

Out-of-Hospital Cardiac Arrest at Home in Japan



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Although majority of out-of-hospital cardiac arrests (OHCAs) occur in private residential locations, that is, at home, the details of emergency patients with OHCAs occurring at home have not been sufficiently investigated at the national level. We obtained data of OHCA cases from the All-Japan Utstein Registry, including detailed information of the location of cardiac arrest. Cases of OHCA occurring at home from 2013 to 2015 were included. Patient characteristics and outcomes after OHCA were described based on the location of cardiac arrest. During the 3-year study period, a total of 212,722 cases of OHCA were documented at home (186,219 in detached houses and 26,503 in multiple dwelling houses), and it accounted for 65.0% of all OHCA cases in Japan. The majority of OHCAs occurred in the living room/bedroom (67.7%), followed by the bathroom (12.9%), entrance/corridor (5.3%), and toilet (4.8%). The characteristics of OHCA at home, widely varied by location of cardiac arrest and residence type. The proportion of bystander-initiated cardiopulmonary resuscitations was less than half at all locations and ranged from 27.9% to 47.1%. The proportion of public-access defibrillation was also low regardless of the location of arrest and ranged from 0.0% to 0.2%. Consequently, the proportion of 1-month survival with favorable neurological outcome was low regardless of the location of arrest and ranged from 0.3% to 2.3%. In conclusion, OHCA occurrence at home accounted for approximately 2/3 of all OHCA cases in Japan, but their outcomes were extremely poor regardless of the location of cardiac arrest. © 2019 Elsevier Inc. All rights reserved. (Am J Cardiol 2019;123:1060–1068)

Early defibrillation using automated external defibrillators (AEDs) and initiation of cardiopulmonary resuscitation (CPR) by bystanders play an important role in improving survival after out-of-hospital cardiac arrest (OHCA).¹ In Japan, the use of AED by bystanders for OHCA patients has been legalized since July 2004. Thereafter, the cumulative sales of public-access AEDs rapidly increased,² and these have been deployed mainly in public locations. Several studies have suggested that this nationwide dissemination of public-access AEDs has allowed early defibrillation by bystanders, leading to increased survival rates after OHCA.^{1,3} Therefore, this

improvement of survival rate was achieved mostly in public locations and not in residential locations, that is, at home. Considering that most of OHCAs worldwide occur at home and range from 65% to 83%,^{4–6} prevention and improvement of survival rate of OHCAs occurring at home is critical and needs to be addressed. Nevertheless, the details of emergency patients with OHCAs occurring at home have not been sufficiently investigated at the national level. The present study aims to reveal the detailed characteristics and outcomes of OHCA occurring at home in Japan.

Methods

Details of the All-Japan Utstein Registry of the Fire and Disaster Management Agency (FDMA) were previously reported.¹ Briefly, this is a prospective population-based OHCA registry based on the international Utstein-style^{7,8} that covers a population of approximately 127 million people in Japan. Cardiac arrest was determined as cessation of cardiac mechanical activity and was confirmed by absence of any signs of circulation by emergency medical service (EMS) personnel. Cardiac arrest was presumed to be of cardiac origin unless obvious evidence suggested any noncardiac causes (i.e., cerebrovascular disease, respiratory disease, malignant tumors, trauma, drug overdose, drowning, electrocution, or asphyxia) based on the current Utstein-style template.⁹ These diagnoses were determined clinically by the physicians in charge, in collaboration with the EMS personnel. Treatment for cardiac arrest by EMS

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personnel was conducted based on the Japanese CPR guidelines.¹⁰ Generally, prehospital termination of resuscitation by EMS personnel is not allowed as do-not-resuscitate orders (or living wills) are not permitted in Japan. Therefore, excluding cases of decapitation, incineration, decomposition, rigor mortis, or dependent cyanosis, most OHCA patients treated by EMS personnel were transported to hospitals, and pertinent data were recorded in this registry. All OHCA survivors were followed for up to 1 month after the event by the EMS providers in charge to assess their outcomes. Data forms were filled by the EMS personnel, in collaboration with the physician in charge of the patient. In addition to the data items included as per the international Utstein style,^{7,8} the FDMA started collecting detailed information on the location of the OHCA occurrence in January 2013. According to the current international Utstein standardized template, the location of cardiac arrest was classified as home/residence, industrial/workplace, sports/recreation event, street/highway, public building, assisted living/nursing home, educational institution, other, and unknown/not recorded.⁹

The subjects of the present study were patients with OHCA whose location of arrest was registered as home/residence⁹ in the registry from January 1, 2013 to December 31, 2015. OHCA patients for whom CPR was attempted by bystanders or by EMS personnel and were subsequently transported to medical institutions by EMS were included. Patients with unknown age, unknown witness status, unknown first documented rhythm, unknown outcome, and unknown location of arrest were excluded.

We obtained the following data from the All-Japan Utstein Registry: location of arrest, origin of arrest, age, gender, first documented rhythm, witness of cardiac arrest, dispatcher instruction of CPR, initiation of bystander CPR, initiation of public-access defibrillation (PAD), time of call to EMS, time of contact with patients by EMS, time of hospital arrival, and outcomes after OHCA. When bystanders provided defibrillations using a public-access AED, the victims' first documented rhythm was regarded as ventricular fibrillation (VF). The location of cardiac arrest in home/residence was further divided into the following categories: living room/bedroom, entrance/corridor, staircase, toilet, bathroom, kitchen/dining room, veranda/balcony/garden/terrace, and other locations (e.g., barn, basement, and garage).

The primary endpoint of this study was 1-month survival with a favorable neurological outcome. The 1-month neurological status was scored by the physician in charge, using the Glasgow-Pittsburgh cerebral performance category scale: category 1 as good performance; category 2 as moderate disability; category 3 as severe cerebral disability; category 4 as coma/vegetative state; and category 5 as death/brain death. One-month survival with favorable neurological outcome was defined as cerebral performance category 1 or 2.^{7,8} The secondary outcome measure was 1-month survival after OHCA.

Summary statistics were expressed as mean and standard deviation for numerical variables and as percentages for categorical variables. Characteristics and outcomes after OHCA were described by location of cardiac arrest in home/residence and residence type (i.e., detached house or

multiple dwelling house). As subgroup analyses, we also classified the outcomes according to residence type and origin of arrest (i.e., cardiac origin or noncardiac origin). Differences in the groups were assessed using chi-square test for categorical variables and analysis of variance or unpaired *t* test for numerical variables. Additionally, a multivariable logistic regression model was used to investigate potential prehospital factors associated with 1-month survival with favorable neurological outcome. The odds ratios (ORs) and associated 95% confidence intervals (CIs) were calculated. The explanatory variables included the following: residence type, location of arrest, origin of arrest, age, gender, first documented rhythm, witness of arrest by bystanders, initiation of bystander CPR, initiation of PAD, and time from call to contact with the patient by EMS personnel. All tests were two-tailed, and a *p* value <0.05 was considered statistically significant. Statistical analyses were conducted using the SPSS statistical package version 25.0 J (IBM Corp, Armonk, NY).

The study protocol was approved by the Ethics Committee of Osaka University and Kyoto University. Personal identifiers were removed in the FDMA before publication of the database. The requirement for informed consent of patients was waived.

Results

Figure 1 shows the flowchart for selection of eligible OHCA patients for the analysis. During the 3-year study period, a total of 327,453 cases of OHCA occurring before arrival of EMS were registered in the All-Japan Utstein Registry. Of these cases, 212,722 (65.0%) succumbed in home/residence (186,219 in detached houses and 26,503 in multiple dwelling houses). The majority of OHCA occurred in living room/bedroom (67.7%), followed by bathroom (12.9%), entrance/corridor (5.3%), and toilet (4.8%).

Table 1 shows the characteristics of eligible patients according to the location of arrest. Overall, 62.3% of OHCA were of cardiac origin; however, the origin of arrest varied widely by the location of arrest. For example, OHCA caused by external causes were likely to occur in the staircase (47.2%), veranda/balcony/garden/terrace (35.9%), and other places (49.6%), and those caused by drowning were significantly in bathrooms (24.9%). The proportion of initiation of bystander CPR was less than half at all locations and ranged from 27.9% to 47.1%. The proportion of OHCA patients receiving PAD was extremely low regardless of location of arrest and ranged from 0.0% to 0.2%. Notably, the characteristics of OHCA cases in bathroom considerably differed from those in other locations. They were more likely to occur in winter (46.8%), in a relatively older (mean age: 77.8 years) population, less likely to be witnessed by bystanders (7.5%), and less likely to have VF rhythm (1.7%). Table 2 shows the characteristics of OHCA patients according to residence type. OHCA cases in multiple dwelling houses were in relatively younger (mean age: 68.2 years vs 75.5 years) patients and were likely to have VF rhythm (6.4% vs 5.4%), witnessed by bystanders (34.4% vs 31.0%) and received

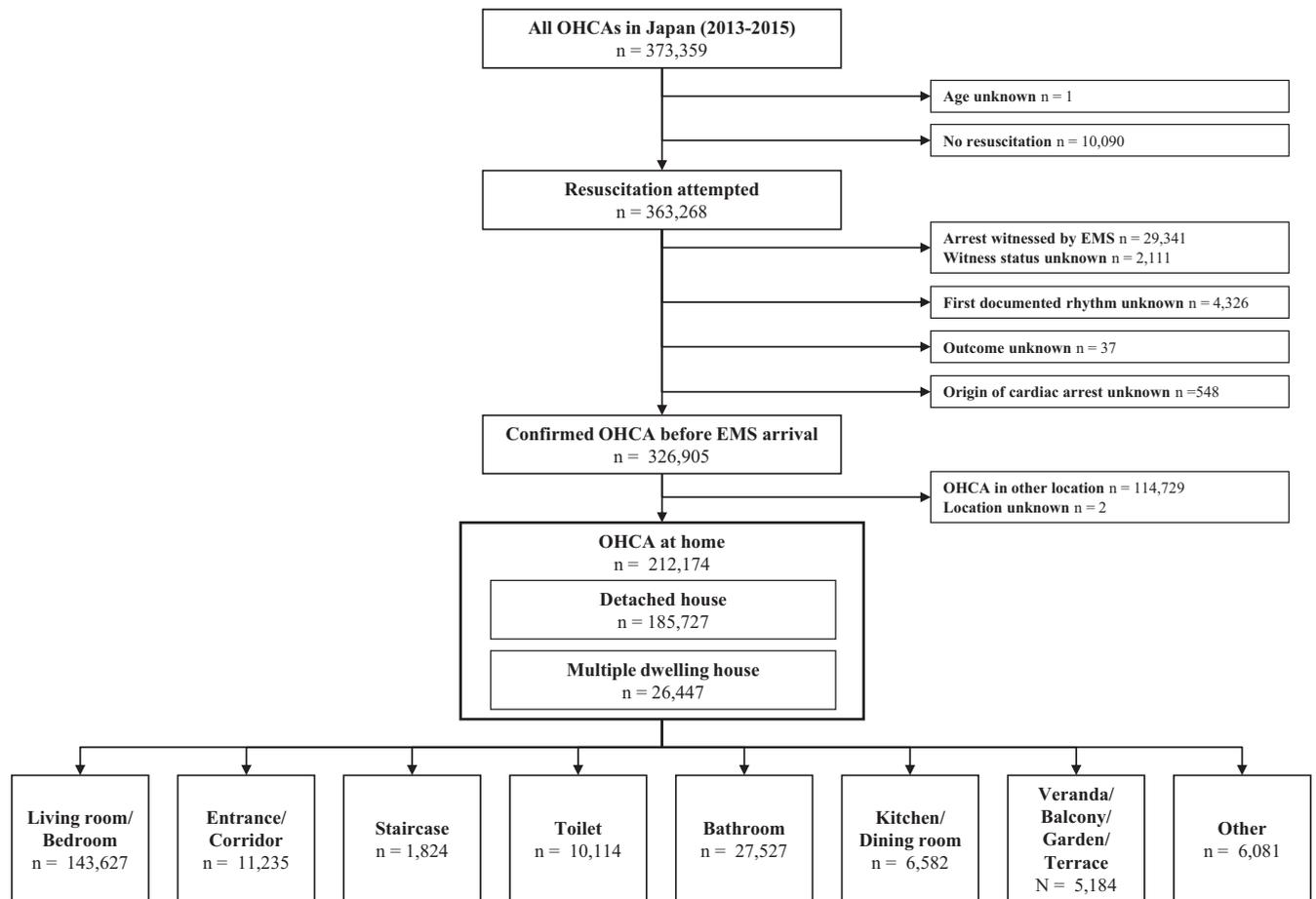


Figure 1. Study flowchart on the selection of patients with OHCA occurring at home in Japan between January 1, 2013, and December 31, 2015. EMS = emergency medical service; OHCA = out-of-hospital cardiac arrest.

PAD (0.2% vs 0.1%) compared with those in dwelling houses. In addition, time of EMS response was significantly earlier in cases in multiple dwelling houses than in detached houses.

Figure 2 shows the outcomes after OHCA according to the location of arrest. Overall proportion of 1-month survival was 3.4% and that of 1-month survival with favorable neurological outcome was 1.4%. The proportion of 1-month survival with favorable neurological outcome differed by location of arrest and ranged from 0.3% to 2.3%. Generally, the cases in the bathroom showed much worse outcomes than those in other locations. Even in cases of OHCA of cardiac origin, only 0.4% of them survived past 1 month with favorable neurological outcome. The proportion of 1-month survival with favorable neurological outcome was also higher in cases in multiple dwelling houses than in those in detached houses (1.8% vs 1.3%). Table 3 shows the factors associated with 1-month survival with favorable neurological outcome after OHCA. In multivariable analysis, bystander interventions such as initiation of bystander CPR (adjusted OR 1.23, 95% CI 1.14 to 1.34) and initiation of PAD (adjusted OR 1.57, 95% CI 1.01 to 2.46) were significantly associated with improved outcomes.

Discussion

Using the exhaustive OHCA registry of Japan, the present study clearly depicted the characteristics, prehospital care, and their prognosis according to detailed location of arrest and residence type. The results demonstrate that approximately 2/3 of all OHCA in Japan occurred at home. The characteristics of OHCA cases at home significantly varied by location of arrest and residence type, but their outcomes were extremely poor regardless of these locations. The finding that only 5.6% of cases had VF rhythm, 45.1% received bystander CPR, and 0.1% received PAD greatly influenced the poor outcomes after OHCA, indicating that there is still room for improvement. These results were almost consistent with the previous studies, which suggested that initiation of bystander CPR and use of on-site AEDs at home remain limited and the prospect of survival for this patient group was poor compared with that in public locations.^{6,11,12} Thus, although more than 4 million people are trained in CPR annually in Japan,¹³ our findings strongly suggest the importance of further efforts to establish effective strategies focused on increasing bystander CPR and AED use at home.

Table 1
 Characteristics of out-of-hospital cardiac arrests according to location of arrest at home in Japan

Variable	Location of arrest												P-value	
	Total n = 212,174	Living room/ n = 143,627	Bedroom n = 11,235	Entrance/ n = 1,824	Corridor n = 10,114	Staircase n = 27,527	Toilet n = 6,582	Bathroom n = 5,184	Kitchen/ n = 6,582	Dining room n = 5,184	Veranda/ n = 5,184	Balcony/ n = 5,184		Garden/Terrace n = 6,081
Detached house	185,727 (87.5%)	125,266 (87.2%)	9,750 (86.8%)	1,503 (82.4%)	8,834 (87.3%)	25,000 (90.8%)	6,008 (91.3%)	4,379 (84.5%)	4,987 (82.0%)					<0.001
Season														<0.001
Spring	52,238 (24.6%)	35,285 (24.6%)	2,752 (24.5%)	472 (25.9%)	2,451 (24.2%)	6,892 (25.0%)	1,494 (22.7%)	1,305 (25.2%)	1,587 (26.1%)					
Summer	38,462 (18.1%)	27,594 (19.2%)	2,183 (19.4%)	383 (21.0%)	2,005 (19.8%)	2,507 (9.1%)	1,201 (18.2%)	1,189 (22.9%)	1,400 (23.0%)					
Autumn	47,090 (22.2%)	32,100 (22.3%)	2,616 (23.3%)	465 (25.5%)	2,376 (23.5%)	5,255 (19.1%)	1,561 (23.7%)	1,269 (24.5%)	1,448 (23.8%)					
Winter	74,384 (35.1%)	48,648 (33.9%)	3,684 (32.8%)	504 (27.6%)	3,282 (32.5%)	12,873 (46.8%)	2,326 (35.3%)	1,421 (27.4%)	1,646 (27.1%)					
Time of call EMS														<0.001
0:00 - 5:59	29,320 (13.8%)	21,509 (15.0%)	1,607 (14.3%)	241 (13.2%)	1,718 (17.0%)	2,703 (9.8%)	467 (7.1%)	471 (9.1%)	604 (9.9%)					
6:00 - 11:59	67,864 (32.0%)	50,695 (35.3%)	3,772 (33.6%)	526 (28.8%)	3,432 (33.9%)	3,043 (11.1%)	2,235 (34.0%)	1,972 (38.0%)	2,189 (36.0%)					
12:00 - 17:59	53,905 (25.4%)	36,563 (25.5%)	3,299 (29.4%)	655 (35.9%)	2,523 (24.9%)	4,772 (17.3%)	1,984 (30.1%)	1,925 (37.1%)	2,184 (35.9%)					
18:00 - 23:59	61,085 (28.8%)	34,860 (24.3%)	2,557 (22.8%)	402 (22.0%)	2,441 (24.1%)	17,009 (61.8%)	1,896 (28.8%)	816 (15.7%)	1,104 (18.2%)					
Origin of arrest														<0.001
Cardiac origin	132,290 (62.3%)	94,205 (65.6%)	7,089 (63.1%)	517 (28.3%)	7,127 (70.5%)	16,160 (58.7%)	3,551 (54.0%)	2,250 (43.4%)	1,391 (22.9%)					
Non-cardiac origin	79,884 (37.7%)	49,422 (34.4%)	4,146 (36.9%)	1,307 (71.7%)	2,987 (29.5%)	11,367 (41.3%)	3,031 (46.0%)	2,934 (56.6%)	4,690 (77.1%)					
Cerebrovascular disease	6,751 (3.2%)	4,267 (3.0%)	383 (3.4%)	31 (1.7%)	567 (5.6%)	917 (3.3%)	306 (4.6%)	186 (3.6%)	94 (1.5%)					
Respiratory disease	16,245 (7.7%)	11,732 (8.2%)	620 (5.5%)	219 (12.0%)	305 (3.0%)	656 (2.4%)	1,652 (25.1%)	301 (5.8%)	760 (12.5%)					
Malignant tumor	7,974 (3.8%)	6,775 (4.7%)	322 (2.9%)	13 (0.7%)	441 (4.4%)	241 (0.9%)	90 (1.4%)	36 (0.7%)	56 (0.9%)					
External causes	15,169 (7.1%)	6,707 (4.7%)	1,348 (12.0%)	861 (47.2%)	239 (2.4%)	878 (3.2%)	261 (4.0%)	1,859 (35.9%)	3,016 (49.6%)					
Drowning	6,859 (3.2%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	6,859 (24.9%)	0 (0.0%)	0 (0.0%)	0 (0.0%)					
Other non-cardiac origin	26,886 (12.7%)	19,941 (13.9%)	1,473 (13.1%)	183 (10.0%)	1,435 (14.2%)	1,816 (6.6%)	722 (11.0%)	552 (10.6%)	764 (12.6%)					
Age, mean (SD) (years)	74.6 (16.8)	75.0 (17.3)	72.0 (16.5)	64.4 (17.2)	74.9 (14.2)	77.8 (13.1)	75.7 (13.4)	67.8 (18.6)	63.2 (19.4)					<0.001
Age group														<0.001
<18 (years)	2,860 (1.3%)	2,308 (1.6%)	94 (0.8%)	17 (0.9%)	40 (0.4%)	227 (0.8%)	16 (0.2%)	64 (1.2%)	94 (1.5%)					
18-74 (years)	77,402 (36.5%)	50,624 (35.2%)	5,099 (45.4%)	1,240 (68.0%)	3,958 (39.1%)	7,353 (26.7%)	2,438 (37.0%)	2,799 (54.0%)	3,891 (64.0%)					
>74 (years)	131,912 (62.2%)	90,695 (63.1%)	6,042 (53.8%)	567 (31.1%)	6,116 (60.5%)	19,947 (72.5%)	4,128 (62.7%)	2,321 (44.8%)	2,096 (34.5%)					
Male	121,564 (57.3%)	82,308 (57.3%)	6,938 (61.8%)	1,201 (65.8%)	6,464 (63.9%)	13,822 (50.2%)	3,334 (50.7%)	3,365 (64.9%)	4,132 (67.9%)					<0.001
VF as first documented rhythm	11,787 (5.6%)	8,790 (6.1%)	772 (6.9%)	72 (3.9%)	545 (5.4%)	462 (1.7%)	490 (7.4%)	407 (7.9%)	249 (4.1%)					<0.001
Witnessed by bystanders	66,615 (31.4%)	50,263 (35.0%)	4,684 (41.7%)	442 (24.2%)	3,401 (33.6%)	2,051 (7.5%)	3,428 (52.1%)	1,242 (24.0%)	1,104 (18.2%)					<0.001
Dispatcher instruction	134,114 (63.2%)	92,098 (64.1%)	6,206 (55.2%)	829 (45.4%)	5,673 (56.1%)	19,402 (70.5%)	4,276 (65.0%)	2,576 (49.7%)	3,054 (50.2%)					<0.001
Initiation of bystander CPR	95,721 (45.1%)	67,579 (47.1%)	4,489 (40.0%)	508 (27.9%)	3,351 (33.1%)	12,588 (45.7%)	2,959 (45.0%)	1,985 (38.3%)	2,262 (37.2%)					<0.001
Initiation of PAD	174 (0.1%)	118 (0.1%)	18 (0.2%)	0 (0.0%)	7 (0.1%)	17 (0.1%)	6 (0.1%)	4 (0.1%)	4 (0.1%)					<0.001
Time from call to contact with the patient by EMS personnel (mins), mean (SD)	9.3 (3.8)	9.3 (3.8)	9.3 (4.0)	8.8 (3.2)	9.1 (3.6)	9.0 (3.6)	9.2 (3.7)	9.8 (4.4)	9.5 (4.3)					<0.001
Time from call to hospital arrival (mins), mean (SD)	32.9 (11.5)	32.8 (11.5)	32.7 (11.7)	31.8 (10.9)	32.9 (11.2)	33.0 (11.2)	33.4 (11.5)	33.3 (12.8)	32.1 (12.3)					<0.001

CPR = cardiopulmonary resuscitation; EMS = emergency medical service; PAD = public-access defibrillation; SD = standard deviation; VF = indicates ventricular fibrillation.

Table 2
Differences of characteristics between OHCA in detached house and multiple dwelling house

Variable	Total n = 212,174		Residence type		P-value
			Detached house n = 185,727	Multiple dwelling house n = 26,447	
Season					<0.001
Spring	52,238	(24.6%)	45,659	(24.6%)	6,579 (24.9%)
Summer	38,462	(18.1%)	33,209	(17.9%)	5,253 (19.9%)
Autumn	47,090	(22.2%)	41,097	(22.1%)	5,993 (22.7%)
Winter	74,384	(35.1%)	65,762	(35.4%)	8,622 (32.6%)
Time of call EMS					<0.001
0:00 - 5:59	29,320	(13.8%)	25,014	(13.5%)	4,306 (16.3%)
6:00 - 11:59	67,864	(32.0%)	59,703	(32.1%)	8,161 (30.9%)
12:00 - 17:59	53,905	(25.4%)	47,118	(25.4%)	6,787 (25.7%)
18:00 - 23:59	61,085	(28.8%)	53,892	(29.0%)	7,193 (27.2%)
Origin of arrest					<0.001
Cardiac origin	132,290	(62.3%)	116,250	(62.6%)	16,040 (60.6%)
Non-cardiac origin	79,884	(37.7%)	69,477	(37.4%)	10,407 (39.4%)
Cerebrovascular disease	6,751	(3.2%)	6,010	(3.2%)	741 (2.8%)
Respiratory disease	16,245	(7.7%)	14,585	(7.9%)	1,660 (6.3%)
Malignant tumor	7,974	(3.8%)	6,980	(3.8%)	994 (3.8%)
External causes	15,169	(7.1%)	11,945	(6.4%)	3,224 (12.2%)
Drowning	6,859	(3.2%)	6,253	(3.4%)	606 (2.3%)
Other non-cardiac origin	26,886	(12.7%)	23,704	(12.8%)	3,182 (12.0%)
Age, mean (SD) (years)	74.6	(16.8)	75.5	(16.1)	68.2 (19.9)
Age group (years)					<0.001
<18	2,860	(1.3%)	2,175	(1.2%)	685 (2.6%)
18-74	77,402	(36.5%)	63,971	(34.4%)	13,431 (50.8%)
>74	131,912	(62.2%)	119,581	(64.4%)	12,331 (46.6%)
Male	121,564	(57.3%)	106,420	(57.3%)	15,144 (57.3%)
VF as first documented rhythm	11,787	(5.6%)	10,085	(5.4%)	1,702 (6.4%)
Witnessed by bystanders	66,615	(31.4%)	57,512	(31.0%)	9,103 (34.4%)
Dispatcher instruction	134,114	(63.2%)	119,294	(64.2%)	14,820 (56.0%)
Initiation of bystander CPR	95,721	(45.1%)	85,310	(45.9%)	10,411 (39.4%)
Initiation of PAD	174	(0.1%)	109	(0.1%)	65 (0.2%)
Time from call to contact with the patient by EMS personnel (mins), mean (SD)	9.3	(3.8)	9.3	(3.9)	9.0 (3.5)
Time from call to hospital arrival (mins), mean (SD)	32.9	(11.5)	32.9	(11.7)	32.6 (10.2)

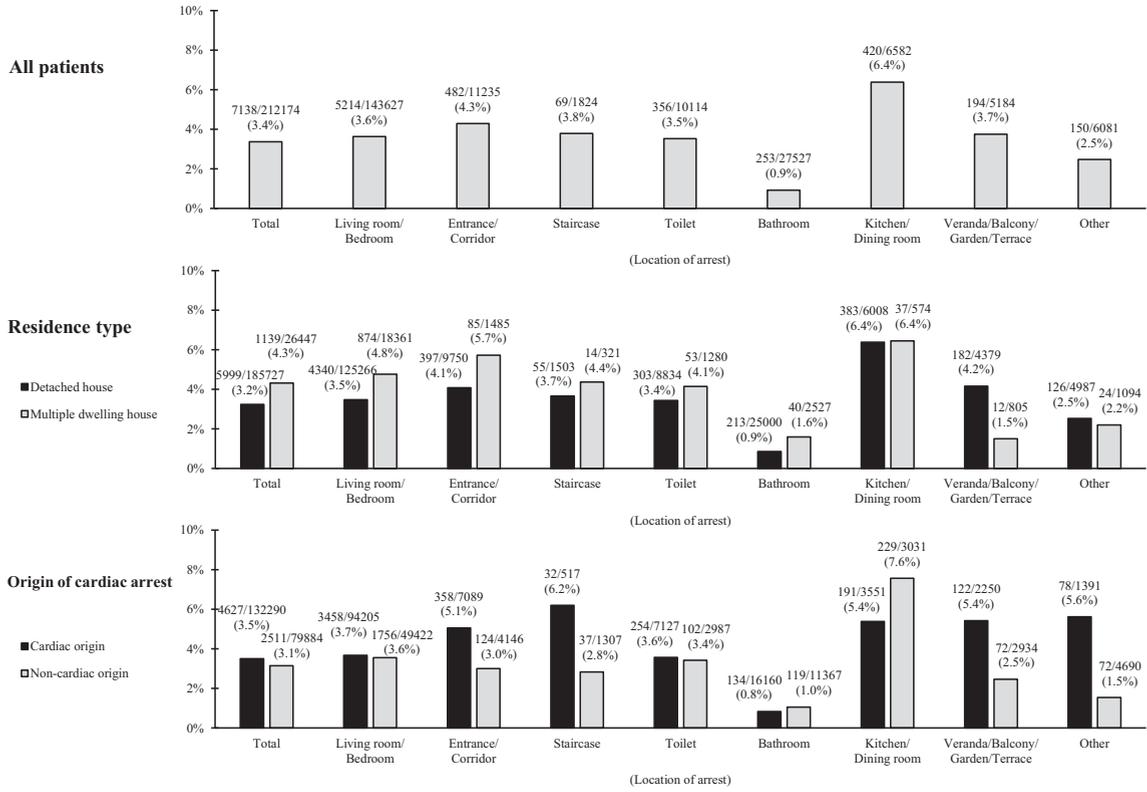
EMS = emergency medical service; CPR = cardiopulmonary resuscitation; OHCA = out-of-hospital cardiac arrest; PAD = public-access defibrillation; SD = standard deviation; VF = ventricular fibrillation.

The extremely low proportion of initiation of PAD at home may be due to poor dissemination of AEDs at home and lack of public awareness regarding the nearest locations of AED installations.¹⁴ Although the effectiveness of deployment of home AEDs is still under debate in community settings,^{15,16} another report suggested that the dissemination of public-access AEDs in multiple dwelling houses was potentially lifesaving.¹⁷ The guidelines for appropriate public-access AED placement in Japan also recommend the installation of public-access AEDs in shared spaces of multiple dwelling houses, such as lobbies and common corridors.¹⁸ Nevertheless, our results showed that only 0.2% of patients received PAD even in multiple dwelling houses, and the outcomes of those in these locations were poor as well. Although we were not able to obtain information on the actual number and location of deployment of public-access AEDs in residential areas, our results suggest that dissemination of AEDs was still poor in these locations. In this study, 12.5% of OHCA cases at home were observed in

multiple dwelling houses. The number of multiple dwelling houses, such as apartments and condominiums, has been increasing mainly in urban areas in Japan; 70% of inhabitants in Tokyo and 50% in Osaka live in such types of housing.¹⁹ Considering the ongoing increment of population living in multiple dwelling houses in Japan, the widespread deployment of public-access AEDs in shared spaces in these residences should be a pressing need in the future.

This study also demonstrated that less than half of OHCA patients received bystander-initiated CPR. A previous study suggested that bystanders with OHCA occurred at home were likely to have knowledge, experience, and implementation of CPR.²⁰ Therefore, further efforts are needed to educate the general public on basic life support, including both CPR and AED use. For example, training in simplified compression-only CPR would be an effective solution because it is an easier skill to acquire than conventional CPR with rescue breathing.²¹ The use of more aggressive dispatch-directed chest compressions might be

(A) Proportion of one-month survival



(B) Proportion of one-month survival with favorable neurological outcome

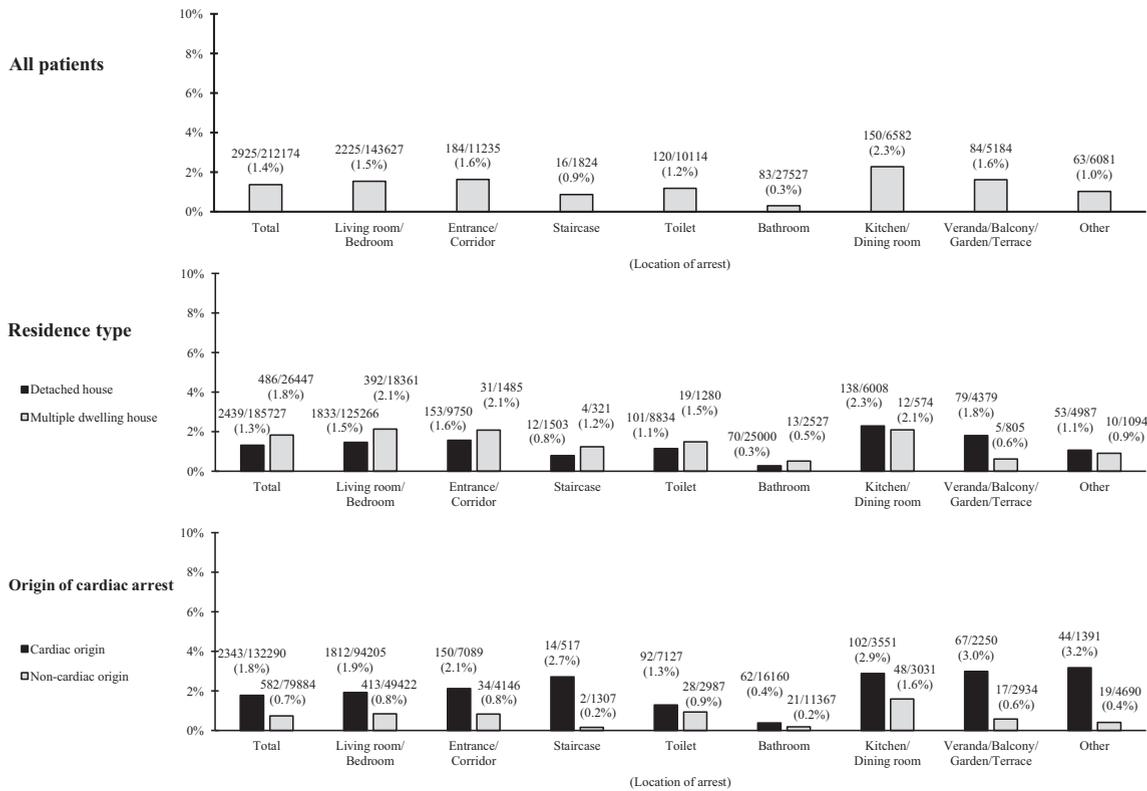


Figure 2. Outcomes in out-of-hospital cardiac arrest according to the location of arrest at home in Japan.

Table 3
Factors associated with 1-month survival with favorable neurological outcomes after OHCA at home

Variable	One-month survival with favorable neurological outcome		Univariable analysis			Multivariable analysis*		
	n/N	(%)	OR	(95% CI)	P-value	OR	(95% CI)	P-value
Residence type								
Detached house	2,439/18,5727	(1.3%)	ref.			ref.		
Multiple dwelling house	486/26,447	(1.8%)	1.41	(1.28-1.55)	<0.001	1.02	(0.91-1.13)	0.739
Location of arrest								
Living room/bedroom	2,225/143,627	(1.5%)	ref.			ref.		
Entrance/corridor	184/11,235	(1.6%)	1.06	(0.91-1.23)	0.465	0.98	(0.83-1.15)	0.769
Staircase	16/1,824	(0.9%)	0.56	(0.34-0.92)	0.022	0.76	(0.45-1.26)	0.285
Toilet	120/10,114	(1.2%)	0.76	(0.63-0.92)	0.004	0.92	(0.76-1.12)	0.425
Bathroom	83/27,527	(0.3%)	0.19	(0.15-0.24)	<0.001	0.52	(0.41-0.66)	<0.001
Kitchen/dining room	150/6,582	(2.3%)	1.48	(1.25-1.75)	<0.001	1.33	(1.11-1.59)	0.002
Veranda/balcony/ garden/terrace	84/5,184	(1.6%)	1.05	(0.84-1.30)	0.684	1.14	(0.90-1.44)	0.271
Other	63/6,081	(1.0%)	0.67	(0.52-0.86)	0.002	0.94	(0.72-1.22)	0.621
Origin of arrest								
Cardiac origin	2,343/132,290	(1.8%)	2.46	(2.24-2.69)	<0.001	1.26	(1.14-1.40)	<0.001
Non-cardiac origin	582/79,884	(0.7%)	ref.			ref.		
Age (1-year increment)	-		0.97	(0.97-0.98)	<0.001	0.97	(0.97-0.98)	<0.001
Sex								
Female	848/90,610	(0.9%)	ref.			ref.		
Male	2,077/121,564	(1.7%)	1.84	(1.70-1.99)	<0.001	1.02	(0.94-1.11)	0.636
First documented rhythm								
VF	1,809/11,787	(15.3%)	32.37	(29.97-34.97)	<0.001	14.47	(13.21-15.85)	<0.001
Non-VF	1,116/200,387	(0.6%)	ref.			ref.		
Witnessed by bystanders								
Witnessed	2,330/66,615	(3.5%)	8.83	(8.07-9.67)	<0.001	4.30	(3.89-4.75)	<0.001
Not witnessed	595/145,559	(0.4%)	ref.			ref.		
Initiation of bystander CPR								
With bystander CPR	1,596/95,721	(1.7%)	1.47	(1.37-1.58)	<0.001	1.23	(1.14-1.34)	<0.001
Without bystander CPR	1,329/116,453	(1.1%)	ref.			ref.		
Initiation of PAD								
With PAD	27/174	(15.5%)	13.25	(8.78-20.01)	<0.001	1.57	(1.01-2.46)	0.047
Without PAD	2,898/212,000	(1.4%)	ref.			ref.		
Time from call to contact with the patient by EMS personnel (1-min increment)								
	-		0.91	(0.90-0.93)	<0.001	0.91	(0.89-0.92)	<0.001

CI = confidence interval; CPR = cardiopulmonary resuscitation; EMS = emergency medical service; OHCA = out-of-hospital cardiac arrest; OR = odds ratio; PAD = public-access automated external defibrillation; VF = ventricular fibrillation.

* All items listed in this table were included as independent variables in the multivariable logistic regression model.

helpful in increasing the bystander CPR rate. In addition, the introduction of new information technology, such as a positioning system to dispatch to bystanders²² and text message alert system of mobile-phone/smart-phone,²³ would help to increase initiation of both CPR and PAD by bystanders.

Our results showed that OHCA occurring in bathroom accounted for 12.9% of all OHCA cases at home. Taking a long, deep, hot bath almost daily is a traditional habit in Japan.²⁴ Habitual bathing of this style is reported to be associated with better self-rated health,²⁵ but this habit may be related to sudden cardiac arrest occurrence.^{26,27} Therefore, the high incidence of OHCA in bathrooms may be a unique characteristic in Japan. Consistent with previous studies,^{26,27} OHCA in the bathroom were less likely to be witnessed by bystanders and the occurrence of OHCA

with VF rhythm was very low. Additionally, 1/4 of OHCA cases in the bathroom were due to drowning, which was suggested to result in very low survival rates regardless of location.²⁸ Thus, these patient characteristics observed in this study would explain the extremely low survival rate of OHCA cases in the bathroom. Considering that bathrooms are closed private spaces, it is difficult to increase the proportion of witnessed cardiac arrest. Therefore, prevention of OHCA occurrence should be most important in this setting, especially for high-risk elderly people. The Japan Resuscitation Council Resuscitation Guidelines 2015 provides some preventive measures specific to OHCA in the bathroom. For example, they recommend warming the bathroom and dressing room, refraining from bathing in hot water for a long time, taking a half-body bath instead of a deep bath, and avoiding bathing immediately after

consumption of alcohol or a sleep-inducing drug.²⁹ In addition, earlier recognition of cardiac arrest by a bystander is also important. Family members should pay special attention to elderly people with a high risk of sudden heart attack during bathing. Installation of systems that can make contact with the environment outside the bathroom may be another solution.²⁹

This study has some limitations. First, we were unable to obtain information about several individual factors associated with occurrence and/or prognosis of cardiac arrests, such as activities at the time of arrest, past medical history, medication, quality of bystander-initiated CPR, and life habits before arrest. The potential variability in postarrest care was also not addressed. Second, this study was conducted based on the Utstein-style registry, and the cause of arrest was presumed to be of cardiac origin unless obvious evidence suggested non-cardiac causes. Autopsy was not performed in all cases of sudden cardiac death, and the reported autopsy rate in 2014 was only 2.4% of all death cases in Japan.³⁰ Therefore, there is some uncertainty in the classification of origin of arrest. Third, although our data collection was nationwide, we were unable to consider the geographical conditions of each residence (e.g., population density and accessibility to hospital). These unmeasured factors may affect EMS response and initiation of bystander interventions. Finally, as with all epidemiologic studies, the integrity and validity of the data, as well as ascertainment bias, are potential limitations of our study. However, the use of uniform data collection based on the international Utstein-style guidelines for reporting cardiac arrest, large sample size, and population-based study design should minimize these potential sources of bias.

In conclusion, using a nationwide registry, this study demonstrated that OHCA occurrence at home accounted for approximately 2/3 of all OHCA cases in Japan, but their outcomes were extremely poor regardless of the location of cardiac arrest.

Disclosures

The investigators have no conflicts of interest to disclose.

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