SPECIAL ARTICLE

Public-Access Defibrillation and Out-of-Hospital Cardiac Arrest in Japan

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ABSTRACT

BACKGROUND

Early defibrillation plays a key role in improving survival in patients with out-of-hospital cardiac arrests due to ventricular fibrillation (ventricular-fibrillation cardiac arrests), and the use of publicly accessible automated external defibrillators (AEDs) can help to reduce the time to defibrillation for such patients. However, the effect of dissemination of public-access AEDs for ventricular-fibrillation cardiac arrest at the population level has not been extensively investigated.

METHODS

From a nationwide, prospective, population-based registry of patients with out-of-hospital cardiac arrest in Japan, we identified patients from 2005 through 2013 with bystander-witnessed ventricular-fibrillation arrests of presumed cardiac origin in whom resuscitation was attempted. The primary outcome measure was survival at 1 month with a favorable neurologic outcome (Cerebral Performance Category of 1 or 2, on a scale from 1 [good cerebral performance] to 5 [death or brain death]). The number of patients in whom survival with a favorable neurologic outcome was attributable to public-access defibrillation was estimated.

RESULTS

Of 43,762 patients with bystander-witnessed ventricular-fibrillation arrests of cardiac origin, 4499 (10.3%) received public-access defibrillation. The percentage of patients receiving public-access defibrillation increased from 1.1% in 2005 to 16.5% in 2013 (P<0.001 for trend). The percentage of patients who were alive at 1 month with a favorable neurologic outcome was significantly higher with public-access defibrillation than without public-access defibrillation (38.5% vs. 18.2%; adjusted odds ratio after propensity-score matching, 1.99; 95% confidence interval, 1.80 to 2.19). The estimated number of survivors in whom survival with a favorable neurologic outcome was attributed to public-access defibrillation increased from 6 in 2005 to 201 in 2013 (P<0.001 for trend).

CONCLUSIONS

In Japan, increased use of public-access defibrillation by bystanders was associated with an increase in the number of survivors with a favorable neurologic outcome after out-of-hospital ventricular-fibrillation cardiac arrest.

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Owing to an emphasis on the chain of survival[1,2] as well as revisions to cardiopulmonary resuscitation (CPR) guidelines,[3,4] the rate of survival after out-of-hospital cardiac arrest in industrialized countries has been increasing,[5-7] but it remains low (approximately 10%). Early defibrillation plays a key role in improving survival after out-of-hospital cardiac arrest due to ventricular fibrillation (ventricular-fibrillation cardiac arrest).[8] Many reports have shown that public-access defibrillation by laypersons contributes to improving outcomes after out-of-hospital cardiac arrest,[9-12] and the introduction of public-access automated external defibrillators (AEDs) has been widely accepted in developed communities.[13,14] However, the effects of dissemination of public-access defibrillators on survival after ventricular-fibrillation arrest at the population level have not been extensively investigated.

In Japan, citizen use of public-access AEDs was legally authorized in July 2004.[15] The aim of our study was to assess whether nationwide dissemination of public-access defibrillators has been associated with an increase in the rate of survival with a favorable neurologic outcome after ventricular-fibrillation arrest at the population level.

METHODS

STUDY DESIGN, POPULATION, AND SETTINGS

The All-Japan Utstein Registry of the Fire and Disaster Management Agency (FDMA) is a prospective, population-based, nationwide registry of out-of-hospital cardiac arrests in which data are recorded according to the internationally standardized Utstein style.[16] Details of the registry have been described previously.[9] The establishment of the registry cohort, data collection, and data-quality assurance were performed by the FDMA. The authors wrote the manuscript and vouch for the completeness and accuracy of the data and analyses. The ethics committees of the Kyoto University Graduate School of Medicine and the Osaka University Graduate School of Medicine approved the study. In this registry study, the requirement of written informed consent was waived, and the researchers analyzed only deidentified (anonymized) data.

In this analysis, we included all patients who had ventricular-fibrillation arrests of cardiac origin that were witnessed by bystanders, who were resuscitated by bystanders or emergency medical service (EMS) personnel, and who were then transported to medical institutions between January 1, 2005, and December 31, 2013. Cardiac arrest was defined as the cessation of cardiac mechanical activity, as confirmed by the absence of signs of circulation.[16] The arrest was presumed to be of cardiac origin unless it was caused by respiratory disease; malignant tumors; cerebrovascular disease; external factors, including drowning, hanging, trauma, asphyxia, and drug overdose; or any other noncardiac factor. The diagnosis of cardiac or noncardiac origin was determined clinically by the physicians in charge, in collaboration with EMS personnel.

EMS SYSTEMS IN JAPAN

Japan had a population of approximately 127 million in 2005, with a geographic area of approximately 378,000 km^2. EMS is provided by regional governments through local fire departments, and there were 752 fire departments with dispatch centers in 2014.[15] Among EMS personnel, emergency life-saving technicians, a subgroup of highly trained emergency care providers, are allowed to insert an intravenous catheter and an adjunct airway and to use semiautomated external defibrillators for patients with out-of-hospital cardiac arrest. Specially trained emergency life-saving technicians are also allowed to insert tracheal tubes and administer intravenous epinephrine. Each ambulance has a crew of three emergency providers, including at least one emergency life-saving technician. Treatments for cardiac arrest were based on the Japanese CPR guidelines.[17] Most patients with out-of-hospital cardiac arrest who were treated by EMS personnel were transported to a hospital and were included in this registry, because EMS providers in Japan are not permitted to terminate resuscitation in the field.

DISSEMINATION OF PUBLIC-ACCESS AEDS AND CPR TRAINING

The number of AEDs deployed in public spaces in Japan such as nursing facilities, schools, sports or cultural facilities, workplaces, and transportation facilities was estimated on the basis of data from AED sales.[18] AEDs used in medical facilities and EMS institutions were excluded. CPR training programs have been conducted mainly by local fire departments and are based on the Japanese CPR guidelines.[17] In 2006, telephone-assisted CPR instructions by dispatchers for bystanders were changed from conventional CPR to chest-compression-only CPR,[19] with chest-compression-only CPR being specifically recommended if it was difficult for the bystander to administer rescue breathing.

DATA COLLECTION AND QUALITY CONTROL

Data were collected prospectively on resuscitation-related factors including origin of arrest (cardiac or noncardiac), sex and age of the patient, type of bystander (family member or other), first documented cardiac rhythm, time course of resuscitation, type of bystander-initiated CPR, dispatcher instruction, and delivery or nondelivery of public-access AED shocks, as well as the return or no return of spontaneous circulation before arrival at the hospital and survival and neurologic status 1 month after the event. The times of the receipt of an emergency call by the EMS, the initial contact with the patient, the initiation of CPR or defibrillation by EMS personnel, and hospital arrival were recorded according to the times on the clock used by each EMS system.

When bystanders provided shocks with the use of a public-access AED, the patient's first documented rhythm was regarded as ventricular fibrillation, on the assumption that the AED would administer a shock only if it detected ventricular fibrillation. We defined bystander CPR as either chest-compression-only CPR or conventional CPR with assisted breathing initiated by bystanders. The times of collapse and initiation of bystander CPR or public-access defibrillation were obtained by EMS interview with the bystander or from public-access AED records before the EMS personnel left the scene.

All survivors were followed for up to 1 month after the out-of-hospital cardiac arrest by the EMS providers who had provided their emergency care. Neurologic outcome was determined by the physician responsible for the care of the patient by a follow-up interview 1 month after successful resuscitation, with the use of the Cerebral Performance Category scale, on which category 1 represents good cerebral performance; category 2, moderate cerebral disability; category 3, severe cerebral disability; category 4, coma or vegetative state; and category 5, death or brain death.[16]

The study data form was filled out by EMS personnel in cooperation with the physician in charge of the patient, and the data were stored in the registry system on the FDMA database server. The data were checked for consistency by the computer system and were confirmed by the FDMA, and if the data form was incomplete, the FDMA returned it to the respective fire station, and the form was then completed.

OUTCOME MEASURES

The primary outcome measure was survival with a favorable neurologic outcome at 1 month after out-of-hospital cardiac arrest. A favorable neurologic outcome was defined as a Cerebral Performance Category score of 1 or 2.[16] Secondary outcome measures were the return of spontaneous circulation before arrival at the hospital and survival at 1 month.

STATISTICAL ANALYSIS

Patient characteristics and outcomes with or without public-access defibrillation were compared with the use of t-tests for continuous variables and chi-square tests for categorical variables. Trends in categorical values were tested with univariable regression models. Multivariate logistic-regression analysis was used to assess the contribution made by public-access defibrillation to survival with a favorable neurologic outcome; odds ratios and their 95% confidence intervals were calculated.

Potential confounding factors that were adjusted for in the multivariable analyses included sex, age (0 to 17, 18 to 74, or ≥75 years), type of bystander (family member or other), receipt of dispatcher instruction during CPR (no or yes), type of bystander-initiated CPR (none, chest-compression only, or conventional), EMS response time (time from collapse to contact with the patient), and year. We also estimated a propensity score by fitting a logistic-regression model that adjusted for these seven items above. One-to-one pair matching between the group receiving public-access defibrillation and the group not receiving public-access defibrillation was performed by nearest-neighbor matching without replacement, with the use of a caliper width equal to 0.2 of the standard deviation of the logit of the propensity score. Covariate balances before and after matching were checked by comparison of standardized mean differences. A standardized mean difference of less than 10.0% was considered to indicate a negligible imbalance between the two groups.

To assess the effect of dissemination of public-access defibrillation on ventricular-fibrillation

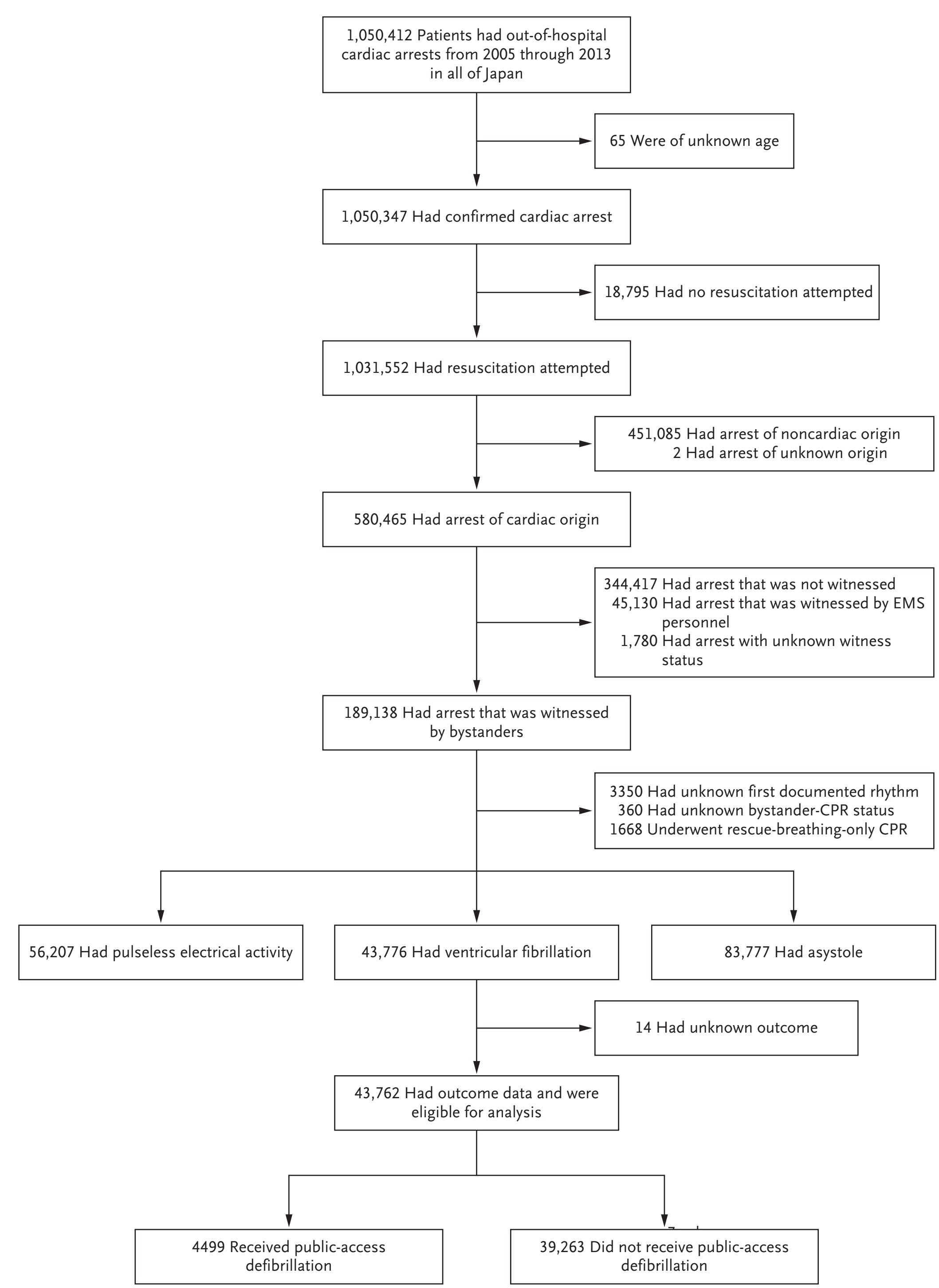


Figure 1. Patients with Out-of-Hospital Cardiac Arrests during the Study Period and Patients Included in the Analysis.
CPR denotes cardiopulmonary resuscitation, and EMS emergency medical service.

arrest at the population level, the number of patients in whom survival with a favorable neurologic outcome was attributed to public-access defibrillation was estimated annually as follows: the number of patients with ventricular-fibrillation cardiac arrest receiving public-access defibril-

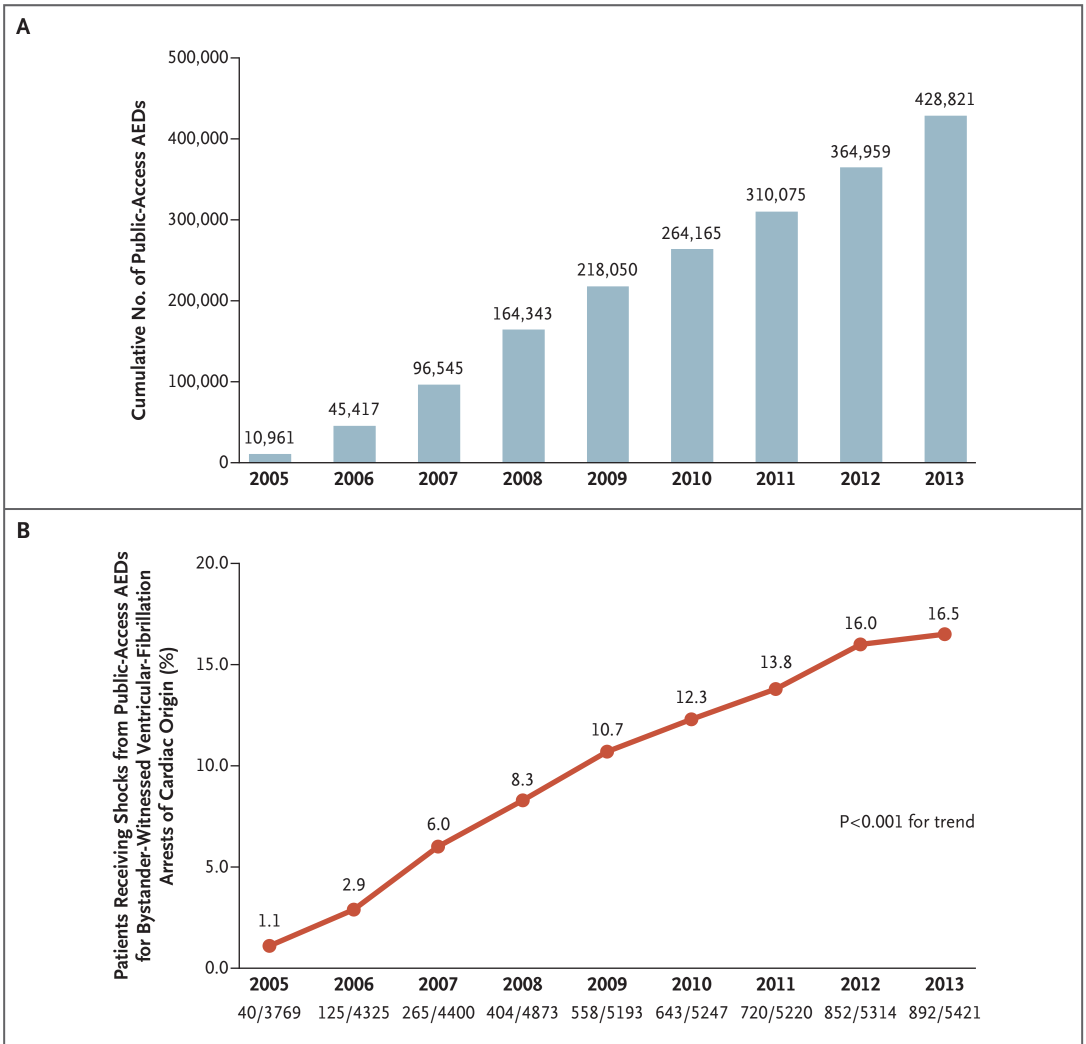


Figure 2. Public-Access Automated External Defibrillators (AEDs) in Japan and Percentage of Patients Receiving Shocks from Public-Access AEDs for Bystander-Witnessed Ventricular-Fibrillation Arrest of Cardiac Origin.

Panel A shows the annual trend in the cumulative number of public-access AEDS in Japan. Data are from a database of the Japanese National Institute of Public Health.[18] In Panel B, the numerator for each year is the number of patients who received shocks from public-access AEDs for bystander-witnessed ventricular-fibrillation arrest of cardiac origin and the denominator is the total number of patients with bystander-witnessed ventricular-fibrillation arrest of cardiac origin.

lation in each year × (the percentage of patients surviving with a favorable neurologic outcome among patients receiving public-access defibrillation in each year – the percentage surviving with a favorable neurologic outcome among those not receiving public-access defibrillation in each year). The trend in numbers of attributable favorable outcomes over time was tested with a linear regression model. Subgroup trends by age group (0 to 17, 18 to 74, or ≥75 years) were also analyzed. All statistical analyses were performed with the use of the SPSS statistical package, version 20.0J (IBM). All tests were two-tailed, and P values of less than 0.05 were considered to indicate statistical significance.

Results

Study Population

During the study period, 1,050,412 out-of-hospital cardiac arrests were confirmed (Fig. 1). Of 1,031,552 patients with out-of-hospital cardiac arrests in whom resuscitation was attempted, 189,138 had arrests of cardiac origin that were

Table 1. Characteristics of Patients with Bystander-Witnessed Ventricular-Fibrillation Arrest of Presumed Cardiac Origin Who Did and Who Did Not Receive Public-Access Defibrillation (PAD).*

Variable	All Patients before Propensity-Score Matching					Matched Patients after Propensity-Score Matching†				
	Total (N=43,762)	PAD (N=4499)	No PAD (N=39,263)	P Value	SMD	Total (N=8442)	PAD (N=4221)	No PAD (N=4221)	P Value	SMD
					%					%
Year of cardiac arrest — no. (%)				<0.001					0.41	
2005	3,769 (8.6)	40 (0.9)	3,729 (9.5)		39.5	97 (1.1)	39 (0.9)	58 (1.4)		4.2
2006	4,325 (9.9)	125 (2.8)	4,200 (10.7)		32.0	254 (3.0)	122 (2.9)	132 (3.1)		1.4
2007	4,400 (10.1)	265 (5.9)	4,135 (10.5)		17.0	536 (6.3)	258 (6.1)	278 (6.6)		1.9
2008	4,873 (11.1)	404 (9.0)	4,469 (11.4)		8.0	813 (9.6)	388 (9.2)	425 (10.1)		3.0
2009	5,193 (11.9)	558 (12.4)	4,635 (11.8)		1.8	1075 (12.7)	534 (12.7)	541 (12.8)		0.5
2010	5,247 (12.0)	643 (14.3)	4,604 (11.7)		7.6	1220 (14.5)	616 (14.6)	604 (14.3)		0.8
2011	5,220 (11.9)	720 (16.0)	4,500 (11.5)		13.2	1302 (15.4)	667 (15.8)	635 (15.0)		2.1
2012	5,314 (12.1)	852 (18.9)	4,462 (11.4)		21.2	1494 (17.7)	757 (17.9)	737 (17.5)		1.2
2013	5,421 (12.4)	892 (19.8)	4,529 (11.5)		23.0	1651 (19.6)	840 (19.9)	811 (19.2)		1.7
Age — yr	64.6±16.2	63.0±18.6	64.8±15.9	<0.001	10.4	63.3±18.2	63.3±18.5	63.2±17.9	0.78	0.5
Age group — no. (%)				<0.001					0.11	
0–17 yr	459 (1.0)	141 (3.1)	318 (0.8)		16.8	213 (2.5)	120 (2.8)	93 (2.2)		4.1
18–74 yr	30,569 (69.9)	3104 (69.0)	27,465 (70.0)		2.1	5848 (69.3)	2895 (68.6)	2953 (70.0)		3.0
≥75 yr	12,734 (29.1)	1254 (27.9)	11,480 (29.2)		3.0	2381 (28.2)	1206 (28.6)	1175 (27.8)		1.6
Male sex — no. (%)	34,662 (79.2)	3542 (78.7)	31,120 (79.3)	0.41	1.3	6654 (78.8)	3315 (78.5)	3339 (79.1)	0.52	1.4
Arrest witnessed by family member — no. (%)	24,092 (55.1)	411 (9.1)	23,681 (60.3)	<0.001	127.5	809 (9.6)	405 (9.6)	404 (9.6)	0.97	0.1
Receipt of dispatcher instruction during CPR — no. (%)	18,766 (42.9)	1674 (37.2)	17,092 (43.5)	<0.001	12.9	3286 (38.9)	1641 (38.9)	1645 (39.0)	0.93	0.2
Bystander CPR — no. (%)	24,615 (56.2)	4470 (99.4)	20,145 (51.3)	<0.001	134.2	8384 (99.3)	4192 (99.3)	4192 (99.3)	0.12	<0.1
Chest-compression-only CPR	16,547 (37.8)	2286 (50.8)	14,261 (36.3)		29.5	4612 (54.6)	2259 (53.5)	2353 (55.7)		4.5
Conventional CPR with rescue breathing	8,068 (18.4)	2184 (48.5)	5,884 (15.0)		77.3	3772 (44.7)	1933 (45.8)	1839 (43.6)		4.5
No bystander CPR — no. (%)	19,147 (43.8)	29 (0.6)	19,118 (48.7)		134.2	58 (0.7)	29 (0.7)	29 (0.7)		<0.1
Time from collapse to call — min‡§	2.1±5.2	3.3±6.1	1.9±5.0	<0.001	25.1	2.9±5.7	3.0±5.4	2.7±5.9	0.004	5.3
Time from collapse to contact with patient by EMS personnel — min‡	10.1±5.8	12.4±7.0	9.8±5.6	<0.001	41.0	11.9±6.7	12.2±6.7	11.5±6.7	<0.001	10.0

Time from collapse to first shock — min¶	11.3±6.6	2.4±3.6	12.3±6.0	<0.001	200.1	7.9±7.8	2.4±3.6	13.5±7.0	<0.001	199.4
Time from collapse to hospital arrival — min‡§	34.3±13.6	37.2±14.9	34.0±13.4	<0.001	22.6	36.0±14.4	36.7±14.3	35.2±14.5	<0.001	10.4

* Plus–minus values are means ±SD. CPR denotes cardiopulmonary resuscitation, EMS emergency medical service, and SMD standardized mean difference.
† The area under the receiver-operating-characteristic curve of the logistic-regression model to calculate a propensity score was 0.920.
‡ The times from collapse to call, collapse to contact with the patient by EMS personnel, and collapse to hospital arrival were calculated for the 43,301 patients, 43,331 patients, and 43,370 patients, respectively, who had available data.
§ These time factors were not used to calculate a propensity score.
¶ For the group receiving public-access defibrillation, this time is the interval from collapse to either first shock or initiation of CPR by bystanders, and it was calculated for 4387 patients. For the group not receiving public-access defibrillation, this time is the interval from collapse to first shock by EMS personnel, and it was calculated for 37,256 patients with data available for EMS defibrillation time.

witnessed by bystanders. Of these, 43,776 patients had ventricular fibrillation as the first documented rhythm. A total of 43,762 patients with outcome data (4499 who received public-access defibrillation [10.3%] and 39,263 who did not receive public-access defibrillation [89.7%]) were eligible for our analysis.

Nationwide, the estimated cumulative number of public-access AEDs increased from 10,961 in 2005 to 428,821 in 2013 (Fig. 2A). The percentage of patients receiving shocks from public-access AEDs for bystander-witnessed ventricular-fibrillation arrest of cardiac origin increased from 1.1% (40 of 3769 patients) in 2005 to 16.5% (892 of 5421 patients) in 2013 (P<0.001 for trend) (Fig. 2B).

PATIENT CHARACTERISTICS

Characteristics of patients with bystander-witnessed ventricular-fibrillation arrest of cardiac origin who received public-access defibrillation and those of patients who did not receive public-access defibrillation are shown in Table 1. The mean age was 63.0 years in the group that received public-access defibrillation and 64.8 years in the group that did not receive public-access defibrillation; the percentage of male patients was approximately 79% in both groups. The group that received public-access defibrillation was less likely to have a cardiac arrest that was witnessed by family members than the group that did not receive public-access defibrillation (9.1% vs. 60.3%) but was more likely to receive bystander CPR (99.4% vs. 51.3%). The time from collapse to contact with a patient by EMS personnel was longer in the group that received public-access defibrillation, but the time from collapse to first shock was shorter. Propensity-score matching yielded 4221 patients who received public-access defibrillation matched to 4221 patients who did not receive public-access defibrillation. Propensity-score matching improved the covariate balance considerably (Table 1).

OUTCOMES

Table 2 shows outcomes of bystander-witnessed ventricular-fibrillation arrests of cardiac origin with or without public-access defibrillation. The rate of 1-month survival with a favorable neurologic outcome was significantly higher in the group that received public-access defibrillation than in the group that did not receive public-

Table 2. Outcomes of Bystander-Witnessed Ventricular-Fibrillation Arrest of Presumed Cardiac Origin with or without Public-Access Defibrillation.*

Outcome	Total (N=43,762)	Public-Access Defibrillation (N=4499)	No Public-Access Defibrillation (N=39,263)	Crude Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
Return of spontaneous circulation before arrival at hospital — no. (%)	13,660 (31.2)	2232 (49.6)	11,428 (29.1)	2.40 (2.25–2.55)	1.98 (1.84–2.13)†
Survival at 1 mo — no. (%)	12,947 (29.6)	2009 (44.7)	10,938 (27.9)	2.09 (1.96–2.22)	1.66 (1.54–1.79)†
CPC — no. (%)					
1: good cerebral performance	7,521 (17.2)	1539 (34.2)	5,982 (15.2)		
2: moderate cerebral disability	1,365 (3.1)	192 (4.3)	1,173 (3.0)		
3: severe cerebral disability	1,459 (3.3)	118 (2.6)	1,341 (3.4)		
4: coma or vegetative state	2,257 (5.2)	137 (3.0)	2,120 (5.4)		
5: death or brain death	31,160 (71.2)	2513 (55.9)	28,647 (73.0)		
CPC of 1 or 2					
In all patients — no. (%)	8,886 (20.3)	1731 (38.5)	7,155 (18.2)	2.80 (2.63–3.00)	2.03 (1.87–2.20)†
In propensity-score–matched patients — no./total no. (%)	2730/8442 (32.3)	1627/4221 (38.5)	1103/4221 (26.1)	1.77 (1.62–1.94)	1.99 (1.80–2.19)†
By age group — no./total no. (%)					
0–17 yr	207/459 (45.1)	89/141 (63.1)	118/318 (37.1)	2.90 (1.92–4.37)	2.11 (1.24–3.61)‡
18–74 yr	7407/30,569 (24.2)	1446/3104 (46.6)	5961/27,465 (21.7)	3.10 (2.91–3.40)	2.29 (2.09–2.50)‡
≥75 yr	1272/12,734 (10.0)	196/1254 (15.6)	1076/11,480 (9.4)	1.79 (1.52–2.11)	1.29 (1.06–1.56)‡

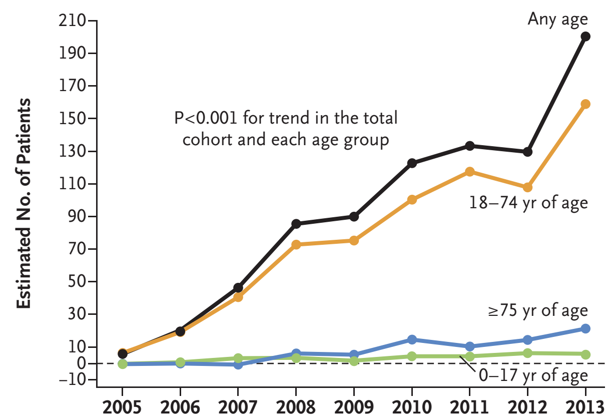
* CI denotes confidence interval, and CPC Cerebral Performance Category.
† These odds ratios were adjusted for age group, sex, type of bystander (family member or other), receipt of dispatcher instruction during CPR (no or yes), type of bystander-initiated CPR (none, chest-compression only, or conventional), the time from collapse to contact with the patient by EMS personnel, and year.
‡ These odds ratios were adjusted for sex, type of bystander (family member or other), receipt of dispatcher instruction during CPR (no or yes), type of bystander-initiated CPR (none, chest-compression only, or conventional), the time from collapse to contact with the patient by EMS personnel, and year.

access defibrillation (38.5% vs. 18.2%; adjusted odds ratio, 2.03; 95% confidence interval [CI], 1.87 to 2.20). Among children and adolescents 0 to 17 years of age, the percentages were 63.1% with public-access defibrillation and 37.1% without public-access defibrillation (adjusted odds ratio, 2.11; 95% CI, 1.24 to 3.61). Among adults 18 to 74 years of age, the percentages were 46.6% and 21.7%, respectively (adjusted odds ratio, 2.29; 95% CI, 2.09 to 2.50), and among elderly adults 75 years of age or older, the percentages were 15.6% and 9.4%, respectively (adjusted odds ratio, 1.29; 95% CI, 1.06 to 1.56). After propensity-score matching, the adjusted odds ratio was 1.99 (95% CI, 1.80 to 2.19) in the total cohort.

Figure 3 shows the estimated number of patients in whom survival for 1 month with a favorable neurologic outcome was attributable to the use of public-access defibrillation after bystander-witnessed ventricular-fibrillation arrest of cardiac origin. The number increased from 6 in 2005 to 201 in 2013 ($P<0.001$ for trend). Most of this increase was observed among adults 18 to 74 years of age (from 6 in 2005 to 159 in 2013, $P<0.001$ for trend).

DISCUSSION

In our analysis of data from a nationwide, population-based registry of out-of-hospital cardiac arrests in Japan, we found that the use of public-access defibrillation increased significantly over a 9-year period. We confirmed previous evidence that public-access defibrillation is associated with an increase in the likelihood of survival with a favorable neurologic outcome after out-of-hospital ventricular-fibrillation cardiac arrest.[9-12]



Estimated No. of Patients	2005	2006	2007	2008	2009	2010	2011	2012	2013
Any age	6	20	46	86	90	123	133	130	201
0–17 yr of age	0	1	3	3	2	4	4	6	6
18–74 yr of age	6	19	41	73	75	100	118	108	159
≥75 yr of age	0	0	−1	6	5	15	10	14	21

Figure 3. Estimated Number of Patients in Whom Survival with a Favorable Neurologic Outcome Was Attributed to Public-Access Defibrillation (PAD) after Bystander-Witnessed Ventricular-Fibrillation Arrest of Cardiac Origin.

The number of patients in whom survival with a favorable neurologic outcome was attributed to public-access defibrillation was estimated annually as follows: the number of patients with ventricular-fibrillation cardiac arrest receiving public-access defibrillation in each year × (the percentage of patients surviving with a favorable neurologic outcome among patients receiving public-access defibrillation in each year − the percentage surviving with a favorable neurologic outcome among those not receiving public-access defibrillation in each year). The trends were tested with linear regression models. Subgroup analyses by age group (0 to 17, 18 to 74, and ≥75 years) were also performed.

We also estimated the number of patients in whom survival with a favorable neurologic outcome was attributable to the use of public-access defibrillation. This figure increased steadily during the 9 years of the study, from 6 cases in 2005 to 201 cases in 2013.

The marked increase in the number of patients surviving with a favorable neurologic outcome owing to the increasing use of public-access defibrillation is encouraging. However, the absolute numbers are very low. Of more than 1 million cardiac arrests recorded in Japan during the study period, only 835 (<1 in 1000) had a favorable outcome that was attributable to public-access defibrillation. Even in our analysis, which included only patients with bystander-witnessed arrest of cardiac origin in whom ventricular fibrillation was the first documented rhythm (43,762 patients), we found that only 1.9% benefited from public-access defibrillation.

There are several reasons for the small number of patients benefiting from public-access defibrillation. As indicated in Figure 1, only about half of the out-of-hospital cardiac arrests in our study were of cardiac origin, and of these, only about one third were witnessed by bystanders. Among patients with a witnessed arrest, fewer than one in four had ventricular fibrillation as their first documented rhythm; for all other initial rhythms, AEDs are not effective and are not programmed to deliver a shock. Thus, for many patients with out-of-hospital cardiac arrest, the specific circumstances of the arrest render public-access defibrillation not applicable or ineffective.

However, even among arrests that were eligible for our analysis, the 1.9% rate of benefit from public-access defibrillation is quite low. There are a number of contributing factors, some of which might be mitigated by focused public health policies. First, not all out-of-hospital cardiac arrests occur in a public setting. In two previous studies, only 9.5% and 22.3% of bystander-witnessed out-of-hospital cardiac arrests occurred in public places; in contrast, two thirds in each study occurred at home.[20,21] These observations suggest that deployment of public-access AEDs in multidwelling houses including condominiums and apartments should be considered.[22] It has even been suggested that private homes could be provided with or obtain AEDs,[23] although this approach is likely to be expensive unless targeted to high-risk persons.[24] In addition, because ventricular fibrillation deteriorates rapidly[25] and the provision of CPR maintains ventricular fibrillation,[2,5] reinforcement of early CPR and AED use by bystanders can increase the benefit from public-access defibrillation.

A second issue is that, even in public places, AEDs are not as widely accessible as they could be. Some studies have shown a poor correlation between the locations of most out-of-hospital cardiac arrests and the locations of most AEDs.[26,27] In addition, many AEDs are located inside buildings or in other sites that cannot be accessed at night or on weekends, which further reduces the availability of public-access defibrillation.[28] Policies for improving the location and accessibility of AEDs may help to alleviate these problems.[29-32] Finally, even when AEDs are accessible, potential users may not be able to find them; in a recent report, only 5% of persons surveyed at a busy urban shopping center knew where or how to find their nearest public-access AED.[33] Providing EMS dispatchers with an alert system to identify AEDs within a given radius of the location of the cardiac arrest may be one option for mitigating this problem.[34] Another approach that has been proposed is to establish an alert system from the EMS dispatch center that uses social-media technologies to notify volunteer lay responders of the locations of a nearby cardiac arrest and the nearest available AED.[35,36]

This study has some inherent limitations. First, we analyzed only patients with out-of-hospital cardiac arrest to whom shocks were actually administered by public-access AEDs; we did not have information on all those for whom an attempt was made to use an AED. Second, the first documented rhythm in patients receiving public-access defibrillation was defined as ventricular fibrillation. We did not obtain information on the actual first documented rhythm, since we assumed that the AED would deliver a shock only for ventricular fibrillation. However, because the sensitivity and specificity of AEDs for ventricular fibrillation is high, the likelihood of either missing or overdiagnosing ventricular fibrillation should be low.[37] Third, we did not obtain information about where arrests occurred and where public-access AEDs were deployed. Fourth, the time of collapse that was estimated from EMS interview with the bystander may be unreliable.[38] Fifth, our data do not address the potential variability in patients' preexisting medical conditions or in advanced treatments received after the arrests.[39]

In conclusion, increased use of public-access defibrillation by bystanders in Japan was associated with an increase in the number of survivors with a favorable neurologic outcome after out-of-hospital ventricular-fibrillation cardiac arrest.

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

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