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Study on Automatic External Defibrillators deployed at General Supermarkets

Sang-Kyu PARK*, Jee-Hee KIM, Tai-Hwan UHM*****

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Abstract

Purpose: This study was to propose effective deployment of automatic external defibrillators (AEDs) installed at general supermarkets. **Research design, data, and methodology :** We conducted interview and data surveys on 72 large distributors in Seoul and Gyeonggi province in South Korea. The content of this survey was consisted of general status on the general supermarkets, AED deployment and management regarding public access defibrillation (PAD*). G*Power* (v 3.1.9.4; Universität Kiel, Kiel, Germany) was also used to analyze statistical power. Radius and actual distance, radius and retrieval time were compared by *t-test* at α=.05. respectively. **Results :** Difference between the radius (102.7 meters) and the actual distance (187.8 meters) was 85.1m, it had statistically significant difference (p<.001). The actual distance was longer compared to the radius distance. Difference between the radius (114.1 seconds) and the retrieval time (208.7 seconds) was 94.6s, it had statistically significant difference (p<.001). The retrieval time took longer compared to the radius time as well. **Conclusions :** The finding shows that only 45.9% of the general supermarkets are satisfied with the actual AED coverage within 3 minutes. This needs to enhance AED deployment to reduce defibrillation time and AED management to boost application in South Korea.

Keywords : Large Distributors, Public Access Defibrillation (PAD), Radius, Actual Distance, Retrieval Time

JEL Classification Code : I11, I12

1. Introduction

If defibrillation for patient with shockable rhythm is delayed, survival rate declines by 7-10% every minute without cardiopulmonary resuscitation (CPR), and by 3-4% every minute with CPR (Parry, Danielson, Brennenstuhl, Drennan, & Morrison, 2017). Layperson's CPR and defibrillation on out-of-hospital cardiac arrest (OHCA) patient are crucial for return of spontaneous circulation (ROSC) in prehospital. In the United States, application of the public access defibrillation (PAD) has enhanced ROSC by 47-74% (Weisfeldt, Kerber, McGoldrick, Moss, Nichol, Omato, Palmer, Rieqel, & Smith, 1995; White, Loccoh, Goble, Yu, Duquette, Davis, Odetola, & Russell, 2016; Rea, Olsufka, Bemis, White, Yin, Becker, Copass, Eisenberg, & Cobb, 2010; Viereck, Møller, Ersbøll, Folke, & Lippert, 2017). Brain death begins at 4 to 5 minutes after cardiac arrest, and the cardiac rhythm must be restored within 4 minutes. CPR and AED are required within 4 minutes. In order to perform defibrillation within 4 minutes, AED shall be provided within 3 minutes for delivery plus within 1 minute for preparing defibrillation.

In South Korea, survival to discharge rate was 7.6% in 2016 and 8.7% in 2017, 43% of cardiac arrest patients with CPR was treated by defibrillator (Gyeonggi Disaster and Safety Headquarters, 2018; Korea Centers for Disease Control and Prevention, 2017; Shin & Noh, 2014). However, the mean time for defibrillation by Gyeonggi Fire Services was 11 minutes, and PAD applications by bystanders were only 1.9% (Uhm & Kim, 2014; Ahn, Shin, Suh, Cha, Song, Kim, Lee, & Ong, 2010). Since there was only 1 defibrillation case mentioned in the 2015 study, the use of automatic external defibrillation (AED) by bystander

1 First Author, Professor, Department of Emergency Medical Technology, College of Health Science, Gachon University, South Korea.Tel: +82-32-820-4344, Email: psk9322@gachon.ac.kr
2 Co-Author, Professor, Department of Emergency Medical Services, College of Health Science, Kangwon National University, South Korea.Tel: +82-33-540-3342, Email: kjh1962@hanmail.net
3 Corresponding Author, Professor, Department of Emergency Medical Services, College of Health Sciences, Eulji University, South Korea.Tel: +82-31-740-7258, Email: emtec@eulji.ac.kr

needs to be promoted (Uhm & Kim, 2018).

In accordance with the Emergency Medical Service Act (EMS Act) (Korea Ministry of Government Legislation, 2016), 40,928 AEDs have been installed in public facilities such as public health & medical institutions, ambulances, passenger airplanes, passenger coaches, ships, multi-family houses, and other public-use facilities (National Emergency Medical Center, 2018). Though commercial facilities do not regally require AED installation, the facilities have 903 AEDs. However, their use was extremely rare as noted above. To make good use of these installed AED, designation of managers, training in use, management of equipment, and guidance of residents according to the EMS act should be made, however, the government is now focusing only on installation.

Furthermore, even the general supermarkets equipped with AEDs have to be applied with PAD program to enable defibrillation before brain death begins. Therefore, AEDs should be placed at a certain distance and easily accessible to anyone. Also, AEDs should be deployed according to general supermarkets size. It is expected that this will contribute to the prompt defibrillation and the improved survival rate. So far, there has been no data on the cardiac arrests and the defibrillation in the general supermarkets in South Korea, and there has been no research regarding AED on the general supermarket.

There may be a possibility of cardiac arrest in general supermarkets with any shoppers. In order to increase survival rate by providing rapid defibrillation to the patients with cardiac arrest in general supermarkets, a systemized PAD program wili be needed. This study performed by surveying on the general supermarkets with AED and is to suggest effective AED deployment for the rapid defibrillation.

2. Literature Review

As defined by the Distribution Terminology Definition Committee in the Korea Distribution Science Association (Korea Distribution Science Association, 2006), the General Supermarket is similar to large retailers under the Distribution Industry Development Act, and retailing to consumers by without shop assistants, focusing on foods, home appliances, household goods (Kwon, Kim, Kim, Kim, Namkung, Park, Park, Park, Youn, Lee, Hwang, & Kim, 2007).

In a dictionary sense, the General Supermarket is the most common distributor to sell 20-30% cheaper than other markets, using the method of mass sales thorough self-service. it is called Super Center in the United States and Hyper Market in the European Union (Kim & Kim, 2010).

The General Supermarket carries out marketing activities for retail distribution and sells products for large number of consumers, at low prices through the improvement and rationalization of the distribution structure (Kim, 2015).

Not only installing AED, but also, training layperson to do rapid defibrillation improved hospital discharge after OHCA in public locations. Trained layperson who can use AED safely and effectively could be great member of emergency medical service system (EMSS) (Hallstrom, Ornato, Weisfeldt, Travers, Christenson, McBurnie, Zalenski, Becker, Schron, & Proschan, 2004).

Short delivery time to shock and frequent start of basic life support (BLS) improved neurologically outcome and increased survival discharge rate. Despite of high number of installed AEDs, number of patients treated remained small. This negative situation raises need for AED deployment to use easily, and layperson trained to be able to defibrillate OHCAs (Fleischhackl, Roessler, Domanovits, Singer, Fleischhackl, Foitik, Czech, Mittlboeck, Malzer, Eisenburger, & Hoerauf, 2008).

Access to home AED did not significantly improve overall survival, as compared with conventional resuscitation methods. Although there are many OHCAs in home, resuscitation effect by AED is small. Therefore, strengthening PAD in commercial facilities will have great effect on survival (Bardy, Lee, Mark, Poole, Toff, Tonkin, Smith, Dorian, Packer, White, Longstreth, Anderson, Johnson, Bischoff, Yallop, McNulty, Ray, Clapp-Channing, Rosenberg, & Schron, 2008).

Application of PAD made nearly doubling of survival after OHCA. The results reinforce the importance of community-based AED programs in prehospital (Weisfeldt, Sitlani, Ornato, Rea, Aufderheide, Davis, Dreyer, Hess, Jui, Maloney, Sopko, Powell, Nichol, & Morrison, 2010).

Minority of individuals demonstrated sufficient knowledge and willingness to operate AED. It means that the public is not yet sufficiently prepared for defibrillation. In case of South Korea, where PAD has been implemented only since 2008 under the EMS Act, it is expected to be further lacking in the knowledge and intent for defibrillation compared to other advanced countries (Schober, van Dehn, Bierens, Loer, & Schwarte, 2011).

AEDs deployed as a part of large PAD program made a very high survival rate for patients with cardiac arrest. It could expect the same effect at general supermarkets as where people frequently use the airports (Eckstein, 2012).

Neurologically intact survival rate of 69% with a 30-day for OHCA patients with shockable rhythms, this study provides further evidence of the lifesaving potential of PAD. This means that not only ROSC, but also, survival and neurologically superior results can have a positive effect on the quality of life (Nielsen, Folke, Lippert, & Rasmussen, 2013).

The OHCA cases in public places showed that high

incidence areas defined as those with ≥1 OHCA every 2 years accounted for a small portion of the total area studied, however, about one-fifth of the total OHCA cases. OHCA patients in high incidence areas were more likely to experience events from 16:00 to 23:59. These results raise need to identify the frequency of OHCA outbreaks at general supermarkets, which will result in enhanced AED deployment and management in the places (Hansen, Wissenberg, Weeke, Zinckernagel, Ruwald, Karlsson, Lippert, Gislason, Nielsen, Køber, Torp-Pedersen, & Folke, 2013).

In study on public location OHCAs and non-medical facility AEDs, high OHCA incident at areas lacking AEDs were identified by mapping. Therefore, between OHCA event and AED placement showed a weak correlation. Events occurred most frequently in cars, roads, parking lots, and there were no registered AEDs for these areas. AEDs were placed most frequently in public business, office, workplace, and cardiac arrests occurred with the second highest frequency in these places. It seems that there is a need to prepare for cardiac arrest even at the general supermarket including the large parking lot (Moon, Vadeboncoeur, Kortuem, Kisakye, Karamooz, White, Brazil, Spaite, & Bobrow, 2015).

The study revealed attitude education influencing willingness to perform CPR. This attitude education such as prevention of brain damage, confidence to perform chest compression, understanding on the damage caused by chest compression, ability to overcome the patient's features, awareness of exemption from liability, confidence in their own physical ability, low probability of infection from OHCAs could be applied to defibrillation training for labors working at general supermarkets (Uhm, Kim, & Lee, 2017).

This study was the first time to design public AED location sign. Effective signage has the potential to help break down the barriers to more widespread use of AEDs in public places. Furthermore, being able to recognize AED quickly will reduce retrieval time at general supermarkets crowded with shoppers (Smith, Colquhoun, Samuel, Hodson, Mitchell, & O'Sullivan, 2017).

Total of 344 AEDs utilization was investigated in Taiwan, for those with shockable rhythm and received CPR, survival to discharge (STD) were 56.8% and CPC1-2 54.1%. ROSC were highest among public baths or hot springs (60%), followed by traffic hubs (53.3%), schools/large gathering venues (47.6%), hotels (46.7%). Overall survival rates of PAD patients were three-fold compared to data from best performing EMS. general supermarkets is included in large gathering venues, we could expect a high survival rate at general supermarkets with PAD program (Lin, Lin, Chiang, Yang, Hsieh, Chang, Ko, Wang, Hsu, Lee, Wang, Tsai, Chung, & Kuo, 2018).

The percentage of AEDs that fail testing is high, and the incidence of potentially life-threatening malfunction likely underreported. Based upon the results, we believe campaigns to enhance awareness and perhaps mandatory local AED registration and maintenance regulations should be considered. Designation of managers, training in use, management of equipment, and guidance of residents will have to be verified at general supermarkets (Matzke, Sutton, Crawford, Heimroth, & Sutton, 2018).

In application of AEDs in apartment houses, shorter delivery time was positively affected by smaller number of households and larger number of AEDs. The results will be applicable to commercial facilities such as general supermarkets (Uhm & Kim, 2018).

3. Methodology

3.1. Research Design and Data

We selected some general supermarkets which are more than 3,000m^2 in total, the general supermarkets are mainly retailing under the relevant act, and the general supermarket places are used directly for the sale of goods and the provision of services supporting them (Distribution Industry Development Act, 2016). From July to September 2019, 10 investigators conducted data survey and interview on 72 out of 242 general supermarkets in Seoul and Gyeonggi (including Incheon) province. The general supermarkets in Seoul and Gyeonggi employed 332 employees per general supermarket, with total sales per general supermarket of $50,000,000. A total of 497 general supermarkets in South Korea employed 70,536 employees, with total sales of $25,014,000,000 (Statistics Korea, 2017) <Table 1>. The surveyed 72 (14.5%) out of 497 belong to 3 major and other general supermarkets were composed of 29 (38.7%) out of 75 in Seoul and 43 (25.7%) out of 167 in Gyeonggi (Statistics Korea, 2017) <Table 2>.

Before obtaining consent from the general supermarkets, the investigators provided information on the purpose of our survey and confidentiality. The content of the survey was consisted of general status on the general supermarket, AED installation and management, AED training and use. Although it will be affected by the structure of the general supermarkets, difference between the radius and actual distance could mean a skewed placement of AED. For brain death begins within 4 to 5 minutes after cardiac arrest, 3 or 1.5 minutes (162 or 100 meters radius) for defibrillation should be reflected (Uhm & Kim 2018; Chan, Nichol, Krumholz, Spertus, & Nallamothu, 2009; Aufderheide, Hazinski, Nichol, Steffens, Buroker, McCune, Stapleton, Nadkarni, Potts, Ramirez, Eigel, Epstein, Sayre, Halperin, & Cummins, 2006).

Table1: Scale of the general supermarket in South Korea

Province	Number of Store	Total sales($)	Total sales($)/ General Supermarket	Employee	Employee/ General Supermarket
Seoul	75	5,091	68	13,948	186
Gyeonggi	167	8,855	53	24,393	146
Other	255	11,068	43	32,195	126
Overall	497	25,014	50	70,536	142

Table 2: Surveyed store out of the general supermarket

Province	Lotte Mart*		E-Mart**		Homeplus***		Other****		Overall****	
	General Super-market	Subject	General Super-market	Subject	General Super-market	Subject	General Super-market	Subject	General Super-market	Subject
Seoul	15	9	29	11	19	6	12	3	75	29
Gyeonggi	46	11	50	12	44	15	27	5	167	43
Other	63	0	47	0	78	0	67	0	255	0
Overall	124	20	126	23	141	21	106	8	497	72

*based on data from Lotte Mart homepage (Lotte Mart, 2019)
**based on data from E-Mart homepage (E-Mart, 2019)
***based on data from Homeplus homepage (Homeplus. LTD, 2019)
****derived from Statistics Korea homepage (Statistics Korea, 2017)

3.2. Methodology

The total floor area of the general supermarkets obtained from government data was converted to radius by formula. The application 'Samsung Health' (Samsung Electronics Co., Ltd, Suwon, Korea) was used to determine the actual distance to the furthest point from the AED. The retrieval time was calculated as the actual distance divided by 1.8m/s. The radius and actual distance converted to time was compared by *t-test.* The collected data were analyzed using *SPSS 21.0 for Windows* (IBM Inc., New York, USA) at α=.05(two-tailed).

The radius and radius time were obtained as follows: The total floor area was divided by the number of AEDs. And then, the radius induced from the floor area was converted to the radius time. If there are 2 AEDs in a 17,308m^2 general supermarket, The radius time was calculated by $S=\pi r^2 \div 1.8$m/s. Working speed was derived from 6.5km/h (i.e. 1.8m/s) (Wikipedia, 2018).

*G*Power* (v 3.1.9.4; Universität Kiel, Kiel, Germany) was also used to analyze statistical power.

4. Results

Survival to admission(STA) transported by Gyeonggi Fire Services were highest among home (4,020; 69.4%), followed by commercial & leisure facility (365; 6.3%), road & highway (322; 5.6%), health facility (286; 4.9%), residence (151; 2.6%), public place (83; 1.4%), industrial facility (64; 1.1%), educational facility (22; 0.4%). On the other hand, STA in the same area were highest among educational facility (11; 50.0%), followed by industrial facility (15; 23.4%), commercial & leisure facility (70; 19.2%), road & highway (57; 17.7%), public place (11; 13.3%), home (152; 3.8%), health facility (10; 3.5%), residence (4; 2.6%) (Gyeonggi Disaster and Safety Headquarters, 2018) <Table 3>.

Table 3: Location of out-of-hospital cardiac arrest and return of spontaneous circulation

Location	OHCA(%)	STA(rate)
Home	4,020(69.4)	152(3.8)
Commercial & Leisure facility	365(6.3)	70(19.2)
Road & Highway	322(5.6)	57(17.7)
Health facility	286(4.9)	10(3.5)
Residence	151(2.6)	4(2.6)
Public place	83(1.4)	11(13.3)
Industrial facility	64(1.1)	15(23.4)
Educational facility	22(0.4)	11(50.0)
Other	479(8.3)	64(13.4)
Overall	5,792	394(6.8)

Note: OHCA; out-of-hospital cardiac arrest, STA; survival to admission

The average area of 72 general supermarkets surveyed was 46,207m^2. 23 (31.9%) General supermarkets were from 3,000 to 19,999m^2, while 8 (11.1%) general supermarkets were over 80,000m^2. There were a total of 97 AEDs in the general supermarkets, with an average of 1.4 AEDs, with

40 (55.6%) general supermarkets having an AED. There were 59 lobbies (53.6%), 41 around display stands (37.3%), etc. in location deployed. There were 55 instructions (38.5%), 35 locations (24.4%), etc. in contents of notice. However, there was no defibrillation case <Table 4>.

Table 4: General characteristics of automatic external defibrillator installed at the general supermarket

General characteristics	N(%)	Mean*(s)*
General supermarket	72	
Area(m^2)		46,207.6 (42,936.3)
3,000-19,999	23(31.9)	
20,000-39,999	16(22.2)	
40,000-59,999	19(26.4)	
60,000-79,999	6(8.4)	
above 80,000	8(11.1)	
Number of AEDs	97	1.4(0.6)
0	11(15.2)	
1	40(55.6)	
2	17(23.6)	
above 3	4(5.6)	
Location deployed (multiple answers)	110	1.5(0.6)
lobby	59(53.6)	
around display stand	41(37.3)	
office	3(2.7)	
other	7(6.4)	
Notice (multiple answers)	143	2.1(1.3)
instructions	55(38.5)	
location	35(24.4)	
other	53(37.1)	
Defibrillation case	0	

Note: *s*; standard deviation, AED; automatic external defibrillator

The number of employees who received AED training was around 1.8 persons per the general supermarket, with most of them being directors 59 (45.4%) and manager 51 (39.2%). The number of employees who could use AED was around 1.9 persons per the general supermarket, with most of them being directors 60 (45.8%) and manager 50 (38.2%). Managing by the EMS Act was highest among checking once or more a month 50 (24.1%), followed by checking cleanliness & damage 43 (20.8%), equipment replacement according to expiration date 30 (14.5%), etc. However, the feedback & review was very low because there was no self-training or defibrillation implementation <Table 5>.

Table 5: Status of managing on automatic external defibrillator installed at the general supermarket

Management	N(%)	Mean*(s)*
Employee training of using AED (multiple answers)	120	1.8(0.9)
director	59(45.4)	
manager	51(39.2)	
guard	19(14.6)	
other	1(0.8)	
Employee capable of using AED (multiple answers)	131	1.9(0.8)
director	60(45.8)	
manager	50(38.2)	
guard	20(15.3)	
other	1(0.7)	
Managing by EMS Act (multiple answers)	207	3.0(2.0)
checking once or more a month	50(24.1)	
checking cleanliness & damage	43(20.8)	
equipment replacement according to expiration date	30(14.5)	
documentation & 3 years retention	20(9.7)	
anti-theft & daily inspection	20(9.7)	
feedback & review	4(1.8)	
other	40(19.4)	

Note: *s*; standard deviation, AED; automatic external defibrillator, EMS; emergency medical service

Radius by geometric distance was high proportion at below 100 (39; 54.2%), 101 to 162 meters (27; 37.5%), on the other hand, actual distance for effective defibrillation was low proportion at below 100 (21; 29.2%), 101 to 162 meters (10; 13.9%). Difference between the radius and the actual distance was 85.1 meters, it had statistically significant difference (p<.001). The actual distance was longer compared to the radius distance. Radius by geometric time was high proportion at below 90 (29; 40.3%), 91 to 180 seconds (37; 51.4%), on the other hand, retrieval time for effective defibrillation was low proportion at below 90 (14; 19.5%), 91 to 180 seconds (19; 26.4%). Difference between the radius and the retrieval time was 94.6 seconds, it had statistically significant difference (p<.001). The retrieval time took longer compared to the radius time as well <Table 6>.

Table 6: Comparison of distance, time on automatic external defibrillator deployed at the general supermarket

Distance(m)	Radius*(%)	Actual**(%)
below 100	39(54.2)	21(29.2)
101-162	27(37.5)	10(13.9)
above 163	6(8.3)	30(41.7)
N/A		11(15.2)
mean*(s)*	102.7(48.4)	187.8(122.5)
d	+85.1	
t	5.10	
p	<.001	
1-β	.93	
Time(s)	Radius***(%)	Retrieval****(%)
below 90	29(40.3)	14(19.5)
91-180	37(51.4)	19(26.4)
above 181	6(8.3)	28(38.9)
N/A		11(15.2)
mean*(s)*	114.1(53.8)	208.7(136.0)
d	+94.6	
t	5.11	
p	<.001	
1-β	.93	

Note: N/A; not available, *s*; standard deviation
*total floor area divided by AED, and radius induced from floor area, i.e. $S=\pi r^2$
**furthest point from AED by app 'Samsung Health'
***shuttling between radius and the center of general supermarket, i.e. radius×2÷1.8m/s
****shuttling between furthest point and AED, i.e. distance×2÷1.8m/s

5. Discussion

OHCA and ROSC at general supermarket were not classified above. It is inferred that general supermarket might be included in commercial & leisure facility category which has 6.3% at OHCA proportion and 19.2% at STA rate. According to some studies on ROSC from OHCA, training layperson to do rapid defibrillation improved hospital discharge. Trained layperson will be great member of EMSS (Hallstrom et al., 2004). STA out of OHCA transported by squads in Gyeonggi Fire Services was 6.8%. The highest outcome was arrest at educational facility (50.0%), and the lowest was residence (2.6%). The results support that witnessed arrests had more chance to be received Basic Life Support (BLS) such as basic CPR including defibrillation by bystander. OHCA outcomes at public place such as general supermarkets are probably better than other private places. For instance, home is where cardiac arrest occurs the most, on the other hand, STA rate at home is generally very low (Uhm & Kim, 2014; Sasson, Rogers, Dahl, & Kellermann, 2010). ROSC in Taiwan were highest among public baths or hot springs (60%), followed by traffic hubs (53.3%), schools/large gathering venues (47.6%) including general supermarkets, hotels (46.7%). it will expect improved survival rate at general supermarkets in South Korea such as Taiwan (Lin et al., 2018).

In public locations, the probability of bystander defibrillation decreased rapidly after the first 100 m (retrieval radius) whereas the probability of bystander defibrillation was low for all distances in residential areas. These findings indicate that the actual AED coverage area is more limited than anticipated in the AHA guidelines. In this study, other factors not mentioned such as non-witnessed arrest, non-shockable rhythm, non-accessible location, and non-capable to use might affect negatively bystander defibrillation (Sondergaard, Hansen, Pallisgaard, Gerds, Wissenberg, Karlsson, Lippert, Gislason, Torp-Pedersen, & Folke, 2018). Therefore, strengthening PAD such as reducing retrieval distance and time by increasing AED deployment in commercial facilities will have a great effect on survival (Bardy et al., 2008) compared to residential area.

The surveyed AEDs were placed in easily accessible lobbies, etc., and the information was relatively well marked, however, 15.2% of the general supermarkets had no AED. The employees had the ability to implement defibrillation after receiving defibrillation training in accordance with the EMS Act, however, there was no case of defibrillation. Based on the frequency of OHCA's occurrence, despite of installed AEDs, the negative situation raises need for AED to use easily. The results reinforce the importance of community-based AED program in prehospital. AEDs deployed as a part of large PAD program made a very high survival rate for patients with cardiac arrest. It could expect the same effect at general supermarkets where people frequently use (Fleischhackl et al., 2008; Weisfeldt et al., 2010; Eckstein, 2012). In case of South Korea, where PAD has been implemented only since 2008 under the EMS Act, minority of individuals demonstrated sufficient knowledge and willingness to operate AED (Schober et al., 2011). Moreover not only AED deployment, but also, it has to provide attitude education for the employees (Uhm et al., 2017).

6. Conclusions

The implementation of defibrillation by bystander has been shown to rely on distance from AED. This indicate needs for retrieval time in the general supermarket and for placement where it is easily visible and accessible. Radius had proportion at below 100 (54.2%) plus 101 to 162 meters (37.5%), however, actual distance for practical

defibrillation had proportion at below 100 (29.2%) plus 101 to 162 meters (13.9%). The actual distance was statistically significant longer than radius distance. Radius time had proportion at below 90 (40.3%) plus 91 to 180 seconds (51.4%), however, retrieval time for practical defibrillation had proportion at below 90 (19.5%) plus 91 to 180 seconds (13.9%). The retrieval time took statistically significant longer than radius time as well. Retrieval time for effective defibrillation was at below 90 (19.5%), 91 to 180 seconds (26.4%).These findings show that only 45.9% of the general supermarkets are satisfied with the actual AED coverage. This needs to enhance AED deployment to reduce defibrillation time and AED management to boost application in South Korea.

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