Available online at www.sciencedirect.com

Resuscitation Plus

journal homepage: www.elsevier.com/locate/resuscitation-plus

Clinical paper

Sex disparities in bystander defibrillation for out-of-hospital cardiac arrest

Elizabeth D. Paratz[a,b,c,d,e,*], *Emily Nehme*[e,f], *Natalie Heriot*[e], *Vijaya Sundararajan*[d], *Gregory Page*[g], *Louise Fahy*[a,b], *Stephanie Rowe*[a,b], *David Anderson*[e], *Dion Stub*[e,f,h], *Andre La Gerche*[a,b,c], *Ziad Nehme*[e,f]

Abstract

Background: Previous studies have suggested that females experiencing out-of-hospital cardiac arrest (OHCA) receive lower rates of both bystander cardiopulmonary resuscitation (CPR) and defibrillation compared to males. Whether this disparity has improved over time is unknown.

Methods: A state-wide OHCA registry in Victoria, Australia collected data over twenty years (2002–2021) regarding rates of bystander interventions in OHCA. Characteristics and outcomes of each OHCA were compared with logistic regression according to sex and time (defined in two-year periods).

Results: 32,502 OHCAs were included (69.7% male). Both bystander CPR and defibrillation rates increased for females over time ($p < 0.0001$). There was no sex disparity in receipt of bystander CPR after adjustment for baseline differences. Females were less likely than males to receive bystander defibrillation, with sex disparity increasing from 2010 onwards (adjOR 0.26 (95%CI 0.09–0.80) in 2020–21 for females compared to males).

Conclusion: Initiatives to increase bystander CPR and defibrillation have resulted in higher overall rates of bystander interventions in the last two decades and no significant sex differences in provision of bystander CPR. However, females receive less bystander defibrillation than males, and sex disparity is increasing. Strategies to promote bystander defibrillation in females experiencing OHCA with a shockable rhythm should be a priority.

Keywords: Sex, Female, Cardiac arrest, Bystander CPR, Bystander defibrillation

Background

Out-of-hospital cardiac arrest (OHCA) is one of the major causes of death worldwide, affecting almost 4 million people globally each year.[1] As with many disease conditions, it is an area in which females experience systematically different management and outcomes to males.[2,3]

Bystander interventions include bystander cardiopulmonary resuscitation (CPR), application of automatic external defibrillator (AED) pads and bystander defibrillation if a shockable rhythm is identified. Early intervention by bystanders has been shown to be superior to subsequent interventions by first responders or paramedics,[4] and may result in approximately a doubling in OHCA survival.[5,6] As ambulance response times increase worldwide[7,8] the role of bystanders becomes increasingly important.

Unfortunately, there are suggestions in many countries that females experience lower rates of bystander CPR, AED pad placement and appropriate defibrillation compared to males.[9,10] In Victoria, Australia, Bray et al documented that from 2003-2010, females were less likely than males to receive bystander CPR. Bystander defibrillation rates were not assessed.[11] In the intervening decade, large community and government initiatives have resulted in increased overall rates of bystander CPR and defibrillation.[6,8] It is important to reassess whether this sex disparity in bystander CPR persists or has resolved, and whether bystander defibrillation rates are equivalent.

* Corresponding author at: Baker Heart and Diabetes Institute, 75 Commercial Rd., Prahran, VIC 3181, Australia.
E-mail address: elizabeth.paratz@baker.edu.au (E.D. Paratz).
@pretzeldr (E.D. Paratz)

https://doi.org/10.1016/j.resplu.2023.100532
Received 27 November 2023; Accepted 1 December 2023

Table 1 – Changes in OHCA characteristics amongst all OHCA patients over time (sex-disaggregated).

	2002–3		2004–5		2006–7		2008–9		2010–11		2012–13		2014–15		2016–17		2018–19		2020–21		P (change over time)	P (males vs females)
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F		
Number	2104	882	1941	801	1955	776	2028	925	2029	836	2217	1004	2449	1072	2584	1131	2728	1260	2602	1178		
Age (years), median [IQR]	69 [58–77]	74 [63–82]	69 [57–78]	75 [63–82]	69 [57–79]	74 [59–82]	68 [56–79]	73 [58–83]	67 [56–79]	74 [58–84]	68 [56–79]	73 [56–83]	68 [56–79]	75 [60–85]	68 [55–79]	73 [58–83]	69 [56–79]	72 [57–83]	69 [57–79]	73 [58–83]	P = 0.1395	P = 0.006
Metropolitan location, n(%)	1605 (76.3%)	667 (75.6%)	1503 (77.4%)	625 (78.0%)	1490 (76.2%)	616 (79.4%)	1529 (75.4%)	715 (77.3%)	1480 (72.9%)	634 (75.8%)	1565 (70.6%)	726 (72.3%)	1731 (70.7%)	794 (74.1%)	1817 (70.3%)	824 (72.9%)	1894 (69.4%)	905 (71.8%)	1853 (71.2%)	848 (72.0%)	P < 0.0001	P < 0.0001
Public location, n(%)	477 (22.7%)	88 (10.0%)	500 (25.8%)	91 (11.4%)	491 (25.1%)	70 (9.0%)	492 (24.3%)	96 (10.4%)	530 (26.1%)	93 (11.1%)	558 (25.2%)	119 (11.9%)	544 (22.2%)	112 (10.5%)	580 (22.5%)	104 (9.2%)	572 (21.0%)	91 (7.2%)	391 (15.0%)	70 (5.9%)	P < 0.0001	P < 0.0001
Witnessed OHCA, n(%)	1285 (61.1%)	520 (59.0%)	1252 (64.5%)	467 (58.3%)	1188 (60.8%)	405 (52.2%)	1281 (63.2%)	550 (59.5%)	1205 (59.4%)	456 (54.6%)	1319 (57.7%)	507 (50.5%)	1414 (53.5%)	500 (46.6%)	1382 (55.1%)	516 (45.6%)	1503 (52.4%)	577 (45.8%)	1364 (58.3%)	563 (47.8%)	P < 0.0001	P < 0.0001
Shockable rhythm, n(%)	980 (46.6%)	222 (25.3%)	933 (48.2%)	230 (28.8%)	866 (44.8%)	172 (22.3%)	871 (43.2%)	234 (25.6%)	959 (47.6%)	230 (28.0%)	958 (43.4%)	250 (25.0%)	1024 (42.0%)	241 (22.6%)	945 (36.7%)	248 (22.1%)	1022 (37.7%)	238 (19.0%)	934 (36.0%)	234 (19.9%)	P < 0.0001	P < 0.0001
Ambulance response time (min), median [IQR]	7[6–10]	8[6–10]	8[6–10]	8[6–10]	8.3 [6.5–11]	8.7 [7–11.0]	8.5 [6.8–11.2]	8.8 [6.9–11.5]	8.9 [7.0–11.7]	9.2 [7.1–12.4]	9.2 [7.1–12.4]	8.7 [6.7–11.2]	8.7 [6.7–11.5]	8.4 [6.5–11.2]	8.3 [6.5–11.0]	8.3 [6.3–11.2]	8.3 [6.5–11.1]	8.4 [6.5–11.2]	9.0 [7.0–12.2]	9.0 [6.9–11.5]	P < 0.0001	P = 0.617

F = female; IQR = interquartile range; OHCA = out-of-hospital cardiac arrest; M = male.

This study utilised a statewide OHCA registry to assess two decades of data and define sex-specific trajectories in rates of bystander interventions.

Methods

Patient inclusion

The Victorian Ambulance Cardiac Arrest Registry (VACAR) records data on all out-of-hospital cardiac arrests (OHCA) attended by emergency medical services (EMS) within the state of Victoria, Australia (population 6.5 million). Its methods have been described in detail previously, with all patient-level details are collected according to standard Utstein template metrics.[12] Missingness of data is very low within the registry, at <1% across all variables.[13] Within this study, all patients receiving an attempted resuscitation for cardiac arrest of presumed cardiac cause by EMS personnel between 2002 and 2021 were initially identified. Arrests with precipitating causes of trauma, overdose or hanging were excluded from analysis. Cardiac arrests witnessed by EMS personnel were then excluded, as bystander interventions would not be relevant.

Data regarding baseline characteristics and components of the OHCA's management were collected for all patients. The primary outcome was the proportion of patients receiving bystander interventions (CPR and defibrillation) according to sex, and variation over time. Bystanders included first responders who were local volunteers, such as those participating in the GoodSAM or Hatzolah initiatives.[14,15]

Statistical analysis

Periods of time were defined as ten two-year intervals, corresponding to 2002–3, 2004–5, 2006–7, 2008–9, 2010–11, 2012–13, 2014–15, 2016–17, 2018–19 and 2020–21. The 2002–3 period was used as the reference category for all comparisons. Changes in baseline and OHCA characteristics over time were assessed for females and females versus males. Adjusted odds of receiving bystander interventions were then calculated for each time-period.

For continuous variables, statistical comparisons were made using the Kruskal-Wallis test, with results reported as median value and interquartile range. Categorical variables are reported as absolute values and percentages, with unadjusted logistic regression used to assess trends over time. Multiple logistic regression was performed to assess bystander interventions after adjustment for identified baseline differences, with an interaction term included between time-period and sex. Results were reported as odds ratios and 95% confidence intervals. A significance threshold of $P < 0.05$ was considered significant in all analyses. All statistical analysis was performed using STATA/MP v17.0 (STATACorp LLC, Texas United States of America).

Ethical approval

The VACAR holds overarching ethical approval through Monash University. This study was performed as a sub-study of the larger registry.

Results

Overall female vs male cohort characteristics

Over the twenty-year time-period, 32,502 OHCAs were included, of whom 22,637 (69.7%) were male (Table 1). Females were

Table 2 – Changes in OHCA characteristics amongst female OHCA patients over time.

	2002–3	2004–5	2006–7	2008–9	2010–11	2012–13	2014–15	2016–17	2018–19	2020–21	Significance
Number	**882**	**801**	**776**	**925**	**836**	**1004**	**1072**	**1131**	**1260**	**1178**	
Age (years), median [IQR]	74 [63–82]	75 [63–82]	74 [59–82]	73 [58–83]	74 [58–84]	73 [56–83]	75 [60–85]	73 [58–83]	72 [57–83]	73 [58–83]	P = 0.0968
Metropolitan location, n(%)	667 (75.6%)	625 (78.0%)	616 (79.4%)	715 (77.3%)	634 (75.8%)	726 (72.3%)	794 (74.1%)	824 (72.9%)	905 (71.8%)	848 (72.0%)	**P < 0.0001**
Public location, n(%)	88 (10.0%)	91 (11.4%)	70 (9.0%)	96 (10.4%)	93 (11.1%)	119 (11.9%)	112 (10.5%)	104 (9.2%)	91 (7.2%)	70 (5.9%)	**P < 0.0001**
Witnessed OHCA, n(%)	520 (59.0%)	467 (58.3%)	405 (52.2%)	550 (59.5%)	456 (54.6%)	507 (50.5%)	500 (46.6%)	516 (45.6%)	577 (45.8%)	563 (47.8%)	**P < 0.0001**
Shockable rhythm, n(%)	222 (25.3%)	230 (28.8%)	172 (22.3%)	234 (25.6%)	230 (28.0%)	250 (25.0%)	241 (22.6%)	248 (22.1%)	238 (19.0%)	234 (19.9%)	**P < 0.0001**
Ambulance response time (min), median [IQR]	8 [6–10]	8 [6–10]	8.7 [7–11.0]	8.8 [6.9–11.5]	9.2 [7.1–12.4]	8.7 [6.7–11.2]	8.4 [6.5–11.2]	8.3 [6.3–11.2]	8.4 [6.5–11.2]	9.0 [6.9–11.5]	**P = 0.0001**
BYSTANDER INTERVENTIONS											
Bystander CPR, n(%)	377 (42.7%)	340 (42.5%)	310 (40.0%)	481 (52.0%)	506 (60.5%)	683 (68.0%)	779 (72.7%)	815 (72.1%)	911 (72.3%)	840 (71.3%)	**P < 0.0001**
Bystander defibrillation, n(%)	6 (1.8%)	1 (0.3%)	4 (1.5%)	8 (2.2%)	7 (2.1%)	16 (4.6%)	15 (4.5%)	22 (6.6%)	29 (7.4%)	21 (5.3%)	**P < 0.0001**

CPR = cardiopulmonary resuscitation; IQR = interquartile range; OHCA = out-of-hospital cardiac arrest.

consistently older than males (p = 0.006), without variation over time. Although females were more likely than males to be in a metropolitan location (p < 0.0001), they were less likely to be in a public location at the time of their arrest, have a witnessed arrest, or shockable initial rhythm (p < 0.0001 for all).

Female OHCA trends over time

Females were less likely to arrest in a metropolitan or public location in 2020–21 (which incorporated COVID-19 lockdowns) compared to earlier time-periods and were less likely to have a witnessed OHCA (p < 0.0001 for all) (Table 2). Rates of shockable rhythm declined over the time periods (19.9% of OHCAs in 2020–21 compared to 25.3% of OHCAs in 2002–3, p < 0.0001), and ambulance response times lengthened by approximately 1 minute (p = 0.0001).

Rates of bystander interventions increased for females over time. Specifically, bystander CPR rates increased from 42.7% in 2002–3 to 71.3% in 2020–21 (p < 0.0001) and bystander defibrillation rates rose from 1.8% in 2002–3 to 5.3% in 2020–21 (p < 0.0001).

Changes in bystander interventions over time

When calculating probability of receiving bystander interventions, adjustment for baseline differences in age, witnessed status, metropolitan location and public location was performed.

Bystander CPR rates rose significantly from 2008 onwards (Fig. 1). Analysis of the interaction of sex and time did not demonstrate a significant difference between female and male receipt of bystander CPR over time.

Bystander defibrillation commenced at low levels in the community in the first time-period but increased significantly from 2008 (Fig. 2). Increasing sex disparities in bystander defibrillation were evident from 2010 onwards (adjOR 0.26 (95% CI 0.09–0.80 in 2020–21)).

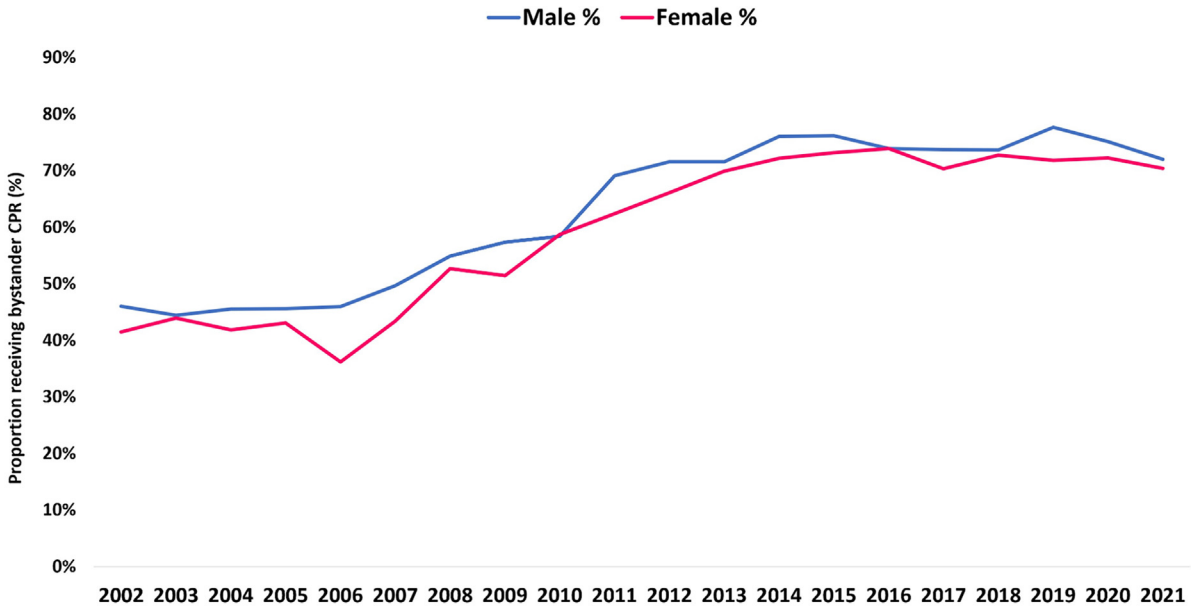
Discussion

Our study is the largest to date to provide temporal analysis of sex disparities in bystander interventions over two decades. While a range of initiatives (for example, education, dispatcher instructions, wider defibrillator availability) appear to have increased overall bystander CPR and defibrillation rates, sex disparity exists. Our study identifies equivalent rates of bystander CPR for females but a widening sex gap in bystander defibrillation.

Global variation in bystander CPR for females

International studies have consistently shown reduced rates of bystander CPR for females compared to males, even when adjusted for baseline differences in female OHCA presentations.[16–20,9,10]

Two interesting patterns have emerged that run counter to this general trend of reduced bystander CPR for females. Firstly, the reductions in bystander CPR seem to be most pronounced in public locations where it is less likely that the patient will be known to the bystander.[21] Blewer et al demonstrated in an American study of almost 20,000 patients that bystander CPR differences were statistically significant between the sexes only in public locations.[17] The same pattern was observed in



Adjusted odds of bystander CPR	2002-3	2004-5	2006-7	2008-9	2010-11	2012-13	2014-15	2016-17	2018-19	2020-2021
Bystander CPR odds compared to 2002-3 (OR, 95% CI)	1	0.99 (0.87-1.12)	1.12 (0.97-1.26)	**1.55 (1.37-1.76)**	**2.16 (1.90-2.45)**	**3.18 (2.79-3.62)**	**4.24 (3.72-4.83)**	**3.78 (3.33-4.29)**	**4.24 (3.74-4.82)**	**3.98 (3.51-4.52)**
Bystander CPR odds for females compared to males in the same year (OR, 95% CI)	0.92 (0.65-1.32)	0.99 (0.78-1.26)	0.82 (0.64-1.04)	0.93 (0.74-1.17)	0.98 (0.77-1.24)	0.94 (0.74-1.18)	0.93 (0.74-1.18)	1.02 (0.81-1.28)	0.91 (0.73-1.14)	0.93 (0.75-1.17)

CPR = cardiopulmonary resuscitation; OR = odds ratio
Adjusted for age, witnessed status, public location and metropolitan location
Yellow shaded boxes are significantly different to the reference category

Fig. 1 – The proportion of bystander CPR rose from 2008, with no significant sex disparity.

Denmark in a similar-sized cohort from 2001-10, although in this cohort significant differences were still observed in both private and public locations.[10] This pattern has been interpreted by multiple study authors as reflecting particular discomfort in performing CPR or exposing the chest of an unknown female in public locations.[22,23] In our study, where adjustment for baseline differences included public location status, we did not identify a significant difference in receipt of bystander CPR.

The second interesting pattern to have emerged from the literature is that reduced bystander CPR for females does not appear as prevalent in Asian countries.[24] Multiple large studies across Japan and Korea have demonstrated equivalent or even superior rates of bystander CPR for females.[25–27] Cultural factors and/or widespread CPR education may therefore have assisted in overcoming hesitations seen in more Westernized countries regarding performing bystander CPR on females.

Global variation in bystander defibrillation for females

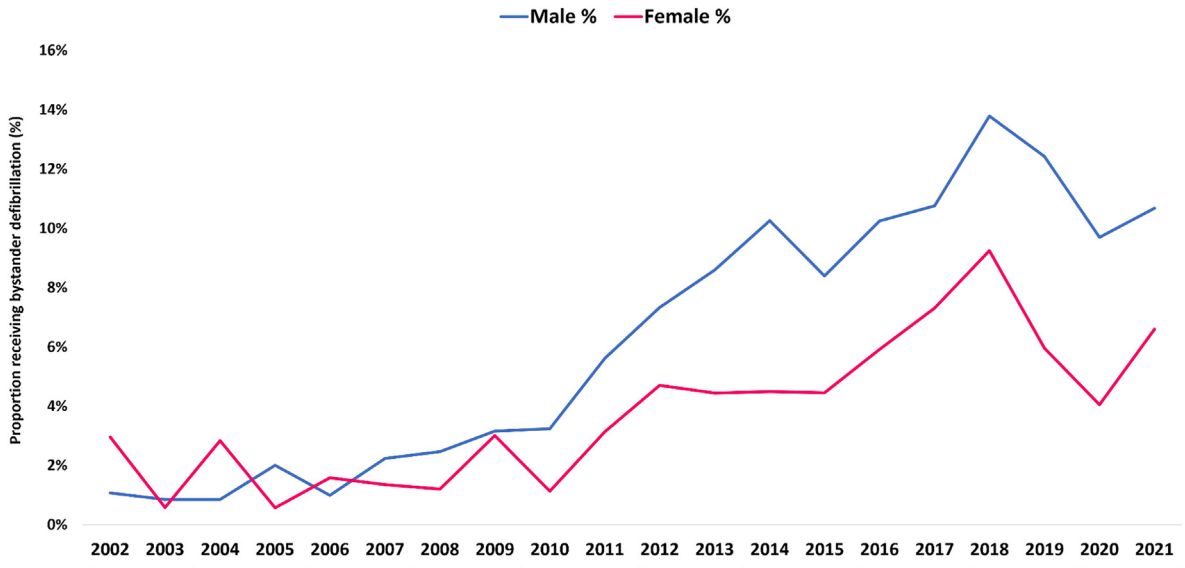
There is less available data regarding sex disparities in bystander defibrillation. Concerningly, reductions in bystander defibrillation of female OHCA patients are not limited to performing actual defibrillation. Multiple studies across Japan, the Netherlands and the United States have reported that female OHCA patients are less likely to have AED pads applied to ascertain cardiac rhythm in the first instance.[28–33]

In a sub-analysis of the TTM trial across 36 intensive care units in Europe and Australia, Winther-Jensen et al reported that females with shockable rhythms received bystander defibrillation less frequently than males.[34] An analysis of approximately 20,000 American OHCA cases with high overall bystander defibrillation rates reported similar findings,[35] as did a larger analysis of the CARES and NEMSIS registries[29,36] and a study in Denmark.[10] Concerningly, the Danish study incorporated a longitudinal analysis over ten years that demonstrated that, while males experienced a significant increase in bystander AED usage, females did not.[10]

The Asian trend to equivalency in bystander CPR does not appear to extend to bystander defibrillation.[37] In an analysis of OHCAs in Japanese schools, Matsui et al identified no sex-specific differences in receipt of bystander CPR, but that high-school girls were less likely to either have AED pads placed or an appropriate shock delivered.[28] Hosomi et al reported in a larger analysis of 314,460 Japanese OHCA patients that while bystander CPR rates were actually higher in females, males were approximately twice as likely to receive bystander defibrillation.[25] Both study groups hypothesised that this apparent paradox resulted from the fact that chest compressions could be performed without removing clothing whilst defibrillation demanded exposure of the chest.[25,28]

Addressing reasons underlying paradoxical sex disparities between bystander interventions

There are consistent themes in interviews with bystanders that reasons underpinning the reduced rates of interventions primarily relate



Adjusted odds of bystander defibrillation	2002-3	2004-5	2006-7	2008-9	2010-11	2012-13	2014-15	2016-17	2018-19	2020-2021
Bystander defibrillation odds compared to 2002-3 (OR, 95% CI)	1	1.35 (0.64-2.86)	1.49 (0.72-3.11)	**2.71 (1.39-5.29)**	**4.25 (2.25-8.02)**	**8.13 (4.41-14.97)**	**10.20 (5.57-18.67)**	**11.61 (6.35-21.23)**	**16.53 (9.12-30.01)**	**15.73 (8.61-28.74)**
Bystander defibrillation, for females compared to males in the same year (OR, 95% CI)	0.23 (0.11-1.12)	0.11 (0.011-1.01)	0.52 (0.12-2.25)	0.42 (0.12-1.49)	**0.27 (0.-08-0.98)**	**0.27 (0.09-0.84)**	**0.23 (0.07-0.71)**	**0.33 (0.11-0.99)**	**0.30 (0.10-0.88)**	**0.26 (0.09-0.80)**

OR = odds ratio
Adjusted for age, witnessed status, public location and metropolitan location
Yellow shaded boxes are significantly different to the reference category

Fig. 2 – The proportion of bystander defibrillation rose significantly from 2008. Females received relatively less bystander defibrillation compared to males from 2010 onwards.

to concerns around public exposure of females' chests, causing injury, and mis-attribution of female OHCA.[22,38] These themes would fit with Hosomi and Matsui's observation that it is possible to provide CPR to a clothed female, but usually infeasible to place AED pads and defibrillate a patient without some degree of exposure.[25,28] This may explain the paradox of equivalent bystander CPR but reduced defibrillation for females.

Becker et al interviewed over 500 CPR course attendees in the United States, with 20.5% reporting concerns performing CPR on female OHCA patients; 14% specifically reported concerns exposing the patient or of breasts interfering with CPR performance. A further 6% reported concern regarding the potential for being accused of sexual assault.[39] Another similarly-sized cohort of Americans (42% of whom had previously received formal CPR training) raised concerns that females were too frail to receive CPR, and their perceptions that a female becoming unresponsive was unlikely to represent a true OHCA.[38] In Korea, Lee et al have identified that female bystanders are less likely than males to provide bystander CPR in the first instance.[40] Taiwanese researchers have also identified that females are less likely to perform bystander defibrillation.[41] In Canada, Kramer et al have demonstrated in simulated studies of participants that CPR students remove significantly more clothing from male than female mannequins, with male bystanders more hesitant than females.[42]

Steps to address these bystander concerns that result in real inequity are vital. Firstly, CPR courses should pursue equal recruitment of female volunteers, as well as usage of female mannequins with visibly female anatomy upon which to practise pad placement and defibrillation. Souers et al have emphasised that '*a web-based search for female CPR mannequins results in an anatomically identical torso to the male, except with plastic hair that is styled differently, and a female-oriented name assigned to the mannequin. Without any educational emphasis on anatomical differences, it is no wonder that perceived frailty, presence of female physique, and difficulty in recognizing a female in medical distress are all barriers to bystander [interventions] in female victims*'.[32]

Clear discussions regarding the practicalities of female resuscitation, practising specific female-centred scenarios and exploring participants' concerns may help anticipate future discomforts.[43] Active dispatcher-assisted instructions encouraging bystander interventions on females have been shown to provide benefit,[44] and debriefing where possible may also be of use. We would also advocate for similar analyses to ours within different cultural groups and in other countries. To date, the bulk of countries demonstrating sex disparities in bystander interventions are industrialized countries with low Gender Inequality Index scores.[45] This may imply that other countries with higher structural gender inequality may have even greater sex disparity in rates of bystander intervention. Alternatively, other countries may have more equitable rates of bystander interventions (as seems to be demonstrated regarding bystander CPR in Asian countries), and it would be valuable to identify contributing cultural and medical differences.

Limitations

This study did not collect data regarding AED pad placement independent of shock being administered, which would be a valuable fac-

tor to assess. Changes in dispatcher-assisted instructions have been documented to have occurred over the study period,[46,47] but it was not possible to specifically tie these to changes in outcomes on a per-patient level as specific instructions were not routinely captured in the patient data-sets. As this study is limited to a single statewide registry and restricted to data points collected in a retrospective manner, it would be valuable to replicate the study in other settings.

Conclusion

Initiatives to increase bystander CPR and defibrillation have resulted in higher overall rates of bystander interventions in the last two decades and no significant sex differences in provision of bystander CPR. However, females receive less bystander defibrillation than males, and sex disparity is increasing. Strategies to promote bystander defibrillation in females experiencing OHCA with a shockable rhythm should be a priority.

Funding sources

EDP is supported by the Wilma Beswick Senior Research Fellowship, Department of Medicine at St Vincent's Hospital Melbourne, University of Melbourne. SR is supported by the Cardiac Society of Australia & New Zealand. ZN holds an NHF Future Leadership Fellowship. ALG is supported by an NHF Future Leadership Fellowship. DS is supported by NHF and NHMRC Fellowships. EN is supported by an NHMRC Postgraduate Scholarship.

CRediT authorship contribution statement

Elizabeth D. Paratz: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Emily Nehme:** Data curation, Investigation, Writing – review & editing. **Natalie Heriot:** Project administration, Resources. **Vijaya Sundararajan:** Formal analysis, Methodology, Writing – review & editing. **Gregory Page:** Conceptualization, Writing – review & editing. **Louise Fahy:** Data curation, Project administration. **Stephanie Rowe:** Data curation, Writing – review & editing. **David Anderson:** Conceptualization, Writing – review & editing. **Dion Stub:** Conceptualization, Supervision, Writing – review & editing. **Andre La Gerche:** Conceptualization, Supervision, Writing – review & editing. **Ziad Nehme:** Conceptualization, Data curation, Supervision, Writing – review & editing.

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.

Author details

[a]HEART Lab, St Vincent's Institute of Medical Research, 9 Princes St., Fitzroy, VIC 3065, Australia [b]Department of Cardiology, St Vincent's Hospital Melbourne, 41 Victoria Parade, Fitzroy, VIC 3065, Australia [c]Cardiology Department, Baker Heart & Diabetes Institute, 75 Commercial Rd., Prahran, VIC 3181, Australia [d]Department of Medicine, St Vincent's Hospital Melbourne, The University of Melbourne, 29 Regent Street, Fitzroy, VIC 3065, Australia [e]Ambulance Victoria, 31 Joseph St., Blackburn North, VIC 3130, Australia [f]School of Public Health & Preventive Medicine, Monash University, 553 St Kilda Rd., Melbourne, VIC 3004, Australia [g]Heart of the Nation, Sydney, NSW, Australia [h]Department of Cardiology, Alfred Health, 55 Commercial Rd., Prahran, VIC 3181, Australia

REFERENCES

1. Brooks SC, Clegg GR, Bray J, Deakin CD, Perkins GD, Ringh M, et al. Optimizing outcomes after out-of-hospital cardiac arrest with innovative approaches to public-access defibrillation: A scientific statement from the International Liaison Committee on Resuscitation. Resuscitation. 2022;172:204–28.
2. Butters A, Arnott C, Sweeting J, Winkel BG, Semsarian C, Ingles J. Sex disparities in sudden cardiac death. Circ Arrhythm Electrophysiol. 2021;14 e009834.
3. Nehme Z, Andrew E, Bernard S, Smith K. Sex differences in the quality-of-life and functional outcome of cardiac arrest survivors. Resuscitation. 2019;137:21–8.
4. Nehme Z, Andrew E, Bernard S, Haskins B, Smith K. Trends in survival from out-of-hospital cardiac arrests defibrillated by paramedics, first responders and bystanders. Resuscitation. 2019;143:85–91.
5. Blewer AL, Ho AFW, Shahidah N, White AE, Pek PP, Ng YY, et al. Impact of bystander-focused public health interventions on cardiopulmonary resuscitation and survival: a cohort study. Lancet Public Health. 2020;5:e428–36.
6. Paratz E, Page GJ, Jennings GL. Defibrillator access across Australia: the first step in avoiding a chain of fatality. Med J Aust. 2023;219:146–8.
7. Paratz ED, La Gerche A. The flatlining of cardiac arrest survival: can we revive the upward trend? Eur Heart J. 2022;43:4830–1.
8. Jerkeman M, Sultanian P, Lundgren P, Nielsen N, Helleryd E, Dworeck C, et al. Trends in survival after cardiac arrest: a Swedish nationwide study over 30 years. Eur Heart J. 2022;43:4817–29.
9. Adielsson A, Hollenberg J, Karlsson T, Lindqvist J, Lundin S, Silfverstolpe J, et al. Increase in survival and bystander CPR in out-of-hospital shockable arrhythmia: bystander CPR and female gender are predictors of improved outcome. Experiences from Sweden in an 18-year perspective. Heart. 2011;97:1391–6.
10. Wissenberg M, Hansen CM, Folke F, Lippert FK, Weeke P, Karlsson L, et al. Survival after out-of-hospital cardiac arrest in relation to sex: a nationwide registry-based study. Resuscitation. 2014;85:1212–8.
11. Bray JE, Stub D, Bernard S, Smith K. Exploring gender differences and the "oestrogen effect" in an Australian out-of-hospital cardiac arrest population. Resuscitation. 2013;84:957–63.
12. Nehme Z, Bernard S, Cameron P, Bray JE, Meredith IT, Lijovic M, et al. Using a cardiac arrest registry to measure the quality of emergency medical service care: decade of findings from the Victorian Ambulance Cardiac Arrest Registry. Circ Cardiovasc Qual Outcomes. 2015;8:56–66.
13. Kennedy C, Alqudah Z, Stub D, Anderson D, Nehme Z. The effect of the COVID-19 pandemic on the incidence and survival outcomes of EMS-witnessed out-of-hospital cardiac arrest. Resuscitation. 2023;187 109770.
14. Haskins B, Nehme Z, Dicker B, Wilson MH, Ray M, Bernard S, et al. A binational survey of smartphone activated volunteer responders for out-of-hospital cardiac arrest: Availability, interventions, and post-traumatic stress. Resuscitation. 2021;169:67–75.

15. Chan T, Braitberg G, Elbaum D, Taylor DM. Hatzolah emergency medical responder service: to save a life. Med J Aust. 2007;186:639–42.
16. Blom MT, Oving I, Berdowski J, van Valkengoed IGM, Bardai A, Tan HL. Women have lower chances than men to be resuscitated and survive out-of-hospital cardiac arrest. Eur Heart J 2019.
17. Blewer AL, McGovern SK, Schmicker RH, May S, Morrison LJ, Aufderheide TP, et al. Gender Disparities Among Adult Recipients of Bystander Cardiopulmonary Resuscitation in the Public. Circ Cardiovasc Qual Outcomes. 2018;11:e004710.
18. Awad E, Christenson J, Grunau B, Tallon J, Humphries K. Sex differences in out-of-hospital cardiac arrest interventions within the province of British Columbia. Canada. Resuscitation. 2020;148:128–34.
19. Bougouin W, Mustafic H, Marijon E, Murad MH, Dumas F, Barbouttis A, et al. Gender and survival after sudden cardiac arrest: A systematic review and meta-analysis. Resuscitation. 2015;94:55–60.
20. Rajan S, Wissenberg M, Folke F, Hansen SM, Gerds TA, Kragholm K, et al. Association of bystander cardiopulmonary resuscitation and survival according to ambulance response times after out-of-hospital cardiac arrest. Circulation. 2016;134:2095–104.
21. Liu N, Ning Y, Ong MEH, Saffari SE, Ryu HH, Kajino K, et al. Gender disparities among adult recipients of layperson bystander cardiopulmonary resuscitation by location of cardiac arrest in Pan-Asian communities: A registry-based study. EClinicalMedicine. 2022;44 101293.
22. Perman SM, Shelton SK, Knoepke C, Rappaport K, Matlock DD, Adelgais K, et al. Public perceptions on why women receive less bystander cardiopulmonary resuscitation than men in out-of-hospital cardiac arrest. Circulation. 2019;139:1060–8.
23. Matsuyama T, Okubo M, Kiyohara K, Kiguchi T, Kobayashi D, Nishiyama C, et al. Sex-based disparities in receiving bystander cardiopulmonary resuscitation by location of cardiac arrest in japan. Mayo Clin Proc. 2019;94:577–87.
24. Ng YY, Wah W, Liu N, Zhou SA, Ho AF, Pek PP, et al. Associations between gender and cardiac arrest outcomes in Pan-Asian out-of-hospital cardiac arrest patients. Resuscitation. 2016;102:116–21.
25. Hosomi S, Zha L, Kiyohara K, Kitamura T, Irisawa T, Ogura H, et al. Sex disparities in prehospital advanced cardiac life support in out-of-hospital cardiac arrests in Japan. Am J Emerg Med. 2023;64:67–73.
26. Kitamura T, Iwami T, Nichol G, Nishiuchi T, Hayashi Y, Nishiyama C, et al. Reduction in incidence and fatality of out-of-hospital cardiac arrest in females of the reproductive age. Eur Heart J. 2010;31:1365–72.
27. Yoon H, Kim KH, Ro YS, Park JH, Shin SD, Song KJ, et al. Sex disparities in prehospital advanced cardiac life support in out-of-hospital cardiac arrest in south korea. Prehosp Emerg Care. 2022;1–7.
28. Matsui S, Kitamura T, Kiyohara K, Sado J, Ayusawa M, Nitta M, et al. Sex disparities in receipt of bystander interventions for students who experienced cardiac arrest in japan. JAMA Netw Open. 2019;2:e195111.
29. Kotini-Shah P, Del Rios M, Khosla S, Pugach O, Vellano K, McNally B, et al. Sex differences in outcomes for out-of-hospital cardiac arrest in the United States. Resuscitation. 2021;163:6–13.
30. Grunau B, Humphries K, Stenstrom R, Pennington S, Scheuermeyer F, van Diepen S, et al. Public access defibrillators: Gender-based inequities in access and application. Resuscitation. 2020;150:17–22.
31. Mumma BE, Umarov T. Sex differences in the prehospital management of out-of-hospital cardiac arrest. Resuscitation. 2016;105:161–4.
32. Souers A, Zuver C, Rodriguez A, Van Dillen C, Hunter C, Papa L. Bystander CPR occurrences in out of hospital cardiac arrest between sexes. Resuscitation. 2021;166:1–6.
33. van Dongen LH, Oving I, Dijkema PW, Beesems SG, Blom MT, Tan HL. Sex differences in the association of comorbidity with shockable initial rhythm in out-of-hospital cardiac arrest. Resuscitation. 2021;167:173–9.
34. Winther-Jensen M, Kjaergaard J, Wanscher M, Nielsen N, Wetterslev J, Cronberg T, et al. No difference in mortality between men and women after out-of-hospital cardiac arrest. Resuscitation. 2015;96:78–84.
35. Johnson MA, Haukoos JS, Larabee TM, Daugherty S, Chan PS, McNally B, et al. Females of childbearing age have a survival benefit after out-of-hospital cardiac arrest. Resuscitation. 2013;84:639–44.
36. Jadhav S, Gaddam S. Gender and location disparities in prehospital bystander AED usage. Resuscitation. 2021;158:139–42.
37. Ishii M, Tsujita K, Seki T, Okada M, Kubota K, Matsushita K, et al. Sex- and age-based disparities in public access defibrillation, bystander cardiopulmonary resuscitation, and neurological outcome in cardiac arrest. JAMA Netw Open. 2023;6:e2321783.
38. Perman SM, Vogelsong MA, Del Rios M. Is all bystander CPR created equal? Further considerations in sex differences in cardiac arrest outcomes. Resuscitation. 2023;182 109649.
39. Becker TK, Gul SS, Cohen SA, Maciel CB, Baron-Lee J, Murphy TW, et al. Public perception towards bystander cardiopulmonary resuscitation. Emerg Med J. 2019;36:660–5.
40. Lee G, Ro YS, Park JH, Hong KJ, Song KJ, Shin SD. Interaction between bystander sex and patient sex in bystander cardiopulmonary resuscitation for Out-of-Hospital cardiac arrests. Resuscitation. 2023;187 109797.
41. Pei-Chuan Huang E, Chiang WC, Lu TC, Wang CH, Sun JT, Hsieh MJ, et al. Barriers to bystanders defibrillation: A national survey on public awareness and willingness of bystanders defibrillation(☆). J Formos Med Assoc. 2021;120:974–82.
42. Kramer CE, Wilkins MS, Davies JM, Caird JK, Hallihan GM. Does the sex of a simulated patient affect CPR? Resuscitation. 2015;86:82–7.
43. Greenberg MR, Pierog JE. Evaluation of race and gender sensitivity in the american heart association materials for advanced cardiac life support. Gend Med. 2009;6:604–13.
44. Ko SY, Ahn KO, Do Shin S, Park JH, Lee SY. Effects of telephone-assisted cardiopulmonary resuscitation on the sex disparity in provision of bystander cardiopulmonary resuscitation in public locations. Resuscitation. 2021;164:101–7.
45. Program UND. gender inequality index: UNDP human development reports; 2023 [Available from: https://hdr.undp.org/data-center/thematic-composite-indices/gender-inequality-index#/indicies/GII.
46. Bray JE, Deasy C, Walsh J, Bacon A, Currell A, Smith K. Changing EMS dispatcher CPR instructions to 400 compressions before mouth-to-mouth improved bystander CPR rates. Resuscitation. 2011;82:1393–8.
47. Riou M, Ball S, Whiteside A, Bray J, Perkins GD, Smith K, et al. 'We're going to do CPR': A linguistic study of the words used to initiate dispatcher-assisted CPR and their association with caller agreement. Resuscitation. 2018;133:95–100.