

Mismatch between Sites of Incidence of Out-of-Hospital Cardiac Arrest and Locations of Installed Automated External Defibrillator in the Tokyo Metropolitan Area

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Abstract

Background: Since 2004, the number of installed Automated External Defibrillator (AED) has been increased in Japan annually, the cumulative number of sold AED more than 600,000 units by 2016. Despite there have been about 130,000 out of hospital cardiac arrest annually, there have only 1302 cases delivered defibrillation by bystanders at the scene. Therefore, we investigate that number of AED installation and usage rate for Out of Hospital Cardiac Arrest (OHCA) patients. **Methods:** Retrospective metropolitan wide cohort study. **Subject:** Total 13,364 OHCA patients in the Tokyo Metropolitan area from Jan. 1 through Dec. 31 in 2012 were eligible for these analyses. Also, OHCA occurrence place and AED usage rate were studied. **Results:** 82.8% of OHCA occurred at residences, 10% at outdoors, 6.4% at indoors, only 0.7% at schools. In the other hand, highest bystander's CPR rates were found in sports facilities and schools (71.4%). The installation rate of AEDs in residences was 9.6%, instead of highest incidence for OHCA patients, school and sports institute made up 21.4% of AED installations, but only 1.0% of the incidences of cardiac arrest. We found that there is a mismatch between incidence sites of cardiac arrest and locations of installed AED. **Discussion:** It is essential to increase the number of AED installations. Furthermore, it is desirable to install AEDs in locations where cardiac arrest is liable to occur following guidelines for the proper placement of AEDs, and important to further spread BLS education among the general citizens.

Keywords

AED, Cardiac Arrest, Defibrillation, Bystander, First Aid

1. Introduction

The use of Automated External Defibrillator (AED) by non-healthcare professionals has been approved in Japan from July 2004 [1]. The cumulative number of sales for AEDs throughout Japan in 2004 was 1307 units, but ten years later, in 2014, that number had become 516,135 units [2]. Among these, the Tokyo metropolitan area had the highest installations of AEDs in Japan at 40,504 units as of December 2013 [3].

On the other hand, the number of AEDs used in 2012 by bystanders to deliver the shock at the scene of incidence for cardiac arrest patients was 1802 [4]. This is only 4.9% of the 364,959 installed in Tokyo metropolitan area at the time. It suggested that the Public Access Defibrillators have been not being fully effective utilized.

Thus, we investigated that reason of the low usage rate instead of the high number of installations was perhaps mismatch of the locations of installed AED and the sites of incidence for cardiac arrest patients. No one compared with that before.

2. Objective

The incidence for Out of Hospital Cardiac Arrest (OHCA) patients transported by Tokyo Fire Department (TFD) and bystander's CPR rates in the Tokyo metropolitan area were studied. In addition, mismatch between the actual sites of incidence of OHCA and the locations of AED installations.

3. Method and Subjects

3.1. Study Design

Retrospective metropolitan wide cohort study.

3.2. Subject

From January 1 through December 31, 2012, total of 13,364 OHCA transported data adopted from in Tokyo Metropolitan area (covered by the Tokyo Fire Department) were eligible for these analyses.

3.3. Methods

Ambulance crews of TFD recorded each site of OHCAs in their report. Sites of OHCA incidence were analysed with five categories as follows, "Residences" which including home, nursing homes, and hotels, "Indoors", "Schools", "Outdoors" and "Others" according to annual reports the Tokyo Fire Department Currently State of Emergencies (2012) published in 2013 [5] (Table 1).

The nine items were corrected and analysed as follows: 1) rate of the witnesses cardiac arrest (%), 2) rate of bystander CPR applied (%), 3) rate of bystander first aid, 4) rate of defibrillation (including defibrillation by Emergency Medical Service (EMS), 5) rate of defibrillation when witnessed, 6) rate of return of spontaneous circulation(ROSC) prior to arrival at the hospital, 7) rate of return

Table 1. Categorization of sites of incidence for cardiac arrest.

Residences	Residences, nursing homes, lodgings
Indoors	Company offices and factories; sales and service facilities; entertainment and amusement facilities; health, rehabilitation and cosmetic facilities; medical facilities; art and culture facilities; religious facilities and funeral homes; government and administrative facilities
Outdoors	Roads, vehicles and transportation facilities; natural environments and open spaces; construction sites
Schools	Day care facilities and schools; sports facilities; parks and amusement parks
Others	Others

of spontaneous circulation (ROSC) prior to arrival at the hospital when witnessed, 8) one-month survival rate, and 9) one-month survival rate when witnessed according to the Utstein style, comparison was performed with odds ratio with “Outdoors” as the standard.

Moreover, first aid applied by bystanders was limited effective treatments such as artificial respiration, chest compression or defibrillation with AED for the OHCA patients according to the current definitions in Current State of Emergencies published by the Tokyo Fire Department.

Further, the location of Installed AED searching on the website of the Japan Foundation for Emergency Medicine [6] was used for examining the locations of AEDs installed.

These were grouped into the five categories for the sites of incidence above, the percentages among all registered AEDs were calculated and a comparison was made with the actual sites of incidence for cardiac arrest.

3.4. Ethical Issue

This study was approved after a review by the Kokushikan University Ethics Committee. Since the data adopted in this study from the Tokyo Fire Department Current State of Emergencies, that not includes any personal information.

3.5. Statistical Analysis

Microsoft® Excel® for Mac 2011 was used for data and processing.

Comparison was performed with odds ratio (95% confidence interval listed in parentheses) for simple tabulation and statistical analysis.

4. Results

4.1. Patients Background

Total 13,364 cardiac arrest patients transported within the Tokyo metropolitan area in 2012. As for the backgrounds of the 13,364 patients, the average age was 72.8 years old, for gender was 57.2% (7649) were men and 42.8% (5715) were women, the cardiac arrest was witnessed for 45.1% (6021), bystander’s CPR for 27.7% (3704), defibrillations for 9.9% (1320), ROSC prior to arrival to the hos-

pital for 9.2% (1228) and the one-month survival rate was 3.3% (442).

4.2. Sites of Incidence for OHCA

The incidences of for OHCA occurrence place were compared. The cardiac arrest occurred at “Residences” for 11,068 patients (82.8%), “Outdoors” for 1334 patients (10.0%), “Indoors” for 859 patients (6.4%), “Schools” for 98 patients (0.7%) and “Others” for 5 patients (0.0%).

The average ages of the OHCA was the highest in the “Residences” at 77.5 yr, followed by “Others” at 62.6 yr, “Indoors” at 61.6 yr, and “Outdoors” at 55.7 yr. and lowest in the “Schools” at 49.5 yr, respectively (**Table 2**).

4.3. Locations of Installed AED in the Tokyo Metropolitan Area

Total 21,017 AEDs registered in the Tokyo metropolitan area as of June 2013 with five categories of the location of Installed AED into matched by the website information of the Japan Foundation for Emergency Medicine (6). The results showed that “Indoors” had the highest percentage at 62.4% (13,124 units), followed by “Schools” at 21.4% (4500), “Residences” at 9.6% (2012), “Outdoors” at 5.3% (1119) and “Others” at 1.2% (262), respectively.

Comparing the incidence of OHCA with percentage for PAD for “Residences” was extremely low at 9.6% even though this category had the highest percentage of incidences of cardiac arrest at 82.8%. The percentage of AED installations for “Indoors” was very high at 62.4% even though the rate of incidence for cardiac arrest was 6.0%. “Schools” made up 21.4% of AED installations, but only 1.0% of the incidences of cardiac arrest (**Figure 1**).

4.4. Comparisons of OHCA Sites and of 9 Utstein Data Items

Table 3 indicates comparisons of OHCA occurred sites of incidence with 9 Utstein data item.

1) Witnesses OHCA

The witnessed OHCA most commonly at “Schools” at 80.6%, followed by “Indoors” at 66.0%, “Outdoors” at 56.8% and “Other” at 60.0%. It was witnessed the least at “Residences” at 41.7%. The odds ratio (“Outdoors” as the standard) was highest for “Schools” at 3.16 (1.89 - 5.27).

Table 2. Number and average ages of cardiac arrest patients by site of incidence.

	Site of incidence ^a	Total number (patients)	Percentage (%)	Average age (years)
Comparison by site of incidence for cardiac arrest	Residences	11068	82.8	77.5
	Outdoors	1334	10.0	55.7
	Indoors	859	6.4	61.6
	Schools	98	0.7	49.5
	Others	5	0.0	62.6

^aSite of incidences: See **Table 1**.

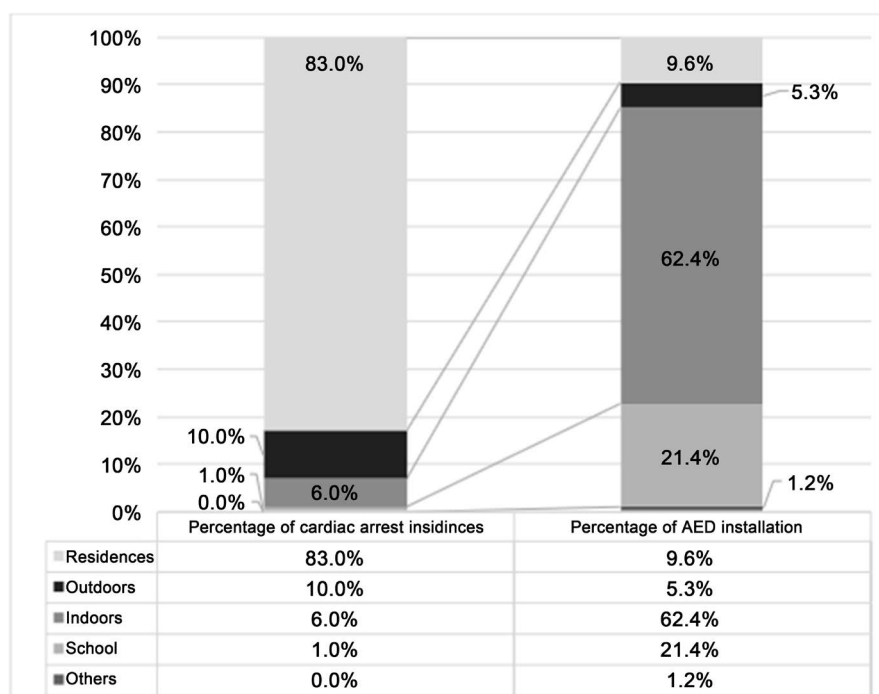


Figure 1. Comparison of percentages for sites of incidence for cardiac arrest and percentages for Location of AED installed.

2) Rate of first aid and bystander's CPR

First aid and bystander CPR rate (%) was very high for "Schools" at 71.4%, and followed by "Indoors" at 48.0%, "Outdoors" at 28.3%, "Residences" at 25.7% and "Others" at 20.0%. The odds ratio of the bystander CPR rate ("Outdoors" as the standard) was highest for "Schools" at 6.35 (4.03 - 9.99).

3) Rate of first aid and bystander's CPR with witnessed

The rate of first aid and bystander's CPR with witnessed was extremely high for "Schools" at 88.6% as well, followed by "Indoors" at 72.7%, "Residences" at 61.6%, "Outdoors, etc." at 49.7% and "Others" at 33.3%. The odds ratio bystander CPR with witnessed ("Outdoors" as the standard) was highest for "Schools" at 7.86 (3.87 - 15.96).

4) Rate of defibrillation

For the rate of defibrillation (including defibrillation by EMS) was highest for "Schools" at 46.9%, "Outdoors" at 25.7%, "Indoors" at 25.6% and "Others" at 20.0%. "Residences" was lowest at 6.4%. The odds ratio of defibrillation rate ("Outdoors" as the standard) was highest for "Schools" at 2.56 (1.69 - 3.87).

5) Rate of defibrillation with witnessed

The rate of defibrillation with witnessed was highest for schools at 58.2% as well, followed by "Outdoors" at 45.3%, "Indoors" at 38.8% and "Others" at 33.3%. "Residences" was the lowest at 15.4%. The odds ratio of witness rate of defibrillation ("Outdoors" as the standard) was highest for "Schools" at 1.69 (1.05 - 2.70).

6) Rate of ROCS prior to arrival to the hospital

For the rate of ROSC prior to arrival to the hospital as well, "Schools" was

Table 3. Comparisons of OHCA occurred sites of incidence with 9 Utstein data item.

	Site of incidence ^a	Total number (patients)	Not witnessed		Witnessed	
			Percentage (%)	Odds ratio (95% CI ^b)	Percentage (%)	Odds ratio (95% CI)
Witnessed or not	Outdoors	758	45.8	1.00	-	-
	Residences	6414	41.7	0.54 (0.48 - 0.61)	-	-
	Indoors	567	66.0	1.48 (1.24 - 1.76)	-	-
	Schools	79	80.6	3.16 (1.89 - 5.27)	-	-
	Others	3	60.0	1.14 (0.19 - 6.84)	-	-
Bystander first aid	Outdoors	377	28.3	1.00	49.7	1.00
	Residences	2844	25.7	0.88 (0.77 - 1.00)	61.6	1.62 (1.39 - 1.89)
	Indoors	421	48.0	2.34 (1.96 - 2.80)	72.7	2.69 (2.13 - 3.39)
	Schools	70	71.4	6.35 (4.03 - 9.99)	88.6	7.86 (3.87 - 15.96)
	Others	1	20.0	0.64 (0.07 - 5.70)	33.3	0.51 (0.05 - 5.60)
Defibrillation (Including defibrillation by EMS)	Outdoors	343	25.7	1.00	5.3	1.00
	Residences	710	6.4	0.20 (0.17 - 0.23)	15.4	0.22 (0.19 - 0.26)
	Indoors	220	25.6	1.00 (0.82 - 1.12)	38.8	0.77 (0.61 - 0.96)
	Schools	46	46.9	2.56 (1.69 - 3.87)	58.2	1.69 (1.05 - 2.70)
	Others	1	20.0	0.72 (0.08 - 6.48)	33.3	0.60 (0.05 - 6.70)
ROSC prior to arrival to the hospital	Outdoors	229	17.2	1.00	30.2	1.00
	Residences	750	6.8	0.35 (0.30 - 0.41)	16.3	1.16 (0.10 - 12.80)
	Indoors	206	24.0	1.52 (1.23 - 1.88)	36.3	1.31 (1.05 - 1.66)
	Schools	42	42.9	3.62 (2.37 - 5.53)	53.2	2.62 (1.64 - 4.19)
	Others	1	20.0	1.21 (0.13 - 10.84)	33.3	0.45 (0.48 - 0.53)
One-month survival rate	Outdoors	113	8.5	1.00	14.9	1.00
	Residences	215	1.9	0.35 (0.30 - 0.41)	3.6	0.28 (0.22 - 0.36)
	Indoors	91	10.6	1.28 (0.96 - 1.71)	16.0	1.09 (0.81 - 1.47)
	Schools	23	3.5	3.31 (2.00 - 5.49)	29.1	2.34 (1.39 - 3.96)
	Others	0	0.0	-	0.0	-

^aSite of incidences: See **Table 1**; ^bCI: Confidence Interval.

highest at 42.9%, followed by “Indoors” at 24.0%, “Outdoors” at 17.2%, “Others” at 20.0% and “Residences” at 6.8%. The odds ratio for the comparison of the rate of return of spontaneous circulation prior to hospitalization with “Outdoors” as the standard suggested that the rate of return of spontaneous circulation prior to hospitalization was highest for “Schools” at 3.62 (2.37 - 5.53).

7) Rate of ROSC prior to arrival to the hospital with witnesses

For the rate of return of spontaneous circulation prior to hospitalization when the cardiac arrest is witnessed as well, “Schools” was highest at 53.2%, followed by “Indoors” at 36.3%, “Outdoors” at 30.2%, “Others” at 33.3% and “Residences” at 16.3%. The odds ratio for ROSC rate prior to hospitalization with

witnessed (“Outdoors” as the standard) was highest for “Schools” at 2.62 (1.64 - 4.19).

8) One-month survival rate

The one-month survival rate was highest for “Schools” at 23.5%, followed by “Indoors” at 10.6%, “Outdoors” at 8.5%, “Residences” at 1.9% and “Others” at 0.0%. The odds ratio (“Outdoors” as the standard) was highest for “Schools” at 3.31 (2.00 - 5.49).

9) One-month survival rate with witnesses

For the one-month survival rate for the cardiac arrest victim when the cardiac arrest is witnessed as well, “Schools” was highest at 29.1%, followed by “Indoors” at 16.0%, “Outdoors” at 14.9%, “Residences” at 4.6% and “Other” at 0.0%. The odds ratio (“Outdoors” as the standard) was highest for “Schools” at 2.34 (1.39 - 3.96).

5. Discussion

The OHCA occurrence sites and Installed AED location were investigated. The results showed that “Residences” were the most common site of incidence for cardiac arrest, but that AED installation for the same was lowest at 9.6%. On the other hand, it was found that while “Schools” had the lowest incidence of cardiac arrest at 98 patients (0.7%), the rate of the cardiac arrest with witnesses, bystander’s CPR rate and one-month survival rate were conspicuously higher.

The nine Utstein items were all highest for schools and Sports institute as following which matched the report by Mitani, *et al.*

Witnessed cardiac arrests at schools are (97%), with high incidents bystander’s CPR (84%), and school AEDs applied (38%) [7]. The bystander’s CPR rate, ROSC rate prior to arriving at the hospital and one-month survival rate are thought to be high at “Schools” due to the fact that a high percentage of teachers, who have a strong possibility of witnessing the cardiac arrest, have received instruction on CPR [8], and according to an investigation by the Ministry of Education, Culture, Sports, Science and Technology [9], the rate of installation of AEDs at public and private schools was 92.3% as of 2010 and is now reached to 100%.

On the other hand, except for 5) rate of bystander first aid when witnessed, “Residences” had the lowest scores for six out of seven of the items among the four categories for sites of incidence, excluding “Others.” Since the results were like those in the study in Osaka. [10], it was revealed that “Residences” are locations where cardiogenic cardiac arrest is likeliest to occur in Japan.

The rate of defibrillation (including that performed by ambulance service) had the lowest score for “Residences” compared to other sites of incidence. These results were like the studies by Folke, *et al.* [11] [12] and the study by Roger [13] that showed the application of defibrillation and chance of rescuing are higher in public spaces than residences when witnessed since the detection rate of ventricular fibrillation (VF) is higher.

Also, this study shows that installations of AEDs were most common in “In-

doors”, followed in order by “Schools” “Residences” “Outdoors” and “Others.” The results showed that despite “Residences” are the most common site of incidence, the most common location of Installed AED is “Indoors”. In advanced countries, the installation AEDs has been mostly recommended for public facilities [11] [12]. In Japan as well, emphasis had been placed on increasing the number of AED installations, but there has been a shift in thinking to the need to strategically deploy and manage AEDs now that the number of total installations exceeds 500,000 units. In response, the Japan Foundation for Emergency Medicine announced, “Guideline for proper placement of the AED” [14] on September 9, 2013. In addition to specific and ranked degrees of recommendations for facilities for which AED installation is recommended, the guidelines provide specific examples.

However, “Residences” where most cardiac arrests occur, are not included among the facilities recommended in the guidelines, making re-examination necessary in the future.

In the investigation by Folke, *et al.* [12], it was said that there should be recommendations for AEDs to be installed at 100 m intervals in residential areas, and in the same way, it is thought that there needs to be an examination on how to spread AEDs to “Residences” in the future in Japan as well due to the ageing of society and the increase of the population within residences.

Also, beyond direct installations in “Residences” it is thought to also be necessary to focus on taking the locations of AEDs within facilities as outlined in the “Guideline for proper placement of the AED” into consideration once more and increase awareness of AEDs that are currently installed by posting easy-to-understand signboards showing the locations of the AEDs to increase the rate of PAD.

On the other hand, increasing the number of people among the general citizens who can use AEDs will be an important factor in the effective utilization of installed AEDs. In the study by Nishiyama, *et al.*, it was reported that the general citizens can learn CPR and how to use AEDs through even a short training [15] [16], and it will be necessary in the future to actively train people in CPR more than has been done in the past.

Limitations of the Study

This study has several limitations. This is a retrospective cohort study. It also has limitations in that public data was used in the examination to specify the sites of incidence, and no examination was made of individual cases.

6. Conclusions

It was revealed that mismatch between the sites of incidence for OHCA and locations of Installed AED place. Since while “Residences” were the most common sites of incidence for cardiac arrest, “Indoors” is the most common location for AED installation. On the other hand, all our data indicated that, rate of the cardiac arrest with witnesses, rate of bystander first aid, rate of defibrillation and

one-month survival rate, were all highest for “Schools and sports institute”.

These results suggest the importance of installation of AEDs that follows guidelines for the proper locating of AEDs as well as the importance of the role of school CPR/AED educational implementation lay persons.

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