International Journal of Psychosocial Rehabilitation, Vol. 24, Issue 7,
2020 ISSN: 1475-7192

Delivery Time of Automated External Defibrillators at Apartment Houses

Tai-Hwan Uhm[1], Jee-Hee Kim*[2]

[1] *Professor, Department of Emergency Medical Services, Eulji University, 553, Sanseongdaero, Seongnam, 13135, Republic of Korea*

*[2]*Professor, Department of Emergency Medical Services, Kangwon National University, 346, Hwangjori, Samcheok, 25949, Republic of Korea*

emtec@eulji.ac.kr[1], kjh1962@kangwon.ac.kr*[2]

Abstract

Background/Objectives*: This study aimed to present installation criteria and a management proposal for public access defibrillation by investigating the current status of automated external defibrillators positioned in apartment housing complexes.*

Methods/Statistical analysis*: A correlation was expected between the distance to the installed unit and the number of housing units and AEDs. Regression analysis was conducted to identify the correlations. Delivery time was determined by converting the physical distance measured by a software application (app) to the pace of a briskly walking adult. Movement time between the different levels of the apartment building was determined using a standard-speed elevator.*

Findings*: Regression analysis revealed an intercept of 274.190 and slope of 0.106, each of which was statistically significant ($p < 0.001$). The regression equation was determined to be $Y=274.190+0.106X$. The number of housing units was equal to $274.190+0.106\times180$(seconds)$=293$, indicating that one AED for every 293 units should be the installation criterion required to enable an AED delivery of less than three minutes.*

Improvements/Applications*: The findings of this study may be used in efforts to produce installation criteria for other public multi-use locations.*

Keywords: *Arrests occurred at home, Public access defibrillation, Management proposal, Regression equation, Automated external defibrillator*

1. Introduction

Cases of out-of-hospital cardiac arrests (OHCAs) transported by Korean first responders number approximately 20,000 each year, with most of them (63 to 72%) occurring in the home. The rate of defibrillation conducted by laypersons was only 1.9%[1-3]. The survival to discharge (STD) rate for Korean OHCA patients has increased to 8.5% but it is still less than the rates in advanced industrialized countries[4]. Lack of CPR and delayed defibrillation decrease the survival rate by 7-10% per minute and CPR with delayed defibrillation cuts the survival rate by 3-4% per minute, highlighting the need for layperson defibrillation[5]. Public access defibrillation programs were initiated in the U.S. in 1995, which has helped increase the return of spontaneous circulation (ROSC) in patients who have cardiac arrests in public places[6-9]. When initial defibrillation was

delayed, even first responder defibrillation failed to increase the survival rate. Defibrillation programs, reinforced by training, practice, and equipment maintenance, and linked to the emergency medical service system have doubled the out-of-hospital survival rates[10-12].

According to Korea's Emergency Medical Service Act (June 15, 2008), and its clauses related to the installation of emergency equipment for CPR, only apartment housing complexes with over 500 units are required to maintain it. Thus, scientific criteria enabling the deployment of an automated external defibrillator (AED) in communal housing in less than three minutes is necessary. Today, there are 8,505 AEDs in apartment houses with over 500 units and 1,481 in apartments with less than 500 units. In Seoul, 2,465 AEDs are installed in 500 unit apartments and 605 are in apartments with fewer than 500 units[13]. While effective utilization of these AEDs requires, as mandated by the EMS Act cited above, a designated maintenance manager, training in their use, and maintenance and education for residents, actual attention is often only focused on the physical installation of the devices[14]. While AEDs were installed in apartment housing to better respond to in-home arrests, the survival rate will not be improved without a systematic layperson-oriented AED program.

This study aimed to present installation criteria and a management proposal for public access defibrillation (PAD) that can be deployed in response to arrests occurring in the home by investigating the current status of AEDs positioned in apartment housing in Seoul.

2. MATERIALS AND METHODS

In August of 2018, four researchers conducted interview investigations of 160 apartments with AEDs installed in Seoul. The researchers finalized the details of the interview by June and, after receiving prior approval by contacting the management offices of housing complexes, conducted interviews after explaining the purpose of the investigation and explaining the protection of respondent identity and privacy. The interviews included questions on overall status, the installation and maintenance of the AEDs, training and use of the devices, and awareness of defibrillation. The collected data were processed using SPSS 21.0 for Windows (IBM Inc, New York, NY, USA). The data are expressed as frequency (%) for discrete variables and by mean and standard deviation for continuous variables. The significance level was set at 0.05.

The number of units and the number of AEDS were expected to correlate with the installation distance. Regression analysis was performed to determine the delivery time, i.e., how long it took to retrieve an AED, for 143 apartment houses that had AEDs installed on site. The Samsung Health (Samsung Electronics Co., Ltd, Suwon, Korea) app was used to determine the distance to the farthest point from the AED, as well as the highest story of the apartment, and was time-converted to match the brisk walking pace of an adult. Travel time between the levels was determined by the time taken by a standard-speed residential elevator, with waiting time factored in. The brisk walking pace of younger individuals was 6.5km/h, or 1.8m/1 sec. A residential elevator was determined to travel at 45m/min, which was converted to 3m (one story)/4 sec[15-16].

Regression analysis was performed to provide installation criteria recommendations to determine the number of units in an apartment to which an AED can be brought in less than three minutes. Since brain death begins four to five minutes after cardiac arrest, three minutes was chosen for AED delivery. Another minute would be needed for defibrillation preparation. Information was collected to provide policy proposals on installation criteria for apartment, management systems, and education and training. A self-evaluation, scored

on the Likert scale, was used to determine how much the subjects knew about automatic defibrillation (knowledge), ability to use the device (skill), and willingness to perform emergency defibrillation (attitude).

3. RESULTS AND DISCUSSION

Table AED on the 160 apartment housing complexes surveyed for this study, the average number of units per apartment was 867, with the largest proportion having between 500 and 1,000 units (98 cases, 61.9%). Some apartments with less than 500 units that were not required by law to maintain an AED on-site, had installed the devices (28 cases, 17.5%). Nevertheless, and although most only had a single unit installed as mandated by law, some complexes maintained two or more units. Regulatory requirement (115 cases, 62.1%) was cited as the main reason for purchasing the devices, rather than awareness of the need for timely defibrillation (45 cases, 24.3%). Most devices were installed in the management office (133 cases, 83.1%), rather than in the actual residential buildings (18 cases, 11.3%), presenting a barrier to rapid deployment. While a reasonable number of complexes (71 cases, 44.4%) had less than 300 m in distance between the AED and the farthest point in the housing complex, there were more cases in which over three minutes was required to access the device. The average number of stories in the apartment buildings was surveyed to factor in the time needed to travel by elevator. The average round-trip time was 222.3 seconds, with an average elevator travel time of 136.4 seconds. The average time required to deliver an AED was 358.6 seconds, or as much as six minutes. Four cases of actual AED use on-site were identified, with no case of successful ROSC.

Table 1. General characteristics of AEDs installed at apartment

	Mean(SD*)	N(%)
Households	867(639.5)	
below 499		28(17.5)
500-1000		99(61.9)
above 1001		33(20.6)
Number of AEDs**	1.4(1.90)	
1		143(89.4)
2		7(4.4)
above 3		10(6.2)
Reason for installation (multiple answers)		
legal liability		115(62.1)
necessity recognition		45(24.3)
residents asking		16(8.7)
Other		9(4.9)
Location installed		
management office		133(83.1)
Lobby		18(11.3)
security office		6(3.8)
Other		3(1.9)
Distance from AED**(meter, m)	400.2(265.98)	
below 300m		71(44.4)
301-600m		57(35.6)
above 601m		32(20.0)

Story	17(5.5)	
below 10		5(3.1)
11-20		122(76.2)
above 21		33(20.7)
Conversion time of distance*** (second, sec)	222.3(147.77)	
Conversion time of story**** (sec)	136.4(43.72)	
Delivery time(sec)	358.6(149.69)	
below 180		9(5.6)
181-240		27(16.9)
above 241		124(77.5)

*standard deviation

**automated external defibrillators

***1.8m/1 sec

****1 story/4 sec

Daytime maintenance ownership usually rested on the apartment management supervisor (38 cases, 23.8%) or junior supervisor (60 cases, 37.5%), there were cases where no one had maintenance responsibility (46 cases 28.8%). Nighttime maintenance responsibility often went to security personnel (74 cases, 46.3%) but was also often unassigned (73 cases, 45.6%). Personnel capable of providing AED treatment were management employees (148 cases, 51.9%) or the management supervisor (93 cases, 32.6%). For regulatory compliance, some complexes conducted monthly maintenance (127 cases, 31.5%) or had a designated AED maintenance supervisor (120, 29.9%). Maintenance issues included the burden of having to maintain expensive equipment often costing over two million won (66 cases, 38.4%) and learning how to use the devices (39 cases, 22.7%) but fortunately, very few devices were kept under lock and key, a major hindrance to timely AED deployment. The residents were informed of the location of the devices (138 cases, 64.4%) by posted notices but there was less information on how to use the AEDs.

Table 2. Status of managing on AEDs installed at apartment

	Mean(SD*)	N(%)
Number of employees	15(13.8)	
Employee in charge of AED**	Day	Night
Director	38(23.8)	0(0.0)
Manager	60(37.5)	0(0.0)
Guard	0(0.0)	74(46.3)
Other	16(10.0)	13(8.1)
None	46(28.8)	73(45.6)
Employee capable of using AED**	1.8(0.87)	
Director		93(32.6)
Manager		148(51.9)
Guard		33(11.6)
Resident		11(3.9)
Managing at EMS*** Act	2.5(1.25)	
checking once or more a month		127(31.5)
designating person in charge		120(29.9)

Documentation		79(19.6)
designating person trained		76(18.8)
Other		1(0.2)
Problem of managing AED**	3.2(1.30)	
maintaining AED**		66(38.4)
training employee		39(22.7)
designating person in charge		20(11.6)
Documentation		12(7.0)
Other		35(20.3)
Locking up		5(3.1)
Notice (multiple answers)		
Location		138(64.4)
how to use		59(27.7)
Precautions		12(5.6)
key keeper		5(2.3)

*standard deviation

**automated external defibrillator

***emergency medical service

AED training in the apartment houses was received by the management office employee most often (140 cases, 56.2%), followed by the management supervisor (82 cases, 32.9%). The main training body was the district public clinic (58 cases, 36.2%), which provided one (33 cases, 20.6%) or two (38 cases, 23.8%) training sessions. When training sessions also included a CPR component, many lasted for more than four hours (63 cases, 39.3%) but almost an equal number of training sessions lasted fewer hours or was not conducted at all (59 cases, 36.9%).

Table 3. Defibrillation training toward employees working at apartment

	Mean(SD*)	N(%)
Trained person (multiple answers)	1.6(0.73)	
Director		82(32.9)
Manager		140(56.2)
Guard		26(10.5)
Resident		1(0.4)
Training institution		
none or no response		92(57.5)
community health center		58(36.2)
fire station		4(2.5)
Other		6(3.8)
Number of training	1.8(1.8)	
None		43(26.9)
1		33(20.6)
2		38(23.8)
3		28(17.5)
above 4		18(11.2)
Training hour	3.0(3.61)	

less than 1		59(36.9)
1		3(1.9)
2		18(11.3)
3		17(10.6)
above 4		63(39.3)

*standard deviation

Surveys of the knowledge level of the apartment management personnel revealed that only 30-36% were aware that resuscitation rates fell when defibrillation was delayed and 73% were aware that CPR had to be performed concurrently. The training level determined by a survey on knowledge, skill, and attitude self-assessment scored on a Likert scale (1 point = none and 4 points = significant) showed that the average training level ranged from 2.4 to 2.6 points.

Table 4. Education levels of employees working at apartment

Question	Mean(SD*)	N(%)
Basic knowledge(Correct answer)		
Chances of probability of survival to discharge reduce		49(30.6)
Chances of probability of survival to discharge are		58(36.3)
Defibrillation with (CPR**) has more probability of		117(73.1)
Education levels (Self assessed score***)		
Knowledge	2.4(0.56)	
Skills	2.4(0.61)	
Attitude	2.6(0.72)	

*standard deviation

**cardiopulmonary resuscitation

***Likert scale 1, not at all; 2, not really; 3, somewhat; 4, very much

The correlation coefficient between the number of housing units and the time required to deliver an AED was 0.466, and the number of housing units accounted for 21.7% of the time required for delivery. A correction of 21.1% was applied to the correlation coefficient to address the increase in the number of variables.

Table 5. Correlation between households and delivery time

	R	R^2	Adjusted R^2
Households	.466	.217	.211

The regression intercept was 274.190 and the slope of 0.106, each of which was statistically significant ($p < 0.001$). The regression equation was determined to be $Y = 274.190 + 0.106X$. The number of housing units was equal to 274.190+0.106×180(seconds)=293, indicating that the installation criteria should specify that an AED should be installed for every 293 units to enable an AED delivery of less than three minutes.

Table 6. Linear regression analysis between households and delivery time

	Un-standardized coefficients		*t*	*p*
	Beta	Standard error		
Constants	274.190	18.492	14.872	.000
Households Defibrillator delivery time	0.106	0.017	6.251	.000

As brisk walking speed was 1.8m/1 sec, the round-trip distance must be set to 324 m to maintain a round-trip time of less than three minutes. Therefore, the AED must be installed within ~~a user movement area of~~ 162 meters or less.

Apartment housing complexes were found to keep AEDs on-site, as required by the EMS Act. Some housing with less than the 500 units required by law had AEDs installed on-site and some had more than two units. This appeared to be a positive effect of the law (EMS Act). Since this only takes into account the travel time, and considering the fact that in 83.1% of the surveyed cases the devices were located in the management office, the location of the AEDs should either be made more clear or be moved to the apartment entrance so that they can be used by anyone. Only four cases of actual AED use were found, and only one case[17] was identified in a 2015 study. This finding was likely due to the rate of layperson basic CPR training in Korea (9.1% for CPR, 1.9% for defibrillation) and the delayed discovery of cardiac arrest in the home[18].

There was no one assigned AED maintenance responsibility during the daytime in 46 cases (28.8%) and during the nighttime in 73 cases (45.6%). The implications of studies that show pre-hospital survival rates doubling after the adoption of systematic defibrillation programs are clear[19].

4. CONCLUSION

The present study provides a basis for identifying the number of housing units that should be used as criteria to keep AED delivery time to less than three minutes in apartment. This study suggests that AEDs should be installed within 162 meters in public multi-use facilities where AED installation is mandatory. It is also important that the devices are placed to ensure their rapid deployment by anyone in the vicinity.

This study presented reasonable installation criteria for AEDs in apartment housing to enable a rapid defibrillation response, increasing the survival rate of out-of-hospital cardiac arrest patients. The findings of this study may be used in efforts to produce installation criteria for other public multi-use locations.

REFERENCES

[1] Kim KW, Moon HJ, Choi HJ, Cho JS, Kim SJ, Chung WJ, et al. 2015 Report on smart medical direction program for emergency medical technicians. Seoul, Korea: National Emergency Medical Center Press; 2015. Korean.

[2] Uhm TH, Kim JH. Survival to admission after out-of-hospital cardiac arrest in Seoul, South Korea. OAEM. 2014;6:63-8. DOI:https://doi.org/10.2147/OAEM.S68758

[3] Ahn KO, Shin SD, Suh GJ, Cha CW, Song KJ, Kim JS, et al. Epidemiology and outcomes from non-traumatic out-of-hospital cardiac arrest in Korea: a nationwide observational study. Resuscitation 2010;81:974-81. DOI:https://doi.org/10.1016/j.resuscitation.2010.02.029

[4] Kim KW, Moon HJ, Choi HJ, Cho JS, Kim SJ, Chung WJ, et al. 2015 Report on smart medical direction program for emergency medical technicians. Seoul, Korea: National Emergency Medical Center Press; 2015.

[5] Larsen MP, Eisenberg MS, Cummins RO, Hallstrom AP. Predicting survival from out-of-hospital cardiac arrest; a graphic model. Ann Emerg Med. 1993;22:1652-8. DOI:https://doi.org/10.1016/s0196-

0644(05)81302-2

[6] Weisfeldt ML, Kerber RE, McGoldrick RP, Moss AJ, Nichol G, Ornato JP, et al. Public access defibrillation. A statement for healthcare professionals from the American Heart Association Task Force on Automatic External Defibrillation. Circulation. 1995;92:2763. DOI:https://doi.org/10.1161/01.cir.92.9.2763

[7] Caffrey SL, Willoughby PJ, Pepe PE, Becker LB. Public use of automated external defibrillators. N Engl J Med. 2002;347:1242-7. DOI:https://doi.org/10.1056/nejmoa020932

[8] Valenzuela TD, Bjerke HS, Clark LL, Hardman R, Spaite DW, Nichol G. Rapid defibrillation by nontraditional responders: the Casino Project. Acad Emerg Med. 1998;5:414-5.

[9] Valenzuela TD, Roe DJ, Nichol G, Clark LL, Spaite DW, Hardman RG. Outcomes of rapid defibrillation by security officers after cardiac arrest in casinos. N Engl J Med. 2000;343:1206-9. DOI:https://doi.org/10.1056/nejm200010263431701

[10] The Public Access Defibrillation Trial Investigators. Public-access defibrillation and survival after out-of-hospital cardiac arrest. N Engl J Med. 2004;351:637-46. DOI:https://doi.org/10.1056/nejmoa040566

[11] Weisfeldt ML, Sitlani CM, Ornato JP, Rea T, Aufderheide TP, Davis D, et al. Survival after application of automatic external defibrillators before arrival of the emergency medical system: evaluation in the resuscitation outcomes consortium population of 21 million. J Am Coll Cardiol. 2010;55:1713-20. DOI:https://doi.org/10.1016/j.jacc.2009.11.077

[12] Kitamura T, Iwami T, Kawamura T, Nagao K, Tanaka H, Hiraide A. Nationwide public-access defibrillation in Japan. N Engl J Med. 2010;362:994-1004. DOI:https://doi.org/10.1056/nejmoa0906644

[13] National Emergency Medical Center. 2016 Statistics Annual Report. Available at: http://www.e-gen.or.kr/nemc/statistics_annual_report.do, 2018.

[14] Jung JH. A survey on installation, management, and usability of automated external defibrillators-Focused on apartments with over 500 households in Chungnam. Korean J Emerg Med Ser 2017;21:73-84. DOI:https://doi.org/10.14408/KJEMS.2017.21.3.073

[15] Wikipedia. Available at: https://en.wikipedia.org/wiki/Walking, 2018.

[16] Wikipedia. Available at:https://ko.wikipedia.org/wiki/%EC%97%98%EB%A6%AC%EB%B2%A0%EC%9D%B4%ED%84%B0, 2018.

[17] Uhm TH, Kim JH. Affecting delivery time of public access defibrillator at apartment houses. Indian Journal of Public Health Research & Development. 2018;9(9):126-32. DOI:https://doi.org/10.5958/0976-5506.2018.01054.9

[18] Descatha A, Dagrenat C, Cassan P, Jost D, Loeb T, Baer M, et al. Cardiac arrest in the workplace and its outcome: a systematic review and meta-analysis. Resuscitation. 2015 Nov;96:30-6. DOI: https://doi.org/10.1016/j.resuscitation.2015.07.004

[19] Bardy GH, Lee KL, Mark DB, Poole JE, Toff WD, Tonkin AM, et al. Home use of automated external defibrillators for sudden cardiac arrest. N Engl J Med. 2008;358:1793-804. DOI:https://doi.org/10.1056/NEJMoa0801651