



# BMJ Open Incidence of out-of-hospital cardiac arrests and survival rates after 1 month among the Japanese working population: a cohort study

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## ABSTRACT

**Objectives** The prevention and improvement of the prognosis of out-of-hospital cardiac arrests (OHCAs) are important issues especially with respect to their social and economic significance in working populations. The age distribution of the working population in Japan is expected to change continually due to its ageing society and extension of retirement; however, few reports have examined the long-term condition of OHCA in the working population, defined by age. The aim of this study was to determine the incidence of OHCAs and the survival rates after 1 month, among the Japanese working population, defined by age, considering the changing age distribution.

**Design and setting** We analysed the All-Japan Utstein registry, a prospective, nationwide, population-based, observational registry (2005–2016).

**Participants** From the registry, 212 961 patients with OHCA from the Japanese working population (defined aged 20–69 years), with only cardiogenic aetiology participated in this study. These patients were further divided into four groups according to the type of citizen bystander (family, friends, work-colleagues and passers-by).

**Primary and secondary outcome measures** The main outcomes were 1-month survival with favourable neurological outcomes.

**Results** The incidence of OHCAs, in any age group, was almost constant during the 12-year period. The work-colleagues had the best prognosis despite having significantly longer times to initial defibrillations compared with the passers-by (13 vs 12 min, respectively,  $p < 0.001$ ) that was associated independently with 1-month survival with favourable neurological outcomes (adjusted OR: 0.94 (1 min increments),  $p < 0.001$ ).

**Conclusions** In the 12-year period, the incidence of OHCAs in any age group remained almost constant, whereas the prognosis improved each year. Reducing the time to initial defibrillation may further improve the prognosis of OHCAs with a work-colleague bystander.

## INTRODUCTION

The prevention and improvement of the prognosis of out-of-hospital cardiac arrests (OHCAs) are important issues especially with

## Strengths and limitations of this study

- In this population-based study, we analysed data collected between 2005 and 2016 in the All-Japan Utstein registry of the Fire and Disaster Management Agency; a prospective, nationwide, population-based registry.
- A large sample size and longer follow-up allowed for the detailed assessment of the relationship between a work-colleague bystander and the prognosis following an out-of-hospital cardiac arrest (OHCA) in the Japanese working population.
- We assessed independent factors associated with 1-month survival with favourable neurological outcomes after OHCAs in the Japanese working population.
- The All-Japan Utstein registry did not contain information on the actual employment status, individual medical therapy, activities of daily living before the OHCAs, or in-hospital treatment interventions.

respect to their social and economic significance in working populations.

Japan and other developed countries have ageing populations.<sup>1</sup> Out of concern for future labour shortages due to the ageing population, the Japanese parliament enacted a partial amendment to the law with respect to the stabilisation of the employment of elderly persons that recommended an extension of the retirement age from 65 to 70 years. This reform bill came into effect for companies from April 1, 2021. In addition, a study reported that patients aged  $\geq 65$  years comprised approximately 76% of patients with OHCAs in Japan.<sup>2</sup> Although the age distribution of the working population is expected to change continuously, few reports have examined the long-term condition of OHCAs in the working population, according to age.



We defined the working population as individuals aged 20–69 years previously, and we analysed relatively short-term cardiogenic OHCA in the Japanese working population using data from the Utstein registry, in Japan—a prospective, nationwide, population-based OHCA registry—between 2005 and 2008.<sup>3</sup> Although this earlier study revealed that the incidence of OHCA in the working population was the highest during winter, on Sundays and Mondays, and during the early hours of the morning, it did not report on the prognosis of the OHCA.

The aim of this study was to determine the incidence of OHCA and the survival rates after 1 month, among the Japanese working population, defined by age, considering the changing age distribution.

## METHODS

The population of Japan in 2019 was estimated to be 126.2 million, of which 67.33 million were employed, including both part-time and full-time workers.<sup>4</sup> In 2019, 726 fire stations with emergency dispatch centres provided emergency services 24 hours a day.<sup>5</sup> Patients with OHCA who underwent resuscitation attempts by emergency medical service (EMS) personnel were transported to hospitals and then registered in the Utstein registry.

In this population-based study, we analysed data collected between 2005 and 2016 from the All-Japan Utstein registry of the Fire and Disaster Management Agency (FDMA); a prospective, nationwide, population-based registry of OHCA victims based on the standardised Utstein style.<sup>6</sup> As described in previous reports that used the Utstein data,<sup>2,7,8</sup> EMS personnel filled the information sheet and updated the OHCA patient information based on the information recorded by the treating physician, including sex, age, prefecture, time of occurrence, initial cardiac rhythm, witness status, type of bystander, time course of resuscitation, bystander-initiated cardiopulmonary resuscitation (CPR), use of an automated external defibrillator (AED), administration of intravenous fluids, tracheal intubation and prehospitalisation return of spontaneous circulation. The person who performed the basic CPR or defibrillation using a public access AED was defined as a bystander. The EMS personnel followed-up these patients with OHCA for 1 month to ascertain the survival rates and neurological outcomes. The data of 1 423 338 patients were collected between 1 January 2005 and 31 December 2016.

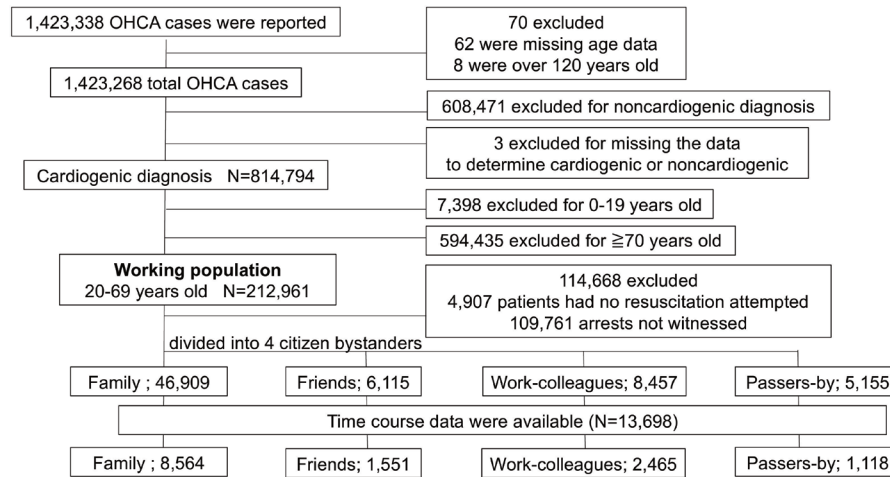
We excluded the non-cardiogenic OHCA group, and only the cardiogenic OHCA group participated in our present study. As reported in a previous study,<sup>9</sup> the cardiogenic group was defined as those having confirmed absence of signs of circulation, with the following exclusion criteria: cerebrovascular diseases, respiratory diseases, malignant tumours, external factors, drug overdoses, drownings, traffic accidents, hypothermia, anaphylactic shocks and other non-cardiac factors. The cardiogenic or non-cardiogenic classification was determined clinically

by physicians at the hospitals in collaboration with the EMS providers and was confirmed by the FDMA. In this study, the cardiogenic OHCA group of the working population (aged 20–69 years) was analysed. After excluding those who did not receive OHCA resuscitations (n=4907) or those who lacked witnesses (n=109 761), the working population was further divided into four bystander groups (family, friends, work-colleagues and passers-by). We focused on the absolute number and incidences of OHCA, the proportion that received CPR/AEDs, the 1-month survival rate following the OHCA each year and the characteristics of the bystanders. The incidence of the OHCA was calculated as follows: the absolute number of OHCA in the 20–69 age group divided by the number of individuals in the entire 20–69 age group.

The population size was based on the estimated data obtained from the Statistics Bureau of Japan.<sup>10,11</sup> The neurological outcomes were evaluated by physicians based on 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 or brain death.<sup>2,6</sup> Favourable neurological outcomes at 1 month after admission were defined as categories 1 or 2. Since some abnormal values were noted in the data in the intervals between the emergency calls and the patient contact times (call to contact time), witness to call times, times from witnessing OHCA to bystander-initiated CPRs and times from witnessing OHCA to the times of the initial defibrillations, we only analysed the data recorded between 0 and 60 min (online supplemental table 1). According to the FDMA, until 2012, patients with null values for bystander use of AEDs were converted automatically into the group ‘without bystander use of AEDs’; however, since 2013, they did not automatically convert the null value into the group ‘without bystander use of AEDs’ and these data were handled as missing data. To homogenise these data, we included all the cases with missing AED data (n=8180) in the group without bystander use of AEDs. The requirement for informed consent was waived due to the use of anonymised data.<sup>12</sup>

## Statistical analysis

We used the t-test to compare the differences between the two independent groups, when the dependent variable was continuous. The incidence rate ratios (IRRs) for the incidence of cardiogenic OHCA were estimated using a Poisson regression analysis, with the age groups separated by 5 years and a dummy variable for the year included in the model. A log-transformed version of the numbers in each age group (in 5-year increments) for each year, which was obtained from the official statistics, was used as the offset. Univariate and multivariable logistic regression models were used to estimate the relationships between the prehospitalisation factors, such as age, sex, bystander chest compressions, shock by public access AEDs, first documented rhythms, types of bystander, onset times of day, onset years, times from witnessing OHCA to



**Figure 1** A flow diagram of patients with OHCA. Of the 1 423 338 patients with OHCA included in the All-Japan Utstein registry between 2005 and 2016, we excluded cases with missing data of age (n=62) or patients who were over 120 years old (n=8). Cardiogenic and non-cardiogenic groups comprised 57.2% and 42.8% of the total OHCA population (n=1 423 268), respectively. We excluded non-cardiogenic OHCA group. In the cardiogenic OHCA group, 212 961 patients with OHCA aged 20–69 years (working population) were enrolled in this study. After excluding those who did not receive OHCA resuscitation (n=4907) or those who lacked a witness (n=1 09 761), the working population was further divided into four bystander groups (family, friends, work-colleagues and passers-by). OHCA, out-of-hospital cardiac arrest.

bystander-initiated CPRs, times from witnessing OHCA to the initial defibrillations, call to contact times, and 1-month survival with favourable neurological outcomes after OHCA. For the multivariable regression models, Cook's distance and variance inflation factors (VIFs) were determined to ascertain the presence of influential observations and multicollinearity, respectively. All the statistical analyses were conducted using Stata (V.16.1; StataCorp LLC).

### Patient and public involvement

The patients and the public were not involved in the design of this study.

## RESULTS

Of the 1 423 338 patients with OHCA included in the All-Japan Utstein registry between 2005 and 2016, we excluded cases with missing age data (n=62) or patients who were over 120 years old (n=8). The cardiogenic and non-cardiogenic groups comprised 57.2% and 42.8% of the total OHCA population (n=1 423 268), respectively. In the cardiogenic OHCA group, 212 961 patients with OHCA aged 20–69 years (working population) were enrolled in this study. After excluding those who did not receive OHCA resuscitations (n=4907) or those who lacked witnesses (n=109 761), the working population was further divided into four bystander groups (family, friends, work-colleagues and passers-by). Figure 1 shows a flow diagram of patients with OHCA.

### Overall trend of OHCA

The total general population reported by the Statistics Bureau of Japan declined from 127 768 000 in 2005 to 126 933 000 in 2016, while a transient increase was observed in 2010 alone (n=128 057 000). Both the

absolute number and the total incidence of OHCA increased, from 102 737 (80 per 100 000 population) in 2005 to 123 552 (97 per 100 000 population) in 2016. Moreover, the absolute number and incidence of cardiogenic OHCA in all age groups increased from 56 412 (44 per 100 000 population) in 2005 to 75 109 (59 per 100 000 population) in 2016.

### OHCA trend in the working population

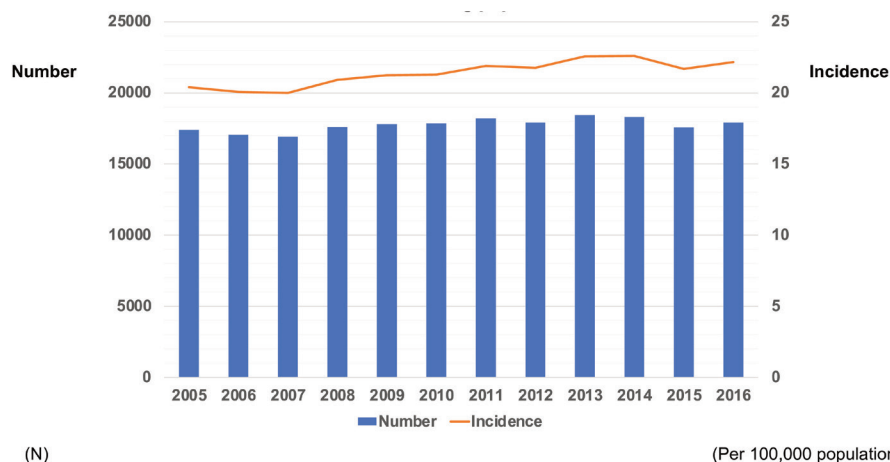
Of the OHCA population (n=1 423 268), the working population comprised 428 958 (30.1%) of the OHCA cases, whereas in the cardiogenic OHCA group (n=814 794), the working population comprised 212 961 (26.1%) OHCA cases.

Figure 2 shows that both the absolute number of cases and the incidence of cardiogenic OHCA in the working population mostly remained unchanged, from 17 403 (20 per 100 000 population) in 2005 to 17 917 (22 per 100 000 population) in 2016. The proportion of CPRs and AEDs performed for the cardiogenic OHCA in the working population increased every year, from 32.3% and 0.2% in 2005 to 47.7% and 4.9% in 2016, respectively, and the 1-month survival and favourable neurological outcomes of the cardiogenic OHCA in the working population also increased from 7.8% and 4.5% in 2005 to 16.3% and 11.7% in 2016, respectively (figure 3).

### Sixty-five to 69 age group

The Statistics Bureau of Japan reported that the population aged 20–64 years declined from 77 829 000 in 2005 to 70 522 000 in 2016, whereas the population in the 65–69 age group increased, from 7 460 000 in 2005 to 10 275 000 in 2016. Table 1 shows the incidence of cardiogenic OHCA in each age group (in 5-year increments) in the working population. A Poisson regression analysis





**Figure 2** Absolute number and incidence of cardiogenic OHCA in the working population. Both the absolute number and the incidence of cardiogenic OHCA in the working population were mostly unchanged over the period of 12 years, from 17 403 (20 per 100 000 population) in 2005 to 17 917 (22 per 100 000 population) in 2016. OHCA, out-of-hospital cardiac arrest.

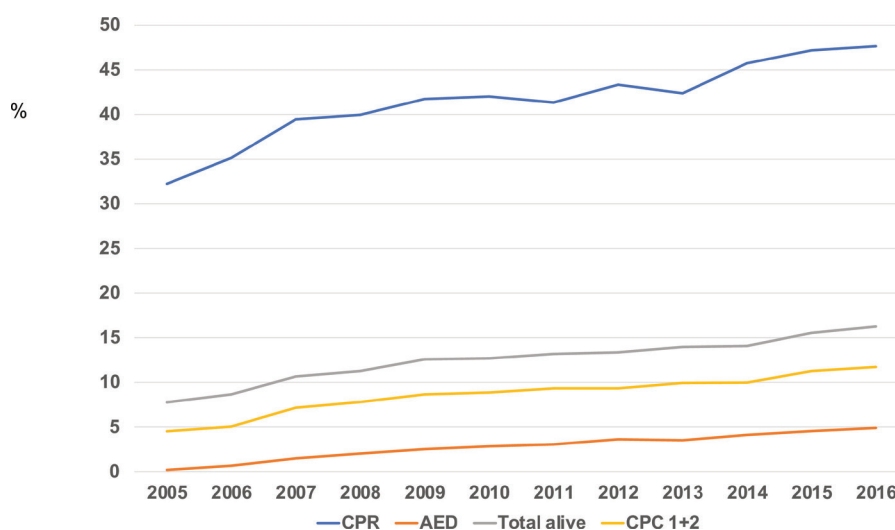
revealed that there were no significant improvements in the incidence of cardiogenic OHCA over the last 12 years in any age group, and the IRRs for the incidence of cardiogenic OHCA in age groups separated by 5 years were 1.08.

#### Citizen bystander in OHCA in the working population

Table 2 presents the characteristics (age, sex, CPR/AED proportions and 1-month survival/neurological outcomes) of the cardiogenic OHCA cases in the working population for each type of citizen bystander. The work-colleague bystander group had the highest percentage for both CPRs and AEDs (56.6% and 10.2%, respectively). Furthermore, the work-colleague bystander group had the highest 1-month survival and best neurological outcomes (28.1% and 20.8%, respectively). When the time course data were available (n=13 698), the time

course was identified for each citizen bystander group (table 3). The work-colleague bystander group had significantly longer median intervals between witnessing OHCA and the initial defibrillations than the passers-by bystander group (13 vs 12 min, respectively,  $p<0.001$ ).

Using a multivariable logistic regression, 13 698 patients were analysed. There were 11 808 (86.2%) males, 13 509 (98.6%) patients received bystander chest compression, 1062 (7.8%) were shocked by public access AEDs, 13 698 first documented rhythms were analysed. The number of patients with VT/VF rhythm was 11 882 (86.7%), pulseless electrical activity 741 (5.4%), asystole 834 (6.1%) and others 241 (1.7%). There were 8564 (62.5%) family bystanders, 1551 (11.3%) friends bystanders, 2465 (18.0%) work-colleagues bystanders and 1118 (8.2%) passers-by



**Figure 3** Proportion of CPR, AED, 1-month survival and favourable neurological outcome in the working population for each year. The percentage of CPR and AED increased each year from 32.3% and 0.2% in 2005 to 47.7% and 4.9% in 2016, respectively. One-month survival rate of cardiogenic OHCA in the working population increased from 7.8% in 2005 to 16.3% in 2016, and the 1-month survival with favourable neurological outcome also increased from 4.5% in 2005 to 11.7% in 2016. AED, automated external defibrillator; CPC, Cerebral Performance Category; CPR, cardiopulmonary resuscitation.

**Table 1** Incidence of cardiogenic OHCA in each age group (in 5-year increments) in the working population

Incidence by year (per 100 000 population)												
Age (years)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
20–24	2.8	2.5	2.3	2.2	2.9	2.3	2.3	2.5	2.7	2.8	2.4	2.6
25–29	3.1	2.8	3.3	3.1	3.0	3.0	3.0	2.9	3.3	3.1	3.2	3.1
30–34	4.5	4.4	4.3	4.2	4.1	4.2	4.6	3.9	4.6	4.5	3.9	3.9
35–39	6.3	6.4	6.5	6.4	6.5	6.5	6.3	6.8	6.2	6.6	6.2	6.6
40–44	10.2	10.1	10.1	10.7	10.8	10.0	11.2	9.9	10.9	10.5	10.7	10.3
45–49	15.7	14.7	14.9	15.3	16.1	15.4	16.2	15.4	17.5	16.1	16.2	16.4
50–54	22.0	22.4	21.6	22.7	22.6	22.4	23.3	23.3	24.8	24.3	22.8	24.0
55–59	30.2	30.5	30.9	32.3	32.8	31.4	31.0	31.2	32.3	31.9	30.1	31.6
60–64	45.7	45.5	43.9	45.9	43.9	45.3	46.6	46.5	47.4	47.8	44.7	44.3
65–69	66.3	62.9	61.4	62.9	63.5	64.5	66.2	65.6	64.5	65.2	61.3	61.5

OHCA, out-of-hospital cardiac arrest.

bystanders. With respect to the onset time of day, 13 698 were analysed, of which the time period 0:00–7:59 comprised 3835 (28.0%), 8:00–16:59 5696 (41.6%) and 17:00–23:59 4167 (30.4%). Age, sex, bystander chest compressions, shock by public access AEDs, first documented rhythms, types of bystander, onset years, times from witnessing OHCA to bystander-initiated CPRs, times from witnessing OHCA to initial defibrillations and the call to contact times were associated independently with 1-month survival with favourable neurological outcomes in this study population (table 4). According to the Cook's distance calculation, none were above 0.5. The mean VIF was 1.27 and none of the variables exceeded a VIF of 3.

## DISCUSSION

Using the data obtained from the Utstein registry, that were collected for 12 years between 2005 and 2016, we investigated OHCA in the Japanese working population with respect to age. We found that: (1) approximately 30% of all the OHCA cases occurred in the

working population and that the working population comprised 26% of all the cases in the cardiogenic OHCA group; (2) both the absolute number and the incidence of cardiogenic OHCA in the working population remained mainly unchanged over the 12-year period; (3) in any age group in the working population, there was no significant improvement in the incidence of cardiogenic OHCA over the 12-year period, with the incidence of OHCA increasing with increasing age; (4) the proportion of CPRs and the use of AEDs increased each year, and the prognosis after 1 month improved in the working population; and (5) among the citizen bystanders, the work-colleague bystander group had the highest bystander CPR/AED proportion, highest 1-month survival rate and best neurological outcomes. However, the work-colleague bystanders had a significantly longer time from witnessing OHCA to the initial defibrillations than the passers-by bystander group, and the time from witnessing OHCA to initial defibrillations was associated independently with 1-month survival with favourable neurological outcomes.

**Table 2** Characteristics of patients with cardiogenic OHCA in the working population according to the bystander groups

Characteristic	Bystander group			
	Family	Friends	Work-colleagues	Passers-by
Total, n	46 909	6115	8457	5155
Age, years, median (Q1–Q3)	61 (52–66)	59 (48–65)	56 (48–62)	60 (52–65)
Sex, men, %	73.6	83.0	92.2	86.6
CPR, %	44.3	52.7	56.6	47.6
AED (bystander defibrillation), %	0.7	7.1	10.2	9.3
1-month survival rate, %	15.9	22.0	28.1	26.5
1-month neurological outcome (CPC 1+2, %)	10.1	15.8	20.8	18.5

AED, automated external defibrillator; CPC, Cerebral Performance Category; CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest; Q1–Q3, first to third quartile.

**Table 3** Characteristics of patients with cardiogenic OHCA in the working population according to the bystander group (time course data available)

Characteristic	Family	Friends	Work-colleagues	Passers-by
	Time course, min, median (Q1–Q3)			
Witness call	2 (1–4)	2 (1–4)	2 (1–4)	2 (1–4)
Call to contact	8 (7–10)	8 (6–11)	8 (6–10)	7 (6–9)
Witness-initiated CPR by bystander	3 (1–5)	2 (1–5)	2 (1–5)	2 (1–4)
Witness-initial defibrillation	13 (11–17)	13 (10–17)	13 (10–16)	12 (9–15)

CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest; Q1–Q3, first to third quartile.

**Table 4** Effect of prehospitalisation factors on the 1-month survival with favourable neurological outcomes after OHCA

Prehospitalisation factor	Crude OR	95% CI	P value	Adjusted OR	95% CI	P value
Age (10-year increments)	0.98	0.98 to 0.99	<0.001	0.98	0.98 to 0.99	<0.001
Sex						
Male	Ref.	–	–	Ref.	–	–
Female	1.16	1.04 to 1.29	0.006	1.33	1.19 to 1.50	<0.001
Bystander chest compression						
No	Ref.	–	–	Ref.	–	–
Yes	1.77	1.23 to 2.56	0.002	1.54	1.05 to 2.22	0.027
Shock by public access AEDs						
No	Ref.	–	–	Ref.	–	–
Yes	1.72	1.51 to 1.95	<0.001	1.53	1.31 to 1.77	<0.001
First documented rhythm						
VT/VF	Ref.	–	–	Ref.	–	–
PEA	0.35	0.28 to 0.43	<0.001	0.49	0.39 to 0.61	<0.001
Asystole	0.13	0.09 to 0.17	<0.001	0.21	0.15 to 0.29	<0.001
Others	2.16	1.67 to 2.79	<0.001	1.73	1.31 to 2.29	<0.001
Type of bystander						
Family	Ref.	–	–	Ref.	–	–
Friends	1.42	1.26 to 1.59	<0.001	1.28	1.13 to 1.46	<0.001
Work-colleagues	1.55	1.41 to 1.71	<0.001	1.28	1.15 to 1.44	<0.001
Passers-by	1.69	1.48 to 1.93	<0.001	1.25	1.08 to 1.45	0.003
Onset time of day						
0:00–7:59	0.76	0.69 to 0.84	<0.001	0.92	0.83 to 1.03	0.141
8:00–16:59	Ref.	–	–	Ref.	–	–
17:00–23:59	0.90	0.82 to 0.98	0.018	0.93	0.84 to 1.02	0.116
Onset year (1-year increments)	1.08	1.07 to 1.09	<0.001	1.09	1.08 to 1.11	<0.001
Witness-initiated CPR by bystander time (1 min increments)	0.91	0.90 to 0.92	<0.001	0.96	0.95 to 0.98	<0.001
Witness-initial defibrillation time (1 min increments)	0.89	0.89 to 0.90	<0.001	0.94	0.93 to 0.95	<0.001
Call to contact time (1 min increments)	0.87	0.86 to 0.89	<0.001	0.93	0.91 to 0.95	<0.001

AED, automated external defibrillator; CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest; PEA, pulseless electrical activity; Ref., reference; VT/VF, ventricular tachycardia/ventricular fibrillation.

## Causality of OHCA and their countermeasures in the working population

The acute coronary syndrome is the leading cause of cardiac arrest in Western countries. At least one significant coronary artery lesion was found in 70% of all patients with OHCA in the absence of an obvious extra-cardiac cause.<sup>13</sup> The Kumamoto Acute Coronary Events study of acute myocardial infarctions (AMIs) revealed that from 2004 to 2011, the incidence of AMIs decreased in both men and women.<sup>14</sup> The rate of ST-segment elevation myocardial infarction decrease was attributed to the increased use of angiotensin-converting enzyme inhibitors, angiotensin II receptor blockers and lipid-lowering medications (eg, statins).<sup>15–17</sup> However, the Miyagi AMI registry reported that between 1985 and 2014, the incidence of AMIs in both men and women who were <59 years continued to increase. This was attributed to the high incidence of dyslipidaemia, secondary to the westernisation of young peoples' diets and lifestyles, as well as the high smoking rates (~50% and >30% in young men and women, respectively).<sup>18</sup> Therefore, an improvement in the diet and the cessation of smoking may be important in the reduction of the incidence of cardiogenic OHCA in this population.

Compared with Western countries, ischaemic heart disease is less common in Japan,<sup>19</sup> whereas the prevalence of the Brugada syndrome is relatively high.<sup>20,21</sup> The Brugada syndrome was described by Pedro Brugada and Josep Brugada<sup>22</sup> in 1992, as a disease that causes ventricular fibrillation despite the absence of obvious structural cardiac diseases, electrolyte abnormalities or QT prolongations. The Brugada-type electrocardiogram (ECG; right bundle branch block and ST-segment elevation in V1 through V3) may be associated closely with a sudden unexplained death syndrome, such as Lai Tai ('death during sleep') in northeast Thailand, Bangungut ('moaning and dying during sleep') in the Philippines, and Pokkuri ('sudden unexpected death at night') in Japan.<sup>23</sup> A troublesome characteristic of the Brugada syndrome is its nocturnal tendency, which may delay therapeutic interventions and thus lead to worse prognosis. In the univariate analysis of this study, a night-time onset (0:00–7:59 and 17:00–23:59) of OHCA was associated with a worse prognosis than a daytime onset (8:00–16:59), although this tendency was not shown in the multivariable analysis (table 4). Using a 12-lead ECG at screening, a history of syncope and a family history of sudden cardiac death may help identify patients who are in need of preventive pharmacological and non-pharmacological therapy (eg, use of an implantable cardioverter defibrillator).<sup>24</sup>

Previous meta-analyses of prospective cohort studies have revealed associations between work stressors and cardiovascular diseases. The summary relative risk for long working hours (≥55 hours per week) compared with the standard 35–40 hours per week was 1.13 (95% CI: 1.02 to 1.26).<sup>25</sup> The total working hours tended to decline in Japan<sup>26</sup>; however, the reduction in the number of working hours was minor, and it is unknown whether

it contributed significantly to the incidence of OHCA in the working population.

## Analysis of OHCA in the 65–69 age group

In 2018, the Japanese Cabinet Office reported that the proportion of workers in the 65–69 age group was low; in the 5-year age groups, the proportions of male and female workers were 91.0% (55–59), 79.1% (60–64), and 54.8% (65–69) and 70.5% (55–59), 53.6% (60–64), and 34.4% (65–69).<sup>27</sup> Considering the extension of the retirement age that came into effect from 2021, the employment rates are expected to increase for people in the 65–69 age group. Thus, we investigated the characteristics of cardiogenic OHCA in the 65–69 age group.

In fact, the proportion of workers aged ≥65 years in the total labour force population has been increasing every year, by 7.6% in 2005 to 12.8% in 2018.<sup>28</sup> We identified that there were no significant improvements in the incidence of cardiogenic OHCA in any age group over the last 12 years, and the incidence increased with increasing age (table 1). A study of OHCA in the Osaka Prefecture, Japan, that was conducted for 2 years revealed that the incidence of OHCA increased exponentially with increasing age.<sup>29</sup> Our present study revealed that the incidence of cardiogenic OHCA in any age group was almost constant over the 12-year period. It should be noted that the incidence of OHCA in the 65–69 age group (extended retirement age group) was high and that age was associated independently with 1-month survival with favourable neurological outcomes (adjusted OR: 0.98 (10-year increments), 95% CI: 0.98 to 0.99;  $p < 0.001$ ). Therefore, it is important for companies with older employees to take this into account. Nevertheless, this is not a problem that is limited to Japan; the ageing of the population is progressing worldwide, especially in developed countries.<sup>1</sup> In the future, there is a possibility that the retirement age will be extended in many countries around the world.

## Effect of work-colleagues and other types of bystanders

A previous study found that a key predictor of survival after OHCA is the bystander witness.<sup>30</sup> Another previous study reported that most of the cases of OHCA in Japan that were witnessed by family members and family bystanders had a worse prognosis than those witnessed by other bystanders.<sup>7</sup> Moreover, in our present study, the worst 1-month survival and neurological outcomes were observed in the family bystander group. This unfavourable result may be attributed to the lowest CPR/AED proportions (44.3% and 0.7%, respectively). Another study that reported a similar association for the bystander–patient relationship indicated that the large delays (≥5 min) in the witness call interval and large witness bystander CPR interval were most frequent in the family bystander group.<sup>31</sup>

A previous systematic review revealed that the OHCA survival rate was better in the workplace,<sup>32</sup> and the findings of our study were similar: work-colleague bystanders



were associated with a better 1-month survival and favourable neurological outcomes. A possible reason for such a favourable prognosis was that the CPR/AED proportion was highest in the work-colleague bystander group. Furthermore, we found further improvements in the prognosis of OHCA in the work-colleague bystander group. The work-colleague bystander group had significantly longer median intervals between the witnessing OHCA and initial defibrillations than the passers-by bystander group (13 vs 12 min, respectively;  $p < 0.001$ ). It is known that a 1 min delay can reduce the survival rate by 7%–10%,<sup>33</sup> and the results from [table 4](#) also indicate that a 1 min difference does have a clinically meaningful benefit for 1-month survival with favourable neurological outcomes (adjusted OR: 0.94 (1 min increments), 95% CI: 0.93 to 0.95;  $p < 0.001$ ). A possible reason why work-colleagues took longer to perform the first defibrillation compared with passers-by may have been due to most of the initial defibrillations being performed by EMS providers and that the median call to contact intervals was significantly longer in the work-colleague bystander group than in the passers-by bystander group (8 vs 7 min, respectively;  $p < 0.001$ ). The travel distance and time to travel within buildings may also have contributed to the delays. Another study that used the model of a large-scale skyscraper calculated the length of time taken by the emergency services to reach a patient within the building (ie, travel time) and found that the minimum travel time was approximately 19 s, the intermediate value 2 min and the worst value 4 min.<sup>34</sup>

Recently, the importance of CPR has become known widely, and the findings of this study supported this, given that the CPR proportion in the working population has increased over the years ([figure 3](#)). However, our present study revealed that in 2016 in >30% of the cases CPR was not performed despite the witnessing of the cardiogenic OHCA by work-colleagues (shown in online supplemental figure 1). More opportunities for CPR awareness activities in companies may be useful in preventing cardiac death and poor neurological outcomes in patients with OHCA in the working population. A previous study reported that approximately two-thirds of OHCA survivors return to work,<sup>35</sup> which is important in terms of public health and socioeconomic significance.

### Limitations

This study had several limitations. First, this was a retrospective population-based study of data obtained from a prospective registry, with some instances where data were missing or abnormal values were present. Second, the actual employment status of the patients with OHCA in the 20–69 age group (working population) was unknown. Third, the Utstein registry did not contain any information on individual medical therapy, and activities of daily living before the OHCA, or the details of the in-hospital treatment interventions. Finally, there may have been unmeasured confounding factors that may have influenced the 1-month survival with favourable neurological outcomes.

### CONCLUSIONS

Over the 12-year period (2005–2016), both the absolute number and the incidence of cardiogenic OHCA in the working population remained mainly unchanged, whereas the prognosis of OHCA at 1 month improved. Among the citizen bystanders, the work-colleague bystander group showed the highest CPR/AED proportion, highest 1-month survival rate and best neurological outcomes, despite significantly longer times from witnessing OHCA to initial defibrillations than the passers-by bystander group. Reducing the time from witnessing OHCA to initial defibrillations may further improve the prognosis of patients with OHCA that have been witnessed by work-colleagues.

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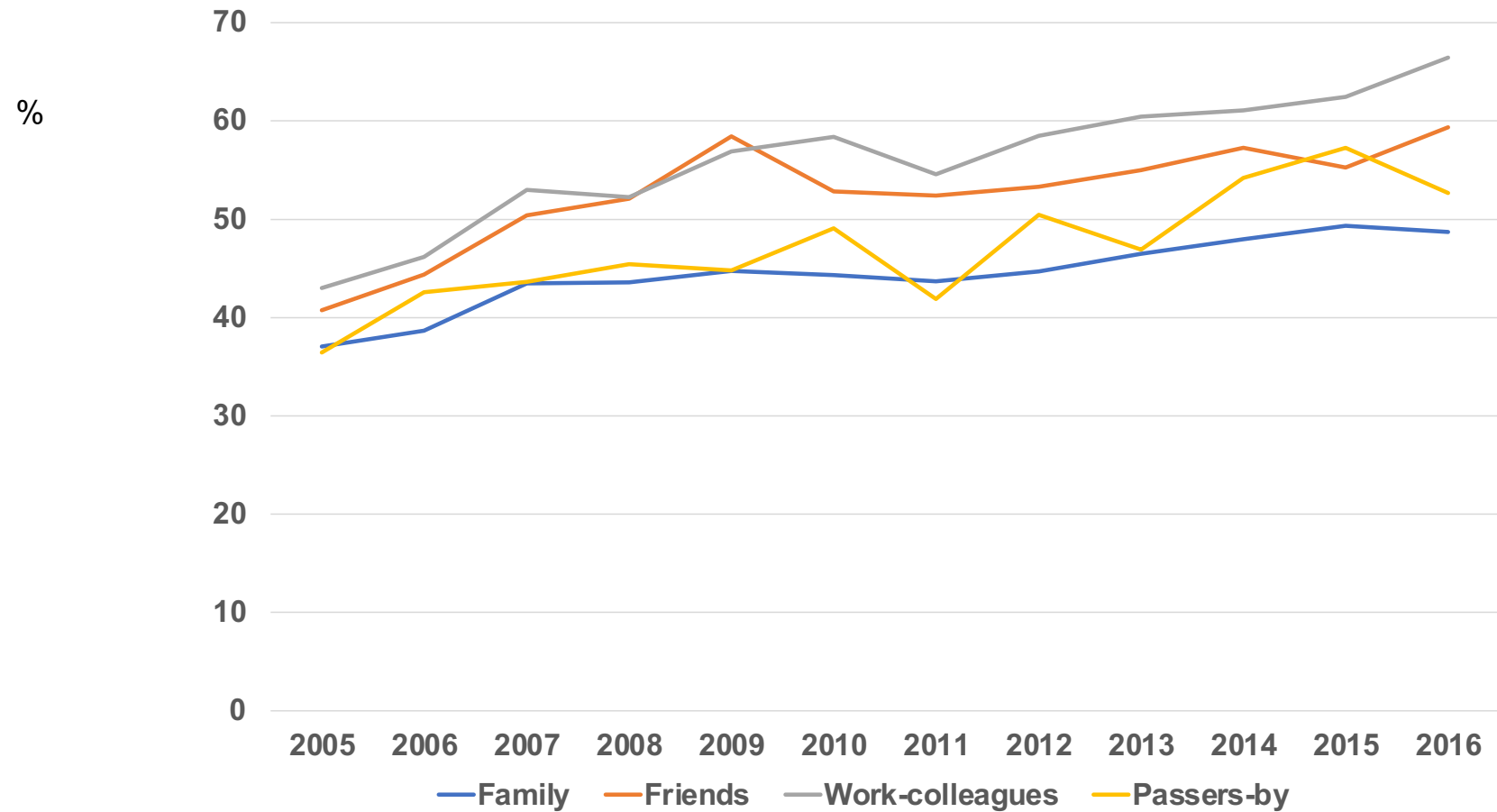
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Supplementary Figure. 1

**Percentage of CPR for cardiogenic OHCA's  
in the working population for each year  
among the citizen bystanders**



**Supplementary Table 1.** Information about the abnormal value of time course

	Time course, minutes		
	< 0	0 - 60	60 <
Witness call, n (%)	13,784 (20.7)	52,281 (78.6)	472 (0.7)
Call to contact, n (%)	20 (0.0)	66,440 (99.9)	83 (0.1)
Witness-initiated CPR by bystander, n (%)	40 (0.1)	30,264 (99.4)	152 (0.5)
Witness-initial defibrillation, n (%)	112 (0.4)	31,190 (98.8)	253 (0.8)

Abbreviations: CPR, cardiopulmonary resuscitation.