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# Characteristics and outcomes of out-of-hospital cardiac arrest in Japan

## —All-Japan utstein registry including information on the location of arrest—

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## Abstract

**Objective:** We described the profiles of the All-Japan Utstein Registry including new information on the location of out-of-hospital cardiac arrest (OHCA) and investigated patient characteristics and outcomes after OHCA. **Methods:** The All-Japan Utstein Registry is a prospective population-based OHCA registry based on the international Utstein-style covering the entire population of Japan. The subjects of this study were OHCA patients enrolled in this registry from January 2013 to December 2015. Patients with OHCA that occurred before emergency medical service (EMS) arrival for whom cardiopulmonary resuscitation was attempted by bystanders or by EMS personnel and subsequently transported to medical institutions by the EMS were included. Patient characteristics, location of arrest, and survival outcomes after OHCA were described according to the resuscitation situations of patients (i.e., bystander-witness status, origin of cardiac arrest, and first documented rhythm). **Results:** During the 3-year study period, a total of 327,451 confirmed cases of OHCA occurring before the arrival of EMS were analyzed. Overall, 56.9% of all cases (186,276/327,451) were men and their mean age was 74.6 years (Standard deviation, 17.3). Approximately two-thirds of all OHCA incidents occurred at home (65.0%, 212,722/327,451). The locations of OHCA occurrence widely varied by the resuscitation situations of patients, e.g., OHCAs with ventricular fibrillation rhythm were more likely to be observed in public locations than at home. In total, the proportion of one-month survival with favorable neurological outcome was 2.2% (7,059/327,451). Bystander-witnessed OHCA cases of medical origin with ventricular fibrillation rhythm were likely to have better outcomes, and 25.0% of them (4,477/17,886) survived for one month with favorable neurological outcome. **Conclusion:** The All-Japan Utstein Registry including the information on the location of arrest enables us to reveal the location-specific features of OHCA. Investigations using this registry will lead to the establishment of effective strategies for prevention of OHCA occurrence and improving the survival after OHCA.

## 1. Introduction

Out-of-hospital cardiac arrest (OHCA) is a major public health problem in industrialized countries worldwide. In Japan, over 120,000 OHCAs occur every year, but the survival rate after OHCA remains still low[1]. Therefore, a better understanding of the current condition of OHCA incidence, the patient and emergency medical service (EMS) characteristics, and the potential prognostic factors of OHCA is needed to establish effective strategies for improving survival after OHCA. Analysis using large-scale registry data is one way to address these issues. In January 2005, the Fire and Disaster Management Agency (FDMA) of Japan launched a prospective, nationwide, population-based, OHCA registry, the All-Japan Utstein Registry. This registry has successfully provided much scientific evidence which has contributed greatly to the improvement of pre-hospital care and patient outcomes[2-8]. However, since there was a lack of information about the location of arrest in this registry, location-specific research subjects of OHCA have been poorly investigated at the national level. Therefore, issues surrounding the proper deployment of public-access automated external defibrillators (AEDs) and the effective dissemination of cardiopulmonary resuscitation (CPR) training has still been under debate.

The FDMA started to collect information on the location of OHCA occurrence, including detailed locations both inside and outside buildings, in 2013, and these data have been available as the All-Japan Utstein Registry. In this paper, we described the profile of the All-Japan Utstein Registry including the new information on the location of arrest and investigated patient characteristics and outcomes after OHCA in Japan between 2013 and 2015.

## 2. Methods

### 2.1. Design of the All-Japan Utstein Registry

The All-Japan Utstein Registry of the FDMA is a prospective population-based OHCA registry based on the international Utstein-style[9, 10], that covers an entire population of approximately 127 million people in Japan, within a geographic area of approximately 378,000 km$^2$. Cardiac arrest was determined as cessation of cardiac mechanical activity and was confirmed by the absence of any signs of circulation by EMS personnel, and OHCA data were prospectively enrolled in the registry. The cardiac arrest was presumed to be of cardiac origin unless obvious evidence suggested any non-cardiac causes (i.e., cerebrovascular disease, respiratory disease, malignant tumors, trauma, drug overdose, drowning, electrocution, or asphyxia), based on the current Utstein-style template[11]. These diagnoses were determined clinically by the physicians in charge, in collaboration with the EMS personnel. All OHCA survivors were followed up for up to one month after the event by the EMS providers in charge, to assess their outcomes. Details of the registry have also been described previously[5].

### 2.2. EMS system in Japan

EMS is provided by regional governments, and there were 750 fire departments with dispatch centers throughout Japan in 2015. Emergency life-saving technicians (ELSTs), who are highly trained emergency care providers, are allowed to insert an intravenous line and an adjunct airway, and to use semi-AEDs for OHCA patients. Specially trained ELSTs are allowed to intubate and administer adrenaline. Basically, each ambulance has a crew of three emergency providers including at least one ELST. Treatment for cardiac arrest was conducted based on the Japanese CPR guidelines[12]. Most OHCA patients were treated by EMS personnel, transported to a hospital, and registered in the registry, because EMS providers are usually not permitted to terminate resuscitation in the field, except in cases involving victims of decapitation, incineration, decomposition, rigor mortis, or dependent cyanosis.

**2.3. Dissemination of public-access AEDs in Japan**

In Japan, the use of AED by bystanders for OHCA patients has been legal since July 2004. The cumulative sales of public-access AEDs rapidly increased thereafter and had reached 602,382 in 2015 (excluding the ones used in medical facilities and EMS institutions)[13]. Public-access AEDs have been deployed mainly in public spaces such as schools, nursing facilities, sports facilities, cultural facilities, workplaces, and transportation facilities. This has been driven by both private and public initiatives.

**2.4. Systemic CPR training for the general public**

In Japan, CPR training programs have been conducted mainly by local fire departments, and the program has been recommended by the FDMA and the Ministry of Health, Labour and Welfare on the basis of the Japanese CPR guidelines[12]. In 2012, local fire departments trained approximately 1.4 million citizens in conventional 3-hour CPR training programs consisting of chest compressions, mouth-to-mouth ventilation, and AED use[1]. The Japanese Red Cross, other organizations such as local non-profit organizations, and driver's training schools have also provided CPR training. In total, it is expected that approximately 3 million people are trained in CPR annually in Japan. The 45- to 90-minute chest compression-only CPR training was recommended beginning in September 2013[14]. In addition, the Ministry of Education, Culture, Sports, Science and Technology has recommended training in CPR and AED use in junior high schools and high schools[15]. The number of people in the general population who received any form of CPR training increased from 3,311,131 in 2005 to 4,402,343 in 2015[16].

**2.5. Data collection**

The data items of the registry included the time course of resuscitation, sex, age, origin of cardiac arrest, first documented cardiac rhythm, witnessed status of the arrest, dispatcher instruction of CPR, bystander interventions (initiation of bystander-CPR and public-access defibrillation), EMS interventions (intravenous fluid, epinephrine administration, and advanced airway management) and survival outcomes. The one-month neurological status was scored by the physician in charge, using the Glasgow-Pittsburgh cerebral performance category (CPC) 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. In addition to the data items included as per the Utstein-style[9, 10] described above, the FDMA started collecting detailed information on the location of 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[11].

**2.6. Quality control**

The data forms were filled by the EMS personnel for each patient, in collaboration with the physician in charge of the patient, based on the international Utstein-style guidelines for reporting OHCA[9, 10]. The information from input data forms was transferred and integrated into the registration system on the FDMA database server. The data were checked at data terminals and confirmed by the FDMA. If incomplete data forms were found, EMS personnel in charge were asked to complete them.

**2.7. Study subjects**

The subjects of the present study were OHCA patients enrolled in the All-Japan Utstein Registry from January 1, 2013 to December 31, 2015. Patients with OHCA occurring before EMS arrival for whom CPR was attempted by bystanders or by EMS personnel and subsequently transported to medical institutions by the EMS were included. Patients with unknown age, unknown witness status, unknown first documented rhythm, unknown outcome, and unknown location of arrest were excluded.

**2.8. Statistical analysis**

In accordance with the current Utstein template[11], we divided the patients by their resuscitation situations; i.e., bystander-witness status (witnessed by bystander or unwitnessed), origin of cardiac arrest (medical origin or non-medical origin), and first documented rhythm (ventricular fibrillation [VF] rhythm or non-VF rhythm). Patient characteristics, location of arrest, and survival outcomes after OHCA were described according to the resuscitation situations of patients. The origin of cardiac arrest was defined to be medical unless it was caused by trauma, drug overdose, drowning, electrocution, or asphyxia[11]. When bystanders provided public-access defibrillation, the patient's first documented rhythm was regarded as VF. Outcome measures considered were prehospital return of spontaneous circulation, one-month survival after OHCA, and one-month survival with favorable neurological outcome which was defined as CPC 1 or 2[9, 10]. Summary statistics were expressed as the mean and standard deviation for numerical variables, and as percentages for categorical variables. All statistical analyses were conducted using SPSS version 25.0J (IBM Corp., Armonk, NY, USA).

### 2.9. Ethics

The study conformed to the principles of the Helsinki Declaration, and the study protocol was approved by the Ethics Committee of the Osaka University and Otsuma Women's University. Personal identifiers were removed from the database. The requirement for individual informed consent was waived.

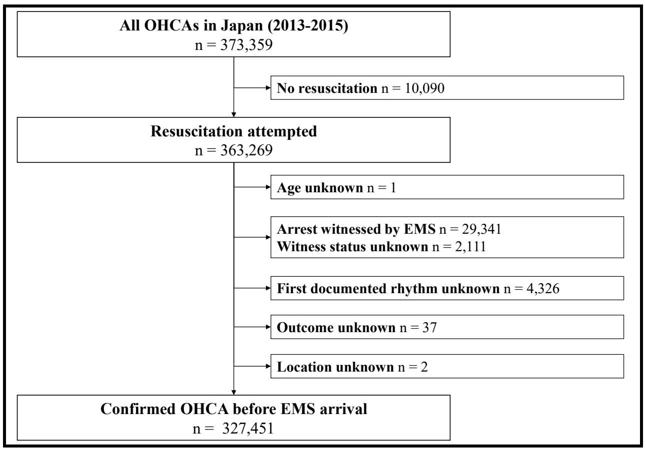


Figure 1. Study flowchart on the selection of patients with OHCA occurring in Japan between January 1, 2013 and December 31, 2015. OHCA denotes out-of-hospital cardiac arrest, and EMS emergency medical service.

## 3. Results

### 3.1. Patient selection

Figure 1 shows the flowchart for selection of eligible OHCA patients for the analysis. During the 3-year study period, a total of 373,359 cases of OHCA were registered in the All-Japan Utstein Registry. Of these, 327,451 confirmed cases of OHCA occurring before arrival of EMS were analyzed. Overall, 35.7% of all cases (116,976/327,451) were witnessed by bystanders, 87.1% (285,137/327,451) were of medical origin, and 8.4% (27,669/327,451) had VF rhythm.

### 3.2. Characteristics of OHCA

Table 1 shows the characteristics of eligible patients according to bystander-witness status, origin of arrest, and first documented rhythm. Overall, 56.9% of all cases (186,276/327,451) occurred among men and their mean age was 74.6 years. The proportions of patients receiving bystander-CPR and public-access defibrillation were 50.2% (164,509/327,451) and 1.5% (4,929/327,451), respectively. However, these characteristics seemed to vary widely by the resuscitation situations of patients.

### 3.3. Locations of OHCA

Table 2 shows the locations of OHCA occurrence according to bystander-witness status, origin of arrest, and first documented rhythm. Overall, approximately two-thirds of all OHCA cases occurred at home (65.0%, 212,722/327,451). The proportion of OHCA occurrence at home was relatively high among the patients with non-VF rhythm (e.g., bystander-witnessed OHCA cases of medical origin with non-VF rhythm 62.5%, unwitnessed OHCA cases of medical origin with non-VF rhythm 71.9%, and unwitnessed OHCA cases of non-medical origin with non-VF rhythm 65.6%). The proportions of OHCA occurrence in sports/recreation events, public buildings, and educational institutions were higher among the bystander-witnessed OHCA cases of medical origin with VF rhythm (6.0%, 12.3%, and 1.4%, respectively) compared to other resuscitation situations of patients. The proportion of OHCA occurrence in street/highway was considerably high among the bystander-witnessed OHCA cases of non-medical origin with non-VF rhythm (42.3%, 3,944/9,317).

Table 1. Characteristics of out-of-hospital cardiac arrest according to bystander-witness status, origin of arrest, and first documented rhythm

| | Total | Bystander-witness status/Origin of arrest/First documented rhythm | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Witnessed Medical VF | Witnessed Medical Non-VF | Witnessed Non-medical VF | Witnessed Non-medical Non-VF | Unwitnessed Medical VF | Unwitnessed Medical Non-VF | Unwitnessed Non-medical VF | Unwitnessed Non-medical Non-VF |
| | (N=327451) | (n=17886) | (n=89421) | (n=352) | (n=9317) | (n=8673) | (n=169157) | (n=758) | (n=31887) |
| Year, n (%) | | | | | | | | | |
| 2013 | 106814 (32.6%) | 6019 (33.7%) | 28700 (32.1%) | 143 (40.6%) | 3329 (35.7%) | 3795 (43.8%) | 53888 (31.9%) | 462 (60.9%) | 10478 (32.9%) |
| 2014 | 111389 (34.0%) | 5933 (33.2%) | 30510 (34.1%) | 113 (32.1%) | 3031 (32.5%) | 2459 (28.4%) | 58164 (34.4%) | 166 (21.9%) | 11013 (34.5%) |
| 2015 | 109248 (33.4%) | 5934 (33.2%) | 30211 (33.8%) | 96 (27.3%) | 2957 (31.7%) | 2419 (27.9%) | 57105 (33.8%) | 130 (17.2%) | 10396 (32.6%) |
| Season, n (%) | | | | | | | | | |
| Spring | 81001 (24.7%) | 4434 (24.8%) | 21669 (24.2%) | 80 (22.7%) | 2216 (23.8%) | 2030 (23.4%) | 42026 (24.8%) | 168 (22.2%) | 8378 (26.3%) |
| Summer | 63381 (19.4%) | 4040 (22.6%) | 17807 (19.9%) | 92 (26.1%) | 2180 (23.4%) | 1815 (20.9%) | 30960 (18.3%) | 133 (17.5%) | 6354 (19.9%) |
| Autumn | 74433 (22.7%) | 4361 (24.4%) | 20822 (23.3%) | 75 (21.3%) | 2374 (25.5%) | 1970 (22.7%) | 37649 (22.3%) | 156 (20.6%) | 7026 (22.0%) |
| Winter | 108636 (33.2%) | 5051 (28.2%) | 29123 (32.6%) | 105 (29.8%) | 2547 (27.3%) | 2858 (33.0%) | 58522 (34.6%) | 301 (39.7%) | 10129 (31.8%) |
| Weekday, n (%) | 231954 (70.8%) | 12529 (70.0%) | 62846 (70.3%) | 237 (67.3%) | 6597 (70.8%) | 6271 (72.3%) | 120117 (71.0%) | 524 (69.1%) | 22833 (71.6%) |
| Time of call EMS, n (%) | | | | | | | | | |
| 0:00 - 5:59 | 46174 (14.1%) | 2135 (11.9%) | 11982 (13.4%) | 30 (8.5%) | 1234 (13.2%) | 1053 (12.1%) | 25521 (15.1%) | 101 (13.3%) | 4118 (12.9%) |
| 6:00 - 11:59 | 106843 (32.6%) | 5966 (33.4%) | 28526 (31.9%) | 109 (31.0%) | 2687 (28.8%) | 3202 (36.9%) | 58002 (34.3%) | 237 (31.3%) | 8114 (25.4%) |
| 12:00 - 17:59 | 89122 (27.2%) | 5601 (31.3%) | 26494 (29.6%) | 146 (41.5%) | 3009 (32.3%) | 2584 (29.8%) | 41716 (24.7%) | 207 (27.3%) | 9365 (29.4%) |
| 18:00 - 23:59 | 85312 (26.1%) | 4184 (23.4%) | 22419 (25.1%) | 67 (19.0%) | 2387 (25.6%) | 1834 (21.1%) | 43918 (26.0%) | 213 (28.1%) | 10290 (32.3%) |
| Age, mean (SD) | 74.6 (17.3) | 66.1 (16.6) | 78.1 (14.3) | 57.0 (24.2) | 59.8 (22.5) | 71.0 (16.1) | 76.8 (16.0) | 64.2 (20.1) | 63.2 (21.5) |
| Age group, n (%) | | | | | | | | | |
| Age 0-17 | 4062 (1.2%) | 169 (0.9%) | 568 (0.6%) | 27 (7.7%) | 374 (4.0%) | 54 (0.6%) | 2030 (1.2%) | 14 (1.8%) | 826 (2.6%) |
| Age 18-35 | 8802 (2.7%) | 702 (3.9%) | 762 (0.9%) | 48 (13.6%) | 1278 (13.7%) | 194 (2.2%) | 2246 (1.3%) | 75 (9.9%) | 3497 (11.0%) |
| Age 36-64 | 55781 (17.0%) | 6549 (36.6%) | 10952 (12.2%) | 118 (33.5%) | 2989 (32.1%) | 2355 (27.2%) | 23092 (13.7%) | 242 (31.9%) | 9484 (29.7%) |
| Age 65-79 | 99511 (30.4%) | 6474 (36.2%) | 27224 (30.4%) | 79 (22.4%) | 2598 (27.9%) | 3082 (35.5%) | 50577 (29.9%) | 228 (30.1%) | 9249 (29.0%) |
| Age 80-89 | 110812 (33.8%) | 3065 (17.1%) | 33576 (37.5%) | 63 (17.9%) | 1604 (17.2%) | 2147 (24.8%) | 63124 (37.3%) | 160 (21.1%) | 7073 (22.2%) |
| Age 90- | 48483 (14.8%) | 927 (5.2%) | 16339 (18.3%) | 17 (4.8%) | 474 (5.1%) | 841 (9.7%) | 28088 (16.6%) | 39 (5.1%) | 1758 (5.5%) |
| Men, n (%) | 186276 (56.9%) | 13881 (77.6%) | 49532 (55.4%) | 259 (73.6%) | 6123 (65.7%) | 5926 (68.3%) | 91097 (53.9%) | 463 (61.1%) | 18995 (59.6%) |
| Dispatcher instruction, n (%) | 188677 (57.6%) | 9343 (52.2%) | 46997 (52.6%) | 114 (32.4%) | 2811 (30.2%) | 5003 (57.7%) | 108275 (64.0%) | 366 (48.3%) | 15768 (49.4%) |
| Bystander CPR, n (%) | 164509 (50.2%) | 11474 (64.2%) | 46432 (51.9%) | 183 (52.0%) | 3090 (33.2%) | 5189 (59.8%) | 85385 (50.5%) | 375 (49.5%) | 12381 (38.8%) |
| Public access defibrillation, n (%) | 4929 (1.5%) | 3394 (19.0%) | 0 (0.0%) | 66 (18.8%) | 0 (0.0%) | 1386 (16.0%) | 0 (0.0%) | 83 (10.9%) | 0 (0.0%) |
| Intravenous fluid, n (%) | 103183 (31.5%) | 6624 (37.0%) | 31645 (35.4%) | 100 (28.4%) | 2235 (24.0%) | 3103 (35.8%) | 50059 (29.6%) | 210 (27.7%) | 9207 (28.9%) |
| Epinephrine, n (%) | 56496 (17.3%) | 4974 (27.8%) | 23897 (26.7%) | 80 (22.7%) | 1489 (16.0%) | 2220 (25.6%) | 20021 (11.8%) | 155 (20.4%) | 3660 (11.5%) |
| Advanced airway management, n (%) | 134738 (41.1%) | 6707 (37.5%) | 40798 (45.6%) | 126 (35.8%) | 2902 (31.1%) | 3751 (43.2%) | 69247 (40.9%) | 318 (42.0%) | 10889 (34.1%) |
| Time from collapse to initiation of bystander-CPR, in minutes, mean (SD) | 3.6 (5.6) | 2.8 (3.9) | 3.7 (5.9) | 3.4 (5.0) | 4.1 (6.1) | — | — | — | — |
| Time from collapse to public access defibrillation, in minutes, mean (SD) | 5.3 (4.8) | 5.4 (4.8) | — | 4.8 (5.3) | — | — | — | — | — |
| Time from call to epinephrine administration by EMS personnel, in minutes, mean (SD) | 24.6 (8.3) | 23.4 (7.7) | 24.6 (8.3) | 27.7 (9.6) | 27.7 (9.6) | 23.8 (7.8) | 24.4 (8.1) | 27.1 (8.4) | 25.9 (9.2) |
| Time from call to advanced airway management by EMS personnel, in minutes, mean (SD) | 18.3 (7.2) | 17.8 (6.9) | 18.5 (7.1) | 20.9 (9.9) | 21.5 (9.4) | 17.8 (6.6) | 17.9 (7.0) | 19.9 (8.7) | 19.6 (8.4) |
| Time from call to contact with the patient by EMS personnel, in minutes, mean (SD) | 9.3 (4.2) | 8.7 (3.5) | 9.3 (3.8) | 10.4 (6.7) | 10.3 (6.5) | 8.5 (3.4) | 9.2 (3.8) | 9.8 (6.7) | 10.3 (6.2) |
| Time from call to hospital arrival, in minutes, mean (SD) | 32.8 (12.0) | 32.8 (12.6) | 33.4 (11.8) | 35.2 (14.9) | 35.6 (16.0) | 31.5 (11.5) | 32.1 (11.2) | 33.4 (12.6) | 34.6 (14.0) |

VF: ventricular fibrillation; CPR: cardiopulmonary resuscitation; EMS: emergency medical service; SD: standard deviation

Table 2. Locations of out-of-hospital cardiac arrest according to bystander-witness status, origin of arrest, and first documented rhythm

| | Total | Bystander-witness status/Origin of arrest/First documented rhythm | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Witnessed Medical VF | Witnessed Medical Non-VF | Witnessed Non-medical VF | Witnessed Non-medical Non-VF | Unwitnessed Medical VF | Unwitnessed Medical Non-VF | Unwitnessed Non-medical VF | Unwitnessed Non-medical Non-VF |
| | (N=327451) | (n=17886) | (n=89421) | (n=352) | (n=9317) | (n=8673) | (n=169157) | (n=758) | (n=31887) |
| Home/Residence, n (%) | 212722 (65.0%) | 8258 (46.2%) | 55920 (62.5%) | 66 (18.8%) | 2417 (25.9%) | 3305 (38.1%) | 121667 (71.9%) | 163 (21.5%) | 20926 (65.6%) |
| Detached house | 186219 (56.9%) | 6985 (39.1%) | 48835 (54.6%) | 54 (15.3%) | 1679 (18.0%) | 2910 (33.6%) | 107939 (63.8%) | 141 (18.6%) | 17676 (55.4%) |
| Multiple dwelling house | 26503 (8.1%) | 1273 (7.1%) | 7085 (7.9%) | 12 (3.4%) | 738 (7.9%) | 395 (4.6%) | 13728 (8.1%) | 22 (2.9%) | 3250 (10.2%) |
| Industrial/Workplace, n (%) | 5358 (1.6%) | 1178 (6.6%) | 912 (1.0%) | 31 (8.8%) | 482 (5.2%) | 444 (5.1%) | 1525 (0.9%) | 16 (2.1%) | 770 (2.4%) |
| Sports/Recreation event, n (%) | 3737 (1.1%) | 1069 (6.0%) | 1042 (1.2%) | 13 (3.7%) | 69 (0.7%) | 222 (2.6%) | 1059 (0.6%) | 12 (1.6%) | 251 (0.8%) |
| Street/Highway, n (%) | 15318 (4.7%) | 1582 (8.8%) | 2601 (2.9%) | 91 (25.9%) | 3944 (42.3%) | 1007 (11.6%) | 3197 (1.9%) | 65 (8.6%) | 2831 (8.9%) |
| Public building, n (%) | 12835 (3.9%) | 2198 (12.3%) | 3605 (4.0%) | 14 (4.0%) | 556 (6.0%) | 621 (7.2%) | 4078 (2.4%) | 30 (4.0%) | 1733 (5.4%) |
| Assisted living/Nursing home/ Healthcare facility, n (%) | 51746 (15.8%) | 1764 (9.9%) | 20143 (22.5%) | 29 (8.2%) | 545 (5.8%) | 1081 (12.5%) | 27374 (16.2%) | 31 (4.1%) | 779 (2.4%) |
| Educational institution, n (%) | 744 (0.2%) | 257 (1.4%) | 159 (0.2%) | 5 (1.4%) | 30 (0.3%) | 45 (0.5%) | 188 (0.1%) | 3 (0.4%) | 57 (0.2%) |
| Other, n (%) | 24991 (7.6%) | 1580 (8.8%) | 5039 (5.6%) | 103 (29.3%) | 1274 (13.7%) | 1948 (22.5%) | 10069 (6.0%) | 438 (57.8%) | 4540 (14.2%) |

VF: ventricular fibrillation

Table 3. Outcomes of out-of-hospital cardiac arrest according to bystander-witness status, origin of arrest, and first documented rhythm

| | Total | Bystander-witness status/Origin of arrest/First documented rhythm | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Witnessed Medical VF | Witnessed Medical Non-VF | Witnessed Non-medical VF | Witnessed Non-medical Non-VF | Unwitnessed Medical VF | Unwitnessed Medical Non-VF | Unwitnessed Non-medical VF | Unwitnessed Non-medical Non-VF |
| | (N=327451) | (n=17886) | (n=89421) | (n=352) | (n=9317) | (n=8673) | (n=169157) | (n=758) | (n=31887) |
| Pre-hospital ROSC, n (%) | 26234 (8.0%) | 6611 (37.0%) | 11132 (12.4%) | 66 (18.8%) | 656 (7.0%) | 1472 (17.0%) | 5091 (3.0%) | 35 (4.6%) | 1171 (3.7%) |
| One-month survival, n (%) | 14515 (4.4%) | 6174 (34.5%) | 4304 (4.8%) | 55 (15.6%) | 303 (3.3%) | 1280 (14.8%) | 1912 (1.1%) | 33 (4.4%) | 454 (1.4%) |
| CPC 1 or 2, n (%) | 7059 (2.2%) | 4477 (25.0%) | 1208 (1.4%) | 33 (9.4%) | 71 (0.8%) | 737 (8.5%) | 428 (0.3%) | 17 (2.2%) | 88 (0.3%) |

ROSC: return of spontaneous resuscitation; CPC: cerebral performance category

### 3.4. Outcomes after OHCA

Table 3 shows the outcomes after OHCA according to bystander-witness status, origin of arrest, and first documented rhythm. The overall proportion of one-month survival with favorable neurological outcome was 2.2% (7,059/327,451). Bystander-witnessed OHCA cases of medical origin with VF rhythm were likely to have better outcomes, and 25.0% of them (4,477/17,886) survived for one-month with favorable neurological outcome. In contrast, patients with non-VF rhythm tended to have poor outcomes, and the proportion of one-month survival with favorable neurological outcome ranged from 0.3% to 1.4%.

## 4. Discussion

In this study, we reported the profile of the All-Japan Utstein Registry including the new information on the location of arrest. The data collection of location of arrest by FDMA has been conducted since January 2013, and over 360,000 OHCA cases were enrolled in this registry during the first three years. Using this new database, we are able to perform comprehensive analyses separately by OHCA locations in the future. A wide range of study areas can be addressed by using this registry. First, the effectiveness of nationwide dissemination of public-access AEDs at the population level should be assessed according to location of OHCA occurrence. Although public-access AEDs have been widely deployed since the legal permission of AED use by bystanders in 2004, condition of OHCA patients, prevalence of AEDs, and presence of bystanders would widely vary by the locations. To address the issue of appropriate deployment of public-access AEDs, we need to evaluate the performance of AED installation according to the location of arrest. Second, location-specific characteristics, bystander- and EMS-interventions, and subsequent outcomes should be investigated by age-groups of OHCA patients. For example, since children and young adults tend to have good health and high activity, OHCAs may be likely to occur in public locations such as educational institutions and sports/recreational facilities. In contrast, as for elderly people, activities of daily living and functional status are relatively low and OHCAs may be likely to occur in residential locations and nursing homes. Thus, situations surrounding OHCA occurrence would change depending on the age of OHCA patients. Third, the details of OHCA occurring at home are needed to be investigated in order to gain an improved understanding of the present situation and suggest improvement in pre-hospital care. Importantly, the majority of OHCAs occur in private residential locations worldwide[17-21]. However, initiation of bystander-CPR and use of on-site AEDs at home remains very limited and the prospect of survival for this patient group was poor compared to public locations[19, 22-24]. Therefore, improvement of survival rate of OHCAs occurring at home is critical and needs to be addressed.

The present study also described the characteristics and outcomes of OHCA patients in Japan between 2013 and 2015. Among bystander-witnessed OHCA patients of medical origin with VF rhythm, the proportion of one-month survival with favorable neurological outcome were considerably higher, as much as 25%, compared to patients of other resuscitation situations. Considering that more than half of those patients were observed in public locations rather than at home/residence, they would have a better chance of being treated quickly and properly by bystanders. Actually, the proportions of those who received bystander-CPR and public-access defibrillation were considerably high. However, as our results also showed, the overall survival after OHCA was still low in Japan, and there is substantial room for improvement. It may suggest that even though over 600,000 public-access AEDs have been installed in prehospital settings throughout Japan, we need to use them more effectively. Thus, there is a pressing need for establishment of better strategies for deployment of public-access AEDs as well as dissemination of CPR training. To address these issues, better understanding of location-specific features of OHCA occurrence and investigation of potential prognostic factors are imperative. We believe that the All-Japan Utstein Registry including new information has the potential to provide valuable clues to establish appropriate strategies for prevention of OHCA occurrence and improvement of their outcomes.

### 4.1. Strengths

Research using the All-Japan Utstein Registry has several strengths. First, this is an exhaustive cohort study of OHCA covering the entire population of Japan. Individual patient data from most OHCA patients treated by EMS personnel and transported to hospitals were recorded in this registry. Second, to the best of our knowledge, the All-Japan Utstein Registry is the largest national-level OHCA registry in the world. This registry has been enrolling more than 120,000 OHCA patients every year and is ongoing without a set conclusion to the study period. Third, data collection of this registry is based on the internationally unified Utstein-style template[9, 10]. This data-format was also adopted in other large-scale OHCA registries worldwide, such as PAROS[20] in Asia, EuReCa[25] in Europe, and CARES[26] and ROC[27] in the USA. Thus, due to these strong points, findings from the All-Japan Utstein Registry would have low possibility of patient selection bias, high reliability and generalizability, and could be applied to other communities in Japan as well as worldwide.

### 4.2. Limitations

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 post-arrest 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 deaths in Japan[28]. Therefore, there is some uncertainty in the classification of origin of arrest. Third, although our data collection was conducted nationwide, we were unable to consider the geographical conditions of each case (e.g., population density, access to hospital, and prevalence of public-access AEDs). These unmeasured factors may affect EMS response and initiation of bystander interventions. Fourth, we were only able to assess the neurological status one month after the cardiac arrest, since longer follow-up outcomes were not available. 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, the large sample size, and the population-based study design should minimize these potential sources of bias.

## 5. Conclusions

The All-Japan Utstein Registry including the information on the location of arrest enabled us to reveal the location-specific features of OHCA. Investigations using this registry will lead to establishment of effective strategies for the prevention of OHCA occurrence and improving survival after OHCA.

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