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# Citizen bystander–patient relationship and 1-month outcomes after out-of-hospital cardiac arrest of cardiac origin from the All-Japan Utstein Registry: a prospective, nationwide, population-based, observational study

Yasunori Suematsu,[1] Bo Zhang,[2] Takashi Kuwano,[1] Hideto Sako,[1] Masahiro Ogawa,[1] Naohiro Yonemoto,[3] Hiroshi Nonogi,[4] Takeshi Kimura,[5] Ken Nagao,[6] Shin'ichiro Yasunaga,[2] Keijiro Saku,[1] Shin-ichiro Miura,[1] on behalf of the Japanese Circulation Society with Resuscitation Science Study (JCS-ReSS) Group

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KS and S-M contributed equally. YS and BZ contributed equally.

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For numbered affiliations see end of article.

**Correspondence to**
Dr Shin-ichiro Miura;
miuras@cis.fukuoka-u.ac.jp

## ABSTRACT

**Objectives** The presence of a bystander witness is a crucial predictor of patient survival after out-of-hospital cardiac arrest (OHCA). However, the differences in survival and neurological outcomes among different types of citizen bystanders are not well understood.

**Design** We analysed data from the All-Japan Utstein Registry, a prospective, nationwide, population-based, observational study that was started in January 2005.

**Setting** The registry includes all patients with OHCA who were transported to the hospital by emergency medical service (EMS) in Japan. The type of citizen bystander was classified as family member, friend, colleague, passerby or other.

**Participants** We analysed 210 642 patients in the registry who were 18 years or older and experienced OHCA of cardiac origin witnessed by a citizen bystander between 2005 and 2014.

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

**Results** Of the citizen bystander-witnessed cases, 65.1% (137 147/210 642) were witnessed by a family member. However, among patients who survived to 1 month and who had a favourable 1 month neurological outcome, much lower proportions (53.9% (10 907/20 239) and 48.9% (5722/11 696)) were witnessed by a family member. Witness by a friend, colleague or passerby was associated with good 1 month neurological function, after controlling for the patient's age, first recorded rhythm, gender, bystander cardiopulmonary resuscitation (CPR), use of a public-access automated external defibrillator, dispatcher instructions, collapse-call time and response time compared with witness by a family member (friend: OR 1.35, 95% CI 1.24 to 1.46, colleague: OR 1.63, 95% CI 1.33 to 1.98, passerby: OR 1.60, 95% CI 1.39 to 1.84).

**Conclusions** One-month survival and favourable1 month neurological outcome of patients with OHCA of cardiac origin witnessed by a family member were worse than those in cases witnessed by a friend, colleague or passerby, independent of the patient characteristics and the response of EMS.

## Strengths and limitations of this study

- The All-Japan Utstein Registry contains comprehensive nation-wide coverage of cases over several years.
- The Utstein registry includes prognosis data such as return of spontaneous circulation, 1 month survival and 1 month survival with Glasgow-Pittsburgh Cerebral Performance Category.
- The information on bystander witnesses only includes the classification as family, friend, colleague or passerby, and does not include age, experience or training on cardiopulmonary resuscitation.
- The patient background, such as the underlying disease, medication and history regarding cardiovascular disease, was not included.

## INTRODUCTION

Sudden cardiac arrest is one of the major causes of death worldwide. Approximately 356 500 individuals in the USA[1] and 115 600 individuals in Japan[2] experience out-of-hospital cardiac arrest (OHCA) each year. The survival rate after OHCA has improved over time.[3 4] However, the survival rate to hospital discharge is still low: estimated to be 7.9% among patients who were treated by emergency medical service (EMS) personnel, with some regional variation.[5]

Key predictors for survival after OHCA include the cause of cardiac origin,[6 7] witness by a bystander,[8] and initial rhythm of ventricular fibrillation (VF).[9] Among these, witness by a bystander is a particularly strong predictor. Most cases of bystander-witnessed OHCA in Japan were witnessed by a family member.[2 6 9] However, the association between the type of bystander and the outcome of OHCA is not fully understood. It is important to understand the association between the relationship of the bystander to the patient and the outcome after OHCA to improve survival following OHCA.

Using the All-Japan Utstein Registry[2 6 9] database for the period from 2005 to 2014, we examined the association between the bystander–patient relationship and 1 month outcomes of citizen-bystander-witnessed OHCA of cardiac origin.

## METHODS

### Study design

This cohort study used the All-Japan Utstein Registry, a prospective, nationwide, population-based, observational registry The main outcomes were survival at 1 month and survival at 1 month with minimal neurological impairment.

### Study setting

The All-Japan Utstein Registry has collected data from patients with OHCA who were treated by EMS responders and transported to a hospital and followed for at least 1 month in Japan since 2005.[10] The Japan Fire and Disaster Management Agency managed the database of the All-Japan Utstein Registry, checked the data and compiled the data for public use.[10] Detailed information on data collection and quality control have been published elsewhere.[9–11] We used All-Japan Utstein Registry data for patients from 1 January 2005 to 31 December 2014.

### Patient and public involvement

The patients were not involved in recruitment or the conduct of the study.

### Study subjects

The study cohort included OHCA patients from the All-Japan Utstein Registry (n=210 642) who were greater than 18 years or age, witnessed by a citizen bystander, received resuscitation by EMS and had arrest of cardiac origin. Patients who were under 18 years of age, either not witnessed, unknown whether witnessed or not, witnessed by EMS, did not receive resuscitation by EMS or had an arrest of non-cardiac origin were excluded. The study flow diagram is shown in figure 1.

### Variables

The All-Japan Utstein registry includes the following information: resuscitation attempted by EMS personnel (yes/no), patient's age, gender, aetiology (cardiac/noncardiac), witnessed arrest (citizen-bystander witness/EMS witness/unwitnessed/unknown), type of bystander

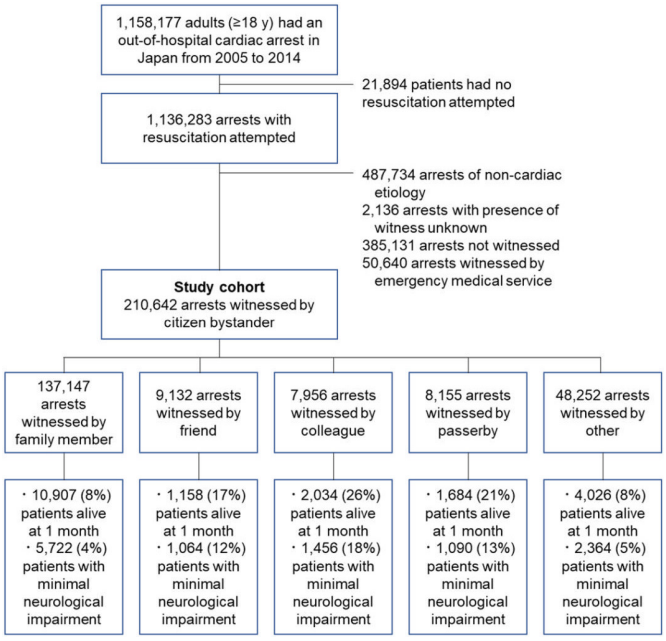


**Figure 1** Flow diagram of patients with OHCA and outcomes. From 2005 to 2014, 1 158 177 adults (aged ≥18 years) who had an OHCA were registered in the All-Japan Utstein Registry database. OHCA, out-of-hospital cardiac arrest.

according to relationship to patient (family member/friend/colleague/passerby/other), bystander cardiopulmonary resuscitation (CPR) provided (yes/no), bystander CPR (chest compression only/conventional CPR (chest compression with rescue breathing)), public-access automated external defibrillator (AED) performed (yes/no), dispatcher CPR instructions (yes/no), first monitored rhythm (VF/pulseless ventricular tachycardia (VT)/pulseless electrical activity (PEA)/asystole/other), use of AED by EMS personnel (yes/no), airway control (yes/no), vascular access (yes/no), drug use (yes/no), response time (the time interval from the incoming call to the time the first emergency response vehicle stops at a point closest to the patient's location), time interval from collapse to bystander CPR, time interval from collapse to call, any return of spontaneous circulation, 1 month survival (yes/no), Glasgow-Pittsburgh Cerebral Performance Category (CPC) (1 (good cerebral performance)/2 (moderate cerebral disability)/3 (severe cerebral disability)/4 (coma, vegetative state)/5 (death)), Overall Performance Category (1 (good overall performance)/2 (moderate overall disability)/3 (severe overall disability)/4 (same as CPC 4)/5 (same as CPC 5)). One-month survival with minimal neurological impairment was defined as Cerebral Performance Category 1 or 2. Age was classified as working age (18–65 years) or senior (over 65 years). The All-Japan Utstein registry does not include information on the patient background (other than age and gender) or demographic data on bystanders.

### Statistical modelling

All of the data analyses were performed using the SAS Software Package V.9.4, (SAS Institute) at Fukuoka University (Fukuoka, Japan). The significance level was considered to be less than 0.05 unless indicated otherwise. Graphs were prepared using the Graph Template Language in SAS[12 13] (for details, please see the online material supplement section).

In the descriptive analyses, absolute number and percentage are given for categorical variables, and median and IQR (25th and 75th percentiles) are given for continuous variables. Categorical and continuous variables were compared between two groups by the $X^2$-analysis/Fisher's exact test[14] and the Wilcoxon rank-sum test,[15] respectively.

Since age is a crucial predictor of the outcome for patients with OHCA, descriptive data are presented for both the overall patients and different age groups, which included working-age patients (18–65 years of age) and senior patients (>65 years).[16]

Since important factors that predict patient outcomes, including initial VF rhythm, gender and bystander CPR, are also related to the bystander–patient relationship, it is possible that the association between the bystander–patient relationship and patient outcomes may be confounded by these factors.[17 18] Because the number of confounding factors was limited and the number of patients was large, sensitivity analyses in subgroups were used to identify plausible confounding factors and the degree of confounding[19] in the association between the bystander–patient relationship and 1 month outcomes. Stratification and a multivariable logistic regression analysis were also used to control (reduce) the effect of confounding.[19]

The independence of the association between the type of citizen bystander and the 1 month outcomes of patients with an initial rhythm of VF/VT was examined after adjusting for plausible confounding factors by multivariate logistic regression.[20] Qualitative variables were coded as dummy variables (factors) and quantitative variables were included as continuous variables.[20] Data are presented as the OR and 95% CI.

## RESULTS

### Outcomes in citizen bystander-witnessed OHCA of cardiac origin

Citizen bystander-witnessed patients with OHCA of cardiac origin who did and did not have 1 month survival and those who did and did not have a favourable 1 month neurological outcome were different with respect to patient characteristics, including age and sex, distributions of the type of citizen bystander (family member, friend, colleague, passerby and other), and the OHCA process, including response time (table 1). The bystander–patient relation was related to the 1 month outcomes of patients independent of age (online eTable 1 in the supplement).

### Factors related to the association between the bystander–patient relationship and patient outcomes in OHCA of cardiac origin

Friend-witnessed, colleague-witnessed and passerby-witnessed patients were combined into one group in the analyses of the factors related to the association between the bystander–patient relationship and patient outcomes (online eTables 2 and 3 in the supplement). Friend/colleague/passerby-witnessed patients with OHCA of cardiac origin had a much higher proportion of arrests with an initial VF rhythm than those witnessed by a family member in the working-age (52.1% vs 38.6%), senior (33.7% vs 13.8%) (data not shown) and other age groups (online eTables 4 and 5 in the supplement). Therefore, we examined the characteristics of patients in the subgroup of patients with initial VF/pulseless VT (shockable rhythms), to control for confounding by the initial VF. Since most patients with initial VF/pulseless VT were male (online eTables 6 and 7 in the supplement), we further examined the characteristics of patients in the subgroup of male patients with initial VF/pulseless VT, to control for confounding by sex, in addition to the initial VF/pulseless VT. About 50% of the family member-witnessed male patients with OHCA of cardiac origin who had initial VF/pulseless VT received bystander CPR (online eTable 8 in the Supplement). Plausible confounding by bystander CPR was further controlled by examining the relationship between the type of citizen bystander and 1 month outcomes in male patients with OHCA of cardiac origin with initial VF/pulseless VT who did (bystander CPR(+)) or did not receive bystander CPR (bystander CPR(−)).

Patients witnessed by a friend/colleague/passerby consistently included higher proportions of patients who survived at 1 month and those who had a favourable 1 month neurological outcome, in all of the age groups (online eTable 9 in the Supplement). Patients witnessed by different types of bystanders (bystander–patient relationship) also differed with respect to Utstein elements including age, sex, initial VF/pulseless VT rhythm and response time. However, after these factors were controlled by subgroup analyses and stratification, the bystander–patient relationship was still associated with the 1 month outcome.

### Independence of the association between the bystander–patient relationship and patient outcomes in citizen-bystander-witnessed OHCA of cardiac origin

Other Utstein elements were further controlled by multivariable logistic regression analyses in the subgroup of patients with initial VF/pulseless VT, because the proportion of patients who had initial VF/pulseless VT was much lower in citizen-bystander-witnessed patients with OHCA of cardiac origin who did not survive at 1 month than in those who survived at 1 month (17.0% vs 64.1%) (table 1).

Univariate logistic regression analyses showed that patients witnessed by a friend, colleague or passerby had a better 1 month survival (online eFigure 1 in the

**Table 1** Characteristics of citizen-bystander witness patients with out-of-hospital cardiac arrest of cardiac origin according to 1 month survival and neurological outcome

| | Survival at 1 month | | | Survival at 1 month with minimal neurological impairment | | |
|---|---|---|---|---|---|---|
| | Yes | No | P value | Yes (CPC score 1,2) | No (CPC score 3,4,5) | P value |
| No. of patients, no (%) | 20239 (9.6%) | 190 403 (90.4%) | | 11696 (5.6%) | 198935 (94.4%) | |
| Patient's age, years | 66 (56, 76) | 78 (68, 86) | <0.001 | 63 (52, 73) | 78 (67, 86) | <0.001 |
| Male sex, no (%) | 15131 (4.8%) | 114 934 (60.4 %) | <0.001 | 9127 (78.0%) | 120929 (60.8%) | <0.001 |
| Type of bystander, no (%) | | | | | | |
| Family member | 10907 (53.9%) | 126 240 (66.3%) | <0.001 | 5722 (48.9%) | 131417 (66.1%) | <0.001 |
| Friend | 1588 (7.8%) | 7544 (4.0%) | | 1064 (9.1%) | 8066 (4.1%) | |
| College | 2034 (10.1%) | 5922 (3.1%) | | 1456 (12.4%) | 6500 (3.3%) | |
| Passerby | 1684 (8.3%) | 6471 (3.4%) | | 1090 (9.3%) | 7065 (3.6%) | |
| Other | 4026 (19.9%) | 44 226 (23.2 %) | | 2364 (20.2%) | 45887 (23.1%) | |
| Bystander CPR, no (%) | 11422 (56.4%) | 90 558 (47.6%) | <0.001 | 7242 (61.9%) | 94732 (47.6%) | <0.001 |
| Chest compression only | 7919 (39.1%) | 63 293 (33.2%) | <0.001 | 5027 (43.0%) | 66182 (33.3%) | <0.001 |
| Conventional CPR | 3451 (17.1%) | 27 079 (14.2%) | | 2182 (18.7%) | 28345 (14.2%) | |
| PAD performed | 1365 (6.7%) | 2867 (1.5%) | <0.001 | 1086 (9.3%) | 3146 (1.6%) | <0.001 |
| Dispatcher instruction | 8620 (42.6%) | 82 758 (43.5%) | 0.017 | 4953 (42.3%) | 86419 (43.4%) | 0.021 |
| First monitored rhythm, no (%) | | | | | | |
| VF | 12778 (63.1%) | 31 808 (16.7%) | <0.001 | 8453 (72.3%) | 36129 (18.2%) | <0.001 |
| Pulseless VT | 204 (1.0%) | 561 (0.3%) | | 148 (1.3%) | 617 (0.3%) | |
| PEA | 3760 (18.6%) | 61 336 (32.2%) | | 1554 (13.3%) | 63537 (31.9%) | |
| Asystole | 2147 (10.6%) | 93 719 (49.2%) | | 482 (4.1%) | 95382 (47.9%) | |
| Other | 1350 (6.7%) | 2979 (1.6%) | | 1059 (9.1%) | 3270 (1.6%) | |
| EMS management, no (%) | | | | | | |
| AED | 13888 (68.6%) | 41 525 (21.8%) | <0.001 | 9076 (77.6%) | 46333 (23.3%) | <0.001 |
| Airway control | 16861 (83.3%) | 169 569 (89.1%) | <0.001 | 9421 (80.5%) | 176999 (89.0%) | <0.001 |
| Vascular access | 5736 (28.3%) | 60 857 (32.0%) | <0.001 | 2694 (23.0%) | 63897 (32.1%) | <0.001 |
| Drug | 2777 (13.7%) | 34 152 (17.9%) | <0.001 | 1011 (8.6%) | 35918 (18.1%) | <0.001 |
| Interval, minutes | | | | | | |
| Response time | 6.0 (5.0, 8.0) | 7.0 (5.0, 9.0) | <0.001 | 6.0 (5.0, 8.0) | 7.0 (5.0, 9.0) | <0.001 |
| Collapse-bystander CPR | 1.0 (0.0, 3.0) | 2.0 (0.0, 5.0) | <0.001 | 1.0 (0.0, 3.0) | 2.0 (0.0, 5.0) | <0.001 |
| Collapse-call | 1.0 (0.0, 3.0) | 2.0 (0.0, 5.0) | <0.001 | 1.0 (0.0, 3.0) | 2.0 (0.0, 5.0) | <0.001 |
| Outcome, no (%) | | | | | | |
| Any ROSC | 14018 (69.3%) | 13 575 (7.1%) | <0.001 | 9812 (83.9%) | 17776 (8.9%) | <0.001 |
| 1 month survival | 20239 (100%) | 0 | | 11696 (100%) | 8532 4.3%) | |
| 1 month CPC score 1,2 | 11696 (57.8%) | 0 | | 11696 (100%) | 0 (0%) | |
| 1 month OPC score 1,2 | 11604 (57.3%) | 0 | | 11482 (98.2%) | 122 (0.1%) | |

Response time is defined as time call received to time arrived at scene.
AED, automated external defibrillator; CPC, Cerebral Performance Category; CPR; cardiopulmonary resuscitation; EMS, emergency medical service; OPC, Overall Performance Category; PAD, public-access automated external defibrillator; PEA, pulseless electrical activity; ROSC, return of spontaneous circulation; VF, ventricular fibrillation; VT, ventricular tachycardia.

supplement) and a favourable 1 month neurological outcome (crude OR (95% CI): 1.35 (1.24–1.46); 1.82 (1.70–1.96) and 1.39 (1.28–1.51), respectively, figure 2) compared with patients witnessed by a family member. The direction of the association between the bystander–patient relationship and 1 month outcomes did not change in working-age patients (age 18–65 years), senior patients (age >65 years) or male or female patients, after adjusting for age, sex, bystander CPR, bystander AED use (PAD used), dispatcher instructions, response time and collapse-call time using multivariate logistic regression analyses (figure 2, online eFigure 1 in the supplement).

## DISCUSSION

This study used data from All-Japan Utstein Registry from 2005 through 2014. In 210 642 citizen-bystander-witnessed OHCA patients, a friend/colleague/bystander witness

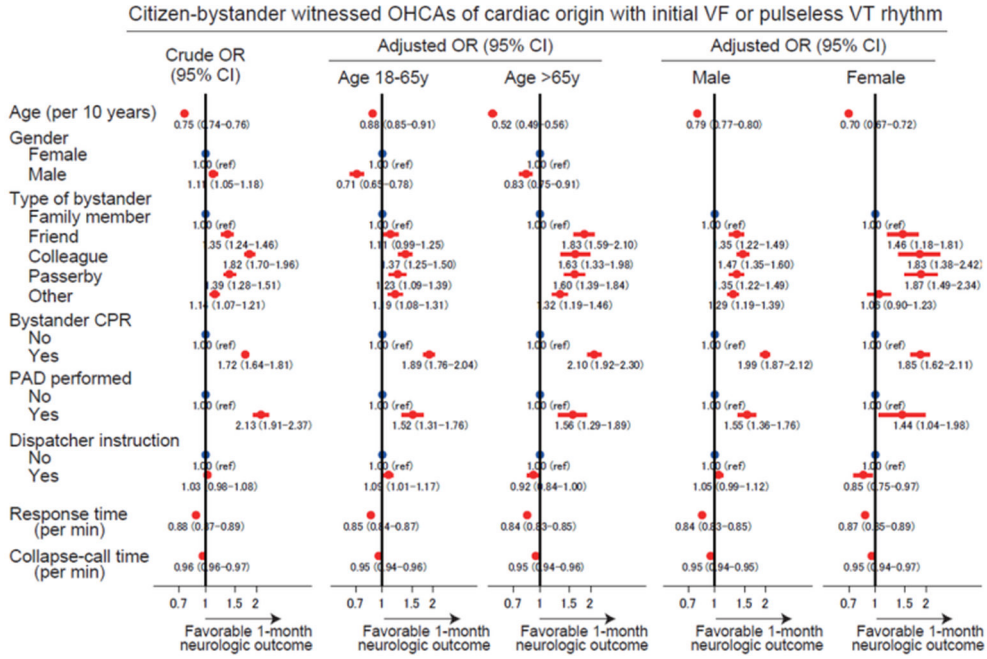


**Figure 2** Association between the bystander–patient relationship and a favourable 1 month neurological outcome in citizen-bystander-witnessed OHCA of cardiac origin with initial VF or pulseless VT rhythm crude (unadjusted) OR and 95% CI were estimated by univariate logistic regression analyses (left panel). Adjusted OR and 95% CI were estimated by multivariate logistic regression analyses in the 18–65 years age group and 65 years age group (middle panel) and in males and females (right panel). OHCA, out-of-hospital cardiac arrest; VT, ventricular tachycardia.

was stably related to favourable 1 month outcomes. The relationship between the bystander and the patient was related to factors that were predictors of 1 month outcomes, including age, sex, initial rhythm, bystander CPR and response time, but was independently associated with 1 month survival and a favourable 1 month neurological outcome after controlling for plausible confounding factors.

There have been few previous reports on the factors that contribute to the association with the bystander–patient relationship, and key confounding factors have not been appropriately controlled.[21–23] OHCA patients witnessed by a friend or colleague were shown to be more likely to have cardiac arrest of cardiac origin than those witnessed by a family member.[21] An initial VF (shockable) rhythm is a key predictor of survival.[9 24] However, cardiac arrest of cardiac origin is much more likely to have an initial VF rhythm and 1 month survival than cardiac arrest of non-cardiac origin.[7] Therefore, in this study, OHCA of cardiac origin was analysed (figure 1) while controlling for confounding by the cause of cardiac arrest. In addition, plausible confounding by the first recorded rhythm was further controlled by performing sensitivity analyses in the subgroup of patients with initial VF/pulseless VT. The present study shows that the variation in the 1 month outcomes among the types of bystander was independent of all of the variables analysed, including Utstein patient and process elements. This finding suggests that there is room to improve survival in OHCA of cardiac origin.

The present study shows that bystander CPR, regardless of the type of bystander, was an important predictor of 1 month outcomes in patients with OHCA of cardiac origin. However, only 50.2% (2969/5912) of family members and 47.0% (621/1322) of friends/colleagues/passersby who witnessed cardiac arrest performed CPR (online supplementary eTable 8). Therefore, a strategy to increase the frequency of bystander CPR should improve survival in OHCA of cardiac origin. Bystander CPR and defibrillation were associated with lower percentages of brain damage or nursing home admission and death from any cause in Denmark.[25] In addition, among patients with OHCA of cardiac origin who received bystander CPR, 71.8% (2131/2969) and 68.9% (428/621) received chest compression-only CPR by a family member or friend/colleague/passerby, respectively (online supplementary eTable 8). However, the rate of 1 month survival with a favourable neurological outcome was 2-fold higher (37.8% (235/621) vs 18.4% (546/2,969)) and the time interval from collapse to call was shorter in patients who received bystander CPR by a friend/colleague/passerby than in patients who received bystander CPR by a family member (online supplementary eTable 8). Therefore, improving the performance of bystander CPR by a family member may help to improve survival. On the other hand, among citizen bystanders who witnessed cardiac arrest but did not perform bystander CPR, about 29% (854/2943) of family members and 16% (113/701) of friends/colleagues/passersby received dispatcher instructions (online supplementary eTable 8). Among citizen bystanders who witnessed a cardiac arrest and performed bystander CPR, a much higher proportion of family members received dispatcher instructions

than friends/colleagues/passersby (75.5% (2242/2969) vs 51.0% (317/621), online supplementary eTable 8). Therefore, dispatcher instructions were not related to the poor survival in OHCA of cardiac origin witnessed by a family member.

We should consider the location of bystander CPR. Family members were likely to perform bystander CPR in their home, be older and more home-bound. These factors may be associated with the poor outcomes of patients with OHCA of cardiac origin, however, the detailed background of bystanders was not included in the All-Japan Utstein Registry.

We found that, among patients with OHCA of cardiac origin who received bystander CPR, the proportions of patients who received defibrillation using a public-access AED were 10.6% (66/621) and 1.1% (32/2969) for patients witnessed by a friend/colleague/passerby and those witnessed by a family member, respectively (online supplementary eTable 8). This finding indicates that the relationship between the bystander and the patient was linked to the location of the arrest.[21] In fact, a population-based study involving OHCA of cardiac aetiology with and without a bystander witness between 1998 and 2001 in Osaka Prefecture of Japan reported that most (74.2% (5561/7494)) cardiac arrests occurred in a private residence, and the proportion of a first-recorded VF/VT rhythm was much higher for cardiac arrest in a public place or workplace (25.2% and 23.9% vs 6.2%).[26] In countries other than Japan, most OHCA of cardiac origin also occurred in a private home/residence,[24 27] and cardiac arrest in a public place is much more likely to have VF or pulseless VT than cardiac arrest in the home.[28] However, access to a home AED, compared with reliance on conventional resuscitation methods, did not significantly improve overall survival in patients at an intermediate risk of sudden cardiac arrest.[29]

This study had some limitations. First, detailed data on the patient backgrounds were not available. Therefore, it is not clear whether or not patients witnessed by family member or friend/colleague/passerby differed with respect to risk factors for cardiac arrest,[1] lifestyle or proactivity in participating in social events.[21] Second, demographic data on bystanders were not available. A witness friend/colleague/passersby may be younger[21] and more trained in CPR. The rate of CPR training among lay people decreases with the age of the bystander. Therefore, studies on causal factors of the poor survival following cardiac arrest witnessed by a family member are needed to improve survival, which is important considering that most citizen-bystander-witnessed cardiac arrests are witnessed by family members.

In conclusion, we found that patients with OHCA of cardiac origin witnessed by a friend, colleague or passerby showed good 1 month survival and a favourable 1 month neurological outcomes compared with patients witnessed by a family member, independent of the characteristics of the patient and the response time. Efforts to increase the frequency and performance of bystander CPR by a family member may help to improve 1 month outcomes.

**Author affiliations**
[1]Cardiology, Fukuoka University, Fukuoka, Japan
[2]Biochemistry, Fukuoka University, Fukuoka, Japan
[3]Department of Epidemiology and Biostatistics, Translational Medical Center, National Center of Neurology and Psychiatry, Kodaira, Japan
[4]Cardiology, Shizuoka General Hospital, Shizuoka, Japan
[5]Department of Cardiovascular Medicine, Graduate School of Medicine, Kyoto University, Kyoto, Japan
[6]Cardiovascular Center, Surugadai Nihon University Hospital, Chiyoda-ku, Japan

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**Contributors** All authors meet all four criteria for authorship. YS and BZ had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: BZ, S-iM. Acquisition, analysis, or interpretation of data: YS, BZ, S-iM. Drafting of the manuscript: BZ, S-iM. Critical revision of the manuscript for important intellectual content: NY, HN, TKuw, KN, SY, KS, S-iM. Statistical analysis: YS, BZ. Obtained funding: S-iM, KS. Administrative, technical or material support: YS, HN, TKim, KN, SY, KS. Study supervision: SY, KS, S-iM.

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**Competing interests** None declared.

**Patient consent for publication** Not required.

**Ethics approval** The study protocol was approved by the Ethics Committee of Fukuoka University (FU-#00000403).

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data sharing statement** No additional data are available.



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