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Clinical paper

# Bystander cardiopulmonary resuscitation differences by sex – The role of arrest recognition

Sonali Munot[a,*], Janet E. Bray[b], Julie Redfern[c], Adrian Bauman[d], Simone Marschner[a], Christopher Semsarian[e], Alan Robert Denniss[f], Andrew Coggins[a,g], Paul M. Middleton[h], Garry Jennings[i], Blake Angell[j], Saurabh Kumar[a,f], Pramesh Kovoor[f], Matthew Vukasovic[g], Jason C. Bendall[k,l], T. Evens[k], Clara K. Chow[a,f,j]

**Abstract**

**Purpose**: To assess whether bystander cardiopulmonary resuscitation (CPR) differed by patient sex among bystander-witnessed out-of-hospital cardiac arrests (OHCA).

**Methods**: This study is a retrospective analysis of paramedic-attended OHCA in New South Wales (NSW) between January 2017 to December 2019 (restricted to bystander-witnessed cases). Exclusions included OHCA in aged care, medical facilities, with advance care directives, from non-medical causes. Multivariate logistic regression examined the association of patient sex with bystander CPR. Secondary outcomes were OHCA recognition, bystander AED application, initial shockable rhythm, and survival outcomes.

**Results**: Of 4,491cases, females were less likely to receive bystander CPR in private residential (Adjusted Odds ratio [AOR]: 0.82, 95%CI: 0.70–0.95) and public locations (AOR: 0.58, 95%CI:0.39–0.88). OHCA recognition during the emergency call was lower for females arresting in public locations (84.6% vs 91.6%, $p = 0.002$) and this partially explained the association of sex with bystander CPR (~44%). This difference in recognition was not observed in private residential locations ($p = 0.2$). Bystander AED use was lower for females (4.8% vs 9.6%, $p < 0.001$); however, after adjustment for location and other covariates, this relationship was no longer significant (AOR: 0.83, 95%CI: 0.60–1.12). Females were less likely to be in an initial shockable rhythm (AOR: 0.52, 95%CI: 0.44–0.61), but more likely to survive the event (AOR: 1.34, 95%CI: 1.15–1.56). There was no sex difference in survival to hospital discharge (AOR: 0.96, 95%CI: 0.77–1.19).

**Conclusion**: OHCA recognition and bystander CPR differ by patient sex in NSW. Research is needed to understand why this difference occurs and to raise public awareness of this issue.

**Keywords**: Out-of-hospital Cardiac Arrest, Cardiopulmonary Resuscitation, Patient Sex

## Introduction

Out-of-hospital cardiac arrest (OHCA) is associated with poor survival.[1–3] Bystander response, including cardiopulmonary resuscitation (CPR) and the use of an automated external defibrillator (AED), is associated with greater survival and better neurological outcomes.[4–6] However, the provision of bystander CPR varies by physical, social, and attitudinal factors related to the bystander and patient.[7,8] There is also emerging evidence that bystander response may differ depending on the patient's sex.[9–11] Lower rates of bystander CPR have been reported for females with the sex difference reported to vary depending on arrest location, patient age and other factors (e.g., bystander characteristics) Previous research from Australia from over a decade ago noted lower bystander CPR in females, however these were unadjusted estimates.[12] A more recent analysis of a larger Victorian dataset found no sex difference in receipt of bystander CPR, but noted females were less likely to receive bystander defibrillation.[13] For many OHCAs, bystander CPR relies on OHCA recognition in the emergency call, which is needed to receive

* Corresponding author at: The University of Sydney, Western Sydney (Baludarri) Precinct, Faculty of Medicine and Health, Westmead Applied Research Centre, Level 5, Block K, Entrance 10, Westmead Hospital, Hawkesbury Road, Westmead, NSW, 2145 Australia.

E-mail address: sonali.munot@sydney.edu.au (S. Munot).

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telephone CPR instructions.[14] It has been suggested that OHCA identification and misperceptions about females being in medical distress are a potential barrier in CPR provision.[15] The primary aim of this study was to assess if patients' sex is associated with bystander CPR and better understand the reasons for this. The secondary objectives were to examine whether sex was associated with bystander AED application, shockable rhythm, survival outcomes.

## Methods

This observational study examined de-identified data from the NSW Public Health Risks and Outcomes Registry (maintained by the NSW Ministry of Health) that includes prospectively collected on all OHCAs attended by NSW Ambulance.[16] Data linkage was carried out by the Centre for Health Record Linkage and it's quality verified by statisticians at the Ministry of Health and study team statistician.[16] OHCA data was collected, coded, and recorded as per the Utstein template.[17,18] NSW has the highest population of any state in Australia (8,153,000 residents as of 30 June 2022), with over three-quarters living in metropolitan areas.[19] NSW Ambulance call-takers are accredited with the International Academies of Emergency Dispatch (IAED) and use the structured call-taking system Medical Priority Dispatch System™ (MPDS).[20] OHCA calls include instructions for CPR and defibrillator retrieval. Ethics approval for this study was obtained from The University of Sydney Ethics Committee (Ref: 2021/017).

### Inclusion and exclusion criteria

Analyses were restricted to bystander-witnessed cases of arrest due to presumed medical causes that were attended by paramedics in NSW between January 2017–December 2019. Arrests from external causes (drowning, overdose, trauma), paramedic-witnessed, unwitnessed, with an advance care directive (do-not-resuscitate (DNR) order), arrests occurring in nursing homes, medical centres / GP clinics, police stations, correctional facilities/jails and ambulance stations were excluded from our analysis (Fig. 1). Patients with unknown or missing sex data were also excluded.

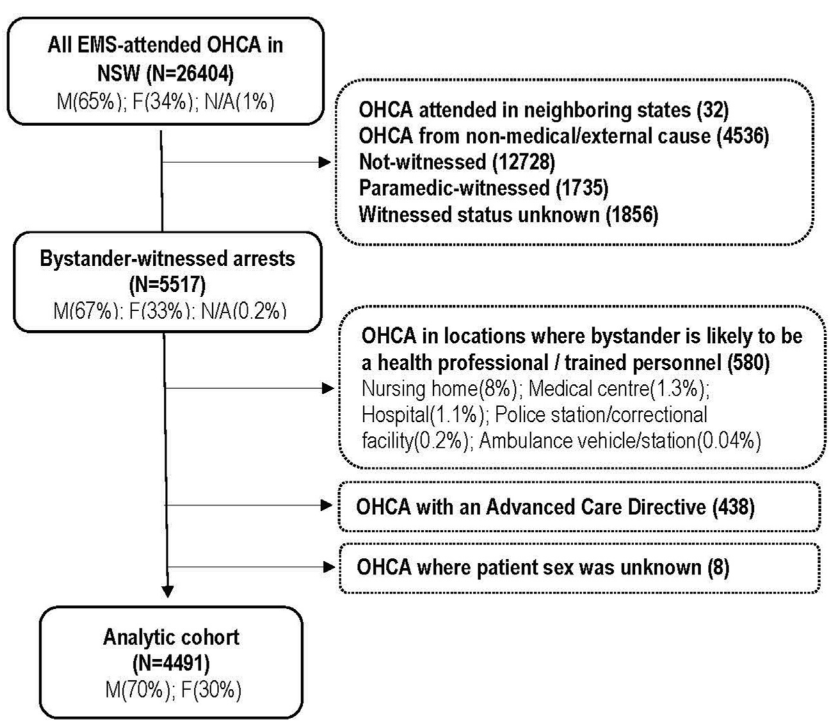
### Definition of variables

*Primary and secondary outcome variables*

Bystander CPR, defined as "CPR provided by any person who happens to be nearby and is not part of the organised emergency response system", was categorised as yes or no.[21] A small proportion of responses recorded as unknown/not stated (3.7% females; 2.9% males) were classified as 'no bystander CPR' for the purpose of our analyses. Sensitivity analyses were conducted with unknown responses excluded.

Secondary outcomes were: AED application by a bystander (defined as an AED connected to the patient prior to ambulance arrival), initial shockable rhythm, OHCA recognition documented in the emergency call, and, survival outcomes, including event survival (defined as patients with a return of spontaneous circulation on arrival at the hospital emergency department) and survival to hospital discharge.

Recognition of OHCA in the emergency call is documented in the registry as 'call-taker identified the presence of OHCA' and is a binary response (yes vs no). Emergency services call-taker assistance is known to influence bystander CPR,[7,22] but requires that the OHCA is recognized in the call. This variable was also assessed as a potential mediator between sex and bystander CPR.




*Note: EMS=Emergency Medical Services; NSW=New South Wales; OHCA: Out-of-hospital Cardiac Arrest*

**Fig. 1 – Selection of study analytic cohort.**

*Primary independent variable*

The primary independent variable was patients' biological sex, recorded as male or female.

*Covariates*

Patients' age, arrest aetiology (presumed cardiac vs other medical), witnessed status (yes vs no), arrest location (private residential vs public location), arrest site (urban vs nonurban), ambulance response time were all considered as factors that could potentially influence the association between bystander CPR and patient sex. This was based on previous studies, data availability, and clinical reasoning. These potentially confounding variables were managed by restriction/exclusion, statistical adjustment or presented as subgroups (arrest location: private residential vs public location). Arrest aetiology was collapsed into binary categories of presumed cardiac v/s other medical cause). Arrest site areas' level of remoteness (urban vs nonurban) was defined using the Accessibility and Remoteness Index of Australia (ARIA) score.[23] ARIA classifies an area as urban/metropolitan or nonurban (regional, rural) based on their relative access to services.

***Statistical analysis***

Analyses were conducted using R, version 4.1.0.[24] Descriptive statistics were calculated with categorical data reported as counts and proportions, and continuous data as medians and interquartile range (IQR). Pearson's $\chi^2$ test was used to examine group differences and the Wilcoxon rank sum test was used for continuous data. For both tests, the p-value was considered significant if below 0.05. Missing data was excluded from analysis (see Table 1 footnote). Primary analysis involved the examination of the association between patients' sex and bystander CPR. Multivariate logistic regression models were adjusted for potentially confounding variables that were retained in the model if clinically relevant and associated with bystander CPR at $p < 0.05$ (Table 2). The primary outcome was stratified by arrest location that were grouped into private residential locations (homes) versus public locations. Public locations included public building/public places (15.1%), street/road/highway (2.7%), sporting/recreation event (2.3%), vehicle (1.4%), workplace/industrial (1.4%), airport (0.7%), school/educational institution (0.4%), public transport (0.3), other- not specified (0.7%). Multivariable models for secondary outcomes use the total sample and were not split by location, given the limited sample size.

Mediation analysis was conducted to test whether the association between the patients' sex and bystander CPR could be potentially explained by recognition of OHCA during the emergency call, and this was examined using the *mediation package* in R[25] (Supplementary section 1). This required comparing regression models with and without the proposed mediator variable and involved a bootstrapping approach to arrive at an estimate of the proportion mediated.[26,27] Mediation was assessed when the following prerequisites were fulfilled: (a) the independent variable (patient sex) affects the mediator (OHCA recognition) (b) the mediating variable affects the outcome (bystander CPR).[28,29]

## Results

In the three years between January 2017 and December 2019, NSW Ambulance attended 21,836 OHCAs from a presumed medical cause (Fig. 1). Of the bystander-witnessed cohort (n = 4491), 30% were female (Table 1). Most arrests occurred in private residential locations, although this was significantly higher in females (84.6% females vs 70.7% males, $p < 0.001$) (Table 1). Four of five arrests occurred in adults over 55 years (Supplementary 2 Table S1).

**Table 1 – Distribution of key arrest/patient characteristics by patient sex in bystander-witnessed OHCA NSW January 2017–December 2019.**

| Characteristic | Study sample N = 4491 | Females N = 1369 | Males N = 3122 | p-value |
|---|---|---|---|---|
| **Arrest location** | | | | *<0.001* |
| Private residential | **3366 (75.0)** | 1158 (84.6) | 2208 (70.7) | |
| Public | **1125 (25.0)** | 211 (15.4) | 914 (29.3) | |
| **Arrest Site** Urban/metropolitan | **3024 (67.4)** | 933 (68.2) | 2091 (67.1) | 0.50 |
| **Presumed cardiac aetiology** | **2675 (59.6%)** | 744 (54.0%) | 1931 (61.9%) | *<0.001* |
| **Age (years), Median (IQR)** | **69 (58–80)** | 71 (59–82) | 68 (57–78) | *<0.001* |
| **Bystander CPR** | **3186 (71.0)** | 884 (64.6) | 2302 (73.7) | *<0.001* |
| **Bystander AED applied** | **366 (8.2)** | 66 (4.8) | 300 (9.6) | *<0.001* |
| **OHCA recognized in call** | **4001 (90.1)** | 1191 (88.5) | 2810 (90.8) | *0.017* |
| **Ambulance response time (minutes), Median (IQR)** | **9 (7–14)** | 10 (7, 14) | 9 (7, 13) | 0.06 |
| **Shockable initial rhythm** | **1565 (35.5)** | 301 (22.4) | 1264 (41.2) | *<0.001* |
| **Survived event** | **1270 (28.3)** | 394 (28.8) | 876 (28.1) | 0.60 |
| **Survived to hospital discharge** | **602 (13.8)** | 142 (10.6) | 460 (15.1) | *<0.001* |

Excluded n/a/missing: Arrest site(7); Age(36); EMS call-taker identified OHCA (51); Shockable initial rhythm (80); Survived event (0); Survived to hospital discharge (114). All n/a excluded from analysis except for Bystander CPR (140) or AED use (9) – where n/a were included in the 'No' category. Note: CPR: Cardiopulmonary resuscitation; AED: Automated External Defibrillator; IQR: Interquartile range (Q1–Q3). Differences in characteristics by location subgroup and age groups are detailed in Supplementary 2 Table S1.

**Table 2 – Univariate associations of key patient/arrest characteristics and the likelihood of receiving bystander CPR (OR and 95%CI).**

| | All arrests | Private residential location | Public location |
|---|---|---|---|
| **Arrest location** | | | |
| Public place | Reference | | |
| Private residential | 0.29 (0.24–0.34) | n/a | n/a |
| **Arrest site:** | | | |
| Urban | Reference | Reference | Reference |
| Regional/Rural | 0.86 (0.75–0.99) | 0.90 (0.77–1.04) | 0.73 (0.51–1.05) |
| **Patient sex** | | | |
| Male | Reference | Reference | Reference |
| Female | 0.65 (0.57–0.74) | 0.76 (0.66–0.88) | 0.59 (0.40–0.89) |
| **Patient age** | | | |
| (per one-year increase in age) | 0.98 (0.97–0.98) | 0.98 (0.98–0.99) | 0.99 (0.98–1:00) |
| (By age group) <55 years | Reference | Reference | Reference |
| 55–75 years | 0.65 (0.53–0.78) | 0.71(0.55–0.88) | 0.52 (0.32–0.83) |
| >75 years | 0.35 (0.29–0.43) | 0.39 (0.32–0.49) | 0.56 (0.32–0.96) |
| **Arrest aetiology** | | | |
| Presumed cardiac | Reference | Reference | Reference |
| Other medical | 0.50 (0.44–0.58) | 0.52 (0.45–0.60) | 0.73 (0.51–1.05) |
| **OHCA recognized during emergency call** | | | |
| Yes | Reference | Reference | Reference |
| No | 0.15 (0.12–0.18) | 0.13 (0.10–0.17) | 0.11 (0.07–0.18) |
| **Ambulance response time (minutes)** | | | |
| <5 | Reference | Reference | Reference |
| 5–7 | 1.64 (1.25–2.14) | 1.55 (1.13–2.14) | 3.65 (1.98–6.99) |
| 7–10 | 1.50 (1.18–1.91) | 1.52 (1.13–2.03) | 2.86 (1.71–4.80) |
| 10–14 | 1.32 (1.03–1.68) | 1.38 (1.03–1.85) | 2.69 (1.56–4.71) |
| >14 | 1.10 (0.86–1.39) | 1.19 (0.89–1.58) | 1.84 (1.10–3.07) |

Note: OR: Odds ratio; CI: Confidence interval; Arrest site (Urban vs nonurban); OHCA: Out-of-hospital cardiac arrest.

Females were older (median age: 71 vs 68 years, $p < 0.001$), and less likely to have a presumed cardiac cause than males (54.0% females vs 61.9% males, $p < 0.001$).

The majority of bystanders in private residential locations were related to the patient as compared with those in a public location (72.3% vs 6.5%, $p < 0.001$) (Supplementary 2 Table S1). The rate of OHCA recognition documented during the emergency call was significantly lower for females that arrested in a public location (84.6% vs 91.6%, $p = 0.002$), but was not significantly different for arrests in private residential locations (89.2% vs 90.5%, $p = 0.2$) (Supplementary 2 Table S1). Ambulance response times were similar for male and female patients, irrespective of location ($p = 0.06$). Compared with males, bystander CPR was significantly lower for female patients overall (64.6% vs 73.7%, $p < 0.001$), and in both private residential (61.5% vs 67.8%, $p < 0.001$) and public locations (81.5% vs 88.2%, $p = 0.010$) (Supplementary 2 Table S1). In sensitivity analysis, excluding cases where bystander CPR status was unknown/not stated did not the results.

The likelihood of bystander CPR was significantly lower with increasing age (OR: 0.98 95%CI: 0.97–0.98); in arrests presumed to be of a non-cardiac medical aetiology (OR: 0.50 95%CI: 0.44–0.58); when OHCA was not recognised during the emergency call (OR: 0.15 95%CI: 0.12–0.18) and when the ambulance arrived at the arrest scene in under five minutes (Global $p < 0.0001$) (Table 2). After adjusting for covariates, females had significantly lower odds of receiving bystander CPR (Private location: AOR 0.82, 95%CI:0.70–0.95; Public location: AOR 0.58, 95%CI:0.39–0.88) (Fig. 2). The association between patient sex and bystander CPR in public locations was partially mediated (estimate ~44%) by recognition of OHCA in the call, with the inclusion of this variable in the adjusted model attenuating the association (between patient sex and bystander CPR) (AOR: 0.67 95%CI:0.43–1.06).

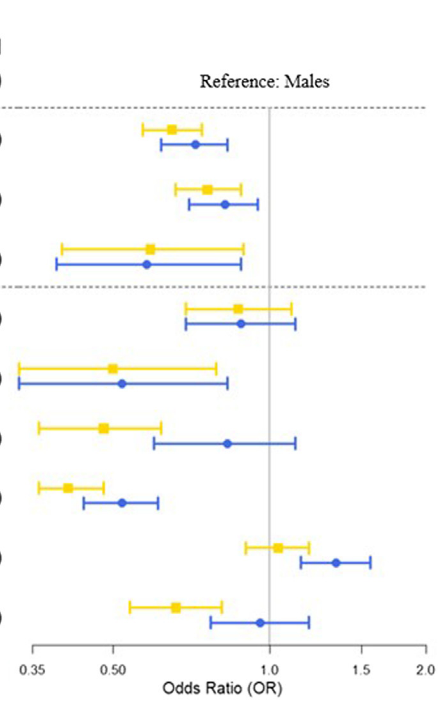
### *Secondary outcomes*

OHCA recognition documented by the emergency call taker was lower for females arresting in public locations (AOR: 0.52 95%CI: 0.33–0.83). Bystander AED use was significantly lower among females (4.8% vs 9.6% $p < 0.001$) (Table 1). Most of AED application reflects use in public locations compared with private residential locations (28.3% vs 1.4%, $p < 0.001$) (Supplementary 2 Table S1). After adjusting for location there was no significant difference in AED application by patient sex (AOR 0.83 95%CI:0.60–1.12) (Fig. 2). Females had lower odds of presenting with a shockable initial rhythm compared with male patients (AOR 0.51, 95%CI:0.43–0.60) (Fig. 2). Females had a greater likelihood of surviving the event to reach the emergency department (AOR: 1.34, 95%CI:1.15–1.56), but this survival advantage was not sustained to hospital discharge (AOR: 0.96 95%CI:0.77–1.19).

## Discussion

Female OHCA patients are less likely to receive bystander CPR compared with male patients and this association was significant after accounting for covariates including age, presumed aetiology, and ambulance response time. This relationship was consistent for both public locations and private residential locations. Emergency call takers were less likely to document recognition of OHCA in

| Variable | Univariate OR (95% CI) | Adjusted OR (95% CI) |
| --- | --- | --- |
| Bystander CPR : All locations | 0.65 (0.57, 0.74) | 0.72 (0.62, 0.83) |
| Private residential | 0.76 (0.66, 0.88) | 0.82 (0.70, 0.95) |
| Public | 0.59 (0.40, 0.89) | 0.58 (0.39, 0.88) |
| OHCA recognition in call (Private residential) | 0.87 (0.69, 1.10) | 0.88 (0.69, 1.12) |
| OHCA recognition in call (Public) | 0.50 (0.33, 0.79) | 0.52 (0.33, 0.83) |
| Bystander AED use | 0.48 (0.36, 0.62) | 0.83 (0.60, 1.12) |
| Shockable initial rhythm | 0.41 (0.36, 0.48) | 0.52 (0.44, 0.61) |
| Survived event | 1.04 (0.90, 1.19) | 1.34 (1.15, 1.56) |
| Survived to hospital discharge | 0.66 (0.54, 0.81) | 0.96 (0.77, 1.19) |




*OR: Odds Ratio; CI: Confidence interval; CPR: Cardiopulmonary resuscitation; AED: Automated external defibrillator. All multivariate models were adjusted for patient age, presumed aetiology, and ambulance response time. Furthermore, Bystander AED use model additionally adjusted for arrest location, while shockable initial rhythm and survival outcomes models additionally adjusted for arrest location, arrest site, bystander CPR and bystander AED use.*

**Fig. 2 – Crude and Adjusted odds ratios explaining the association between patient sex with primary and secondary outcomes.**

females arresting in public locations, and mediation analysis demonstrated that this partially explained the lower rates of bystander CPR in females. Rates of bystander AED use were low overall and while females were less likely to have an AED applied, they were also less likely to present in shockable rhythm, however the association of sex with AED use became non-significant after adjusting for covariates. Survival to hospital discharge was similar by sex.

Some studies have found differences in the provision of bystander CPR by sex with most indicating lower rates in females and some suggesting the observed differences vary by arrest location or patient age.[9,11,30,31] However, results have not been consistent across jurisdictions. A large study in Victoria, Australia that conducted a temporal analysis of OHCA over twenty years found equal rates of bystander CPR for females but an increasing gap in bystander defibrillation.[13] In the United States, males had higher odds of receiving bystander CPR in public locations, but not in private residential locations.[9] An analysis across some Asian countries of 56,192 OHCA cases found females had lower rates of bystander CPR in public locations, but in contrast higher rates in private locations.[11] One study from the U.S. suggests it may be less socially acceptable to perform CPR in females with hesitancy in touching them suggested as a factor in a public survey conducted in the United States.[15]

A variety of factors have been hypothesized to explain lower rates of bystander CPR in females including concerns around modesty, fear of causing harm or legal liability and perceptions of fragility.[15,32] Bystanders may perceive OHCA differently in females compared to males. The current study demonstrating the contributing role of recognition of OHCA by the call taker is consistent with a mixed methods investigation in which audio recordings of emergency calls were analysed.[33] The authors examined factors associated with emergency call-takers sensitivity in OHCA recognition and found a lower recognition in females.[33] Call-takers generally apply standard algorithms in the triage and identification of OHCA[34] which depend on the caller's description of the patient's condition. The lower sensitivity in OHCA identification for female could be related to callers' description of symptoms or the seriousness of patients' condition. Blom et al. (2019) examined if there were delays in OHCA recognition by assessing the time from emergency call to ambulance dispatch but found no difference by patient sex.[30] They noted that they could not factor in delays from OHCA onset to recognition by bystanders. Researchers have pointed to sex-related differences in warning symptoms prior to cardiac arrest noting that while chest pain was more commonly experienced by males, females more typically had shortness of breath.[35,36] Linguistic factors were also found to be important in influencing whether the emergency call will progress to bystander CPR provision.[37,38] Future investigations that involve listening to emergency call recordings and analysing the interaction between caller and call-taker may be able to specifically identify barriers unique to females.

Our findings noted that while rates of bystander AED use were lower among females, the difference was not significant after accounting for covariates. Females were significantly more likely to arrest in residential locations compared with males and the use of AEDs in private residential locations was very low. Studies from larger populations in the United States and Japan have found that males were significantly more likely to have public AEDs applied by a bystander.[10,39] They speculated that the differences observed could relate to embarrassment, concerns around public exposure of female chests or fear of sexual assault.[10,13,39]

Females also had a lower likelihood of presenting in a shockable initial rhythm irrespective of age and location. This could be related to differences in arrest aetiology and mechanisms of cardiac arrest.[12] However, a lack of or a delay in CPR provision could also play a role, given that over time shockable rhythms degenerate to non-shockable rhythms without chest compressions.[40] As reported in other studies, females were more likely to survive to hospital, but there was no difference in survival to hospital discharge.[12,41] Several studies have examined the differences in aetiology and comorbidities among females. However, it is uncertain whether a real difference in survival exists after accounting for known patient, prehospital and treatment factors that could explain disparities.[41]

Our study has limitations. We were limited in our ability to control for unmeasured confounders that could explain the observed sex-based disparities (e.g., bystander characteristics, perceived frailty, comorbidities).[42,43] We controlled for this to some extent by excluding arrests with a DNR order and nursing home/medical facility arrests where females were overrepresented. Additionally, we adjusted for age and arrest aetiology given the higher age at arrest in females and a greater rate of non-cardiac causes (e.g., terminal illness) compared with males. Witness status was missing for several cases and these cases were excluded from our analysis.[30,44] The registry data did not distinguish if bystander CPR provision was spontaneous (bystander-initiated) or in-time (telephone guided). Dispatcher assistance has been shown to influence the initiation and quality of bystander CPR[45] and rates of recognition by OHCA by emergency call takers were high, suggesting that dispatcher assistance could be high in this cohort.[46,47] The mediation analysis examining the role of OHCA recognition during the emergency call should only be considered as hypothesis generation of the suggested mechanism rather than definitive evidence of causal processes given that it is based on non-experimental or observational data.[29,48] It should also be noted that the quality of bystander CPR and other treatment for cardiac arrest was unavailable and not accounted for in our analyses. It should be noted that the dataset is slightly older. The inclusion of more recent data could potentially be impacted by COVID and may have different findings from OHCA data under non-pandemic circumstances. Finally, our sample size limited precision and analysis of secondary outcomes and sub-groups.

## Conclusion

This study provides novel new data demonstrating females are less likely to receive bystander CPR in OHCA. It also describes a potential mitigating mechanism for the observation of sex differences by demonstrating the role of emergency call takers in recognising OHCA. The findings suggest that public education campaigns are needed to address these inequalities and possibly the utility of targeting emergency personnel to help with redressing the issue of recognition of possible OHCA over a call. However further research is needed to better understand this issue and to also develop interventions to address them.

## CRediT authorship contribution statement

**Sonali Munot:** Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Janet E Bray:** Writing – review & editing, Visualization, Investigation, Conceptualization. **Julie Redfern:** Writing – review & editing, Supervision. **Adrian Bauman:** Writing – review & editing. **Simone Marschner:** Writing – review & editing, Formal analysis. **Christopher Semsarian:** Writing – review & editing. **Alan Robert Denniss:** Writing – review & editing, Conceptualization. **Andrew Coggins:** Writing – review & editing. **Paul M Middleton:** Writing – review & editing. **Garry Jennings:** Writing – review & editing. **Blake Angell:** Writing – review & editing. **Saurabh Kumar:** Writing – review & editing. **Pramesh Kovoor:** Writing – review & editing. **Matthew Vukasovic:** Writing – review & editing. **Jason C Bendall:** Writing – review & editing. **T Evens:** Writing – review & editing. **Clara K Chow:** Writing – review & editing, Supervision, Investigation, Funding acquisition, Formal analysis.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. JB is an Editorial Board Member of Resuscitation.

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## Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resuscitation.2024.110224.

## Author details

[a]*Westmead Applied Research Centre, Faculty of Medicine and Health, The University of Sydney, Sydney, Australia*[b]*School of Public*

*Health and Preventive Medicine, Monash University, Victoria, Australia[c]School of Health Sciences, Faculty of Medicine and Health, The University of Sydney, Sydney, Australia[d]School of Public Health, Faculty of Medicine and Health, The University of Sydney, Sydney, Australia [e]Agnes Ginges Centre for Molecular Cardiology at Centenary Institute, The University of Sydney, Sydney, Australia [f]Department of Cardiology, Westmead Hospital, Sydney, Australia[g]Department of Emergency Medicine, Westmead Hospital, Sydney, Australia [h]South Western Emergency Research Institute, Ingham Institute, SWSLHD, Sydney, Australia [i]Sydney Health Partners, Charles Perkins Centre, The University of Sydney, Australia [j]The George Institute for Global Health, University of New South Wales, Newtown, Australia[k]New South Wales Ambulance, Sydney, New South Wales, Australia [l]School of Medicine and Public Health (Anaesthesia and Intensive Care), The University of Newcastle, Australia*

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