (5-5)</td>
<td>5 (5-155)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>- Total no. (%)</td>
<td>129 (31.0)</td>
<td>104 (25.0)</td>
<td>87 (20.9)</td>
<td>96 (23.4)</td>
<td></td>
</tr>
</tbody>
</table>

¹ Company/workplace, institution, health clinic and sports facility/recreational.

*Kruskall-Wallis test. IQR: Interquartile range.
**Manuscript Title:** Use and Coverage of Automated External Defibrillators According to Location in Out-of-Hospital Cardiac Arrest

**Fig. 1.** Flow-chart showing the inclusion-exclusion

- 621 presumed OHCAs where an AED was used
  - 74 Excluded due to missing OHCA location
  - 38 Excluded
    - 16 with signs of prolonged death
    - 22 Patients without OHCA
  - 509 OHCAs where an AED was used
    - 25 Company/workplace
    - 22 Institution
    - 12 Health clinic
    - 50 Sport/Recreational
    - 173 Residential area
    - 131 Public place
    - 96 Nursing home
    - 109 Mixed group
**Manuscript Title:** Use and Coverage of Automated External Defibrillators According to Location in Out-of-Hospital Cardiac Arrest

**Fig. 2.** Percentage of automated external defibrillators (AEDs) used during OHCA (Y axis) relative to the percentage of registered AEDs at different locations (X axis).
**Manuscript Title**: Use and Coverage of Automated External Defibrillators According to Location in Out-of-Hospital Cardiac Arrest

**Fig. 3.** Automated external defibrillator (AED) coverage distances according to location
Conflicts of interest:

Doctor Møller has received grants and personal fees from Abiomed, and personal fees from Orion Pharma and Novartis. All other authors declared no conflict of interests.
Credit Author Statement

CRediT Author statement:

Laura Sarkisian: Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Data Curation, Writing – Original Draft, Writing – Review & Editing, Visualization, Project Administration, Funding Acquisition.

Hans Mickley: Conceptualization, Methodology, Validation, Formal Analysis, Writing – Original Draft, Writing – Review & Editing, Supervision, Project Administration, Funding Acquisition.

Henrik Schakow: Conceptualization, Methodology, Investigation, Resources, Data Curation, Writing – Review & Editing.

Oke Gerke: Conceptualization, Methodology, Validation, Formal Analysis, Writing – Review & Editing, Supervision.

Simon Michael Starck: Methodology, Validation, Investigation, Data Curation, Writing – Review & Editing.

Jonas Junghans Jensen: Methodology, Validation, Investigation, Data Curation, Writing – Review & Editing.

Jacob Eifer Møller: Conceptualization, Methodology, Validation, Writing – Review & Editing, Supervision.

Gitte Jørgensen: Methodology, Validation, Investigation, Resources, Writing – Review & Editing.

Finn Lund Henriksen: Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Resources, Data Curation, Writing – Original Draft, Writing – Review & Editing, Supervision, Project Administration, Funding Acquisition.