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TITLE PAGE

Impact of EMS Call Timing on Bystander CPR and Survival After Cardiac Arrest in Care Facilities

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ABSTRACT

Aim: The impact of pre- versus post-arrest emergency calls from care facilities on out-of-hospital cardiac arrest (OHCA) outcomes remains unclear. This study examined how call timing and time of day influence bystander cardiopulmonary resuscitation (BCPR) and 1-month survival.

Methods: We conducted a nationwide retrospective cohort study from 2017 to 2022. We analyzed 27,222 witnessed OHCAs of presumed cardiac origin in adults aged ≥65 years in care facilities. Pre-arrest calls were defined as cases in which the witnessed time occurred after the EMS call time; post-arrest calls were those in which the witnessed time was the same as or earlier than the call time. The primary outcome was 1-month survival and the secondary was BCPR rate. Propensity score matching and logistic regression were used for survival analysis.

Results: Of all cases, 10,789 (39.6%) were preceded by pre-arrest calls. BCPR was less frequent in pre-arrest than post-arrest cases (43.3% vs. 84.4%; $p<0.01$). Survival was highest during daytime (8.0%) and lowest at night (3.3%). Nighttime occurrence (adjusted odds ratio=0.45, confidence interval=0.40–0.51) and pre-arrest calls (0.78, 0.68–0.89) independently predicted lower survival.

Conclusion: Early EMS activation alone is insufficient. Continuous dispatcher guidance

and improved night-shift preparedness in care facilities may enhance OHCA outcomes.

INTRODUCTION

An ageing population presents a global challenge, particularly in developed countries with increasing life expectancy. Japan, with an ageing rate of nearly 30% in 2022, is one of the world's fastest-ageing societies [1]. As a result, the number of older adults residing in care facilities continues to grow, and these facilities have become critical sites for emergency medical services (EMS), as out-of-hospital cardiac arrests (OHCAs) frequently occur among residents. Approximately 9% of OHCAs in Japan are reported in nursing homes or similar facilities [2–4]. In this study, "care facilities" refer to long-term care institutions in Japan, broadly comparable to nursing homes in the United States, although the level of medical and daily-life support may vary across facility types.

In Japan, care facilities typically operate without on-site physicians [5]. During daytime hours, nurses and multiple care workers are present, whereas night shifts are usually staffed by only a small number of care workers, with nurses often unavailable on-site or providing on-call coverage only [6]. The BLS training is not mandatory nationwide, and participation rates vary across facilities [7]. These differences in staffing and training may influence the timely recognition of cardiac arrest and the initiation of bystander cardiopulmonary resuscitation (BCPR).

Survival after OHCA in care facilities remains poor, with 1-month survival rates of only 1.7–2.6% [8,9]. Witnessed arrests, timely BCPR, and automated external defibrillator (AED) use are associated with improved outcomes [10], but prior studies have rarely addressed contextual factors such as staffing patterns, facility-specific procedures, or call timing [11].

Temporal factors are particularly important. Nighttime OHCAs have consistently worse survival compared with daytime, mainly due to reduced staffing, fewer witnesses, and delays in initiating resuscitation [12–14]. In care facilities, procedural inefficiencies—such as requiring supervisor approval before contacting EMS—may further prolong recognition and response [15]. Conversely, recognition of prodromal symptoms and earlier EMS activation are associated with better neurological outcomes [16].

In Japan, EMS personnel cannot terminate resuscitation in the prehospital setting unless the patient is clearly dead by social criteria such as rigor mortis. Although resuscitation may be withheld when a valid Do-Not-Attempt-Resuscitation (DNAR) order is confirmed by the attending physician, the EMS generally must initiate and continue resuscitation upon arrival. This differs from many EMS systems in North America and Europe that allow termination of resuscitation based on DNAR orders or standardized termination of resuscitation rules, making the timing of EMS activation particularly important in Japanese care-facility OHCAs.

Emergency calls made before the onset of cardiac arrest (pre-arrest calls) represent a distinct but underexplored phenomenon. Although such calls might allow earlier EMS arrival, their impact on BCPR provision and survival remains unclear. Therefore, this nationwide study investigated how EMS call timing (pre- vs. post-arrest) and time of day influence BCPR and 1-month survival among witnessed OHCAs in older adults residing in Japanese care facilities.

METHODS

Study design

This retrospective, population-based cohort study included patients aged ≥65 years who experienced witnessed out-of-hospital cardiac arrest (OHCA) of cardiac origin in older care facilities. The study protocol was reviewed and approved by the ethics committee of Niigata University of Health and Welfare (Approval No.: [19447-241217]). All study methods were carried out in accordance with relevant guidelines and regulations. The requirement for informed consent was waived by the Ethics Committee of Niigata University of Health and Welfare because this study analyzed anonymized secondary data.

Study population and setting

Japan, with a population of approximately 125 million as of 2022, covers an area of 378,000 km² and has an aging rate of 28.9%. Emergency medical services (EMS) are organized at the municipal level, comprising 723 fire headquarters, 1,719 fire stations, and 5,328 ambulances as of 2022 [2]. The Ministry of Internal Affairs and Communications oversees EMS operations, including ambulance services.

EMS operations and prehospital care

In Japan, ambulances are staffed by three crew members, including at least one emergency lifesaving technician (ELST). ELSTs perform advanced medical interventions for patients with OHCA, including defibrillation, airway management, and intravenous access. Specially trained ELSTs can also perform tracheal intubation and administer adrenaline. EMS personnel are dispatched from centralized communication centers to provide care and transport patients.

Data collection

Baseline data were retrospectively obtained from the Fire and Disaster Management Agency (FDMA) database, which contains nationwide EMS records. Use of the FDMA database required an official application and was approved by the agency. All fire departments across Japan submit their EMS records electronically to the Ministry of Internal Affairs and Communications, where the data undergo multiple verification and correction processes before being finalized as official statistics. Although data reliability was lower in the early years of registration, input accuracy by EMS personnel has improved in recent years, increasing the reliability of the data. In addition, the FDMA applies a standardized data-cleaning procedure based on its official Data Cleaning Basic Policy. System- or conversion-related errors are corrected when possible or queried with the respective fire department for confirmation. When the proportion of errors for a specific department or data item exceeds a predefined threshold, the FDMA requests re-verification and correction. All datasets also undergo prefectural-level review before finalization. For the present study, cases with missing or implausible values in essential variables—such as EMS call timing and outcomes—were excluded to ensure analytical validity.

The dataset included 34,099,989 EMS-transported cases and 778,807 OHCA cases between January 2017 and December 2022. Data variables included patient demographics (age, sex); event characteristics (timing of cardiac arrest relative to the call, BCPR status); operational metrics such as the witness-to-call interval, EMS response time (call-to-arrival interval); and on-scene time (arrival-to-departure interval). Witness time is a required field in the Utstein-style template and is obtained by EMS personnel at the scene or during transport through interviews with bystanders such as facility staff or family members.

In this study, "pre-arrest calls" were defined as EMS calls made before cardiac arrest was formally recognized by bystanders or facility staff. Specifically, cases in which the witnessed time (estimated arrest time) occurred after the EMS call time were classified as pre-arrest calls. This term indicates that an emergency call was placed prior to the explicit recognition of arrest, and does not imply that CPR was performed before the onset of arrest. In contrast, "post-arrest calls" were defined as EMS calls made after the recognition of cardiac arrest, that is, when the witnessed time was the same as or earlier than the EMS call time.

Outcome measures

The primary outcome was 1-month survival following OHCA in the care facilities. One-month survival was determined through follow-up surveys conducted by each fire department with the receiving hospital approximately 1 month after the incident. The secondary outcome was the provision of BCPR, defined as chest compressions initiated before EMS arrival. The presence or absence of BCPR was confirmed by EMS personnel upon patient contact, based on whether resuscitation efforts were already in progress at the scene.

Participants

Eligible cases were selected according to predefined criteria. We included adults aged 65 years or older who experienced witnessed out-of-hospital cardiac arrest of presumed cardiac origin within a care facility and for whom essential time variables, including the EMS call time and witnessed time, were available. Cases were excluded if they had inconsistent data linkage, an unknown event location, an occurrence outside a care facility, age under 65 years, a non-cardiac etiology, unwitnessed arrest, or an unknown time of arrest. After applying these criteria, a total of 27,222 patients were included in the final analysis, as detailed in Figure 1.

Classification criteria

Each fire station reports detailed timelines and patient information on cardiac arrest cases to the FDMA, and these data are handled with strict confidentiality. In this study, the time of the emergency call was categorized into three 8-hour periods: midnight/early morning (12:00 a.m.–7:59 a.m.), daytime (8:00 a.m.–3:59 p.m.), and evening/night (4:00 p.m.–11:59 p.m.). This classification was based on the data in prior studies demonstrating that physiological, psychological, and operational conditions vary substantially across shift types, particularly between night and daytime work [17,18]. In addition, such 8-hour divisions align with common rotating shift systems in long-term care and public safety occupations and support balanced statistical comparisons across time periods [18,19].

Statistical analysis

Categorical variables were analyzed using the chi-squared test, and continuous variables were compared using the Kruskal–Wallis test. Characteristics of OHCA cases were compared across the three time periods. In all analyses, the time of the emergency call was treated as a categorical exposure variable using the three predefined 8-hour periods: midnight/early morning (00:00–07:59), daytime (08:00–15:59), and evening/night (16:00–23:59). These categories were consistently applied to descriptive analyses, logistic regression models, and subgroup analyses. The relationship between the timing of the emergency call (pre-arrest vs. post-arrest) and prehospital interventions, including BCPR, was also assessed.

To evaluate the effect of time of day on 1-month survival, time was dichotomized into daytime (8:00 a.m.–3:59 p.m.) and nighttime (4:00 p.m.–7:59 a.m.). Propensity score matching was performed using 1:1 nearest-neighbor matching with a caliper width of 0.2 of the standard deviation of the logit of the propensity score, implemented in JMP Pro® version 18. Covariates included in the propensity score model—patient age and sex, region, and temporal factors (weekday/weekend, year, month)—were selected a priori based on their recognized clinical relevance as baseline characteristics that can influence OHCA prognosis. Variables that occur after the exposure (e.g., BCPR, dispatcher-assisted CPR, initial rhythm, EMS time intervals, and transport destination) were intentionally excluded to avoid overadjustment, in accordance with principles of causal inference. Multivariable logistic regression was then conducted on the matched cohort to identify independent predictors of 1-month survival. Covariate balance before and after propensity score matching was evaluated using standardized mean differences (SMDs). The results are presented in Supplementary Table 1.

To further explore mechanisms, we examined the association between call timing and the likelihood of receiving BCPR. Multivariable logistic regression was performed including patient age and sex, weekday/weekend, region, and an interaction term between call timing (pre- vs. post-arrest) and time of occurrence (daytime vs. nighttime). Propensity score methods were not applied in this model, as BCPR represents a post-exposure outcome and adjustment for subsequent variables could bias the effect estimate.

Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were reported for all models. A two-sided p-value <0.05 was considered statistically significant. All analyses were performed using JMP Pro®, version 18 (SAS Institute, Cary, NC, USA).

RESULTS

Study population

As illustrated in Figure 1, 27,222 patients meeting the inclusion criteria were selected for analysis from the initial pool of 778,807 patients. We excluded cases with unmatched during registry linkage (n=143,313), unknown site of occurrence (n=1,405), non–care facility cases (n=522,648), age <65 years (n=2,762), non-cardiac origin (n=37,094), unwitnessed cases (n=44,301), and time of cardiac arrest was unknown (n=62). These exclusions were made to ensure that the analysis focused on witnessed cardiac-origin OHCAs in care facilities, with complete linkage and reliable event-site information.

A total of 27,222 OHCA cases that occurred at care facilities in Japan between January 2017 and December 2022 were included in the final analysis (Figure 1). Of these, 6,993 cases (25.7%) reported during midnight/early morning, 12,363 (45.4%) during daytime, and 7,866 (28.9%) during evening/night. The crude 1-month survival rates were 3.3% for midnight/early morning, 8.0% for daytime, and 3.8% for evening/night.

Differences in OHCA characteristics by time of day

As shown in Table 1, emergency calls before the onset of cardiac arrest were most frequently made during midnight/early morning (2,970/6,993 cases, 42.5%), followed by evening/night (3,127/7,866, 40.0%), and daytime (4,692/12,363, 37.9%). The proportion of bystander-witnessed arrests was highest during daytime (84.5%), followed by evening/night (83.5%), and midnight/early morning (82.4%). However, despite earlier notification, the proportion of bystander CPR (BCPR) was lowest during midnight/early morning (63.4%), intermediate during evening/night (67.3%), and highest during daytime (71.3%). Dispatcher-assisted CPR (DA-CPR) implementation rates did not differ significantly between the time periods (p=0.261). The proportion of shockable initial rhythms was highest during daytime (4.6%) and lowest during midnight/early morning (2.6%). Transportation to tertiary (Level-3) hospitals was slightly more frequent during evening/night and midnight/early morning (both 27.7%) than during daytime (26.1%). Median EMS response and on-scene times were the longest during midnight/early morning (10 min and 13 min, respectively), compared to those during daytime (9 min and 12 min).

Impact of emergency call timing on prehospital interventions

When cases were classified according to whether the emergency call was made before or after the onset of cardiac arrest (Table 2), 10,789 cases (39.6%) were pre-arrest calls and 16,433 (60.4%) were post-arrest calls. The BCPR was significantly less frequent in the pre-arrest group (43.3% vs. 84.4%). Similarly, DA-CPR was less common in the pre-arrest group (28.3% vs. 65.5%). Bystander-witnessed status was markedly lower in the pre-arrest group (59.3% vs. 99.7%). Median EMS response time was longer in the pre-arrest group (10 min vs. 9 min), and on-scene time was also slightly longer (13 min vs. 12 min). The proportion of shockable initial rhythms was slightly lower in the pre-arrest (3.1%) than in the post-arrest group (3.8%). Transport to tertiary (Level-3) hospitals was slightly less common in the pre-arrest group (71.6% vs. 74.0%). Age, sex, and day of the week did not differ significantly between the groups.

Importantly, among pre-arrest call cases that progressed to cardiac arrest before EMS arrival (59.3%, n=6,394), the rate of BCPR was still markedly lower compared with post-arrest call cases, despite the earlier activation of EMS.

Predictors of 1-month survival

To control for confounding factors, propensity score matching was performed between daytime and nighttime OHCA cases. Standardized differences improved substantially across most covariates after matching (Supplementary Table 1). Multivariable logistic regression analysis of the matched cohort (Figure 2) showed that nighttime occurrence remained independently associated with lower odds of 1-month survival compared with daytime (OR=0.44, 95% CI=0.39–0.49). Increasing age was inversely associated with survival (OR=0.95, 95% CI=0.95–0.96), and female sex also showed a modest reduction in survival compared with male (OR=0.89, 95% CI=0.80–0.99). Pre-arrest emergency calls were independently related to poorer survival (OR=0.78, 95% CI=0.70–0.87). Furthermore, OHCA events occurring on weekends were associated with lower survival compared with weekdays (OR=0.79, 95% CI=0.70–0.90).

Association between call timing and BCPR

The BCPR was performed in 84.4% of post-arrest calls compared with 43.3% of pre-arrest calls (Table 2). Using post-arrest calls as the reference category, pre-arrest calls were associated with a significantly lower likelihood of receiving BCPR (unadjusted OR = 0.14, 95% CI = 0.13–0.15). As presented in Figure 3, in cases with DA-CPR, the BCPR was performed less frequently in pre-arrest calls than in post-arrest calls (2,267/3,053, 74.3% vs. 9,801/10,757, 91.1%; $p < 0.001$). In cases without DA-CPR, BCPR was also less frequent in pre-arrest calls than in post-arrest calls (2,405/7,736, 31.1% vs. 4,071/5,676, 71.7%; $p < 0.001$).

In multivariable logistic regression (Figure 4), both nighttime occurrence (16:00–07:59) (OR = 0.76, 95% CI = 0.72–0.81) and pre-arrest calls (OR = 0.14, 95% CI = 0.13–0.15) were independently associated with a lower likelihood of BCPR. The interaction between nighttime and pre-arrest call timing was significant (p = 0.0056), indicating a compounded risk for reduced BCPR. Patient age (OR = 1.00, 95% CI = 0.996–1.004), sex (OR = 1.00, 95% CI = 0.94–1.07), and weekend occurrence (OR = 0.98, 95% CI = 0.92–1.04) were not significantly associated with BCPR provision.

Interaction between nighttime and emergency call timing on BCPR

Logistic regression analysis including an interaction term between nighttime and call timing showed a statistically significant interaction (χ^2=7.46, $p< 0.01$). Nighttime occurrence (vs. daytime) was associated with lower odds of BCPR (OR=0.76, 95% CI=0.72–0.81), and pre-arrest calls were associated with markedly reduced BCPR likelihood (OR=0.14, 95% CI 0.13–0.15). The significant interaction term indicates that the negative impact of pre-arrest call timing on BCPR was amplified during nighttime hours (Supplementary Table 2).

DISCUSSION

Unexpected findings on pre-arrest emergency calls

This study revealed a novel and counterintuitive finding: pre-arrest calls were more frequent during nighttime, but they were associated with lower rates of BCPR and poorer 1-month survival. Notably, even among pre-arrest cases that progressed to cardiac arrest before EMS arrival, bystander CPR was often not initiated. This tendency was particularly evident in cases without DA-CPR, where the gap in BCPR between pre-arrest and post-arrest calls was markedly larger than in cases with DA-CPR. These results indicate that early EMS activation alone does not guarantee timely recognition and intervention.

Why pre-arrest calls may hinder timely intervention

Several mechanisms may explain this paradoxical association. In some cases, cardiac arrest occurred after the call but before EMS arrival, and bystanders failed to recognize the deterioration. Furthermore, some witnesses may have considered that calling EMS fulfilled their responsibility, thereby delaying further actions such as CPR—the so-called "call-and-wait phenomenon." These tendencies may be exacerbated at night, when staffing levels are reduced and procedures take longer. Although BLS training rates among care facility staff in Japan are relatively high, prior work has shown that correct CPR execution requires not only knowledge but also confidence, situational judgment, and institutional support [20]. Staff may hesitate to initiate CPR when the arrest is not clearly recognized, when they fear causing harm, or when organizational protocols require confirmation from supervisors before beginning resuscitation. In addition, advance care planning and DNAR preferences—common among residents of long-term care facilities—may contribute to hesitation if staff are uncertain about whether CPR is appropriate in a given case [21, 22]. Takei et al. reported that pre-arrest calls were associated with poorer survival, likely due to delays in recognizing arrest and initiating CPR [23]. Another study indicated that institutional routines in care facilities can also contribute to delays in CPR initiation [24]. Our stratified analysis further supports these interpretations, showing that BCPR performance in pre-arrest calls was markedly lower than in post-arrest calls, particularly when DA-CPR was not provided. This suggests that dispatcher involvement may play a key role in compensating for recognition delays or hesitation by facility staff. Together, these findings emphasize that timely recognition and intervention after the call are just as important as the timing of the call itself. Continuous DA-CPR support may help maintain CPR quality, and post-call monitoring may be especially critical during nighttime [25].

Interaction between time of day and call timing

Our analysis demonstrated that the combination of nighttime occurrence and pre-arrest calls was the most unfavorable scenario, where opportunities for recognition and response were diminished. Although early EMS activation would be expected to improve outcomes, its benefit was lost when immediate recognition and bystander action were lacking. Prior studies have shown that off-hours are associated with lower survival due to human-related delays, such as the need to consult supervisors [24]. Strengthening DA-CPR protocols to include continuous guidance and assessment until EMS arrival may help bridge these gaps, particularly in high-risk time windows [25,26].

Determinants of survival after OHCA in care facilities

In the multivariable logistic regression following propensity score matching, younger age was positively associated with 1-month survival, whereas nighttime occurrence and pre-arrest calls were independently associated with worse outcomes. In this analysis, shockable rhythm and BCPR were excluded from the adjustment set because they lie on the causal pathway between exposure (call timing, time of day) and outcome. Excluding such post-exposure variables allowed a more appropriate estimation of the direct effects of call timing and time of day on survival.

Clinical and system-level implications

Our findings indicate that early EMS activation alone is insufficient to improve outcomes unless followed by timely on-site recognition and intervention. Staff training in care facilities should emphasize not only the recognition of prodromal symptoms but also readiness to act immediately after the call. A notable concern is the "call-and-wait phenomenon" [24,27], in which staff disengage after making the call, assuming their responsibility is complete. Simulation-based training, clear procedural guidelines, and continuous dispatcher communication until EMS arrival may help counteract this tendency and ensure readiness for immediate CPR if deterioration occurs [24,27].

Limitations

This study has several limitations. This study has several limitations. First, because of its retrospective design, causal inferences cannot be established. Although propensity score matching and multivariable regression were applied to reduce confounding, matching was performed only for the primary outcome (1-month survival), and small residual standardized mean differences (<10%) remained, indicating the possibility of residual confounding. Second, some potentially important variables—such as staff experience, CPR quality, real-time staffing levels, and the presence of family members—were not available in the registry and may have influenced the results. Third, outcomes were limited to 1-month survival; neurologically intact survival and long-term functional outcomes could not be assessed. Fourth, the study population consisted solely of older-adult care facilities in Japan. Differences in cultural practices, EMS systems, staffing structures, and care protocols may limit generalizability to other countries. Fifth, documentation of prodromal symptoms, arrest recognition, and call timing relied on EMS records and bystander interviews, and these may be subject to recall error. Witness times in particular may include estimations rather than precise measurements. Sixth, the classification of pre-arrest calls may involve inherent subjectivity. Facility staff may activate EMS at various stages of patient deterioration, meaning that the interval between the call and the actual arrest can vary from several minutes to nearly immediate onset. This variability raises the possibility of misclassification between pre- and post-arrest calls and may have influenced the observed associations. In addition, the registry does not include information on advance care planning or DNAR status. As a result, it was not possible to identify residents who may not have been intended candidates for resuscitation. Even in such cases, however, staff who initiated an EMS call would have perceived the situation as emergent, and if cardiac arrest was subsequently recognized, CPR would generally be expected until EMS arrival. This limitation should be considered when interpreting the lower BCPR rate observed in the pre-arrest group. Finally, facility-level characteristics—such as staffing ratios, monitoring intensity, emergency response protocols, and internal decision-making processes—were not recorded in the registry. These institutional factors may have affected both the likelihood of making a pre-arrest call and whether BCPR was initiated, introducing potential selection bias.

CONCLUSION

Early EMS activation alone does not ensure favorable outcomes in care facilities. Pre-arrest calls, especially at night, were linked to lower BCPR rates and poorer survival.

Continuous dispatcher support and staff readiness for immediate CPR are essential to bridge the gap between early calling and effective intervention.

Author Contributions:

GT and YT had full access to all data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: YT. Data acquisition: GT and YT. Analysis and interpretation of data: All authors. Drafting of the manuscript: GT and YT. Statistical analysis: GT and YT. Study supervision: YT. All authors read and approved the final manuscript.

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Data availability

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

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FIGURE LEGENDS

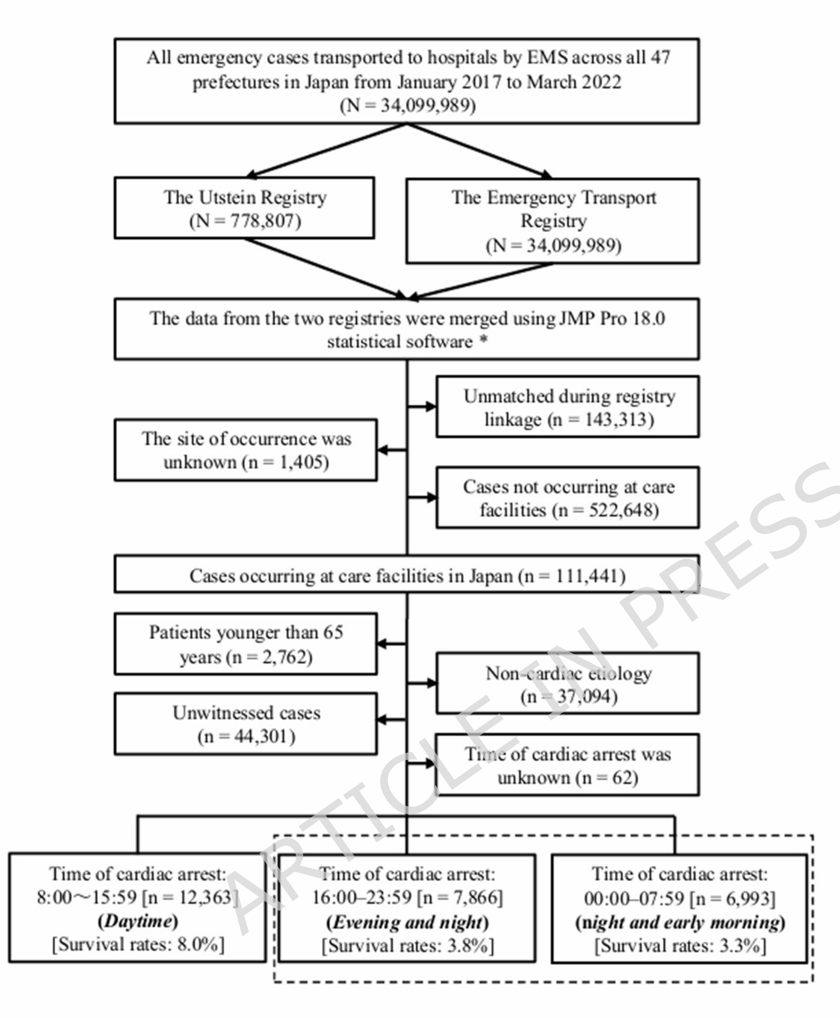

Figure 1. Flowchart of case selection and classification

Foot note:

The Utstein Registry records only cases of cardiac arrest among all emergency transports. In contrast, the Emergency Transport Registry includes all emergency transport data, including cases of cardiac arrest. However, the Utstein Registry uses a specific format focused on cardiac arrest-related data, whereas the Emergency Transport Registry does not collect cardiac arrest-specific data but includes information not found in the Utstein Registry. Cases that could not be merged between the two registries (n = 143,313) were excluded. Linkage was performed using prefecture of occurrence, date and time of occurrence, EMS on-scene arrival time, EMS hospital arrival time, and patient age and sex; unsuccessful linkage was mainly due to missing or inconsistent entries in these variables.

* The data points matched when merging the two registries included the prefecture of occurrence, date and time of occurrence, EMS on-scene arrival time, EMS hospital arrival time, as well as the patient's age and gender. Factors preventing successful merging included missing records for these variables in one of the registries.

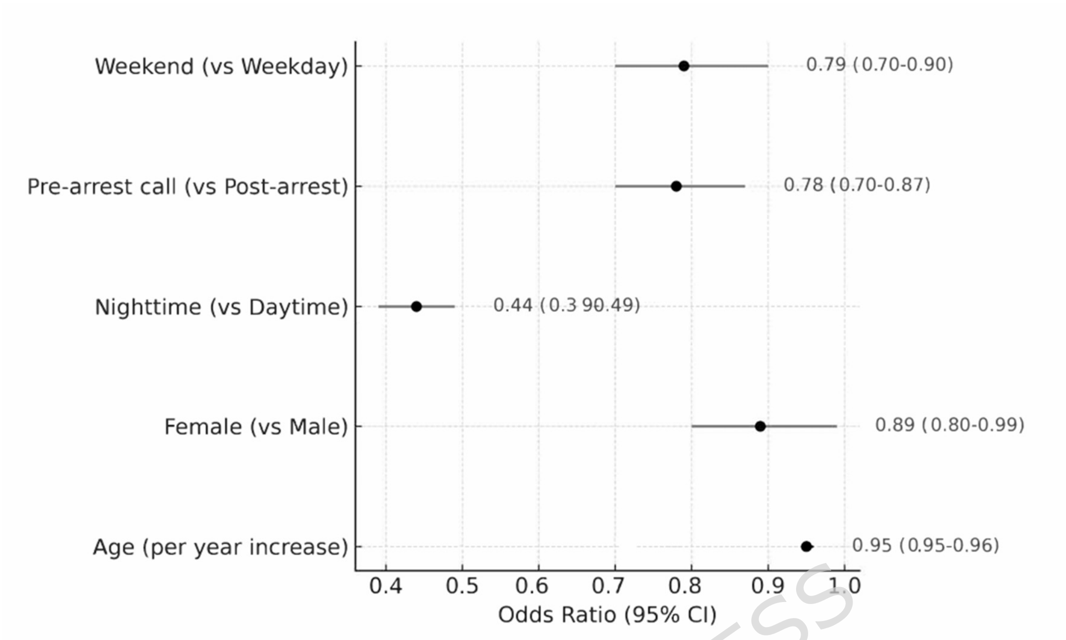

Figure 2: Predictors of 1-month survival

Abbreviations:

- CI: Confidence interval

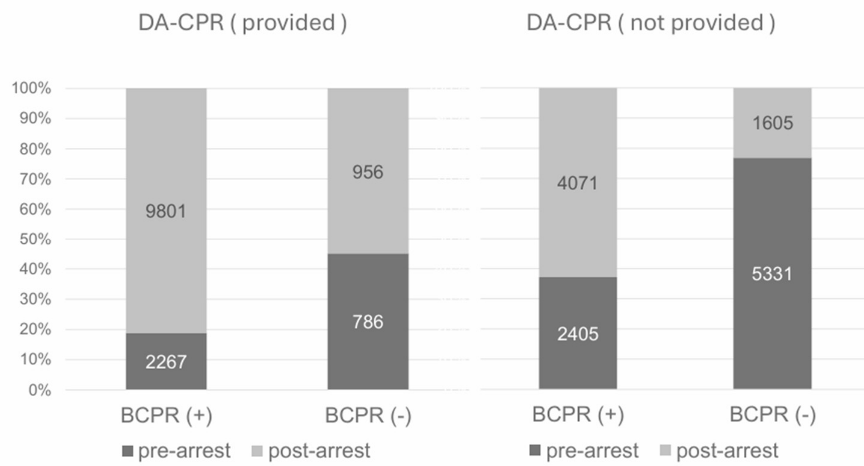

Figure 3: Bystander CPR rates by call timing and dispatcher-assisted CPR status.

Abbreviations:

- BCPR: Bystander cardiopulmonary resuscitation
- DA-CPR: Dispatcher-assisted cardiopulmonary resuscitation
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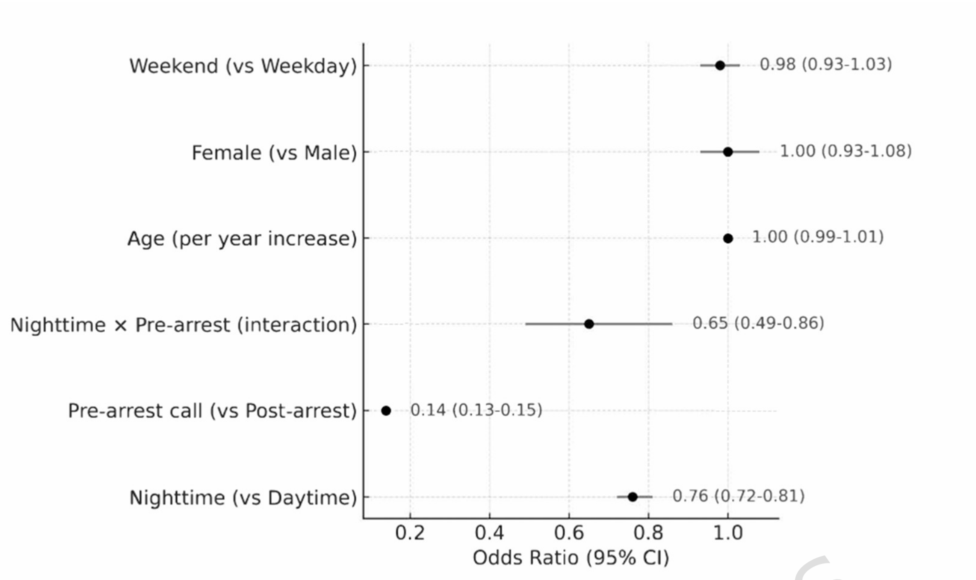

Figure 4: Predictors of bystander CPR

Abbreviations:

- CI: Confidence interval

Table 1. Baseline characteristics of patients with OHCA in elderly care facilities by call timing

Factors	Daytime 8:00 a.m.-3:59 p.m. N = 12,363	Evening and night 4:00 p.m.-11:59 p.m. n = 7,866	Midnight and early morning 12:00 a.m.-7:59 a.m. n = 6,993	p-value
Day of the week				＜ 0.01
Weekday (Monday-Friday)	8,938 (72.3%)	5,403 (68.7%)	4,995 (71.4%)	

Weekend (Saturday-Sunday)	3,425 (27.7%)	2,463 (31.3%)	1,998 (28.6%)	
Patient's age, median (IQR)	88 years (83-93)	89 years (84-93)	88 years (83-93)	< 0.01
Patient sex				< 0.01
Male	4,434 (35.9%)	2,676 (34.0%)	2,553 (36.5%)	
Female	7,929 (64.1%)	5,190 (66.0%)	4,440 (63.5%)	
Witness status				< 0.01
By bystander	10,450 (84.5%)	6,569 (83.5%)	5,760 (82.4%)	
By EMS	1,913 (15.5%)	1,297 (16.5%)	1,233 (17.6%)	
Timing of emergency call				< 0.01
Pre-arrest (before onset)	4,692 (37.9%)	3,127 (40.0%)	2,970 (42.5%)	
Post-arrest (after onset)	7,671 (62.1%)	4,739 (60.0%)	4,023 (57.5%)	
DA-CPR instruction				0.26
Provided	6,215 (50.3%)	3,994 (50.8%)	3,601 (51.5%)	
Not provided	6,148 (49.7%)	3,872 (49.2%)	3,392 (48.5%)	
BCPR				< 0.01
Provided	8,819 (71.3%)	5,291 (67.3%)	4,434 (63.4%)	
Not provided	3,544 (28.7%)	2,575 (32.7%)	2,559 (36.6%)	
Initial cardiac rhythm				< 0.01
Shockable	564 (4.6%)	218 (2.8%)	179 (2.6%)	
Non-shockable	11,799 (95.4%)	7,648 (97.2%)	6,814 (97.4%)	
Destination hospital type				0.02
Level-3 hospital	3,232 (26.1%)	2,178 (27.7%)	1,938 (27.7%)	
Level-1/2 hospital	9,131 (73.9%)	5,688 (72.3%)	5,055 (72.3%)	
Time factors, median				

(IQR)				
EMS response time	9 min (7-11)	9 min (8-11)	10 min (8-12)	< 0.01
On-scene time	12 min (9-15)	12 min (9-16)	13 min (10-18)	< 0.01

Abbreviations: OHCA, out-of-hospital cardiac arrest; EMS, emergency medical service; BCPR, bystander cardiopulmonary resuscitation; ROSC, return of spontaneous circulation. Pre-arrest: EMS call placed before cardiac arrest onset. Post-arrest: EMS call placed after cardiac arrest onset. Destination hospital type refers to the classification of emergency care facilities in Japan (Level-1: primary, Level-2: secondary, Level-3: tertiary emergency center).

Table 2. Comparison between pre- and post-arrest emergency calls

Factors	Pre-arrest calls n = 10,789 (39.6%)	Post-arrest calls n = 16,433 (60.4%)	p-value	Crude OR (CI)
Day of the week			0.71	
Weekday (Monday–Friday)	7,650 (70.9%)	11,686 (71.1%)		0.99 (0.93–1.04)
Weekend (Saturday–Sunday)	3,139 (29.1%)	4,747 (28.9%)		Reference
Patient age, median (IQR)	88 (83–93)	88 (84–93)	0.07	1.00 (0.99–1.01)
Patient sex			0.43	
Male	3,860 (35.8%)	5,803 (35.3%)		1.02 (0.97–1.07)
Female	6,929 (64.2%)	10,630 (64.7%)		Reference

DA-CPR instruction			< 0.01	
Provided	3,053 (28.3%)	10,757 (65.5%)		0.21 (0.20–0.22)
Not provided	7,736 (71.7%)	5,676 (34.5%)		Reference
BCPR*			< 0.01	
Provided	4,672 (43.3%)	13,872 (84.4%)		0.14 (0.13–0.15)
Not provided	6,117 (56.7%)	2,561 (15.6%)		Reference
Witness status †			< 0.01	
by bystander	6,394 (59.3%)	16,386 (99.7%)		0.004 (0.003–0.006)
by EMS	4,395 (40.7%)	48 (0.3%)		Reference
Initial cardiac rhythm			< 0.01	
Shockable	333 (3.1%)	628 (3.8%)		0.80 (0.70–0.92)
Non-shockable	10,456 (96.9%)	15,805 (96.2%)		Reference
Destination hospital type			< 0.01	
Level-3 hospital	7,723 (71.6%)	12,151 (74.0%)		0.88 (0.84–0.93)
Level-1/2 hospital	3,066 (28.4%)	4,282 (26.0%)		Reference
Time factors, median (IQR)				
EMS response time (min)	10 (8–12)	9 (7–11)	< 0.01	0.99 (0.99–1.00)
On-scene time (min)	13 (9–17)	12 (9–16)	< 0.01	0.99 (0.99–1.00)

Abbreviations:

BCPR: bystander cardiopulmonary resuscitation; DA-CPR: dispatcher-assisted cardiopulmonary resuscitation; EMS: emergency medical services; IQR: interquartile range;

OHCA: out-of-hospital cardiac arrest.

* BCPR is defined according to the Utstein criteria as chest compressions performed by laypersons or care-facility staff before EMS arrival. CPR initiated by EMS personnel is not included.

† Witness status indicates who first witnessed the cardiac arrest (bystander or EMS personnel) and does not denote the provider of CPR.