



Original Contribution

Locational effect on automated external defibrillator use and association of age with on-site return of spontaneous circulation

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ABSTRACT

Background: Emergency medical services (EMSs) are used by approximately 383,000 patients with out-of-hospital sudden cardiac arrest (SCA) in the United States. Hence, it is crucial to implement automated external defibrillator (AED) programs to prepare responders for an SCA emergency. Taiwanese pass legislature to enforce AED installation in 8 mandatory areas since 2013. Our study investigated the efficacy of the policy regarding AED installation.

Materials and methods: We collected data of patients who had sudden cardiac arrest (SCA) in pre-hospital settings, and received resuscitative efforts, including cardiopulmonary resuscitation or defibrillation with AEDs. The data were from July 11, 2013 to July 31, 2015. In total, 209 adult patients were documented by on-site caregivers of different facilities, and a report was mailed to the central health and welfare unit.

Results: Schools, large-scale gathering places, and special institutions used AEDs the most, accounting for 33 (15.3%) cases. From non-mandatory AED areas, long-term care facilities had the maximum cases of AED use (32 cases; 14.9%). With commuting stations as a reference, long-distance transport had the lowest odds ratio (OR) of 0.481 (95% confidence interval [CI], 0.24–0.962). The OR for schools, large-scale gathering places, and special institutions was 4.474 (95% CI: 2.497–8.015). Regarding failure of return of spontaneous circulation (ROSC), the OR for the ≥80-year age group was higher than that for the 20–39-year age group.

Conclusions: The policy regarding the legislation to install AEDs in mandatory areas improved AED accessibility. Elderly patients aged ≥80 years have a higher rate of ROSC failure.

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1. Introduction

Out-of-hospital SCA is a major issue, which has attracted global attention, and many countries have therefore legislated installation of automated external defibrillators (AEDs) and encourage their use [1]. Some states in the United States have mandated AED availability in specific public areas, such as schools, fitness facilities, and visible or central locations of certain buildings [1–3]. In Japan, publicly accessible AED installation is not enforced by law, but AEDs are installed voluntarily by individual organizations and business owners [4].

The Taiwanese government has endeavored to increase the number of citizens trained in cardiopulmonary resuscitation (CPR) and to encourage performing CPR. Amendments were passed in the year 2000 to authorize emergency medical technicians to use AEDs. Laypersons are also encouraged to use AEDs since 2011. In 2013, the Taiwanese legislature passed amendments to have AEDs installed in eight different mandatory areas.

The amended law also exempts people from criminal charges and civil liabilities if they fail to save a life despite trying [5]. All AEDs installed in public areas should be consistent in terms of symbols and operating guidelines.

Every case of patients receiving AED treatment should be documented, and a report should be mailed to central health and welfare units. Complete information of the registered 6151 AEDs was available during our study period [5]. However, the factors that influence the frequency of AED use are unknown. We conducted this study to identify the different locations where AEDs are used and age factors associated with on-site return of spontaneous circulation (ROSC) in Taiwan.

2. Materials and methods

2.1. Patient enrollment

Amendments to the Emergency Medical Services (EMSs) Act that enforced AED installation in public areas were passed on July 11, 2013. We prospectively collected data of patients with AED use and on-site defibrillation from July 11, 2013 to July 31, 2015; in total, 215 cases of

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AED use were documented by on-site caregivers of different facilities, and a report was mailed to the central health and welfare unit. However, complete data were available for only 209 cases, including the identity and training information of responders, training information of the location's supervisors, the category and available period of the AED at the location, acreage, population density of the district, and patient's sex and age (Fig. 1). Complete information of the 6151 registered AEDs was available during our study period. Concurrent data were used for different analyses [5]. The definition of a responder was a person who operated the AED or performed CPR, and training information was whether the responder had ever attended a training program for using AEDs or performing CPR.

2.2. Definition of mandatory and non-mandatory areas

Consistent with the definition by the Ministry of Health and Welfare of Taiwan, mandatory areas included (1) commuting stations; (2) long-distance transport; (3) sightseeing areas; (4) schools, large-scale gathering places, and special institutions; (5) large entertainment facilities; (6) large shopping malls or markets; (7) hotels; and (8) hot spring areas, and non-mandatory areas included (1) long-term care facilities; (2) medical institutions; (3) private workplaces; (4) marathons; and (5) others (including residential areas, temples, parks, public restrooms, and township offices).

2.3. Data analysis

Primary data were analyzed using SPSS (SPSS, Chicago, IL, USA); further comparisons were performed using SAS (SAS Institute, Cary, NC, USA). ORs of different locations were analyzed using a multivariate logistic regression model; ROSC failure in different age groups was compared using univariate analysis.

2.4. Ethical approval

This study was approved by the Institutional Review Board (IRB) of Kaohsiung Veterans General Hospital. The IRB code of the study is NMRF151214-003-EX.

3. Results

Basic information showed that 85.2% of the responders who used AEDs were trained for CPR or AED use. The average age of patients who received AED treatment was 56.9 ± 20.4 years, and 73.1% were men. In the eight mandatory areas, 122 patients received AED treatment. The highest frequency of AED use was noted in schools, large-scale gathering places, and special institutions, accounting for 33 cases (15.3%).

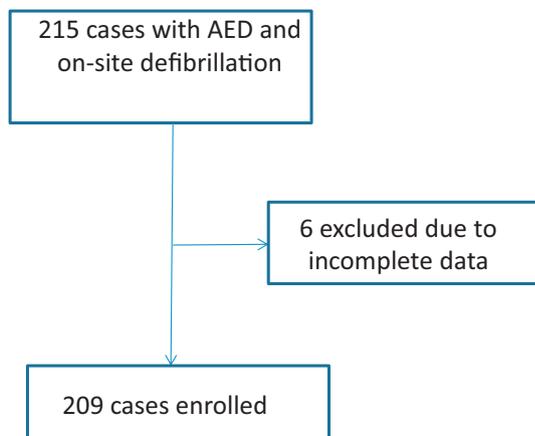


Fig. 1. Flowchart of patient enrollment.

Commuting stations, through which many people pass, had the second highest frequency (27 cases; 12.6%), and out-of-hospital cardiac arrest (OHCA) incidence was likely to be high here. In the non-mandatory areas, 87 cases of AED use were noted. Overall, long-term care facilities had the maximum cases of AED use (32 cases; 14.9%), which was higher than the number of cases reported at commuting stations.

The correlation of AED use with district population, acreage, and population density was non-significant. Mandatory areas had a higher odds ratio (OR) for AED use (OR: 2.302; 95% confidence interval [CI]: 1.407–3.768). We used incidents at commuting stations as a reference for comparison with those at other locations. The OR for long-distance transport was lower than that for commuting stations (OR: 0.481; 95% CI: 0.24–0.962), whereas that for schools, large-scale gathering places, and special institutions and commuting stations was 4.474 (95% CI: 2.497–8.015) (Table 1).

In terms of the OR for patients without on-site ROSC, the OR for the ≥ 80 -year age group was significantly higher than that for the 20–39-year age group (OR: 6.437; 95% CI: 1.544–26.832). Although, the ORs for the 40–59- and 60–79-year age groups were non-significantly higher than the OR for the youngest group, the ORs increased with an increase in age (Fig. 2).

4. Discussion

The policy of AED installation increased AED availability to 8334, with approximately 33.5 AEDs/10⁵ persons in November 2017, which was greater than that in the United Kingdom (25.6 AEDs/10⁵ persons). Furthermore, it facilitated the AED use or CPR training of 86.2% of the responders who operated AED [5]. Changes in our policy, such as reduced liability and training programs for CPR and AED use, may increase the willingness of responders to use AEDs as well as improve AED accessibility [6,7]. The OR of AED use in schools, large-scale gathering places, and special institutions was significantly higher than that at other mandatory locations, accounting for 33 cases (15.3%). However, this category includes an extensive range of locations, which may be the reason for it having more frequent AED use. A previous study showed that the prevalence of OHCA in schools was rare and most patients were adults; however, those patients were easily spotted and timely rescued [8]. Furthermore, the number of AEDs installed in schools,

Table 1
Odds ratio of automated external defibrillator (AED) use.

Odds ratio of AED use	Value	95% CI ^a
District		
District population: $\geq 130,834$ vs $< 130,834$	0.848	0.521–1.381
Acreage: ≥ 38.02 km ² vs < 38.02 km ²	0.872	0.494–1.539
Population density ^b : ≥ 3603.74 vs < 3603.74	1.356	0.71–2.588
Accessible during holiday: No vs Yes	0.667	0.391–1.135
Mandatory areas (n = 122) vs non-mandatory areas (n = 87) ^c	2.302	1.407–3.768
Mandatory areas compared with commuting stations (n = 27)		
Long-distance transport (n = 17)	0.481	0.24–0.962
Sightseeing areas (n = 11)	1.978	0.906–4.318
Schools, large-scale gathering places, and special institutions (n = 33)	4.474	2.497–8.015
Large entertainment facilities (n = 11)	1.546	0.648–3.688
Large shopping malls or markets (n = 9)	1.847	0.733–4.656
Hotels (n = 9)	1.324	0.525–3.337
Hot spring areas (n = 9)	0.696	0.196–2.476
Rescue training information of the location supervisor ^d : Yes vs No	0.443	0.234–0.837

^a 95% confidence interval.

^b Number of people/Land area.

^c Includes long-term care facilities (n = 32), medical institutions (n = 17), private working places (n = 11), marathons (n = 7), and others (n = 20).

^d Rescue training data indicates whether or not responders received training for CPR and AED.

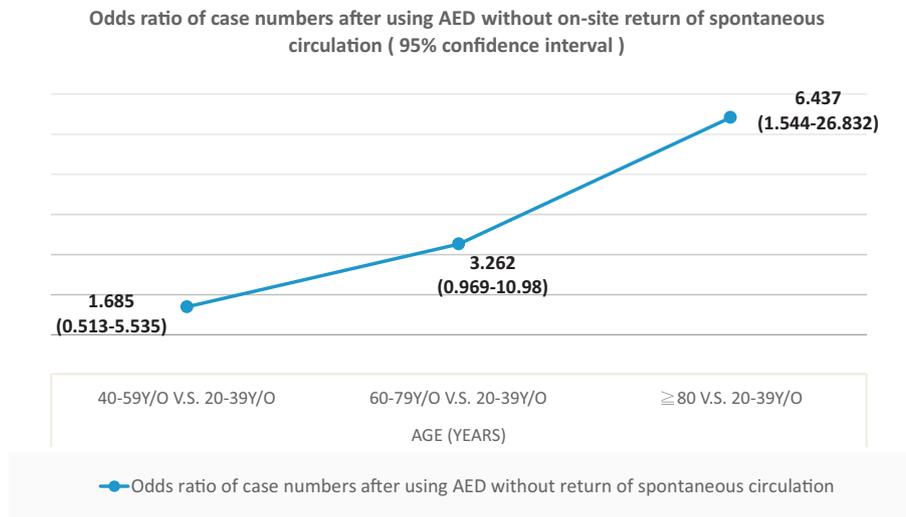


Fig. 2. Linear regression of the odds ratios of the number of patients receiving automated external defibrillator (AED) treatment without on-site return of spontaneous circulation.

large-scale gathering places, and special institutions was higher than that at other locations, accounting for 40.2% of all registered AEDs.

The comparison between variables showed that the number of people, acreage, and population density of districts did not affect the OR of AED use, and accessibility of AEDs during holidays was not a significant factor influencing AED use (95% CI: 0.391–1.135; Table 1). The results differed from our hypotheses, which suggested that districts with higher population densities would have higher odds of using AEDs. Because the highest incidence of non-traumatic OHCA per site over 5 years [9] was reported at commuting stations, we used the OR at commuting stations as a reference for comparison with that at other locations. Among non-mandatory areas, long-term care facilities had the maximum cases of AED use (32 cases; 14.9%), which was greater than the number of cases reported at commuting stations. Long-term care facilities generally have older people who may have more comorbidities [10] compared with people with AED use at commuting stations. From our experience, residential areas had the maximum cases of non-traumatic OHCA, and commuting stations had the highest incidence of non-traumatic OHCA per site over 5 years [10]. Therefore, these places may need more AEDs and training programs for CPR and AED use.

In a previous study, advanced age was associated with decreased survival for patients with OHCA [11]. As age increases, the prevalence of underlying diseases, such as coronary heart diseases and myocardial infarction, may increase the odds of ROSC failure [12]. People who stay in long-term care facilities are usually old with multiple comorbidities, and hence, the percentage of AED use was 73.9%, which was much higher than that at mandatory areas (1.3% for schools) [5]. We should consider installing more AEDs and providing more training for employees in long-term care facilities because such places may lack early defibrillation capacity and AEDs [13,14]. Therefore, legislation should enforce AED installation in long-term care facilities and increase rescue training programs for employees of such facilities.

Several factors, such as age, shockable rhythm, first responder CPR, and EMS response time, are associated with ROSC success rates. In addition to public AED programs, we should incorporate other resources such as pre-hospital EMS and layperson CPR training especially in the care facilities and areas with high incidence of SCA to improve ROSC success rates and decrease subsequent morbidity.

4.1. Limitations

Although this was a prospective study, it has some limitations. First, we could not trace the entire outcome, including mortality and morbidity of the enrolled patients, and we failed to document the time interval

between collapse and AED use. Second, information regarding patients with OHCA who were not treated with an AED was not documented. Furthermore, the level of crowd at each location was not noted in this study, which is a factor that may impact AED use. Finally, the collected data were incomplete, as basic clinical information of patients who received AED treatment, such as their medical history and symptoms before collapse, were lacking because their identities were unavailable at the first-response scene.

5. Conclusions

The policy regarding the legislation to install AEDs in mandatory areas improved AED accessibility. Facilities such as schools, large-scale gathering places, special institutions, and long-term care facilities have higher AED use and hence may need installation of more AEDs in the future. Furthermore, long-term facilities should be included in mandatory areas. Elderly patients aged ≥ 80 years have higher rates of ROSC failure. Integrating medical records and reports by layperson can prevent data omissions.

Conflicts of interest

The authors declare that they have no conflicts of interest related to the subject matter or materials discussed in this article.

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