Improved Survival With Favorable Neurological Outcome in Elderly Individuals With Out-of-Hospital Cardiac Arrest in Japan
– A Nationwide Observational Cohort Study –

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Background: There is sparse data regarding the survival and neurological outcome of elderly patients with out-of-hospital cardiac arrest (OHCA).

Methods and Results: OHCA patients (334,730) aged ≥75 years were analyzed using a nationwide, prospective, population-based Japanese OHCA database from 2008 to 2012. The overall 1-month survival with favorable neurological outcome (Cerebral Performance Category Scale, category 1 or 2; CPC 1-2) rate was 0.88%. During the study period, the annual 1-month CPC 1-2 rate in whole OHCA significantly improved (0.73% to 0.96%, P for trend <0.001). In particular, outcomes of OHCA patients aged 75 to 84 years and those aged 85 to 94 years significantly improved (0.98% to 1.28%, P for trend=0.01; 0.46% to 0.70%, P for trend <0.001, respectively). However, in OHCA patients aged ≥95 years, the outcomes did not improve. Multivariate logistic regression analysis indicated that younger age, shockable first documented rhythm, witnessed arrest, earlier emergency medical service (EMS) response time, and cardiac etiology were significantly associated with the 1-month CPC 1-2. Under these conditions, elderly OHCA patients who had cardiac etiology, shockable rhythm and had a witnessed arrest had acceptable 1-month CPC1-2 rate; 7.98% in cases where OHCA was witnessed by family, 15.2% by non-family, and 25.6% by EMS.

Conclusions: The annual 1-month CPC 1-2 rate after OHCA among elderly patients significantly improved, and the resuscitation of elderly patients in a selected population is not futile.   (*Circ J* 2016; **80:** 1153–1162)

Key Words: Cardiopulmonary resuscitation; Elderly; Epidemiology; Out-of-hospital cardiac arrest

D espite advances in resuscitation knowledge, many communities have not achieved significant improvements in outcomes after out-of-hospital cardiac arrest (OHCA) over the last 30 years.[1–4] Recently, trends in OHCA survival have improved in some communities; however, OHCA survival remains low.[5–14]

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As the proportion of elderly individuals has been rapidly increasing in Japan and other developed countries, the number of elderly OHCA patients has been increasing.[15–17] Studies of elderly OHCA patients have conflicting results due to small sample size and clinical heterogeneity.[15–28] Therefore, little is known about the survival of very elderly OHCA patients. To improve outcomes in elderly OHCA patients, evaluating the characteristics and outcomes of such patients and understanding the factors associated with outcomes are necessary.

In the present study, we investigated predictors associated with survival with favorable neurological outcomes in elderly OHCA patients, and evaluated long-term nationwide trends and factors that may play an important role in further improving outcomes in this population.

Methods

Study Design and Data Source
The Fire and Disaster Management Agency (FDMA) of Japan launched a prospective, nationwide, population-based registry covering the entire population of OHCA victims based on the
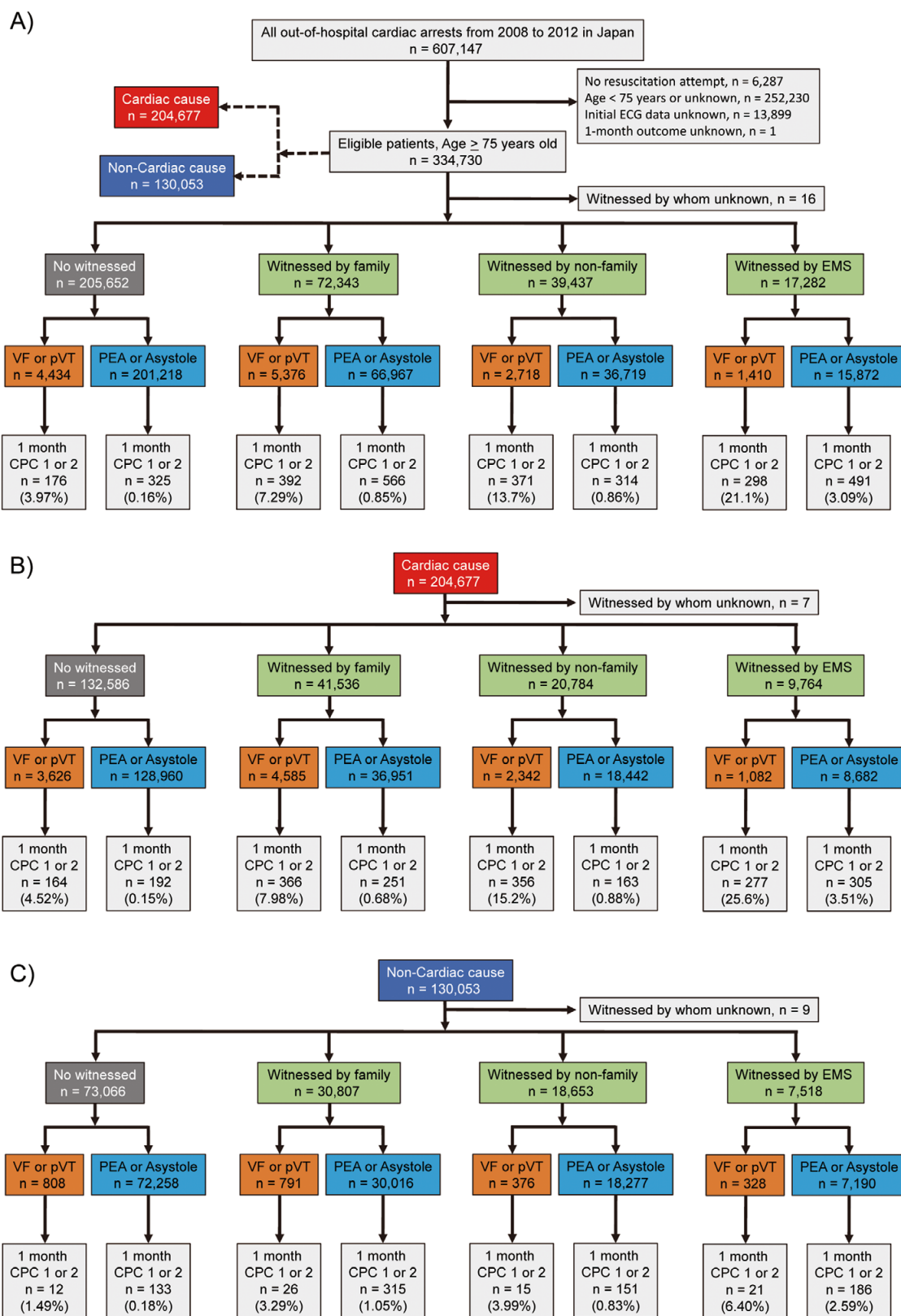
Figure 1. Study flowchart with relevant outcomes by witness status and first documented rhythm. (**A**) Overall, (**B**) cardiac origin and (**C**) non-cardiac origin. ECG, electrocardiography; EMS, emergency medical services; VF, ventricular fibrillation; pVT, pulseless ventricular tachycardia; PEA, pulseless electrical activity; CPC, cerebral performance category.

Table 1. Patient and EMS Characteristics of Elderly Individuals With Out-of-Hospital Cardiac Arrest in Japan From 2008 to 2012

	Overall (n=334,730)	2008 (n=59,595)	2009 (n=62,065)	2010 (n=67,878)	2011 (n=71,705)	2012 (n=73,487)	P value
Age (years)							
Mean±SD	84.7±6.1	84.4±6.1	84.5±6.1	84.7±6.1	84.8±6.1	84.9±6.2	
Median, IQR	84 (80–89)	84 (79–89)	84 (80–89)	84 (80–89)	84 (80–89)	85 (80–89)	<0.001
Age group, n (%)							
75–84 years	174,781 (52.2)	32,432 (54.4)	33,250 (53.6)	35,618 (52.5)	36,854 (51.4)	36,627 (49.8)	<0.001
85–94 years	136,392 (40.7)	23,451 (39.4)	24,583 (39.6)	27,408 (40.4)	29,623 (41.3)	31,327 (42.6)	
≥95 years	23,557 (7.0)	3,712 (6.2)	4,232 (6.8)	4,852 (7.1)	5,228 (7.3)	5,533 (7.5)	
Male, n (%)	164,856 (49.3)	29,361 (49.3)	30,816 (49.7)	33,412 (49.2)	35,238 (49.1)	36,029 (49.0)	0.21
First documented rhythm, n (%)							
VF or pVT	13,954 (4.2)	2,668 (4.5)	2,767 (4.5)	2,851 (4.2)	2,764 (3.9)	2,904 (4.0)	<0.001
PEA or asystole	320,776 (95.8)	56,927 (95.5)	59,298 (95.5)	65,027 (95.8)	68,941 (96.1)	70,583 (96.0)	
Witnessed arrest, n (%)	129,078 (38.6)	22,859 (38.4)	23,869 (38.5)	26,507 (39.1)	27,580 (38.5)	28,263 (38.5)	0.07
Witness type, n (%)							
EMS	17,282 (5.2)	2,964 (5.0)	3,209 (5.2)	3,702 (5.5)	3,711 (5.2)	3,696 (5.0)	
Family	72,343 (21.6)	13,044 (21.9)	13,405 (21.6)	14,944 (22.0)	15,515 (21.6)	15,435 (21.0)	
Non-family	39,437 (11.8)	6,835 (11.5)	7,255 (11.7)	7,861 (11.6)	8,354 (11.7)	9,132 (12.4)	
Unknown	16 (0.0)	16 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Bystander CPR, n (%)	155,838 (46.6)	26,461 (44.4)	28,984 (46.7)	31,609 (46.6)	33,583 (46.8)	35,201 (47.9)	<0.001
Bystander CPR type, n (%)							
Conventional	35,606 (10.6)	8,003 (13.4)	7,621 (12.3)	7,104 (10.5)	6,751 (9.4)	6,127 (8.3)	
Chest compression only	119,039 (35.6)	18,158 (30.5)	21,138 (34.1)	24,270 (35.8)	26,609 (37.1)	28,864 (39.3)	
Ventilation only	1,193 (0.4)	300 (0.5)	225 (0.4)	235 (0.4)	223 (0.3)	210 (0.3)	
Presumed cardiac origin, n (%)	204,677 (61.1)	36,178 (60.7)	38,067 (61.3)	40,980 (60.4)	43,958 (61.3)	45,494 (61.9)	<0.001
EMS response time (min)							
Mean±SD	7.6±3.7	7.2±3.6	7.5±3.7	7.6±3.6	7.8±3.7	7.8±3.6	
Median, IQR	7 (5–9)	7 (5–9)	7 (5–9)	7 (5–9)	7 (5–9)	7 (5–9)	<0.001

CPR, cardiopulmonary resuscitation; EMS, emergency medical services; IQR, interquartile range; PEA, pulseless electrical activity; pVT, pulseless ventricular tachycardia; SD, standard deviation; VF, ventricular fibrillation.

Utstein style in January 2005.[5,6,13,18,29] By using this registry, the present observational study enrolled all elderly patients (age ≥75 years) for whom resuscitation had been attempted after OHCA in Japan between January 2008 and December 2012.

Cardiac arrest was defined as the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation.[29] The cause of arrest was presumed to be cardiac unless evidence suggested external causes, respiratory disease, cerebrovascular disease, malignant tumor, or any other non-cardiac cause. Determination of the cause was made by the attending physicians, in collaboration with the emergency medical services (EMS) personnel.

This study was approved by the ethics committee of Kanazawa University (2012-032). According to informed consent guidelines in Japan,[30] it is unnecessary to obtain informed consent from each patient to use secondary data, such as the data contained in this anonymous database. Therefore, the requirement for written informed consent was waived.

The Japanese EMS System
In 2005, Japan had approximately 127 million residents in an area of 378,000 km². Details of the Japanese EMS system have been described previously.[5] Briefly, municipal governments provide EMS through approximately 800 fire stations with dispatch centers.[31] The FDMA of Japan supervises the national EMS system, whereas each local EMS system is operated by the local fire station. Generally, an ambulance crew includes

3 EMS staff members, including at least 1 emergency lifesaving technician (ELST). ELSTs are allowed to use various resuscitation methods, including semi-automated external defibrillators, insertion of a supraglottic airway device, insertion of a peripheral intravenous line, and administration of Ringer's lactate solution. Since July 2004, only specially trained ELSTs have been permitted to insert a tracheal tube. Since April 2006, they have been permitted to administer intravenous epinephrine in the field under the supervision of an online physician. All EMS providers perform cardiopulmonary resuscitation (CPR) according to the Japanese CPR guidelines.[3,32]

As EMS personnel in Japan are legally prohibited from termination of resuscitation (TOR) in the field, most OHCA patients that receive CPR from EMS providers are transported to hospitals, except in cases where fatality is certain.

Data Collection and Quality Control
Data were collected prospectively for variables such as gender, age, cause of arrest, bystander witness status, bystander CPR with or without automated external defibrillator use, initial cardiac rhythm identified, bystander category, whether epinephrine was administered, whether advanced airway management techniques were used, whether return of spontaneous circulation (ROSC) was achieved before arrival at the hospital, time of the emergency call, time of vehicle arrival at the scene, time of initiation of CPR by EMS personnel, time of ROSC, time of vehicle arrival at the hospital, time of epinephrine administration, time of shock delivery by EMS personnel, 1-month

Table 2. Patient and EMS Characteristics of Elderly Individuals With Out-of-Hospital Cardiac Arrest in Japan by Age Group

	Overall (n=334,730)	75–84 years (n=174,781)	85–94 years (n=136,392)	≥95 years (n=23,557)	P value
Age (years)					
Mean±SD	84.7±6.1	79.8±2.8	88.7±2.7	97.2±2.2	
Median, IQR	84 (80–89)	80 (77–82)	88 (86–91)	97 (95–98)	<0.001
Male, n (%)	164,856 (49.3)	102,300 (58.5)	56,416 (41.4)	6,140 (26.1)	<0.001
First documented rhythm, n (%)					
VF or pVT	13,954 (4.2)	9,306 (5.3)	4,203 (3.1)	445 (1.9)	<0.001
PEA or asystole	320,776 (95.8)	165,475 (94.7)	132,189 (96.9)	23,112 (98.1)	
Witnessed arrest, n (%)	129,078 (38.6)	66,718 (38.2)	52,669 (38.6)	9,691 (41.1)	<0.001
Witness type, n (%)					
EMS	17,282 (5.2)	9,324 (5.3)	6,803 (5.0)	1,155 (4.9)	
Family	72,343 (21.6)	40,146 (23.0)	27,800 (20.4)	4,397 (18.7)	
Non-family	39,437 (11.8)	17,240 (9.9)	18,060 (13.2)	4,137 (17.6)	
Unknown	16 (0.0)	8 (0.0)	6 (0.0)	2 (0.0)	
Bystander CPR, n (%)	155,838 (46.6)	75,640 (43.3)	67,664 (49.6)	12,534 (53.2)	<0.001
Bystander CPR type, n (%)					
Conventional	35,606 (10.6)	15,820 (9.1)	16,217 (11.9)	3,569 (15.2)	
Chest compression only	119,039 (35.6)	59,238 (33.9)	50,922 (37.3)	8,879 (37.7)	
Ventilation only	1,193 (0.4)	582 (0.3)	525 (0.4)	86 (0.4)	
Presumed cardiac origin, n (%)	204,677 (61.1)	104,730 (59.9)	84,902 (62.2)	15,045 (63.9)	<0.001
EMS response time (min)					
Mean±SD	7.6±3.7	7.6±3.7	7.6±3.6	7.4±3.4	
Median, IQR	7 (5–9)	7 (5–9)	7 (5–9)	7 (5–9)	<0.001

Abbreviations as in Table 1.

survival, and neurological outcome at 1 month after cardiac arrest.

Neurological outcome was defined using the Cerebral Performance Category (CPC) scale: category 1, good cerebral performance; category 2, moderate cerebral disability; category 3, severe cerebral disability; category 4, coma or vegetative state; and category 5, death.[29] CPC categorization was determined by the attending physician.

Endpoint

The primary study outcome measure was 1-month survival with favorable neurological outcome, defined as a CPC score of 1 or 2.[29]

Statistical Analysis

Categorical variables were expressed as counts (%), and differences between groups were compared by using the χ^2 test. Continuous variables were expressed as medians (interquartile range) or means and standard deviations, and compared with the Kruskal-Wallis test.

Multivariate logistic regression analysis was used to identify factors associated with 1-month survival with favorable neurological outcome; odds ratios (ORs) and their 95% confidence intervals (CIs) were calculated. Potential confounding factors based on biological plausibility and previous studies were included in the multivariable analysis. These variables included age (75–84, 85–94, and ≥95 years), gender, cause of cardiac arrest (cardiac or non-cardiac), bystander witnessed (yes or no), bystander CPR performed (yes or no), calendar year, EMS response time (interval from call to patient contact), and first documented rhythm (shockable rhythm [pulseless ventricular tachycardia or ventricular fibrillation] or non-shockable rhythm [pulseless electrical activity or asystole]). In this study, bystander CPR included chest compres-

sion-only CPR, conventional CPR with rescue breathing, and ventilation-only CPR.[18,33]

Annual improvements in the proportion of 1-month survival with favorable neurological outcome during the study period was analyzed with the Cochran-Armitage test for trends. Subgroup analysis of the witnessed-OHCA cohort was conducted to evaluate the effect of bystander CPR.

All statistical analyses were performed by using the JMP statistical package, version 11 (SAS Institute, Cary, NC, USA). All tests were 2-tailed, and P values of <0.05 were considered statistically significant.

Results

Patient and EMS Characteristics

A total of 607,147 OHCA events were documented between January 2008 and December 2012. Of 600,860 OHCAs with attempted resuscitation, 334,730 patients aged ≥75 years were eligible for our analysis (**Figure 1**). Patient and EMS characteristics and temporal trends by calendar year are shown in **Table 1**. The median age of all participants was 84 years, and the proportion of OHCA patients aged 75–84, 85–94, and ≥95 years was 52.2%, 40.7%, and 7.0%, respectively. The first documented rhythm was predominantly non-shockable (95.8% vs. 4.2%). The proportion of witnessed arrest was 38.6%, and the most common witness was a family member (21.6%).

During the study period, the annual OHCA incidence increased each year, from 59,595 in 2008 to 73,487 in 2012. The proportion of patients in the older age groups, 85–94 years and ≥95 years, increased while the proportion of patients aged 75–84 years decreased. While the proportion of shockable first documented rhythm and conventional CPR decreased, that of bystander CPR and chest compression-only CPR increased. The proportion of males, witnessed arrests, cardiac

etiology, and the distribution of witness type was similar across calendar years.

Patient and EMS characteristics by age group are shown in **Table 2**. The proportion of the following decreased with age: male, shockable first documented rhythm, and witnessed by family. In contrast, the proportion of witnessed arrests by non-family members and bystander CPR increased with age. Both conventional CPR and chest compression-only CPR increased with age. EMS response time decreased with age.

One-Month Survival With Favorable Neurological Outcome
The proportion of patients achieving 1-month survival with favorable neurological outcome was 0.88% (2,933/334,730) among overall patients, 1.18% (2,067/174,781) among patients aged 75–84 years, 0.59% (803/136,392) among patients aged 85–94 years, and 0.27% (63/23,557) among patients aged ≥95 years.

Predictors of 1-Month Survival With Favorable Neurological Outcome
In the multivariate logistic regression analysis (**Table 3**), compared to 2008, the proportion of 1-month survival with favorable neurological outcome improved significantly in 2009 (adjusted OR 1.29; 95% CI 1.13–1.46) and in 2012 (adjusted OR 1.52; 95% CI 1.34–1.72). Compared to patients aged 75–84 years, those aged 85–94 years and ≥95 years had significantly worse outcomes (adjusted OR 0.60; 95% CI 0.55–0.65 and adjusted OR 0.30; 95% CI 0.23–0.38, respectively). Shockable first documented rhythm (adjusted OR 10.51; 95% CI 9.67–11.41), witnessed arrest (adjusted OR 5.70; 95% CI 5.17–6.30), cardiac origin (adjusted OR 1.17; 95% CI 1.07–1.27), and faster EMS response time (adjusted OR for each 1-min increase 0.90; 95% CI 0.89–0.91) were associated with 1-month survival with favorable neurological outcome. However, bystander CPR was negatively associated with 1-month survival with favorable neurological outcome (adjusted OR 0.77; 95% CI 0.71–0.83). Gender was not associated with 1-month survival with favorable neurological outcome. Under these conditions, elderly OHCA individuals who had cardiac etiology, shockable rhythm and witnessed arrest had acceptable 1-month survival with a favorable neurological outcome rate; 7.98% in cases of witnessed by family, 15.2% by non-family, and 25.6% by EMS, while unwitnessed OHCA with a non-shockable initial rhythm had the poorest outcomes (0.16%; **Figure 1**).

Trends in 1-Month Survival With Favorable Neurological Outcome Over Time
The proportion of 1-month survival with favorable neurological outcome improved from 0.73% (433/59,595) in 2008 to 0.96% (708/73,487) in 2012 (P for trend <0.001; **Figure 2A**). Annual trends in 1-month survival with favorable neurological outcome by age (**Figure 2A**), witness status (**Figure 2B**), first documented rhythm (**Figure 2C**), and etiology (**Figure 2D**) demonstrated that almost all subgroups showed improvements in outcome; however, 1-month survival with favorable neurological outcomes did not improve among patients in the oldest age group (aged ≥95 years) or for those who had unwitnessed OHCA events (**Figures 2A,B**). When witnessed OHCA patients were divided into 3 groups by type of witness (EMS, family member, and non-family member), those with EMS or family as witnesses had improved 1-month survival with favorable neurological outcome, with no change for those with non-family witnesses (**Figure 2E**).

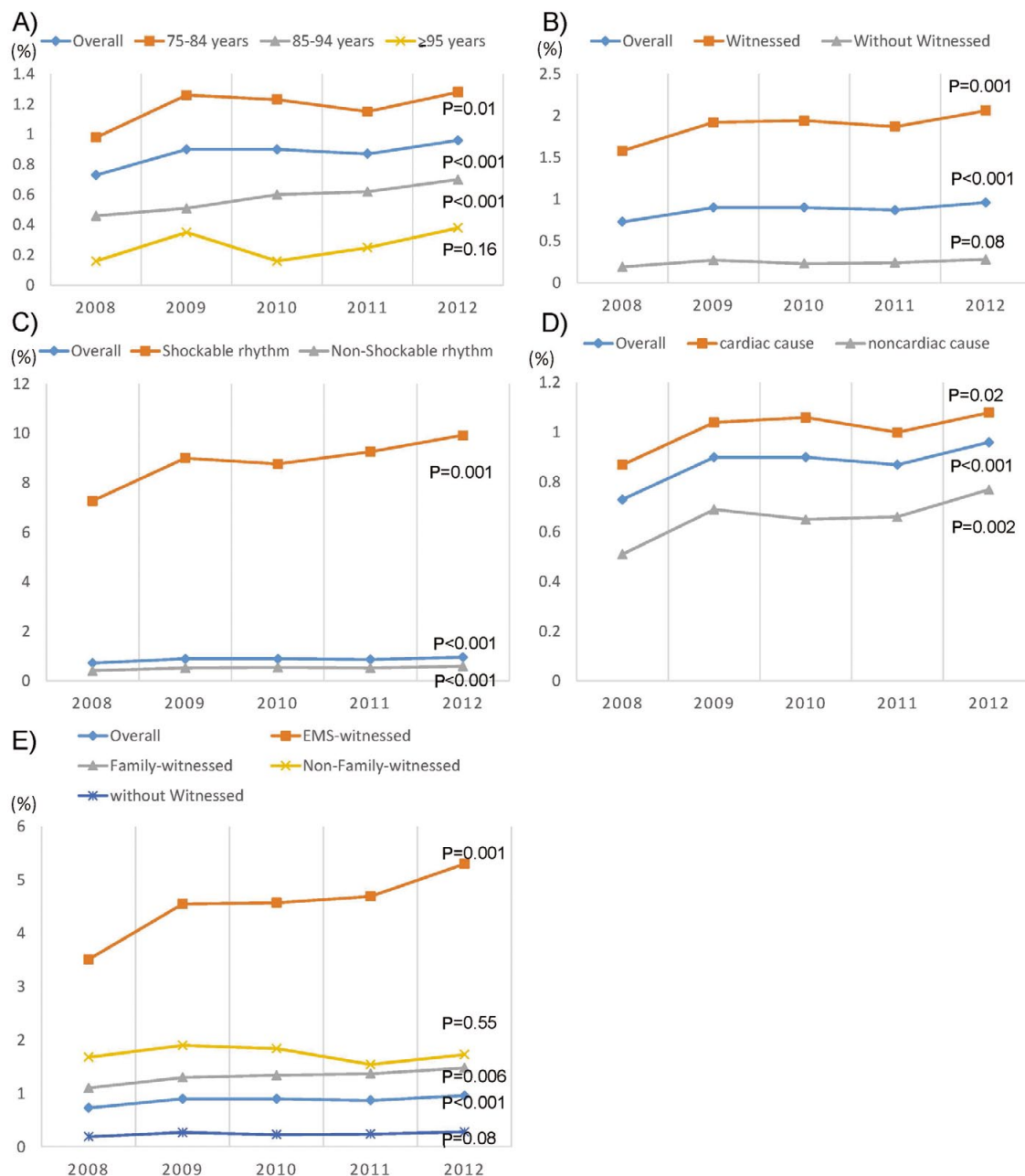| **Table 3.** Factors Associated With 1-Month Survival With Favorable Neurological Outcome After Out-of-Hospital Cardiac Arrest in Elderly Individuals	
	Adjusted OR (95% CI)
Year	
2008	Reference
2009	1.29 (1.13–1.46)
2010	1.32 (1.16–1.50)
2011	1.34 (1.18–1.52)
2012	1.52 (1.34–1.72)
Age group	
75–84 years	Reference
85–94 years	0.60 (0.55–0.65)
≥95 years	0.30 (0.23–0.38)
Male	1.02 (0.94–1.10)
VF or pVT	10.51 (9.67–11.41)
Witnessed arrest	5.70 (5.17–6.30)
Bystander CPR	0.77 (0.71–0.83)
Presumed cardiac origin	1.17 (1.07–1.27)
EMS response time/1-min increase	0.90 (0.89–0.91)

CI, confidence interval; OR, odds ratio. Other abbreviations as in Table 1.

Factors Associated With 1-Month Survival With Favorable Neurological Outcome After OHCA in Elderly Individuals by Bystander-Witness Type and Bystander CPR Type
When OHCAs witnessed by EMS (n=17,282) or by an unknown person (n=16) were excluded and adjusted for prehospital confounding factors, 1-month survival with favorable neurological outcome did not differ in terms of whether bystander CPR was performed (n=317,432; **Table 4A**). In addition, excluding unwitnessed OHCAs (n=205,652), in OHCAs witnessed by non-family or family members and adjusting for prehospital confounding factors, bystander CPR was positively associated with 1-month survival with favorable neurological outcome (n=111,780; **Table 4B**). Furthermore, in OHCAs with bystander-witnessed arrest excluding ventilation-only CPR (n=627), a non-family witness was associated with a higher rate of 1-month survival with favorable neurological outcome compared to a family witness after adjusting for prehospital confounding factors (n=111,153) (1.73% and 1.32%, P<0.001; adjusted OR 1.35; 95% CI 1.22–1.50). Chest compression-only CPR but not conventional CPR was associated with 1-month survival with favorable neurological outcome after adjusting for prehospital confounding factors (adjusted OR 1.18; 95% CI 1.06–1.32; **Table 4C**). In patients with unwitnessed OHCAs (n=205,652), bystander CPR was negatively associated with 1-month survival with favorable neurological outcome after adjusting for prehospital confounding factors (**Table 4D**).

Relationship Between Bystander CPR and Prehospital Factors in Elderly Individuals
Factors associated with bystander CPR for OHCAs, excluding those witnessed by EMS or a witness of an unknown type (n=317,432), in multivariate logistic regression models are shown in **Table 5**. Older age, female sex, and non-family witness were associated with implementation of bystander CPR; however, OHCAs witnessed by family were less likely to be associated with bystander CPR than those witnessed by non-family.

Figure 2. Temporal trends in the proportion of patients with 1-month survival with favorable neurological outcome by age group (**A**), witness status (**B**), first documented rhythm (**C**), etiology of cardiac arrest (**D**) and detailed witness status (**E**). EMS, emergency medical services.

Discussion

Predictors Associated With 1-Month Survival With Favorable Neurological Outcome in Elderly Individuals

In this study, we demonstrated that 1-month survival with favorable neurological outcome after OHCAs in elderly patients significantly improved each year. Recent calendar year, younger age, shockable first documented rhythm, witnessed arrest, faster EMS response time, and cardiac etiology were significantly associated with 1-month survival with favorable neurological

outcome even in elderly individuals, which was consistent with previous reports.[5,8,15–17,19–23,27,34]

A number of studies have suggested that decisions regarding resuscitation attempt should not be based on age alone because age has less effect on the success of resuscitation than other established factors such as bystander-witnessed arrest, shockable rhythm, cardiac origin, or early CPR.[19,25–27] In the present study, advanced age appeared to be independently associated with a lower rate of 1-month survival with favorable neurological outcome after OHCA.[16,21,22] The overall rate

Table 4. Factors Associated With 1-Month Survival With Favorable Neurological Outcome After Out-of-Hospital Cardiac Arrest in Elderly Individuals by Bystander-Witness Type and Bystander CPR Type

	Adjusted OR (95% CI)*
(A) Excluding events witnessed by EMS or unknown witness status (n=317,432)	
Witness status	
Unwitnessed	Reference
Family	3.76 (3.36–4.21)
Non-family	5.24 (4.64–5.91)
Bystander CPR	
No	Reference
Yes	1.04 (0.95–1.14)
(B) Excluding events witnessed by EMS, unknown witness status, and unwitnessed events (n=111,780)	
Witnessed status	
Family	Reference
Non-family	1.35 (1.22–1.50)
Bystander CPR	
No	Reference
Yes	1.17 (1.06–1.30)
(C) Excluding events witnessed by EMS, unknown witness status, unwitnessed events, or ventilation-only CPR (n=111,153)	
Witness status	
Family	Reference
Non-family	1.35 (1.22–1.50)
Bystander CPR	
None	Reference
Conventional CPR	1.14 (0.97–1.33)
Chest compressions only	1.18 (1.06–1.32)
(D) Unwitnessed arrest (n=205,652)	
Bystander CPR	
No	Reference
Yes	0.74 (0.61–0.89)

*Adjusted for potential confounding factors including calendar year, age, gender, initial rhythm, cardiac origin, EMS response time. Abbreviations as in Tables 1,3.

of 1-month survival with favorable neurological outcome was low; however, elderly individuals with OHCA of cardiac etiology, with a shockable rhythm, and witnessed arrest had acceptable 1-month survival with a favorable neurological outcome rate.[16,22,27]

Previous studies about the effects of age and gender on OHCA outcomes has yielded contradictory results.[35–37] In this study, male gender was associated with a higher 1-month survival with favorable neurological outcome rate in the univariate analysis, but there was no significant difference in the multivariate model (**Tables 3,6**). Age group distribution varied significantly by gender. Males were significantly younger and had a higher rate of shockable first documented rhythm and witnessed arrest than females. However, rates of bystander CPR and OHCA due to cardiac etiology were significantly higher in females. This means that factors mentioned above other than gender have significant effects on 1-month survival with favorable neurological outcome in elderly OHCA patients.

Bystander CPR was negatively associated with 1-month survival with favorable neurological outcome overall. When stratified by witnessed status, bystander CPR was positively associated with 1-month survival with favorable neurological outcome in elderly patients with OHCA witnessed by a family member or non-family member, but the association was negative in elderly patients with unwitnessed OHCAs. These results suggest that bystander CPR is beneficial for elderly

Table 5. Factors Associated With Bystander CPR in Elderly Individuals

	Adjusted OR (95% CI)
Year	
2008	Reference
2009	1.11 (1.08–1.13)
2010	1.10 (1.07–1.12)
2011	1.10 (1.07–1.12)
2012	1.14 (1.11–1.16)
Age group	
75–84 years	Reference
85–94 years	1.21 (1.20–1.23)
≥95 years	1.31 (1.28–1.35)
Male	0.81 (0.80–0.83)
Witness status	
Unwitnessed	Reference
Family	0.76 (0.75–0.78)
Non-family	2.36 (2.31–2.42)

Abbreviations as in Tables 1,3.

Table 6. Patient and EMS Characteristics, and Outcome by Gender

	Overall (n=334,730)	Male (n=164,856)	Female (n=169,874)	P value
Year				
2008	59,595	29,361 (49.3)	30,234 (50.7)	0.21
2009	62,065	30,816 (49.7)	31,249 (50.3)	
2010	67,878	33,412 (49.2)	34,466 (50.8)	
2011	71,705	35,238 (49.1)	36,467 (50.9)	
2012	73,487	36,029 (49.0)	37,458 (51.0)	
Age (years)				
Mean±SD	84.7±6.1	83.3±5.6	86.0±6.3	
Median, IQR	84 (80–89)	83 (79–87)	86 (81–91)	<0.001
Age group, n (%)				
75–84 years	174,781 (52.2)	102,300 (58.5)	72,481 (41.5)	<0.001
85–94 years	136,392 (40.7)	56,416 (41.4)	79,976 (58.6)	
≥95 years	23,557 (7.0)	6,140 (26.1)	17,417 (73.9)	
First documented rhythm, n (%)				
VF or pVT	13,954 (4.2)	8,698 (5.3)	5,256 (3.1)	<0.001
PEA or asystole	320,776 (95.8)	156,158 (94.7)	164,618 (96.9)	
Witnessed arrest, n (%)	129,078 (38.6)	65,984 (40.0)	63,094 (37.1)	<0.001
Bystander CPR, n (%)	155,838 (46.6)	70,796 (42.9)	85,042 (50.1)	<0.001
Presumed cardiac origin, n (%)	204,677 (61.1)	98,552 (59.8)	106,125 (62.5)	<0.001
EMS response time (min)				
Mean±SD	7.6±3.7	7.7±3.8	7.5±3.6	
Median, IQR	7 (5–9)	7 (5–9)	7 (5–9)	<0.001
One-month CPC 1or 2	2,933 (0.9)	1,726 (1.0)	1,207 (0.7)	<0.001

CPC, Cerebral Performance Category scale. Other abbreviations as in Table 1.

patients with witnessed OHCA; however, the beneficial effect was negated with unwitnessed OHCAs, a powerful adverse prognostic factor that accounted for 60% of all elderly OHCA patients.

Nationwide improvements in survival from bystander-witnessed OHCA between 2005 and 2009 have been reported based on data from the same registry.[5] However, in OHCA patients aged ≥90 years with a cardiac etiology or ≥80 years with a non-cardiac etiology, the annual rate of 1-month survival with favorable neurological outcome did not improve. Although the improvements in the annual rate of 1-month survival with favorable neurological outcome in elderly OHCA patients has been reported in Osaka from 1999 to 2011,[15] this study investigated only bystander-witnessed OHCAs aged ≥65 years of cardiac origin. Therefore, it remains unclear whether there were recent improvements in elderly OHCA patients overall. In the present study, we demonstrated that the overall annual rate of 1-month survival with favorable neurological outcome after OHCA among elderly patients improved significantly. In particular, outcomes of OHCA patients aged 75–84 and 85–94 years have improved significantly. These improvements are attributable to improvement in "chain of survival", as well as the revisions of CPR guidelines, education of laypersons in bystander CPR, and the development of a public-access defibrillation strategy.[5–13]

In this context, it is intriguing that the annual rate of 1-month survival with favorable neurological outcome did not improve in the oldest age group (≥95 years) and patients with unwitnessed OHCA. The oldest age group (≥95 years) had poor prognosis despite their arrests being more frequently witnessed, especially by non-family members, more frequently receiving bystander CPR, and being of a cardiac etiology than the other

2 age groups. Most poor outcomes in the oldest age group were attributable to an extremely low frequency of shockable first documented rhythm. Although our database did not include detailed information about bystander type and quality of bystander CPR, we speculate that this discrepancy may be explained by the quality of bystander CPR and patient characteristics.[18] Suboptimal CPR, such as insufficient depth of chest compression by a bystander who is a family member (eg, the patient's spouse who may also be elderly and have physical limitations) might affect outcomes. The majority of non-family bystanders for elderly OHCA patients may be nursing home staff. Elderly OHCA patients residing in nursing homes may be more likely to have witnessed OHCAs and receive bystander CPR; however, they are less likely to be responsive to bystander CPR due to their physical condition and various comorbidities. The lack of a bystander witness might be negatively associated with 1-month survival with favorable neurological outcome because of a longer interval between collapse to CPR, which results in shockable rhythms less often and poor neurological outcome.[18,21,38]

The 1-month survival with favorable neurological outcome in this study is markedly lower than that in comparable studies from other developed countries.[16,19] The study population was different from those in previous studies. In the present study, elderly was defined at a higher age and the frequency of shockable first documented rhythm was lower than that of previous studies. These differences might account for worse 1-month survival with favorable neurological outcome in the present study. In contrast, because EMS providers are legally prohibited from TOR in the field unless there are obvious signs of the death, in Japan, this study may have included a certain number of patients with very low probability of achieving survival

with favorable neurological outcome. Therefore, the EMS system might have played a role in the lower rate of 1-month survival with favorable neurological outcome. This suggests that, to reduce futile resuscitation with limited medical resources, the oldest age group (≥95 years) might be taken into consideration to improve present TOR rules, which are already include an unwitnessed status.[1,39] However this rationale is fraught with ethical and legal factors and needs further investigations because end-of-life decisions are complex and do-not-resuscitate orders and living wills are generally not used in Japan.

Further Improvements in 1-Month Survival With Favorable Neurological Outcome in Elderly Individuals

The number and proportion of bystander CPR events increased steadily; however, its use remains low at less than 50%. In the present study, patients with OHCA witnessed by family were less likely to receive bystander CPR and had a lower rate of 1-month survival with favorable neurological outcome than those with a non-family witness, as previously reported.[18,40] In contrast, the annual rate of 1-month survival with favorable neurological outcome in patients with OHCA witnessed by non-family did not improve during the study period. Therefore, to achieve further improvements in 1-month survival with favorable neurological outcome in witnessed arrests, strengthening the frequency and quality of bystander CPR by both family and non-family members is required.

Chest compression-only but not conventional CPR was associated with 1-month survival with favorable neurological outcome after adjusting for prehospital confounding factors. During the study period, the proportion of chest compression-only CPR increased because dispatchers in Japan recommend chest compression-only CPR for untrained laypersons or those unwilling to perform rescue breathing.[3,12,32] In recent years and among elderly OHCA patients, the proportion of patients with a shockable first documented rhythm decreased gradually, and OHCA in elderly individuals were frequently witnessed at home with a low probability of public-access defibrillation.[15,21,41,42] It is well-known that OHCAs at home and witnessed by family are more likely to be associated with a poor outcome, especially in elderly individuals.[18,21,38,40] Therefore, we suggest that education of family members to increase the frequency and quality of bystander CPR, especially chest compression-only CPR, could be more effective for improving the rate of 1-month survival with favorable neurological outcome of elderly individuals than dissemination of public-access defibrillators, although efforts to improve prehospital care by EMS have plateaued and might be reaching its limit.[6,7,15,40,43,44]

Study Limitations

This study has several limitations. First, we did not have sufficient data on location where OHCAs occurred and comorbidities affecting outcome. Based on studies of elderly OHCA patients in Osaka and other countries,[15,21,38] most of our elderly OHCA patients were presumed to have had witnessed events at home. Several studies have reported that pre-arrest comorbidities were not associated with outcome after OHCA, even in elderly patients.[19,20,34] Second, the database did not include detailed information about bystander characteristics such as age and gender, quality of bystander CPR, post-resuscitation care including therapeutic hypothermia, and etiology of the cardiac arrest. Third, as with all epidemiological studies, the integrity, validity, and ascertainment bias of the data are potential limitations. The use of uniform data collection procedures based on Utstein style guidelines for reporting cardiac

arrest, large sample size, and population-based study design covering all known OHCAs in Japan, were intended to minimize these potential sources of bias. Finally, we enrolled elderly OHCA patients aged ≥75 years in the present study because the medical services offered are different for those aged 75 years or older in Japan, which already has an aging society. To apply the results of the present study to other countries, consideration of differences in life expectancy and medical systems might be required. Further investigation including detailed information such as location, pre-arrest comorbidities, and post-resuscitation care will confirm the present study results.

Conclusions

Data drawn from a large subset of elderly OHCA patients in a Japanese registry suggest that resuscitation of elderly individuals in selected populations is not futile, and the annual rate of 1-month survival with favorable neurological outcome from OHCA has significantly improved during the study period, but it is still low. To achieve further improvements in survival with favorable neurological outcome for witnessed arrests, strengthening the frequency and quality of bystander CPR, especially chest compression-only CPR by family and non-family members, is required.

Conflicts of Interest

None declared.

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