

# Advantage of CPR-first over call-first actions for out-of-hospital cardiac arrests in nonelderly patients and of noncardiac aetiology

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## Advantage of CPR-first over call-first actions for out-of-hospital cardiac arrests in nonelderly patients and of noncardiac aetiology

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## **Abstract**

**Aim:** To assess the benefit of immediate call or cardiopulmonary resuscitation (CPR) for survival from out-of-hospital cardiac arrests (OHCAs).

**Methods:** Of 952,288 OHCAs in 2005–2012, 41,734 were bystander-witnessed cases without prehospital involvement of physicians but with bystander CPR (BCPR) on bystander's own initiative. From those OHCAs, we finally extracted the following three call/BCPR groups: immediate Call + CPR (N = 10,195, emergency call/BCPR initiated at 0 or 1 min after witness, absolute call–BCPR time interval = 0 or 1 min), immediate Call-First (N = 1,820, emergency call placed at 0 or 1 min after witness, call-to-BCPR interval = 2-4 min), immediate CPR-First (N = 5,446, BCPR initiated at 0 or 1 min after witness, BCPR-to-call interval = 2-4 min). One-month neurologically favourable survivals were compared among the groups. Critical comparisons between Call-First and CPR-First groups were made considering arrest aetiology, age, and bystander–patient relationship after confirming the interactions among variables.

**Results:** The overall survival rates in immediate Call + CPR, Call-First, and CPR-First groups were 11.5, 12.4, and 11.5%, respectively without significant differences ( $p = 0.543$ ). Subgroup analyses by multivariate logistic regression following univariate analysis disclosed that CPR-first group is more likely to survive in subgroups of noncardiac aetiology (adjusted odds ratio; 95% confidence interval, 2.01; 1.39–2.98) and of nonelderly OHCAs (1.38; 1.09–1.76).

**Conclusions:** Immediate CPR-first action followed by an emergency call without a large delay may be recommended when a bystander with sufficient skills to perform CPR witnesses OHCAs in nonelderly people and of noncardiac aetiology.

Word count: 250

Key words: cardiopulmonary resuscitation; survival

## **INTRODUCTION**

A single rescuer is recommended to perform cardiopulmonary resuscitation (CPR) for 1 or 2 minutes before making an emergency call for paediatric cardiac arrests, particularly those with respiratory origin [1–6]. This “CPR-first” basic life support (BLS) action may be considered when the causes of unconsciousness or unresponsiveness might be trauma and submersion [5–7]. Therefore, adult victims may undergo this CPR-first BLS action because of the bystander’s approach to first aid in a special situation.

The “call-first versus CPR-first” debate was popular in the 1990s [8]. Current guidelines from the American Heart Association [9] recommend CPR-first BLS only in paediatric arrests of presumed noncardiac aetiology, not characterized by sudden collapse. General recommendation for call-first BLS action after the 2000 Guidelines was based on the recognition that early defibrillation is essential in the treatment of sudden cardiac arrest and the call-first BLS enables early arrival of emergency medical technicians (EMTs) equipped with defibrillator [10–12].

This observational cohort study aimed to evaluate the benefit of call-first and CPR-first BLS actions on the outcomes of out-of-hospital cardiac arrests (OHCAs) receiving bystander CPR (BCPR) on bystander’s own initiative [without dispatcher-assisted CPR (DA-CPR)] but no large delay in emergency call or BCPR. We categorized immediate BLS actions into three groups based on the interval between the emergency call and BCPR initiation and compared the outcomes among the three groups.

## **METHODS**

### *Study design and setting*

We obtained the consent from the Japanese Fire and Disaster Management Agency (FDMA) to analyse the OHCA data prospectively collected between 2005 and 2012. The study, comprising members of the

Ishikawa Medical Control Council and their collaborators, was conducted after obtaining an approval by the review board of Ishikawa Medical Control Council.

Japan has a population of 128 million. In 2012, the aged population ( $\geq 65$  years) was 30.79 million. In 2012, there were 770 fire departments with 5,004 ambulance teams [13].

The Japanese emergency medical service is a one-tiered system. EMTs are not allowed to terminate resuscitation on the field unless an OHCA patient has definitive post-mortem changes. All EMTs are allowed to use automated external defibrillators (AEDs) for OHCA patients and deliver defibrillation according to the shock-advisory AED message. All paramedics are authorized to perform resuscitation procedures, such as use of airway adjuncts and peripheral infusion with Ringer's lactate. However, only authorized and specially trained paramedics are permitted to insert tracheal tubes and administer intravenous adrenaline to adult OHCA victims. All EMTs resuscitate the OHCA patients according to manuals based on Japan Resuscitation Council guidelines [14].

#### *Selection of Participants*

The FDMA database includes the following Utstein-style information [15, 16]: patient background, arrest witnesses, aetiology, BCPR initiation, type of bystander, DA-CPR, initial cardiac rhythm, estimated time of collapse (only in bystander-witnessed OHCA cases) and BCPR initiation (only in BCPR-performed OHCA cases), recorded times of EMT CPR initiation and EMT arrival at patients and hospitals, 1-month (1-M) survival and 1-M neurologically favourable survival (cerebral performance category [CPC], 1 or 2) [17]. The time points of collapse and BCPR initiation were determined by EMT's interview of the bystander. The physicians in collaboration with EMTs clinically determined cardiac or noncardiac origin. Fire departments obtained information on 1-M survivals from hospital records. The FDMA logically checked data in the registry system and requested the fire departments to correct and complete the data when necessary. The FDMA database includes no data for callers' background or for patients' information obtained by dispatchers from callers.

As shown in Figure 1, from 952,288 OHCA recorded in 2005–2012, we excluded 547,573 cases of unwitnessed OHCA. Of 377,715 witnessed OHCA, prehospital physician involvement was recorded in 55,298 and unknown in 117 cases. We excluded these cases due to the following reasons: 1) Some cases received prehospital advanced life support performed by on-duty physicians [16]; 2) Most of these OHCA were witnessed in medical offices and sanatoriums or during physician's home visits; 3) The physicians played primary roles in the treatment and transportation of patients; 4) According to the Utstein recommendations [15, 16], physicians on duty should not be categorized as bystanders. Of the remaining 322,300 witnessed OHCA, the arrest was witnessed by EMTs in 66,208 cases. Of the 256,092 bystander-witnessed OHCA, 10,151 were unknown for critical time factors, and 189 for backgrounds of OHCA; we excluded these cases. We further excluded 137,881 cases without BCPR and 65,217 cases with BCPR in compliance to DA-CPR. The remaining 41,734 bystander-witnessed OHCA that received BCPR on bystander's own initiative were analysed based on the time interval distribution between collapse and emergency call or BCPR. In 29,778 cases, either emergency call was placed or BCPR was initiated at 0 or 1 min after patient's collapse. We classified these cases in three groups: immediate Call + CPR group (N = 10,195; emergency call and CPR 0 or 1 min after collapse; absolute time interval between call and BCPR = 0 or 1 min), immediate Call-First group (N = 1,820; emergency call placed after less than 1 min of witness; call-to-CPR interval = 2–4 min), immediate CPR-First group (N = 5,446; bystander CPR within 1 min of witness; CPR-to-call interval = 2–4 min).

### *Outcome*

The primary end point was the neurologically favourable 1-M survival (CPC = 1 or 2).

### *Analysis*

We compared the backgrounds of OHCA and rates of neurologically favourable survival at 1-M among the three groups for all OHCA extracted using univariate analysis followed by simple multinomial logit analysis. After performing interaction tests among the OHCA groups, aetiology of arrest, age, and bystander–patient

relationship, we made additional comparisons in the survival between the Call-First and CPR-First groups for the following subgroups: cardiac and noncardiac subgroups, elderly ( $\geq 65$  years) and nonelderly subgroups, family and other bystander subgroups. In each subgroup, we compared the advantage of call-first or CPR-first BLS and determined the other factors associated with neurologically favourable 1-M survival using multivariate logistic regression analysis.

In univariate analyses of nominal variables, the chi-square test with and without Yates' correction was applied. The results were confirmed by Fisher's exact test. Continuous variables were analysed by the Kruskal–Wallis test followed by Dunn's multiple comparisons. We calculated unadjusted odds ratios (ORs) and 95% confidence intervals (CIs) for significant variables using profile likelihood. Multivariate logistic regression analyses were employed to determine adjusted ORs and 95% CI and to elucidate the factors associated with neurologically favourable 1-M survival. When building the model for neurologically favourable 1-M survival, we sequentially added the variables known to be persuasively associated with survival, including aetiology of arrest, initial rhythm, response time interval after emergency call [15,16,18], and other significant factors in univariate analysis to obtain the lowest Bayesian information criterion. The generalized  $R^2$  was computed as a measure for fitness of the final model. We analysed all data using JMP version 11 Pro (SAS Institute, Cary, NC, USA) and the software by Preacher [19]. For each analysis, the null hypothesis was evaluated at a two-sided significant level of  $p < 0.05$ .

## RESULTS

### *Characteristics of OHCA in the three immediate BLS (call/BCPR) groups*

As shown in Table 1, there were significant and large differences in patient's age, sex, initial ECG rhythm, BCPR type, bystander–patient relationship, and time interval between patient collapse and EMT arrival at patient among the three BLS groups. The immediate CPR-First group was characterized by old patient age, long time interval between call and EMT arrival at patients, high incidence of conventional BCPR (combination of ventilations and compressions), low proportions of male patients, shockable initial rhythm,

and family bystander. The immediate Call-First group was characterized by high proportions of male patients, shockable initial rhythm, defibrillation with public AED, family bystander, and a low incidence of conventional BCPR.

*Comparisons of neurologically favourable 1-M survival rate among the three BLS groups*

When analysed for all extracted OHCA (Figure 2), the neurologically favourable 1-M survival rate did not differ among the three groups in univariate (Chi-square with Yates' correction;  $p = 0.569$ , Fisher's exact test;  $p = 0.537$ , upper panel A) or multivariate logistic regression analysis (lower panel B) including significant factors in univariate analysis (Supplementary Table 1). Significant interactions were found between Call/CPR groups and arrest aetiology (interaction test,  $p = 0.001$ ), age ( $p = 0.043$ ), or bystander-patient relationship ( $p = 0.019$ ): the advantages (or disadvantages) of Call-First and CPR-First groups were significantly altered by the three factors whereas that of the Call + CPR group were not. Therefore, Call-First and CPR-First groups were compared in the following subgroup analyses.

When univariate analyses were performed for arrest aetiology (Figure 3A), Call-First group was more likely to survive than the CPR-First group (unadjusted OR; 95% CI, 1.26; 1.05–1.52) in the subgroup of presumed cardiac aetiology whereas CPR-First group was more likely to survive than the Call-First group (unadjusted OR; 95% CI, 1.59; 1.10–2.30) in the subgroup of presumed noncardiac aetiology. However, multivariate logistic regression analyses (Figure 3B) revealed that only the latter observation was significant (2.01; 1.39–2.98).

Subgroup analyses were performed for age subgroups: <65 years and  $\geq 65$  years (Figure 4). For the subgroup  $\geq 65$ y, there was no significant difference in survival between Call-First and CPR-First groups in either univariate (chi-square with Yates' correction;  $p = 0.281$ , Fisher's exact test;  $p = 0.259$ ) or multivariate analyses ( $p = 0.854$ ). For the subgroup <65y, the CPR-First group was more likely to survive than Call-First group in both univariate (1.40; 1.11–1.76) and multivariate analyses (adjusted OR; 95% CI, 1.38; 1.09–1.76). In this subgroup, there was a significant interaction between Call/CPR groups and arrest aetiology

(interaction test,  $p < 0.001$ ), and further subgroup analyses were performed. When arrest aetiology was noncardiac, the CPR-First group was more likely to survive than the Call-First group (unadjusted OR; 95% CI, 3.74; 1.45–9.61, adjusted OR; 95% CI, 4.31; 2.38–8.48). In contrast, when arrest aetiology was cardiac, there was no significant difference between the two groups (using the Call-First group as reference, unadjusted OR 95% CI, 0.87; 0.69–1.10, adjusted OR; 95% CI, 0.94; 0.75–1.30). Furthermore, the advantage of CPR-First action increased when the patients were younger (for age group of  $<20$  years, unadjusted OR; 95% CI, 3.74; 1.46–9.61, adjusted OR; 95% CI, 3.74; 1.55–1.05).

Lastly, subgroup analyses were performed for the bystander–patient relationship subgroup (Figure 5). For the family bystanders subgroup, there was no significant difference in survival between Call-First and CPR-First groups in either univariate (chi-square with Yates' correction;  $p = 0.235$ , Fisher's exact test;  $p = 0.226$ ) or multivariate analyses ( $p = 0.232$ ). For the other bystander subgroup, the CPR-First group was more likely to survive than the Call-First group in univariate (1.35; 1.11–1.64) analysis; however, the advantage of CPR-First action was not confirmed by multivariate logistic regression analysis (1.14; 0.92–1.41).

## DISCUSSION

After the “call-first versus CPR-first” debate in the 1990s [8], BLS guidelines stated that a single rescuer should perform 1-2 min CPR before making an emergency call for paediatric cardiac arrests, particularly those with respiratory origin [1–7]. As stated clearly in the European Resuscitation Council guidelines 2000 [7], the CPR-first BLS action should be considered when the likely cause of unconsciousness or unresponsiveness is trauma and submersion. These OHCA of noncardiac aetiology are more common in the younger population [20,21]; however, these recommendations were based mainly on theological consideration and not on clinical evidence.

DA-CPR instructions are commonly given to callers in Japan [22,23] when these callers and bystanders have not provided BCPR on victims of OHCA due to poor CPR training experience and/or lack

of confidence of their skill and judgment [23,24,25]. Since these bystanders initiated BCPR few minutes after dialling the emergency number, this action may be classified as the call-first action. However, the quality of BCPR performed by these bystanders has been reported to be poor [24]. Therefore, we first selected bystander-witnessed OHCAs that received BCPR on bystander's own initiative by excluding the cases with BCPR in compliance with DA-CPR instructions. Then, we categorized the three groups of OHCAs with immediate BLS actions according to the time interval between witness and emergency call or BCPR. The analyses among the groups suggested the advantage of bystander-initiated CPR-first BLS actions over call-first BLS actions in the immediate time (0 or 1 min after collapse) of OHCAs of noncardiac aetiology and in nonelderly patients (age < 65 years).

General recommendations for call-first BLS action after the 2000 Guidelines were made after the recognition that the call-first BLS enables early arrival of EMTs equipped with defibrillator and that early defibrillation is essential in the treatment of OHCAs, particularly those of cardiac aetiology [8]. However, the advantage of call-first BLS action, particularly for OHCAs of cardiac aetiology, should be re-evaluated because public AED has been widely introduced worldwide. In univariate analysis of this study, the Call-First group was more likely to survive than the CPR-first group when the arrest aetiology was cardiac. However, multivariate logistic regression analysis did not confirm this advantage of call-first BLS action. Furthermore, neither univariate nor multivariate logistic regression analysis disclosed advantage of Call-First actions over CPR-First actions in any other subgroup. Well-trained single rescuers or bystanders should generally start CPR when they witness almost all subgroups of OHCAs. They should keep on calling for help during BCPR and then place emergency calls without a large (BCPR-to-call interval > 4 min) delay.

BLS guidelines emphasize the importance of early defibrillation [1-7]. It is controversial whether OHCA victims should be treated with CPR before defibrillation when the AED pads are attached to the OHCA patients [27-30]. It is generally recommended that single bystander should go for AED after witnessing patient collapse only when they can see an AED at the scene [9]. Reportedly, the delay in placing an emergency call is common when bystanders use public AED [33]. A single rescuer may wonder which

action they should take first: emergency call, BCPR or going for AED. Apparently, further investigations will be necessary to determine the best sequence of emergency call, BCPR, and defibrillation with public AED for both single and multiple rescuers

There are some limitations in this study. First, the information regarding the number of bystanders involved in the BLS action in the initial phase of rescue was not obtained. Reportedly, the quality of BCPR and outcome of OHCA were affected by the number of rescuers [26,30]. Our classification of the immediate BLS actions was based only on the time interval. Therefore, it is unknown how frequently single rescuers participated to call-first and CPR-first actions. Furthermore, it is unknown whether CPR was continued or interrupted when emergency calls were made in the CPR-First group. It may be possible that CPR-first actions are simply due to lack of telephone or communicating device at the scene and that advantage of CPR-first action may be caused by higher proportion of multiple rescuers in the CPR-First group. Second, the classification of BLS actions was based on the estimated times of collapse and initiation of BCPR. Third, any parameter for CPR quality **was not** collected; this is essential in achieving better OHCA outcomes [23,31]. Finally, longer observation periods for outcomes are usually recommended; however, the outcomes were only measured at 1-M in this study [32]. Despite these limitations, this study provides the first clinical evidence for judging the advantages of call-first and CPR-first actions and suggested the importance of immediate CPR after recognition of cardiac arrests.

## **CONCLUSION**

The immediate (1 or 2 min after collapse) CPR-first BLS action followed by emergency call without a large (>4 min) delay may be recommended when a bystander with fundamental skills to initiate CPR witnesses OHCA of noncardiac aetiology and in young adults/children.

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## CONFLICT OF INTEREST STATEMENT

We have no conflict of interest to disclose.

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### **Figure Legends**

Figure 1. Flow diagram for data selection.

OHCA: out-of-hospital cardiac arrest, EMT: emergency medical technician, CPR: cardiopulmonary resuscitation, BCPR: bystander cardiopulmonary resuscitation

Figure 2. Outcome comparisons among the three BLS groups (Panel A) and factors associated with neurologically favourable 1-M survival (Panel B) in all OHCAs analysed.

OR: odd ratio, CI: confidence interval, EMT: emergency medical technician

Figure 3. Outcome comparisons between Call-First and CPR-First groups (Panel A) and factors associated with neurologically favourable 1-M survival (Panel B) in cardiac and noncardiac subgroups of OHCAs.

OR: odd ratio, CI: confidence interval, EMT: emergency medical technician

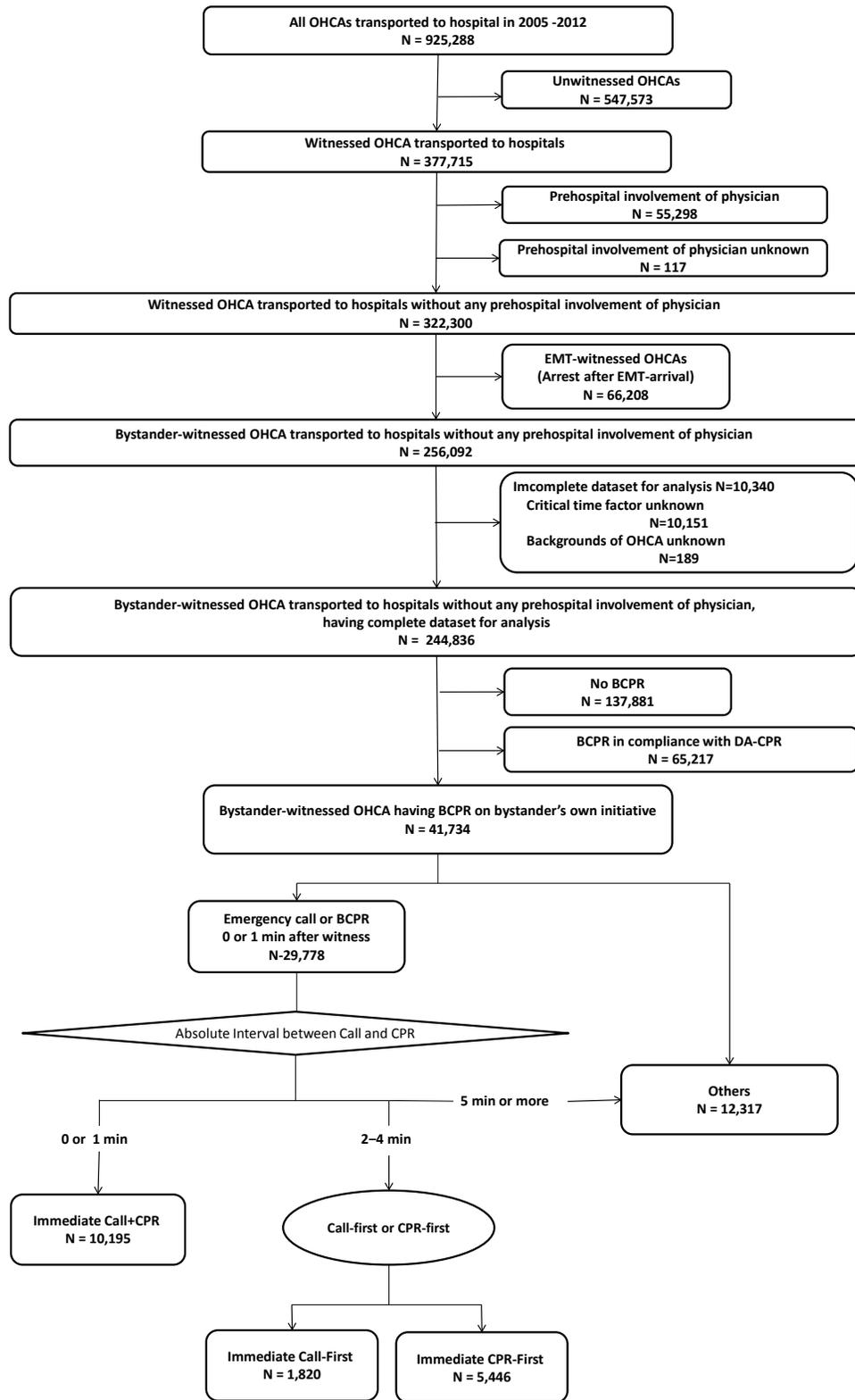
Figure 4. Outcome comparisons between Call-First and CPR-First groups (Panel A) and factors associated with neurologically favourable 1-M survival (Panel B) in two age (age  $\geq 65$  and age  $<65$ ) subgroups of OHCAs.

OR: odd ratio, CI: confidence interval, EMT: emergency medical technician

Figure 5. Outcome comparisons between Call-First and CPR-First groups (Panel A) and factors associated

with neurologically favourable 1-M survival (Panel B) in two bystander (family and others) subgroups of OHCA.

OR: odd ratio, CI: confidence interval, EMT: emergency medical technician



**Fig. 1.** Flow diagram for data selection. OHCA: out-of-hospital cardiac arrest, EMT: emergency medical technician, CPR: cardiopulmonary resuscitation, BCPR: bystander cardiopulmonary resuscitation.

**Table 1.** Backgrounds and characteristics of OHCA among the 3 groups.

| Backgrounds of OHCA   | Groups                               |                                      |                                     | p-value<br>by chi-square test<br>followed by<br>Pearson's<br>correction | Dunn's multiple comparisons for continuous variable/<br>Unadjusted OR (95% CI) for nominal variables |  |  |
|---|--------------------------------------|--------------------------------------|-------------------------------------|---|--|--|--|
|   | Immediate<br>Call +CPR<br>(N=10,195) | Immediate<br>Call-first<br>(N=1,820) | Immediate<br>CPR-first<br>(N=5,446) |   | Immediate<br>Call + CPR  | Immediate<br>Call-first                              | Immediate<br>CPR-first   |
| Patient age, y (25–75%)   | 78 y (63–87)                         | 72 y (59-82.75)                      | 81 y (67–88)                        | $p < 0.01$  | <b>Reference</b><br><b><math>p &lt; 0.001</math></b>   | <b><math>p &lt; 0.001</math></b><br><b>Reference</b> | <b><math>p &lt; 0.001</math></b><br><b><math>p &lt; 0.001</math></b> |
| Patient sex, % (N)<br>–Male   | 56.3% (5,740)                        | 65.2% (1,186)                        | 52.9% (2,879)                       | $p < 0.01$  | <b>Reference</b><br><b>0.69 (0.62–0.76)</b>  | <b>1.45 (1.31–1.61)</b><br><b>Reference</b>          | 0.87 (0.81–0.93)<br>0.60 (0.54–0.67)                                 |
| Aetiology of arrest, % (N)<br>-Presumed cardiac                             | 58.4% (5,955)                        | 60.5% (1,101)                        | 58.6% (3,192)                       | $p > 0.01$  | Reference<br>0.92 (0.83–1.02)  | 1.09 (0.98–1.21)<br>Reference                        | 1.01 (0.94–1.08)<br>0.92 (0.83–1.03)                                 |
| Initial rhythm, % (N)<br>–Shockable   | 18.6% (1,894)                        | 24.9% (453)                          | 15.4% (839)                         | $p < 0.01$  | <b>Reference</b><br>0.69(0.61–0.77)  | <b>1.45 (1.29–1.63)</b><br>Reference                 | <b>0.80(0.73–0.87)</b><br>0.55 (0.48–0.63)                           |
| Type of bystander CPR, % (N)<br>–Conventional                               | 40.1% (4,088)                        | 30.8% (560)                          | 46.6% (2,535)                       | $p < 0.01$  | <b>Reference</b><br><b>1.51 (1.35–1.68)</b>  | <b>0.66 (0.60–0.74)</b><br><b>Reference</b>          | <b>1.30 (1.22–1.39)</b><br><b>1.96 (1.75–2.19)</b>                   |
| Bystanders, % (N)<br>–Family members  | 31.0% (3,163)                        | 44.3% (806)                          | 23.3% (1,266)                       | $p < 0.01$  | <b>Reference</b><br><b>0.57 (0.51–0.63)</b>  | <b>1.77 (1.60–1.96)</b><br><b>Reference</b>          | <b>0.67 (0.62–0.73)</b><br><b>0.38 (0.34–0.43)</b>                   |
| Time interval between call and EMT arrival at patient, min, median (25–75%) | 8 min (7–11)                         | 9 min (7–11)                         | 11 min (9–13)                       | $p < 0.01$  | <b>Reference</b><br>$p = 0.404$  | $p = 0.404$<br><b>Reference</b>                      | <b><math>p &lt; 0.001</math></b><br><b><math>p &lt; 0.001</math></b> |

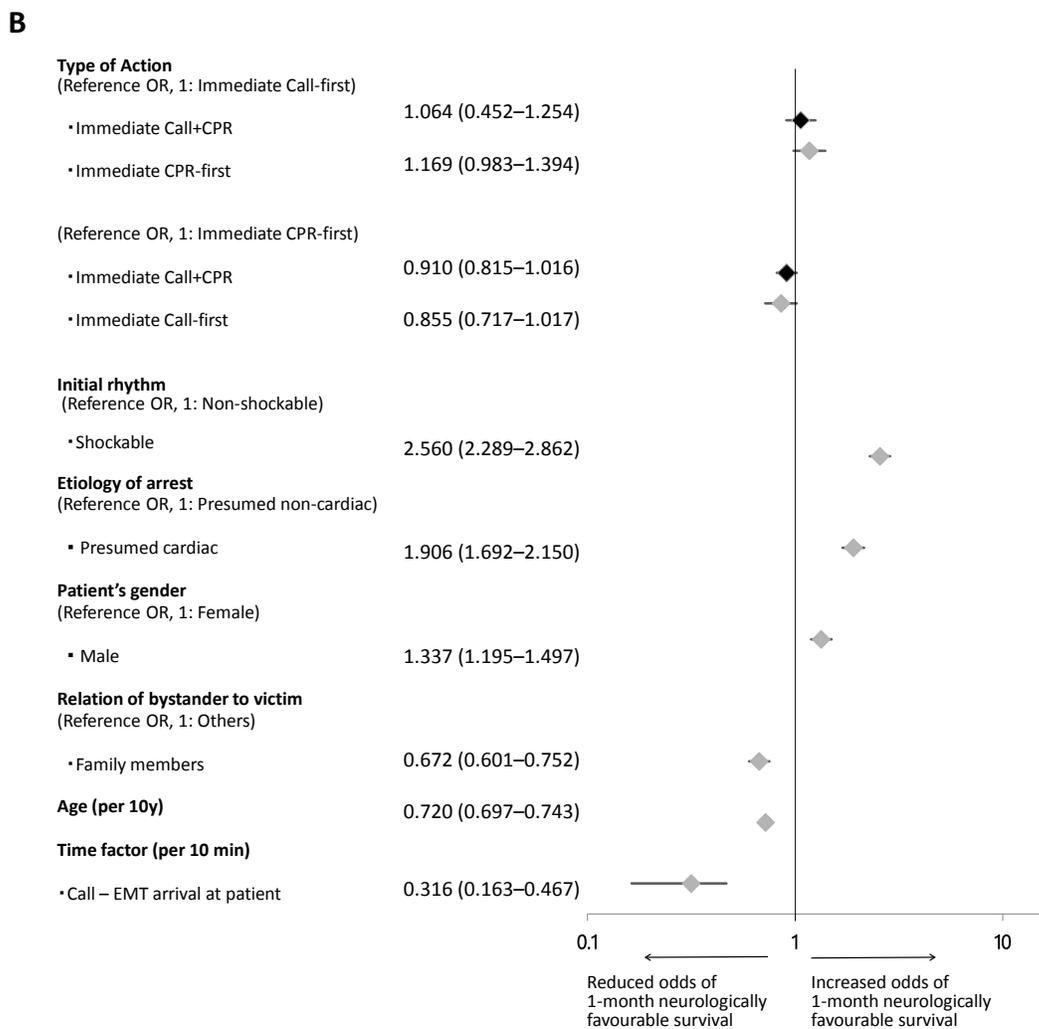
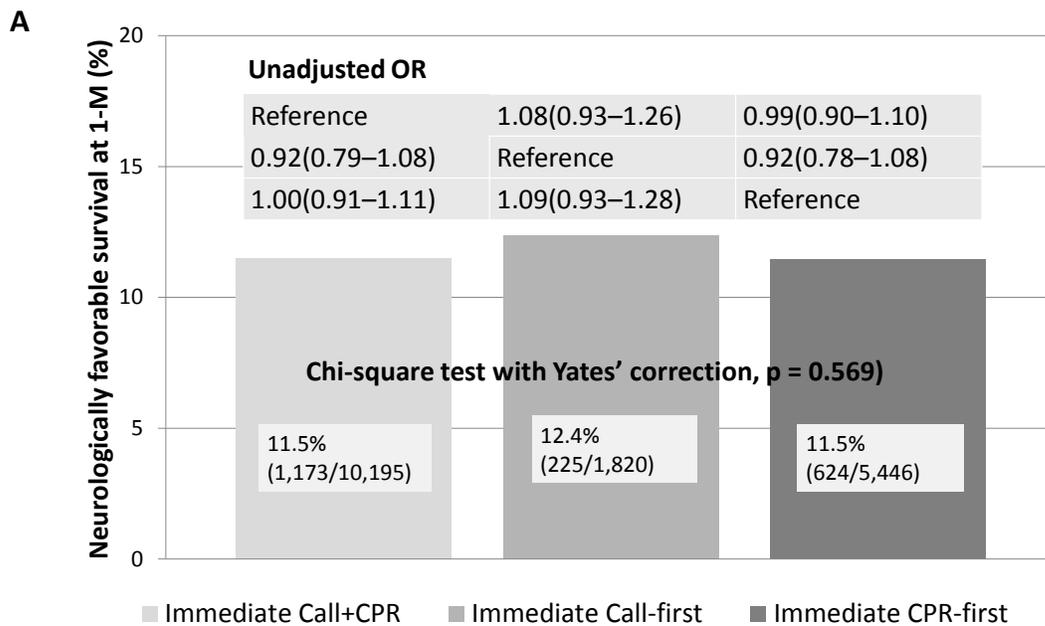
The values printed in bold style are statistically significant.

CPR: cardiopulmonary resuscitation.

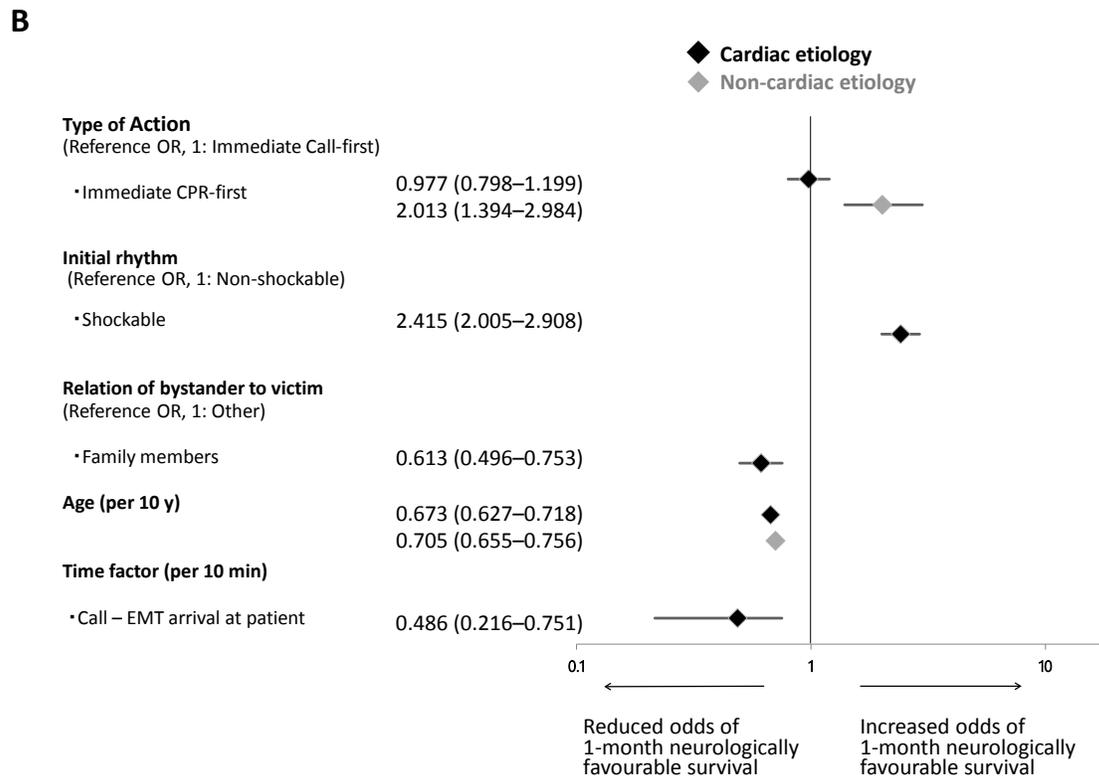
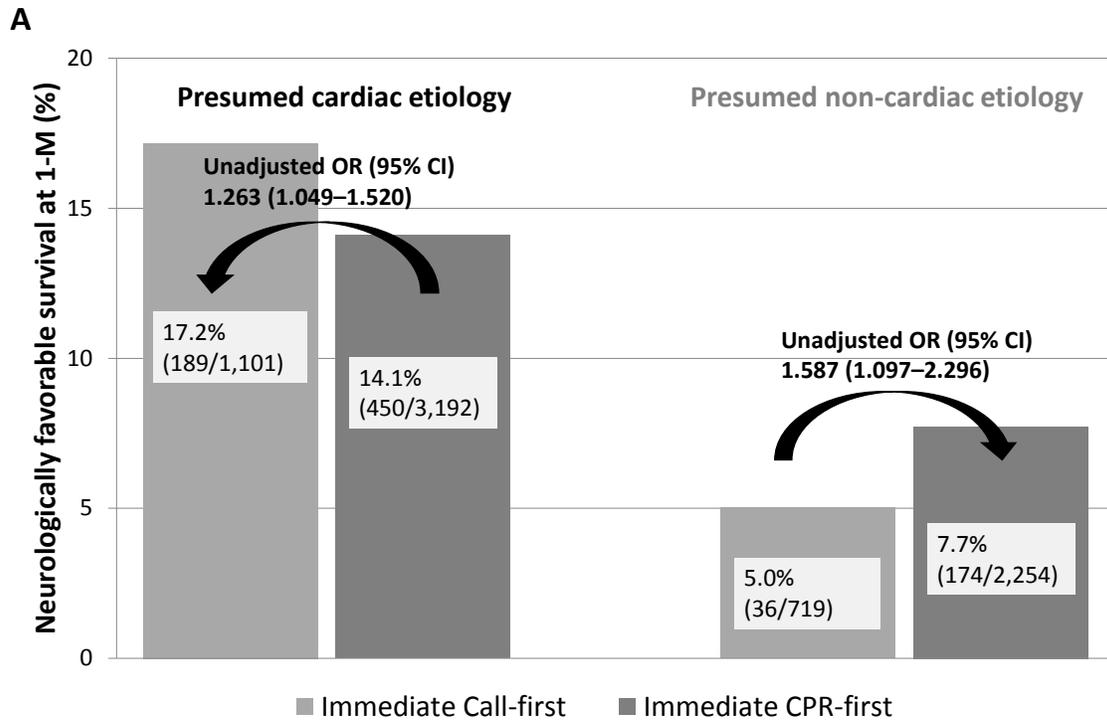
Immediate Call + CPR: emergency call/BCPR initiated at 0 or 1 min after witness, absolute call–BCPR time interval = 0 or 1 min.

Immediate Call-First: emergency call placed at 0 or 1 min after witness, call-to-BCPR interval = 2–4 min.

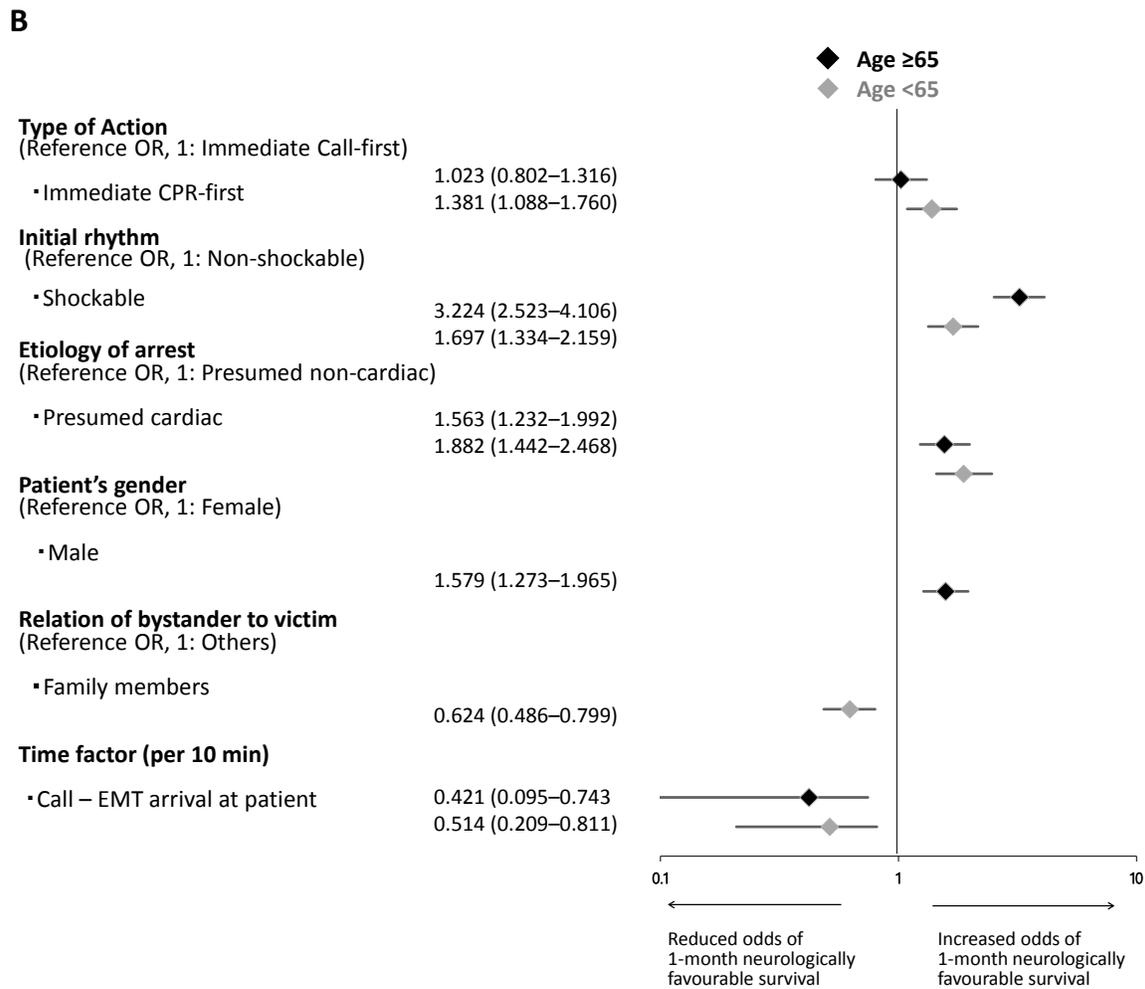
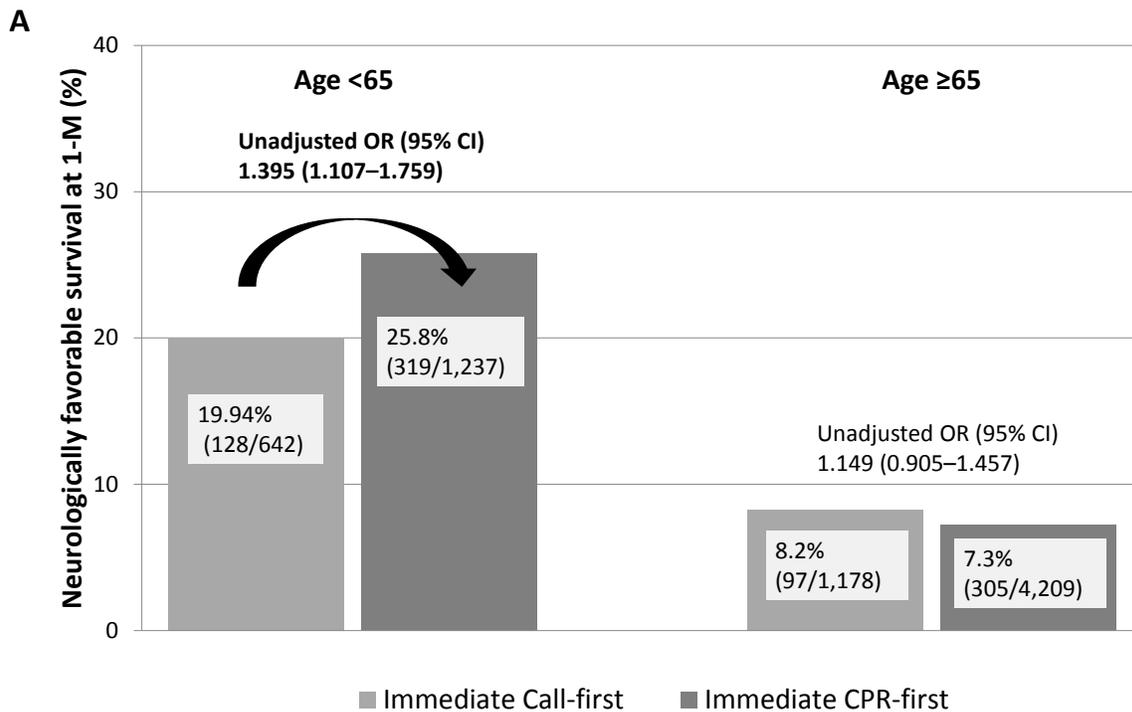
Immediate CPR-First: BCPR initiated at 0 or 1 min after witness, BCPR-to-call interval = 2–4 min patients and of noncardiac aetiology.



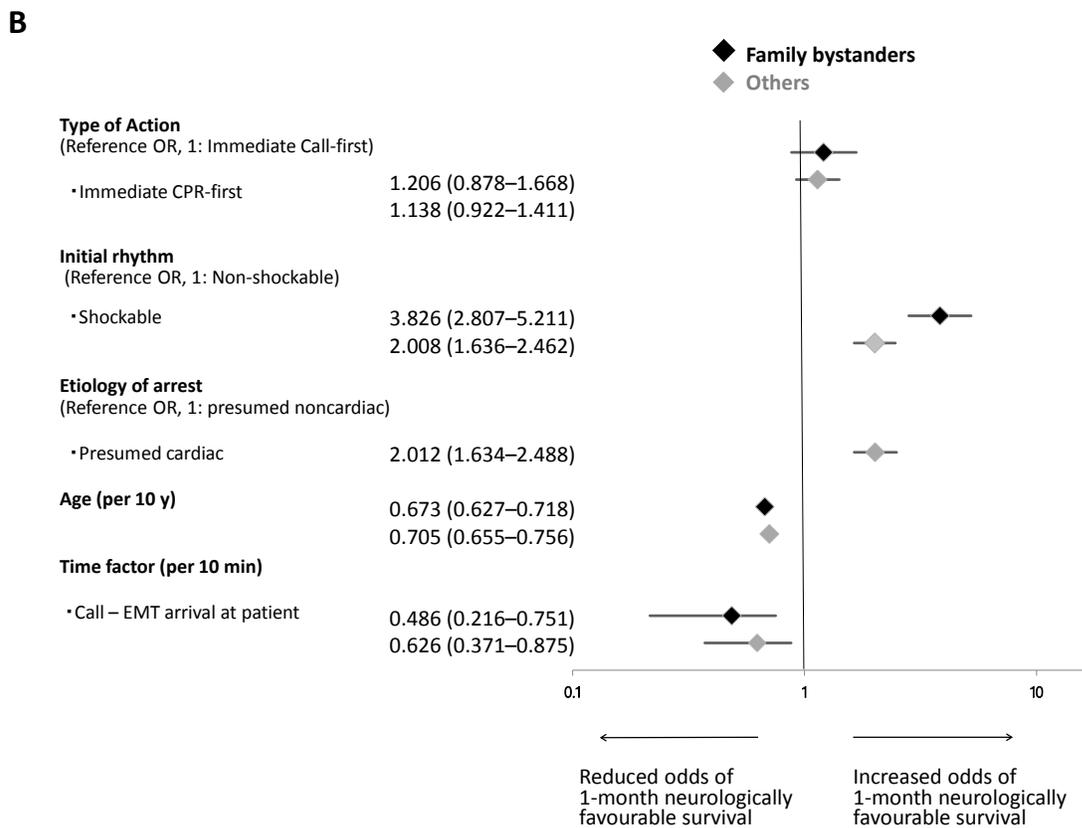
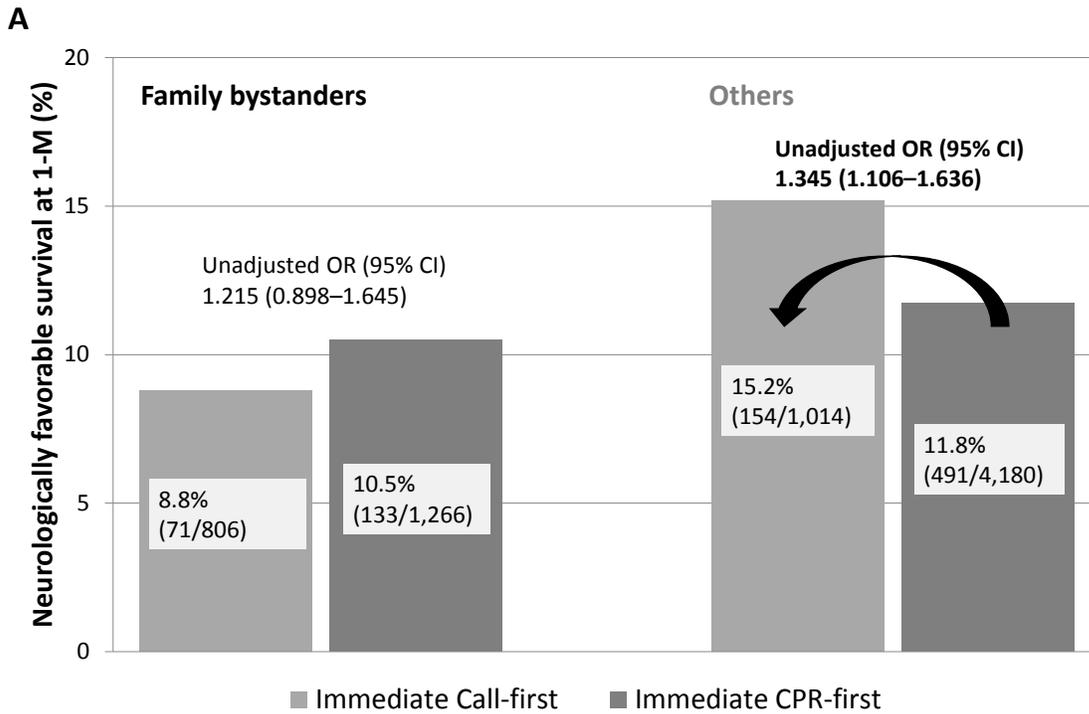
**Fig. 2.** Outcome comparisons among the three BLS groups (Panel A) and factors associated with neurologically favourable 1-M survival (Panel B) in all OHCAs analyzed. OR: odd ratio, CI: confidence interval, EMT: emergency medical technician.



**Fig. 3.** Outcome comparisons between Call-First and CPR-First groups (Panel A) and factors associated with neurologically favourable 1-M survival (Panel B) in cardiac and noncardiac subgroups of OHCA. OR: odd ratio, CI: confidence interval, EMT: emergency medical technician.



**Fig. 4.** Outcome comparisons between Call-First and CPR-First groups (Panel A) and factors associated with neurologically favourable 1-M survival (Panel B) in two age (age≥65 and age <65) subgroups of OHCA. OR: odd ratio, CI: confidence interval, EMT: emergency medical technician.



**Fig. 5.** Outcome comparisons between Call-First and CPR-First groups (Panel A) and factors associated with neurologically favourable 1-M survival (Panel B) in two bystander(family and others) subgroups of OHCA. OR: odd ratio, CI: confidence interval, EMT: emergency medical technician.