Maintenance Status and Availability of Public Automated External Defibrillators: Results of On-Site Inspection

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Abstract

Objective

This study aimed to assess the maintenance status and availability of publicly installed automated external defibrillators (AEDs).

Methods

Public AEDs installed in Seoul 2013 to 2017 were included. An inspector checked the maintenance status and availability of AEDs annually using a checklist.

Results

A total of 23,619 AEDs were inspected for 5 years. Access to AEDs was improved, including reduced obstacles around AEDs (from 9.3% in 2013 to 0.8% in 2017) and increased AED signs (from 34.3% in 2013 to 91.2% in 2017). The number of AEDs in normal operation (from 94.0% in 2013 to 97.5% in 2017), with normal battery charge (from 95.6% in 2013 to 96.8% in 2018), and electrode availability increased (from 97.1% in 2013 to 99.0% in 2017). However, the rate of electrode validity decreased (from 90.0% in 2013 to 87.2% in 2017). Non-ready-to-use AEDs and AEDs with limited 24-h availability accounted for 15.4% and 44.1% of the total number of AEDs, respectively.

Conclusions

Although most AEDs had a relatively good maintenance status, a significant proportion of public AEDs was not available for 24-h use. Invalid electrodes and limited 24-h accessibility were the main reasons that limited the 24-h availability of public AEDs.

Background

Immediate cardiopulmonary resuscitation (CPR) and rapid defibrillation are the most important measures to save patients with cardiac arrest from ventricular fibrillation.¹ Installation of automated external defibrillators (AEDs) in public places is an important way to provide rapid defibrillation to patients with out-of-hospital cardiac arrest (OHCA). By enabling the general public to perform defibrillation, the survival rate of such patients can be increased.^{2–5} It has been reported that the survival rate of patients with OHCA had improved in a community with public access defibrillation (PAD) programs where AEDs were installed in public places as a way to increase the chance of survival.^{6–8} Accordingly, the number of AEDs being installed in public places is increasing with the spread of the PAD programs. However, AED devices might be prone to failure or malfunction.^{9,10}

Importance

Good maintenance of AEDs is important to ensure reliable operation and reduce the risk of failure or malfunctioning of AEDs. The defibrillators in medical facilities or ambulances are used frequently and regularly undergo maintenance checks made by experts. On the other hand, public AEDs may not be maintained efficiently since they are not used frequently or checked by experts. With the increase in the number of publicly installed AEDs increasing, communities

need to pay attention to the maintenance of AEDs installed in their jurisdictions to ensure that they are always available and ready for use.

Goals of this investigation

In this context, it is necessary to assess the maintenance status and availability of AEDs in public places and determine strategies for good maintenance in the process of spreading (disseminating) PAD programs. However, there is little information on the maintenance and availability of AEDs installed in public places. Thus, the objective of this study was to investigate the management status and availability of AEDs installed in public places and provide basic data for establishing future management plans for AEDs.

Methods

Study design and setting

This was a longitudinal, descriptive, observational study using questionnaires and checklist for AED maintenance. Ethical approval was obtained from the Institutional Review Board of Wonju Christian Hospital, Yonsei University Wonju College of Medicine (Approval number: CR320033).

The government of the Republic of Korea has mandated the installation of AEDs for public housing with more than 500 households, subway stations, passenger terminals, casinos, racecourses, prisons, athletic fields with more than 5,000 seats, and government buildings. These AEDs are required to be registered with the government, and the equipment maintenance status is to be reported annually to the government. These AEDs have managers assigned to maintain the equipment and report on equipment status regularly. AEDs installed in places other than the mandatory installation sites must be registered with the government, but there is no obligation to report their maintenance status or appoint a manager for maintenance.

AEDs

AEDs installed in Seoul City from 2013 to 2017 were included in this study. Seoul City is the largest metropolitan city in South Korea with an area of 605 km² and a population of about 10 million. Only the AEDs installed in non-mandatory locations with financial support from the Seoul government were included in this study. AEDs installed with self-funded resources were excluded from this study.

AED inspection

The Korean Association for Safe Communities (Seoul, Republic of Korea), a non-profit organization registered with the Ministry of Public Administration and Security, South Korea, was commissioned by the Seoul Metropolitan Government to conduct the inspection and surveys of AEDs installed in Seoul. The AED inspection is conducted by inspectors annually at the sites where the AEDs are installed.

The inspection items for each AED were selected from the checklist recommended by the guidelines for AED placement and management published by the Korean Ministry of Health and Welfare. These selected inspection items were reviewed by an advisory committee composed of two emergency physicians and one specialist each from the AED manufacturing company, AED management company, and consumer protection group. To confirm the suitability of the developed checklist, a pilot inspection of 10 AEDs in different places was carried out. The final version of the inspection checklist included 11 items consisting of five items on the AED manager and accessibility (designation of AED manager, CPR and AED training of the manager, regular internal check, obstacles near AED, AED guide sign), four items on the maintenance status (operation status, battery status, accessibility and validity of electrodes), and two items on

the availability and actual use of AED (web-only appendices). The definition of a ready-to-use defibrillator is a defibrillator that has valid electrodes, has a good battery status, and is functioning normally. A 24-h available defibrillator was defined as a defibrillator that has valid electrodes, has a good battery status, operates normally, and can be used for 24 h.

Persons with valid basic life support (BLS) certification were selected as inspectors. A manual that included the concept of PAD, related laws, CPR and AED usage, AED management, survey procedure, survey items and their definitions, and how to input survey results was developed for training inspectors. The inspectors were trained with a 1-day course (7 hours of lectures and 1 hour of practice on how to inspect an AED).

Every year in November during the study period, the inspector visited the AED installation sites for inspection of the AEDs. The inspector checked each AED using a structured inspection checklist and surveyed the associated manager. After inspecting the AED, the inspector introduced the AED maintenance manual to the manager and allowed the manager to practice how to maintain the AED. Upon completion of the AED inspection, the inspector entered inspection and survey results into a spread sheet (Excel, Microsoft 2010) and sent it to the data management center which kept input data and performed quality control.

Statistical analysis

A retrospective descriptive time series analysis was conducted in this study. Nominal data were calculated as the percentage of the frequency of occurrence and compared using Chi-square or Fisher's exact test, as appropriate. The Cochran–Armitage trend test was used to assess temporal trends of the proportion of “yes” responses to the parameters. Ordinary least squares regression analysis was used to estimate linear temporal trends among variables for modeling and analyzing variables. All statistical analyses were conducted using R Statistical Software (version 3.6.3; R Foundation for Statistical Computing, Vienna, Austria).

Results

Through recruitment notices distributed via webforms (www.safia.org) and emails, 100 persons with a valid certification for BLS were selected and trained to inspect PADs every year from 2013 to 2017. Among the 36,313 AEDs installed during the study period, 11,783 AEDs installed with self-funded resources were excluded. A total of 911 AEDs that could not be inspected were also excluded (737 for refusal of inspection; 174 for duplicate data, lost data, demolition, or transfer). Finally, 23,619 AEDs, including 3,134 installed in 2013, 3,402 in 2014, 5,622 in 2015, 5,909 in 2015, and 5,552 in 2017, were inspected and included in the final analysis (Figure 1). The places where the defibrillator was installed were residential settings (49%), multi-use facilities (12%), and schools (10.2%) (Table 1).

Table 1
Locations of AEDs

Facility type	Total (N=23,619)	2013 (n=3,134)	2014 (n=3,402)	2015 (n=5,622)	2016 (n=5,909)	2017 (n=5,552)
Residential settings	11,564 (48.96)	1778 (56.73)	1882 (55.32)	2738 (48.70)	2640 (44.68)	2526 (45.50)
Multi-use facilities	2,732 (11.57)	338 (10.78)	280 (8.23)	644 (11.45)	674 (11.41)	796 (14.34)
Schools	2,413 (10.22)	74 (2.36)	300 (8.82)	556 (9.89)	1320 (22.34)	163 (2.94)
Public buildings	2,126 (9.00)	491 (15.66)	113 (3.32)	759 (13.5)	274 (4.63)	489 (8.81)
Police offices	1,515 (6.41)	28 (0.89)	212 (6.23)	294 (5.23)	477 (8.07)	504 (9.08)
Welfare facilities	929 (3.93)	161 (5.14)	258 (7.58)	11 (0.20)	148 (2.50)	351 (6.32)
Transportation facilities	693 (2.93)	0	0	306 (5.44)	11 (0.19)	376 (6.77)
Industrial facilities	637 (2.70)	148 (4.72)	2 (0.06)	134 (2.38)	159 (2.69)	194 (3.49)
Public health/medical clinics	249 (1.05)	67 (2.14)	70 (2.06)	13 (0.23)	63 (1.07)	36 (0.65)
Hotels and conference venues	181 (0.77)	31 (0.99)	40 (1.18)	26 (0.46)	39 (0.66)	45 (0.81)
Religious facilities	137 (0.58)	5 (0.16)	6 (0.18)	82 (1.46)	20 (0.34)	24 (0.43)
Prisons	7 (0.03)	1 (0.03)	3 (0.09)	1 (0.02)	0	2 (0.04)
Other	436 (1.85)	12 (0.38)	236 (6.94)	58 (1.03)	84 (1.42)	46 (0.83)
Data are presented as n and (percentage) from the total number of AEDs per year						
AED, automated external defibrillator						

Regarding the factors of AED management, the rate of designation of AED managers had increased from 86.7% in 2013 to 98.9% in 2017 ($p < 0.0001$) and the rate of regular internal check of AED had increased from 85.2% in 2013 to 85.6%

in 2017 ($p < 0.0001$). The rate of absence of obstacles near AEDs had increased from 90.2% in 2013 to 99.1% in 2017 ($p < 0.0001$) and the rate of AED guide sign installations had increased from 34.3% in 2013 to 91.3% in 2017 ($p < 0.0001$) (Table 2). Regarding the factors of maintenance status and accessibility, the rate of normal operation status had increased from 94.0% in 2013 to 97.6% in 2017 ($p < 0.0001$) and the rate of good battery status had increased from 95.6% in 2013 to 96.8% in 2017 ($p = 0.0016$). The rate of availability of electrodes had increased from 97.1% in 2013 to 99.0% in 2017 ($p < 0.0001$). However, the rate of validity of electrodes had decreased from 90.0% in 2013 to 87.2% in 2017 ($p < 0.0001$). The rate of 24-h accessibility of the AEDs had decreased from 66.0% in 2013 to 63.4% in 2017 ($p < 0.0001$). The rate of actual use of AEDs ranged from 0.7–1.2%, which had not significantly changed during study period ($p = 0.491$) (Table 3).

Table 2
AED management status

Parameter	Total (N=23,619)	2013 (n=3,134)	2014 (n=3,402)	2015 (n=5,622)	2016 (n=5,909)	2017 (n=5,552)	<i>p</i> value
Designation of AED manager	22,434 (94.98)	2,717 (86.7)	2,985 (87.7)	5,551 (98.7)	5,688 (96.3)	5,493 (98.9)	<.0001
CPR and AED training for manager	21,744 (92.06)	2,808 (89.6)	2,994 (88.0)	5,405 (96.1)	5,637 (95.4)	4,900 (88.3)	0.2258
Regular check of AED by manager	20,079 (85.01)	2,670 (85.2)	2,690 (79.1)	4,824 (85.8)	5,145 (87.1)	4,750 (85.6)	<.0001
Absence of obstacles near AED	22,532 (95.39)	2,826 (90.2)	3,117 (91.6)	5,223 (92.9)	5,862 (99.2)	5,504 (99.1)	<.0001
Presence of AED guide sign	13,937 (59.00)	1,074 (34.3)	1,092 (32.1)	1,996 (35.5)	4,709 (79.7)	5,066 (91.3)	<.0001
Data are presented as n and (percentage) from total number of AEDs per year							
CPR, cardiopulmonary resuscitation; AED, automated external defibrillator							

Table 3
Maintenance status, accessibility, and actual use of AEDs

Parameter	Total (N=23,619)	2013 (n=3,134)	2014 (n=3,402)	2015 (n=5,622)	2016 (n=5,909)	2017 (n=5,552)	<i>p</i> value
Normal operating status	22,893 (96.92)	2,947 (94.0)	3,289 (96.7)	5,463 (97.2)	5,776 (97.8)	5,418 (97.6)	< .0001
Good battery status	22,861 (96.79)	2,996 (95.6)	3,282 (96.5)	5,463 (97.2)	5,745 (97.2)	5,375 (96.8)	0.0016
Availability of electrodes	23,342 (98.82)	3,043 (97.1)	3,351 (98.5)	5,582 (99.3)	5,868 (99.3)	5,498 (99.0)	< .0001
Valid electrodes	20,578 (87.12)	2,822 (90.0)	3,117 (91.6)	5,113 (91.0)	4,685 (79.3)	4,841 (87.2)	< .0001†
24-h accessibility	15,771 (66.77)	2,070 (66.0)	2,500 (73.5)	3,842 (67.5)	3,840 (65.0)	3,519 (63.4)	< .0001†
Actual use of the AED	224 (0.99)	22 (0.7)	38 (1.1)	67 (1.2)	56 (0.9)	41 (0.7)	0.4911†
<i>p</i> for trend test. † Negative slope indicated a decreasing linear trend							
Data are presented as n and (percentage) from total number of AEDs per year							
AED, automated external defibrillator							

In terms of availability, non-ready-to-use AEDs accounted for 15.4% of the total AEDs. The causes of non-ready-to-use status were invalid electrode (83.7%), AED malfunction (22.1%), and bad battery status (17.2%). AEDs with limited 24-h availability accounted for 44.1% of the total AEDs, and the causes were limited 24-h accessibility (75.3%), invalid electrode (29.3%), AED malfunction (7.8%), and bad battery status (6.5%) (Table 4) (Figure 2). The proportion of AEDs with limited 24-h availability according to installation location was the highest in residential settings (27.2%), followed by in multi-use facilities (18.4%), schools (16.3%), public buildings (16.3%), and transportation facilities (Table 5).

Table 4
Non-available AEDs and their causes

Parameter	Total (N=23,619)	2013 (n=3,134)	2014 (n=3,402)	2015 (n=5,622)	2016 (n=5,909)	2017 (n=5,552)	p value
Non-ready-to-use AEDs ⁺	3,646 (15.44)	524 (16.72)	354 (10.41)	646 (11.49)	1302 (22.03)	820 (14.77)	< .0001
Bad battery status	677 (17.20)	138 (26.34)	113 (31.92)	159 (24.61)	133 (10.22)	134 (16.34)	< .0001†
AED malfunction	807 (22.13)	187 (35.69)	120 (33.90)	159 (24.61)	164 (12.60)	177 (21.59)	< .0001†
Invalid electrode	3051 (83.68)	322 (61.45)	285 (80.51)	509 (78.79)	1224 (94.01)	711 (86.71)	< .0001
Limited 24-h availability	10,422 (44.13)	1235 (39.41)	1096 (32.22)	2187 (38.90)	3207 (54.27)	2717 (48.94)	< .0001
Bad battery status	677 (6.50)	138 (11.17)	113 (10.31)	159 (7.27)	133 (6.08)	134 (4.93)	< .0001†
AED malfunction	810 (7.77)	187 (15.14)	120 (10.95)	159 (7.27)	164 (7.05)	177 (6.51)	< .0001†
Invalid electrode	3,051 (29.27)	322 (26.07)	285 (26.00)	509 (23.27)	1224 (55.97)	711 (26.17)	< .0001
Limited 24-h accessibility	7,848 (75.30)	1064 (86.15)	902 (82.30)	1780 (81.39)	2069 (94.60)	2033 (74.83)	< .0001
⁺ AEDs with good battery status, normal operation status and valid electrode							
[*] AEDs with good battery status, normal operation status and valid electrode, and 24-h accessibility							
Includes cases with duplicate causes							
† Negative slope indicated a decreasing linear trend							

Table 5
AEDs with limited 24-h availability according to the installation site

Facility type	Total (N=10,439)	2013 (n=1,235)	2014 (n=1,096)	2015 (n=2,187)	2016 (n=3,207)	2017 (n=2,714)
Residential settings	2835 (27.16)	289 (23.40)	255 (23.27)	400 (18.29)	1135 (35.39)	756 (27.86)
Multi-use facilities	1925 (18.44)	283 (22.91)	132 (12.04)	418 (19.11)	451 (14.06)	641 (23.62)
Schools	1704 (16.32)	41 (3.32)	185 (16.88)	411 (18.79)	938 (29.25)	129 (4.75)
Public buildings	1703 (16.31)	401 (32.47)	67 (6.11)	634 (28.99)	232 (7.23)	369 (13.60)
Welfare facilities	705 (6.75)	106 (8.58)	194 (17.70)	5 (0.23)	115 (3.59)	285 (10.50)
Transportation facilities	414 (3.97)	0	0	150 (6.86)	1 (0.03)	263 (9.69)
Police offices	366 (3.51)	13 (1.05)	43 (3.92)	3 (0.14)	161 (5.02)	146 (5.38)
Industrial facilities	207 (1.98)	21 (1.70)	0	66 (3.02)	67 (2.09)	53 (1.95)
Public health/medical clinics	197 (1.89)	49 (3.97)	40 (3.65)	11 (0.50)	63 (1.96)	34 (1.25)
Religious facilities	110 (1.05)	2 (0.16)	5 (0.46)	77 (3.52)	11 (0.34)	15 (0.55)
Hotels and conference venues	35 (0.34)	19 (1.54)	5 (0.46)	4 (0.18)	3 (0.09)	4 (0.15)
Prisons	4 (0.04)	1 (0.08)	1 (0.09)	0	0	2 (0.07)
Other	234 (2.24)	10 (0.81)	169 (15.42)	8 (0.37)	30 (0.94)	17 (0.63)
Data are presented as n and (percentage) from the total number of AEDs per year						
AED, automated external defibrillator						

Discussion

On observing public AEDs for a period of 5 years, we found that most AEDs had a relatively good maintenance status, with more than 97% of the AEDs operating normally. However, 15% of the AEDs were not ready for use, and invalid electrode was the most common cause for this. Further, 44% of the AEDs had limited 24-h use, and limited 24-h accessibility was the most common cause for this. Factors related to management and maintenance of AED and accessibility to AED were found to have improved over time. The proportion of valid electrodes decreased over time. Only around 1% of the AEDs were actually used. This rate did not change during the study period.

For successful implementation of PADs, four essential elements are required, namely planned and practiced response, training of anticipated rescuers in CPR and use of an AED, link to the local emergency medical system (EMS), and a process for continuous quality improvement.¹¹ In the process of developing and implementing the PAD program, the government or community has paid attention mainly to the installation of AEDs and link to the EMS system through legislation or guidelines.^{12,13} In addition, the AED must be maintained in a state of being ready-to-use for 24 h a day. AEDs need to be maintained and tested regularly in accordance with the applicable rules and regulations established by governmental authorities. However, the maintenance and management of AEDs may be the responsibility of the locations holding the AEDs, considering that the community or government may not be able to directly manage the maintenance of the AEDs. Although each country or community has legal provisions for AED registration and management, many public AEDs are not registered in the national registry system or their management status is often unknown. In the Swedish experience, a large proportion (43%) of AEDs was not registered in their registry because of the unawareness of the AED registry or difficulty in registering although those AEDs had high functionality.¹⁴ In a report assessing Canadian public AED registries, governance and administrative processes across registries were found to be irregular. Some registries do not use a standardized validation or quality surveillance process, which might result in the loss of important information on AED usability, including battery and electrode validity.¹⁵

In the present study, a trained inspector checked the management and maintenance status of each AED with regard to manager, accessibility, and equipment and electrode status by annually visiting the installation site. To the best of our knowledge, this is the first report on the management and maintenance status of AEDs by on-site inspection. In this study, the maintenance of the defibrillator itself gradually improved during the observation period. However, a significant proportion (44%) of AEDs had limited 24-h availability and this proportion increased over time. In particular, 3 years after the inspection began, the percentage of electrodes that had passed their expiration date was found to have increased. The defibrillator itself does not need a separate function check as it reports data by performing self-tests on its internal circuitry to ensure readiness.¹⁶ Two important accessories, i.e., batteries and electrodes, are subjected to inspection during defibrillator maintenance checks along with the defibrillator equipment itself. Since the battery is installed in the defibrillator, the charging status can be checked using the indicator. It is checked along with the defibrillator operation status. On the other hand, since the electrode is separate from the defibrillator, the validity of the electrode must be checked separately by its expiration date. Therefore, to ensure the working status of the electrode, the manager needs to be aware of the periodic replacement plan. In addition, in cases where the AED is installed with non-governmental external financial support, there is often no financial plan for replacing defibrillator accessories. In such cases, even if the AED manager or inspector finds a problem with the electrodes, the problem cannot be solved. In this respect, when purchasing a defibrillator and installing it in a public space, it is necessary to establish a supply or financial plan for maintaining its accessories along with an inspection plan.

The use of AEDs in public places is related to the number of cardiac arrests in the installation area, the willingness of witnesses to use AEDs, and 24-h availability of the AEDs.^{17–19} AEDs are highly accessible during weekdays, but their accessibility declines in the evenings, including nighttime, and on weekends. This limitation in accessibility is associated with reduced use of AEDs.²⁰ As observed in our study, the 24-h availability was limited for AEDs installed in places that were not open for 24 h, such as multi-use facilities, schools, public buildings, and welfare facilities. In

addition, we found that the proportion of limited 24-h availability was the highest in residential settings. The limited use of AEDs in a residential setting can be a major hindrance to the PAD program. Only approximately 1% of the AEDs were actually used. This low utilization rate might be associated with the low 24-h availability. Thus, when planning AED installation, it is necessary to consider whether the installation site is open for 24 h.

Limitations

This study has several limitations. Since the AEDs included in this study were not installed according to a systematic plan considering the incidence of cardiac arrest nor were they linked to the EMS, the results of this study cannot be applied to all public AEDs. Most defibrillators were inspected repeatedly but some were replaced during the study period. Since the inspectors were recruited annually, the same inspectors did not check defibrillators during the study period. In order to reduce the bias caused by the inspectors, the recruited inspectors were trained on the inspection method. The results of this study cannot be generalized to other countries because the AED implementation and maintenance regulations are based on the relevant laws of each country.

In conclusion, although the AEDs had a relatively good maintenance status, a significant proportion of public AEDs were not available for 24-h use. Invalid electrodes and limited 24-h accessibility were the main reasons that limited the 24-h availability of public AEDs. Community attention and initiatives are needed to increase the 24-h availability of public AEDs.

Declarations

Author contribution: SOH, SHY, and YJ conceived and designed the study, and obtained research funding. KC supervised the conduct of the study. SJK, WJC, YIR, and SK conducted the data collection and managed the data, including quality control. YJ undertook recruitment of AED installation agency. SHK and DRK provided statistical advice on study design and analyzed the data. TYK drafted the manuscript, and all authors contributed substantially to its revision. SOH takes responsibility for the paper as a whole.

Conflicts of interest: The authors have no conflicts of interest.

Meetings: This work has been presented at the European Emergency Medicine Congress 2021.

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Informed consent: This was a retrospective study using medical records. Informed consent was waived by the Institutional Review Board of Wonju Severance Christian Hospital.

Human rights statement: The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval by the institution's human research committee.

References

1. Perkins, G. D. *et al.* Resuscitation-Part 3: Adult basic life support and automated external defibrillation: 2015 International Consensus on cardiopulmonary resuscitation and Emergency cardiovascular Care Science with Treatment Recommendations., **95**, e43–e69 <https://doi.org/doi: 10.1161/CIR.0000000000000272> (2015).
2. Bækgaard, J. S. *et al.* The effects of public access defibrillation on survival after out-of-hospital cardiac arrest: A systematic review of observational studies., **136** (10), 954–965 <https://doi.org/doi: 10.1161/CIRCULATIONAHA.117.029067> (2017).

3. Hallstrom, A. P. *et al.* Public-access defibrillation and survival after out-of-hospital cardiac arrest. *N Engl J Med*, **351** (7), 637–646 <https://doi.org/doi: 10.1056/NEJMoa040566> (2004).
4. Holmberg, M. J., Vognsen, M., Andersen, M. S., Donnino, M. W. & Andersen, L. W. Bystander automated external defibrillator use and clinical outcomes after out-of-hospital cardiac arrest: A systematic review and meta-analysis. *Resuscitation*, **120**, 77–87 <https://doi.org/doi: 10.1016/j.resuscitation.2017.09.003> (2017).
5. Zijlstra, J. A. *et al.* Different defibrillation strategies in survivors after out-of-hospital cardiac arrest., **104** (23), 1929–1936 <https://doi.org/doi: 10.1136/heartjnl-2017-312622> (2018).
6. Capucci, A. *et al.* Tripling survival from sudden cardiac arrest via early defibrillation without traditional education in cardiopulmonary resuscitation., **106** (9), 1065–1070 <https://doi.org/doi: 10.1161/01.cir.0000028148.62305.69> (2002).
7. Gottschalk, A., Burmeister, M. A., Freitag, M., Cavus, E. & Standl, T. Influence of early defibrillation on the survival rate and quality of life after CPR in prehospital emergency medical service in a German metropolitan area. *Resuscitation*, **53** (1), 15–20 [https://doi.org/doi: 10.1016/s0300-9572\(01\)00483-x](https://doi.org/doi: 10.1016/s0300-9572(01)00483-x) (2002).
8. Kitamura, T. *et al.* Public-access defibrillation and out-of-hospital cardiac arrest in Japan. *N Engl J Med*, **375** (17), 1649–1659 <https://doi.org/doi: 10.1056/NEJMsa1600011> (2016).
9. DeLuca, L. A. Jr *et al.* Analysis of automated external defibrillator device failures reported to the Food and Drug Administration. *Ann Emerg Med*, **59** (2), 103–111 <https://doi.org/doi: 10.1016/j.annemergmed.2011.07.022> (2012).
10. Shah, J. S. & Maisel, W. H. Recalls and safety alerts affecting automated external defibrillators. *JAMA*, **296** (6), 655–660 <https://doi.org/doi: 10.1001/jama.296.6.655> (2006).
11. Aufderheide, T. *et al.* Community lay rescuer automated external defibrillation programs: Key state legislative components and implementation strategies: A summary of a decade of experience for healthcare providers, policymakers, legislators, employers, and community leaders from the American Heart Association Emergency Cardiovascular Care Committee, Council on Clinical Cardiology, and Office of State Advocacy., **113** (9), 1260–1270 <https://doi.org/doi: 10.1161/CIRCULATIONAHA.106.172289> (2006).
12. Gilchrist, S. *et al.* A summary of public access defibrillation laws, United States, 2010. *Prev Chronic Dis*, **9**, E71 (2012). PMID: PMC3372977
13. Priori, S. G. *et al.* ESC-ERC recommendations for the use of automated external defibrillators (AEDs) in Europe. *Eur Heart J*, **25** (5), 437–445 <https://doi.org/doi: 10.1016/j.ehj.2003.12.019> (2004).
14. Fredman, D. *et al.* Experiences and outcome from the implementation of a national Swedish automated external defibrillator registry. *Resuscitation*, **130**, 73–80 <https://doi.org/doi: 10.1016/j.resuscitation.2018.06.036> (2018).
15. d'Amours, L., Negreanu, D., Briard, J. N., de Champlain, F. & Homier, V. Assessment of Canadian Public Automated External Defibrillator Registries. *CJC Open*, **3** (4), 504–509 <https://doi.org/doi: 10.1016/j.cjco.2020.12.013> (2021).
16. Adams, B. D., Baden, E. Y. & Hartman, I. T. Self-reported checklist logs overestimate compliance with defibrillator inspections. *Qual Assur J*, **9** (1), 31–34 <https://doi.org/10.1002/qaj.305> (2005).
17. Agerskov, M. *et al.* Public Access Defibrillation: Great benefit and potential but infrequently used. *Resuscitation*, **96**, 53–58 <https://doi.org/doi: 10.1016/j.resuscitation.2015.07.021> (2015).
18. Suematsu, Y. *et al.* Citizen bystander-patient relationship and 1-month outcomes after out-of-hospital cardiac arrest of cardiac origin from the All-Japan Utstein Registry: A prospective, nationwide, population-based, observational study. *BMJ Open*, **9** (7), e024715 <https://doi.org/doi: 10.1136/bmjopen-2018-024715> (2019).
19. Karlsson, L. *et al.* Automated external defibrillator accessibility is crucial for bystander defibrillation and survival: A registry-based study. *Resuscitation*, **136**, 30–37 <https://doi.org/doi: 10.1016/j.resuscitation.2019.01.014> (2019).
20. Hansen, C. M. *et al.* Automated external defibrillators inaccessible to more than half of nearby cardiac arrests in public locations during evening, nighttime, and weekends., **128** (20), 2224–2231 <https://doi.org/doi:>

Figures

Figure 1

Flow chart showing the enrollment process for AEDs AED, automated external defibrillator

Figure 2

The proportion of non-available AED and their causes A. The proportion of non-available AED B. Causes of non-available AED AED, automated external defibrillator

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