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CLINICAL RESEARCH

Public-access automated external defibrillation and bystander-initiated cardiopulmonary resuscitation in schools: a nationwide investigation in Japan

Kosuke Kiyohara[1]*, Junya Sado[2], Tetsuhisa Kitamura[3], Mamoru Ayusawa[4], Masahiko Nitta[5,6], Taku Iwami[7], Ken Nakata[2], Tomotaka Sobue[3], and Yuri Kitamura[3]; For the SPIRITS investigators

[1]Department of Food Science, Otsuma Women's University, 12 Sanbancho Chiyoda-ku, Tokyo 102-8357, Japan; [2]Department of Health and Sport Sciences, Medicine for Sports and Performing Arts, Graduate School of Medicine, Osaka University, 2-2 Yamada-Oka, Suita 565-0871, Japan; [3]Division of Environmental Medicine and Population Sciences, Department of Social and Environmental Medicine, Graduate School of Medicine, Osaka University, 2-2 Yamada-Oka, Suita 565-0871, Japan; [4]Department of Pediatrics and Child Health, Nihon University School of Medicine, 30-1, Ooyaguchikamichou, Itabashi-ku, Tokyo 173-8610, Japan; [5]Department of Emergency Medicine, Osaka Medical College, 2-7 Daigaku-machi, Takatsuki City, Osaka 569-8686, Japan; [6]Department of Pediatrics, Osaka Medical College, 2-7 Daigaku-machi, Takatsuki City, Osaka 569-8686, Japan; and [7]Kyoto University Health Service, Yoshida Honmachi, Sakyo-ku, Kyoto 606-8501, Japan

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Aims We aimed to reveal the effects of application of public-access automated external defibrillators (AEDs) and bystander-initiated cardiopulmonary resuscitation (CPR) on survival of paediatric patients with out-of-hospital cardiac arrest (OHCA) occurring on school campuses in Japan.

Methods and results Data were obtained from a nationwide prospective observational study of paediatric OHCAs in school settings in Japan, termed Stop and Prevent cardlac aRrest, Injury, and Trauma in Schools (SPIRITS). Non-traumatic OHCA patients from elementary school, junior high school, and high school/technical college between April 2008 and December 2015 were enrolled. A multivariable logistic regression analysis was conducted to assess the effect of bystander interventions (i.e. public-access AED application and bystander-CPR) on 30-day survival with favourable neurological outcome. In total, 232 OHCA cases were analysed. The proportion of 30-day survival with favourable neurological outcome was significantly higher among the patients receiving both public-access AED application and bystander-CPR than those without any bystander intervention (50.9% vs. 20.0%, adjusted odds ratio 4.08, 95% confidence interval 1.25–13.31; $P = 0.020$). During the study period, the proportion of patients to whom public-access AEDs were applied increased significantly (from 61.9% in 2008 to 87.0% in 2015, *P*-for trend = 0.014). Accordingly, the proportion of 30-day survival with favourable neurological outcome improved significantly (from 38.1% in 2005 to 56.5% in 2015, *P*-for trend = 0.026).

Conclusion The combination of public-access AED application and bystander-CPR increased the chance of survival approximately four-fold in schools. The nationwide efforts towards disseminating public-access defibrillation systems in school settings may reduce the risk of sudden cardiac death among school children.

Keywords Out-of-hospital cardiac arrest • Student • School • Automated external defibrillator • Cardiopulmonary resuscitation

* Corresponding author. Tel: +81 3 5275 6954; fax: +81 3 5275 6378. *E-mail address*: kiyosuke0817@hotmail.com

What's new?

- This is the first national-level epidemiological study to investigate the association of public-access automated external defibrillators (AEDs) application and bystander-initiated cardiopulmonary resuscitation (CPR) with patient outcomes after paediatric out-of-hospital cardiac arrest (OHCA) occurring in school campuses in Japan.
- Approximately 50% of OHCA patients who received both public-access AED application and bystander-CPR survived 30 days with favourable neurological outcome.
- The combination of public-access AED and bystander-CPR increased the chance of 30-day survival with favourable neurological outcome approximately four-fold compared with no bystander intervention.
- During the 8-year study period from 2008 to 2015, the proportion of patients to whom public-access AEDs were applied significantly increased (from 61.9% in 2008 to 87.0% in 2015). Accordingly, the proportion of 30-day survival with favourable neurological outcome significantly improved (from 38.1% in 2005 to 56.5% in 2015).

Introduction

Occurrence of out-of-hospital cardiac arrest (OHCA) among school-age children is a tragic event. Although paediatric OHCAs account for a small subset of overall OHCAs,[1–3] paediatric OHCAs have a significant negative influence on family members, friends, and communities.[4] Therefore, a better understanding of epidemiological features of OHCAs in this age group is crucial for planning evidence-based approaches for prevention and better outcomes.

Early defibrillation by an automated external defibrillator (AED) and initiation of bystander-cardiopulmonary resuscitation (CPR) are critical to improve outcomes after OHCA.[5–7] In Japan, the promotion of public-access defibrillation programmes in schools is a high priority.[8] Since the legalization of AED use by bystanders in July 2004, at least one AED has been installed in almost all elementary, junior high, and high schools as of 2015 (~36 000 schools throughout the country).[9] In addition, the proportion of schools that provided basic life support training to teaching staff including instructions on how to use an AED, were reported to be approximately 90%.[9] Thus, in this era of public-access defibrillation, it is important to evaluate the effectiveness of such nationwide efforts in order to devise strategies for further prevention and improvement of outcomes after paediatric OHCA in schools nationally. However, the effects of such bystander interventions (i.e. public-access defibrillation and bystander-CPR) have not been sufficiently explored in school settings.

We launched a nationwide prospective observational study of paediatric OHCAs occurring in school settings in Japan called Stop and Prevent cardiac aRrest, Injury, and Trauma in Schools (SPIRITS).[10] Using data gathered from this study, we aimed to reveal the effects of application of public-access AEDs and bystander-initiated CPR on survival of paediatric patients with OHCA occurring on school campuses in Japan.

Methods

Study design of SPIRITS

The rationale, design, and profile of SPIRITS were previously described in detail.[10] Briefly, SPIRITS is a nationwide prospective observational study of data from two large-scale registries (linked to a single database), the Injury and the Accident Mutual Aid Benefit System of Japan Sport Council (JSC) and the All-Japan Utstein Registry of the Fire and Disaster Management Agency (FDMA). The Injury and Accident Mutual Aid Benefit System provides benefits (medical expenses, disability compensation, or death compensation) in cases of injury, illness, disease, accident, or death that occur among students and younger children under the supervision of schools or nurseries. It covers most students and younger children attending schools in Japan (85.9% of nursery school children, 80.7% of kindergarteners, 99.9% of elementary school students, 99.9% of junior high school students, 98.3% of high school students, and 99.4% of technical college students in 2015; ~17 million students and younger children in Japan). Data on approximately 1.1 million injury/accident cases were reported and registered annually from 73 000 schools nationwide.[11] The All-Japan Utstein Registry is a population-based OHCA registry based on the international Utstein format,[12,13] covering the entire population (approximately 127 million people) of Japan. In this registry, cardiac arrest is defined as the cessation of cardiac mechanical activity confirmed by the absence of signs of circulation, and the OHCA data are recorded by emergency-medical-service (EMS) personnel, in co-operation with the physician in charge of the patient. Since pre-hospital termination of resuscitation by EMS personnel is generally not allowed in Japan, most OHCA patients cared for by EMS personnel are transported to hospitals and the data are recorded in this registry, except for OHCA patients who are not transported to a hospital by EMS (i.e. transported to a hospital by family members/bystanders, non-EMS transporting vehicles, or by air ambulance). Thus, the SPIRITS database, which was developed by merging the two above mentioned nationwide registries, has retained the data for most paediatric OHCA cases occurring in school settings in Japan.

Study subjects

Non-traumatic OHCA patients from elementary schools (age 6–12 years), junior high schools (age 12–15 years), high schools (age ≥15 years), and technical colleges (age ≥15 years) in Japan between 1 April 2008 and 31 December 2015, were enrolled in this study. Patients in whom resuscitation by EMS personnel or bystanders was attempted and the first documented rhythm was recorded, were included. Cases of OHCA occurring due to traumatic causes (traffic accidents, falling incidents, and hanging), those occurring outside the school campus, and those witnessed by EMS personnel were excluded from the analyses.

Data collection

We obtained the following data from the SPIRITS database: date and time of emergency call by bystanders, time of contact with patient by EMS personnel, time of hospital arrival, educational level, sex, location of arrest, activity at the time of arrest, witness of arrest, origin of arrest, first documented rhythm, initiation of bystander-CPR, application of public-access AED pads, shock delivery by public-access AED, and survival outcomes after OHCA.

Key group definition

In this study, eligible OHCA cases were divided into four groups according to four potential combinations of bystander interventions (including application of public-access AED pads and initiation of bystander-CPR): 'AED (+) CPR (+)' (patient received AED and CPR), 'AED (+) CPR (−)' (patient received AED but did not receive CPR), 'AED (−) CPR (+)'

(patient did not receive AED but received CPR), and 'AED (−) CPR (−)' (patient did not receive AED or CPR).

Outcome measures

The primary endpoint of this study was 30-day survival with favourable neurological outcome after OHCA. All OHCA survivors were followed-up for up to 30 days after the event, and neurological status was assessed by the physician in charge, using the Glasgow–Pittsburgh cerebral performance category (CPC) scale: Category 1, good performance; Category 2, moderate disability; Category 3, severe cerebral disability; Category 4, coma/vegetative state; and Category 5, death/brain death. The 30-day survival with favourable neurological outcome was then defined as CPC 1 or 2.[12,13] The secondary endpoints included shock delivery by a public-access AED, ventricular fibrillation (VF) as first documented rhythm, return of spontaneous circulation (ROSC) to pre-hospital level, and 30-day survival after OHCA.

Statistical analysis

Among the eligible OHCA patients, differences in patient characteristics and outcomes between groups were assessed using the χ^2 test for categorical variables and analysis of variance for numerical variables, accordingly. Next, the proportion of VF rhythm, pre-hospital ROSC, 30-day survival, and 30-day survival with favourable neurological outcome were calculated according to the group. Univariable and multivariable logistic regression analyses were also conducted to assess the effect of bystander interventions on 30-day survival with favourable neurological outcome. In the multivariable analysis, odds ratios (ORs) and their associated 95% confidence intervals (CIs) were calculated, adjusting for potential confounding factors including educational level, sex, witness of arrest, origin of arrest, and time from emergency call to contact of patient by EMS personnel. Finally, the yearly trends in the proportion of public-access AED pad application, initiation of bystander-CPR, shock delivery by public-access AED, and 30-day survival with favourable neurological outcome after OHCA during the study period were assessed using the Mantel–Haenszel χ^2 test of linear association. All tests were two-tailed and a *P*-value of <0.05 was considered statistically significant. All statistical analyses were conducted using SPSS v25.0 J (IBM Corp., Armonk, NY, USA).

Ethics

The study conformed to the principles of the Helsinki Declaration, and the study protocol was approved by the Ethics Committee of the Osaka University. The requirement for individual informed consent was waived.

Results

Figure 1 shows the flowchart for selection of eligible OHCA patients for the analysis. During the study period, a total of 409 paediatric OHCA cases were registered in the SPIRITS database. Of these, 232 patients with OHCA due to non-traumatic causes that occurred in school campuses were analysed (42 in elementary school students, 71 in junior high school students, and 119 in high school/technical college students). Overall, public-access AEDs were applied to 76.3% (177/232) of OHCA patients, and bystander-CPR was initiated in 85.8% (199/232).

Table 1 shows the patient characteristics according to combination of bystander interventions. Overall, the majority of patients received both public-access AED application and bystander-CPR (72.8%, 169/232), i.e. 'AED (+) CPR (+)', whereas 10.8% of patients (25/232) did not receive any bystander intervention, i.e. 'AED (−) CPR (−)'.

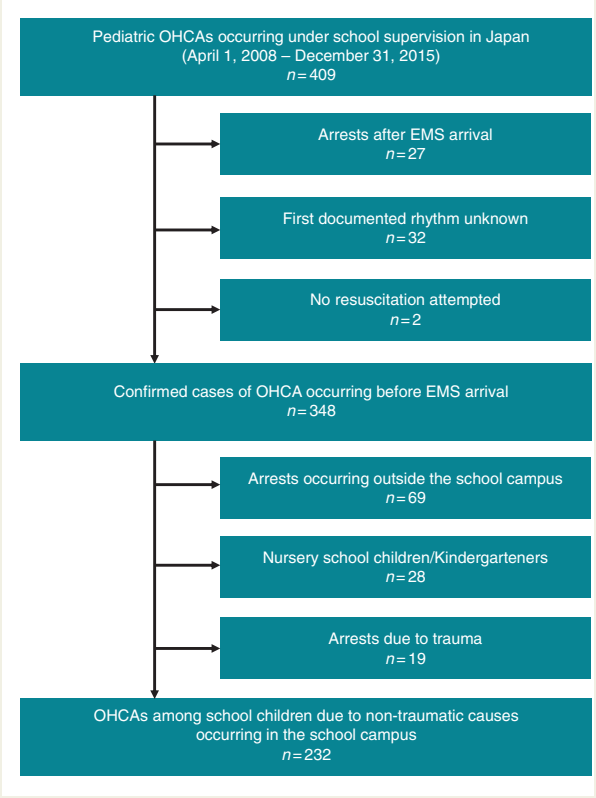

Figure 1 Selection of eligible patients with OHCA (1 April 2008–31 December 2015). EMS, emergency-medical-service; OHCA, out-of-hospital cardiac arrest.

The proportions of OHCAs occurring during exercise activity (84.8%, 143/232) and those witnessed by bystanders (91.1%, 154/232) were notably high among the patients of 'AED (+) CPR (+)'.

Table 2 shows the outcomes after OHCA according to combination of bystander interventions. The proportion of patients with VF rhythm was relatively high when bystander-CPR was initiated: 85.8% in the patients of 'AED (+) CPR (+)' and 70.0% in those of 'AED (−) CPR (+)'. The proportion of 30-day survival with favourable neurological outcome was significantly higher among the patients of 'AED (+) CPR (+)' (50.9%, 86/169) compared with the other groups. Among 177 patients to whom public-access AEDs were applied by bystanders, 73.4% (130/177) received shocks after AED application. The survival outcomes of these 130 patients who received shocks by public-access AEDs were as follows: pre-hospital ROSC, 60.0% (78/130); 30-day survival after OHCA, 69.2% (90/130); and 30-day survival with favourable neurological outcome, 62.3% (81/130).

Table 3 shows the factors associated with 30-day survival with favourable neurological outcome after OHCA. In multivariable analysis, the adjusted OR of 30-day survival with favourable neurological outcome was approximately four times higher among the patients of 'AED (+) CPR (+)' compared with those of 'AED (−) CPR (−)' (adjusted OR 4.08, 95% CI 1.25–13.31, $P = 0.020$). In this multivariable analysis, there were no missing data in the included variables.

Figure 2 shows the yearly trends in the proportion of public-access AED application and bystander-initiated CPR between 2008 and

Table 1 Characteristics of paediatric patients with OHCA in the school campus according to application of public-access AED and bystander-CPR

	Total	Application of public-access AED and bystander-CPR				*P*-values[a]
		AED (+) CPR (+)	AED (+) CPR (−)	AED (−) CPR (+)	AED (−) CPR (−)	
	n = 232	*n* = 169	*n* = 8	*n* = 30	*n* = 25	
Educational level, *n* (%)						0.072
Elementary school	42 (18.1	23 (13.6)	1 (12.5)	11 (36.7)	7 (28.0)	
Junior high school	71 (30.6)	56 (33.1)	3 (37.5)	7 (23.3)	5 (20.0)	
High school/technical college	119 (51.3)	90 (53.3)	4 (50.0)	12 (40.0)	13 (52.0)	
Male, *n* (%)	175 (75.4)	134 (79.3)	7 (87.5)	17 (56.7)	17 (68.0)	0.040
Location of arrest, *n* (%)						0.082
Schoolyard	127 (54.7)	97 (57.4)	4 (50.0)	16 (53.3)	10 (40.0)	
Pool	21 (9.1)	13 (7.7)	0 (0.0)	7 (23.3)	1 (4.0)	
Gymnasium	44 (19.0)	33 (19.5)	2 (25.0)	2 (6.7)	7 (28.0)	
School building	40 (17.2)	26 (15.4)	2 (25.0)	5 (16.7)	7 (28.0)	
Arrests during exercise activity, *n* (%)	185 (79.7)	143 (84.6)	6 (75.0)	21 (70.0)	15 (60.0)	0.013
Arrests during extracurricular time, *n* (%)	146 (62.9)	98 (58.0)	7 (87.5)	21 (70.0)	20 (80.0)	0.057
Arrests witnessed by bystanders, *n* (%)	201 (86.6)	154 (91.1)	6 (75.0)	22 (73.3)	19 (76.0)	0.007
Cardiac origin, *n* (%)	205 (88.4)	153 (90.5)	7 (87.5)	26 (86.7)	19 (76.0)	0.170
Time from call to contact with patient by EMS (min), mean (SD)	7.9 (3.4)	8.0 (3.4)	6.6 (1.3)	8.0 (3.4)	7.6 (3.8)	0.670
Time from call to hospital arrival (min), mean (SD)	30.5 (13.2)	31.0 (13.7)	30.1 (12.7)	29.9 (14.8)	28.4 (6.4)	0.827

AED, automated external defibrillator; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; OHCA, out-of-hospital cardiac arrest; SD, standard deviation.
[a]The differences of each characteristics according to application of public-access AED and bystander-CPR.

Table 2 Outcomes after OHCA according to application of public-access AED and bystander-CPR

	Total	Application of public-access AED and bystander-CPR				*P*-values[a]
		AED (+) CPR (+)	AED (+) CPR (−)	AED (−) CPR (+)	AED (−) CPR (−)	
	n = 232	*n* = 169	*n* = 8	*n* = 30	*n* = 25	
VF as first documented rhythm, *n* (%)	181 (78.0)	145 (85.8)	5 (62.5)	21 (70.0)	10 (40.0)	<0.001
Pre-hospital ROSC, *n* (%)	97 (41.8)	84 (49.7)	2 (25.0)	7 (23.3)	4 (16.0)	0.001
30-day survival, *n* (%)	121 (52.2)	100 (59.2)	3 (37.5)	9 (30.0)	9 (36.0)	0.005
30-day survival with favourable neurological outcome, *n* (%)	100 (43.1)	86 (50.9)	2 (25.0)	7 (23.3)	5 (20.0)	0.001

AED, automated external defibrillator; CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest; ROSC, return of spontaneous circulation; VF, ventricular fibrillation.
[a]The differences of each outcome according to application of public-access AED and bystander-CPR.

2015. *Figure 3* also shows the yearly trends in the proportion of shock delivery by public-access AEDs and 30-day survival with favourable neurological outcome after OHCA. In addition, the yearly trends in bystander-interventions and outcomes after OHCA were presented in Supplementary material online, *Table S1*. During the study period, the proportion of patients to whom public-access AEDs were applied increased significantly (from 61.9% in 2008 to 87.0% in 2015, *P*-for trend = 0.014), whereas the proportion of bystander-initiated CPR did not significantly change (*P*-for trend = 0.569). Accordingly, both the proportion of shock delivery by public-access AEDs (from 33.3% in 2005 to 65.2% in 2015, *P*-for trend = 0.008) and 30-day survival with favourable neurological outcome (from 38.1% in 2005 to 56.5% in 2015, *P*-for trend = 0.026) improved significantly. Conversely, other plausible factors associated with outcomes after OHCA, such as arrest witnessed by bystanders (*P*-for trend = 0.298), origin of arrest (*P*-for trend = 0.523), and mean time from call to contact with patient by EMS (*P*-for trend = 0.096) did not significantly change during the study period.

Discussion

Using a nationwide registry in Japan, we demonstrated the real-world status of bystander interventions and their effects on outcomes

Table 3 Factors of 30-day survival with favourable neurological outcome after OHCA

	30-day survival with favourable neurological outcome *n*/*N* (%)	Univariable analysis		Multivariable analysis[a]	
		OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Application of public-access AED and bystander-CPR					
AED (+) CPR (+)	86/169 (50.9)	4.15 (1.49–11.56)	0.007	4.08 (1.25–13.31)	0.020
AED (+) CPR (−)	2/8 (25.0)	1.33 (0.20–8.71)	0.764	1.09 (0.14–8.56)	0.932
AED (−) CPR (+)	7/30 (23.3)	1.22 (0.33–4.44)	0.766	1.06 (0.23–4.88)	0.941
AED (−) CPR (−)	5/25 (20.0)	Ref.		Ref.	
Educational level					
Elementary school	9/42 (21.4)	0.33 (0.14–0.75)	0.008	0.34 (0.10–1.20)	0.094
Junior high school	37/71 (52.1)	1.31 (0.73–2.36)	0.369	1.04 (0.52–2.05)	0.919
High school/technical college	54/119 (45.4)	Ref.		Ref.	
Sex					
Male	81/175 (46.3)	1.72 (0.92–3.22)	0.088	1.10 (0.50–2.42)	0.819
Female	19/57 (33.3)	Ref.		Ref.	
Witness of arrest					
Witnessed by bystanders	92/201 (45.8)	2.43 (1.04–5.68)	0.041	1.77 (0.57–5.46)	0.321
Not witnessed	8/31 (25.8)	Ref.		Ref.	
Origin of arrest					
Cardiac origin	97/205 (47.3)	7.19 (2.10–24.61)	0.002	3.24 (0.71–14.84)	0.131
Non-cardiac origin	3/27 (11.1)	Ref.		Ref.	
Time from call to contact with patient by EMS (1 min increment)	–	0.86 (0.78–0.95)	0.002	0.83 (0.74–0.92)	<0.001

AED, automated external defibrillator; CI, confidence interval; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; OHCA, out-of-hospital cardiac arrest; OR, odds ratio.
[a]All items listed in this table were included as independent variables in a logistic regression model.

among paediatric patients with non-traumatic OHCA occurring in school campuses, between 2008 and 2015. Our results suggested that the proportion of OHCA patients who survived 30 days with favourable neurological outcome was approximately four times higher among those receiving both public-access AED application and bystander-CPR compared to those without any bystander intervention. The results also indicated that the proportion of OHCA patients to whom public-access AEDs were applied increased considerably over the study period and was followed by a significant improvement in survival outcomes. To the best of our knowledge, this is the first national-level epidemiological study to investigate the association of public-access AED use and bystander-initiated CPR with patient outcomes after paediatric OHCA occurring in school campuses in Japan. Furthermore, we were able to use the information of AED application rather than defibrillations by AEDs as the exposure variable.[7,14,15] Therefore, our findings should provide highly suggestive clues for further prevention of unexpected premature death in school settings.

One of the key findings of this study was that combination of public-access AED application and bystander-CPR in the school campus increased the chance of survival by approximately four-fold. This was largely consistent with our previous report focusing on OHCAs occurring in public locations among the general population in the Osaka prefecture.[14] In addition, this study also demonstrated that 50% of OHCA patients who received both public-access AED application and bystander-CPR displayed 30-day survival rates with favourable neurological outcomes. Importantly, the survival rates observed in this study were much higher than those of OHCA patients with AED application in public locations reported in past studies.[7,14,15] It is possible that the young age of the school students and a physiologically healthier status than that of the general population favoured higher survival rates after OHCA.[16] Furthermore, since our results show that a majority of OHCAs were witnessed, the prompt receipt of AED application and CPR probably had a considerable influence on the improved outcome.

The results also showed that public-access AEDs were applied to 74% of OHCA patients in the entire study period, and this proportion increased throughout the study period (90% in 2014). As per the European Society of Cardiology guidelines, it is recommended that public-access defibrillation be established at sites where cardiac arrest is relatively common and where suitable storage is available, including schools.[17] The Japanese Circulation Society also recommends that all schools should install AEDs in well-marked locations.[8] In Japan, in accordance with these recommendations, at least one AED per school has been deployed in almost all elementary/junior-high/high schools, and the proportion of schools that provided basic life support training, including how to use AEDs, to teachers was 90% in 2015.[9] Thus, our findings confirmed that such nationwide efforts for the implementation of public-access defibrillation programmes in school settings have allowed for early defibrillation by bystanders, leading to increased survival after OHCA among school

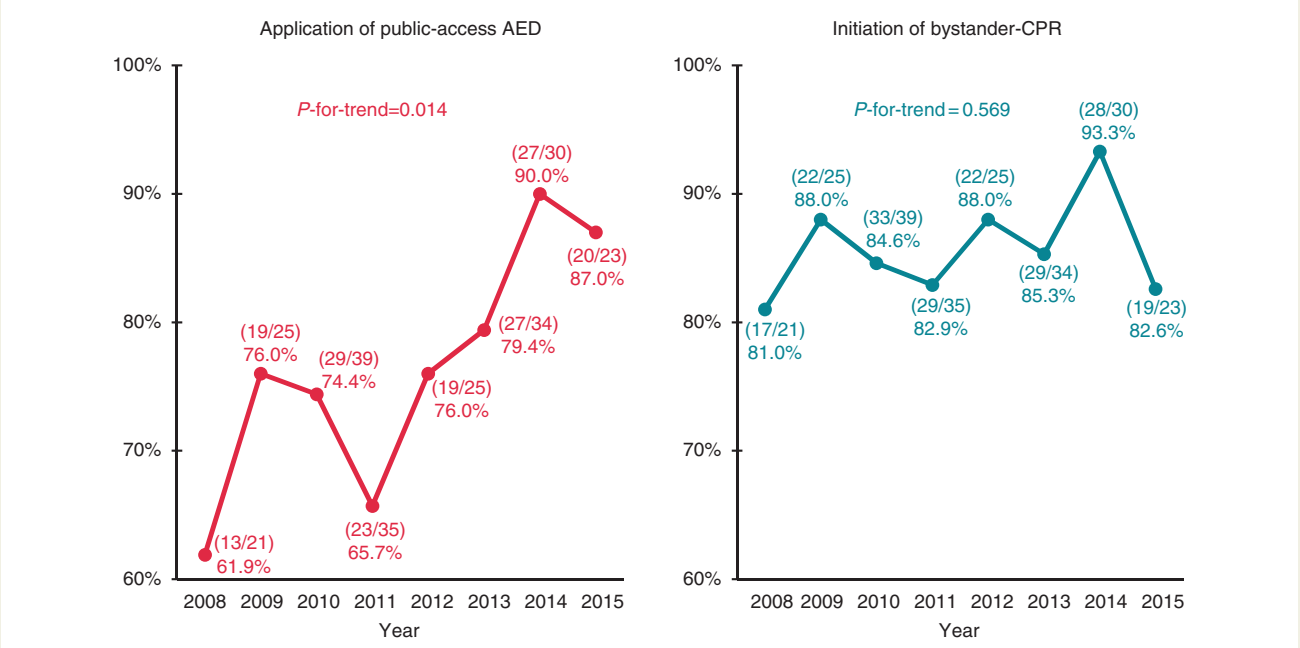

Figure 2 Yearly trends in the proportion of public-access AED application and bystander-initiated CPR. AED, automated external defibrillator; CPR, cardiopulmonary resuscitation.

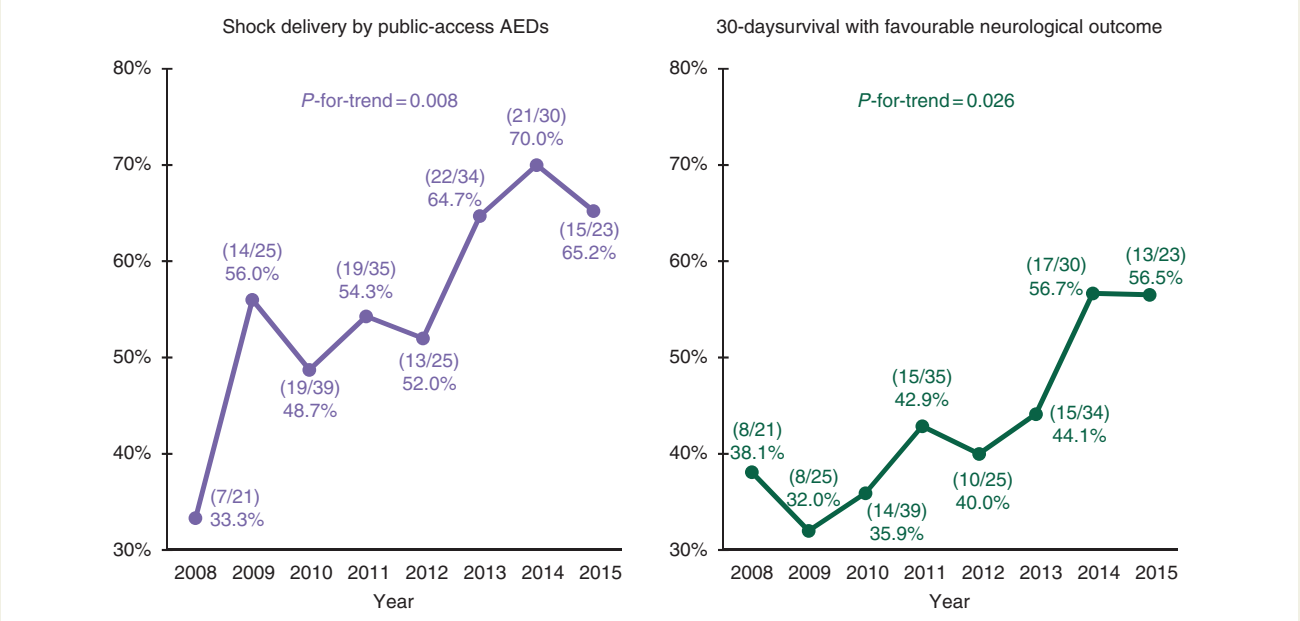

Figure 3 Yearly trends in the proportion of shock delivery by public-access AEDs and 30-day survival with favourable neurological outcome after OHCA. AED, automated external defibrillator; OHCA, out-of-hospital cardiac arrest.

children in Japan. In particular, given that possible factors associated with survival including bystander-CPR, arrest witnessed by bystanders, origin of arrest, and mean time from call to contact with patient by EMS did not show significant change during the study period, the improvement of survival was largely attributable to the dissemination of public-access AED.

As mentioned above, public-access AEDs have been applied to a majority of OHCA patients in school campuses in Japan. However,

there is still room for improvement, in order to fulfil the stated aim of the AED Committee of the Japanese Circulation Society to achieve 'zero sudden cardiac deaths in schools'.[8] For example, in our results, the proportion of AED application was relatively low when an OHCA occurred during extracurricular activities. Many schools in Japan reported that they installed AEDs in places with restricted access within schoolhouses, such as school infirmaries, teachers' rooms, and office rooms.[9] Therefore, in some OHCA cases, there is a possibility that bystanders may not have been able to access AEDs during extracurricular activities. Ideally, AEDs should be positioned in unlocked locations with 24-h availability all-year round for unexpected cardiac arrests that may occur after school hours.[8] In addition, considering that in 2015 more than 80% of schools reported that only one AED was installed in the school campus,[9] installation of multiple AEDs is indicated in schools with large campuses. Placement of multiple AEDs would be helpful to achieve earlier defibrillation.

Our results also showed that the proportion of public-access AED application was considerably lower when bystander-CPR was not initiated. This suggests that bystanders who were skilled at performing CPR understood the importance of AED application. As our results showed, bystander-CPR would thus make it possible to maintain VF rhythm and would lead to a good prognosis after OHCA. Considering that approximately 14% of patients did not receive bystander-CPR in this study, further efforts are needed to disseminate basic life support training in school settings, including training for initiation of CPR and for the use of AEDs. Since cardiac arrests may occur in adults as well as in school children in school campuses,[18–20] the benefit of CPR training and AED installation would be greater in school settings.

Limitations

This study has several limitations. First, we did not obtain information on several factors that could affect outcomes after OHCA, such as time from collapse to public-access AED application, quality of bystander-CPR, past medical history, current medications, in-hospital care, and other relevant life habits. Second, our data did not address the number and detailed locations of public-access AEDs in each school campus, and the witnesses of the cardiac arrest episode (e.g. teachers, school staffs, visitors, or other students). These factors would all affect the likelihood of public-access AED application. Third, as we stated in a previous report,[10] there is the possibility that there were input errors in the items for data-linkage for the development of the SPIRITS database, which could have led to an underestimation of OHCA cases to a certain degree. Moreover, exclusion of subjects who were not transported to hospitals by EMS personnel may also have caused an underestimation of OHCA incidence.

Conclusions

In Japan, approximately 50% of paediatric OHCA patients who received both public-access AED application and bystander-CPR in school settings survived 30 days with favourable neurological outcomes. The combination of public-access AED application and bystander-CPR increased the chance of survival four-fold. The proportion of public-access AED application increased significantly from 2008 to 2015 and correlated with a substantial improvement in patient outcomes. Our findings reinforced the concept that the nationwide efforts towards disseminating public-access defibrillation systems in school settings may reduce the risk of sudden cardiac death among school children.

Supplementary material

Supplementary material is available at *Europace* online.

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