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Sex disparities in ICU care and outcomes after cardiac arrest: a Swiss nationwide analysis

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Abstract

Background Conflicting data exist regarding sex-specific outcomes after cardiac arrest. This study investigates sex disparities in the provision of critical care and outcomes of in-hospital (IHCA) and out-of-hospital cardiac arrest (OHCA) patients.

Methods Analysis of adult cardiac arrest patients admitted to certified Swiss intensive care units (ICUs) (01/2008–12/2022) using the nationwide prospective ICU registry. The primary outcome was ICU mortality, with secondary outcomes including ICU admission probability and advanced treatment provision.

Results Among 41,733 individuals (34.9% women), 21,692 patients (30.6% women) were admitted to ICUs (16,571 OHCA patients/5121 IHCA patients). Women were less likely to be admitted to the ICU than men (incidence rate ratio 0.82 [95% CI 0.80–0.85] and had a higher ICU mortality (41.8% vs 36.2%; $p<0.001$). Mortality differences were more pronounced in OHCA patients (unadjusted HR: 1.35 [95% CI 1.28–1.43]; adjusted HR: 1.19 [95% CI 1.12–1.25]). In IHCA patients, mortality differences were less pronounced (unadjusted HR: 1.14 [95% CI 1.04–1.25]) and vanished after adjustment for confounders: adjusted HR: 1.03 [95% CI 0.94–1.13]). Women after cardiac arrest were older, more severely ill, and received fewer interventions before (44.7% vs 54.0%; $p<0.001$) and during ICU stay. A subgroup analysis of 11,202 patients revealed that treatment limitations were more frequent in women (46.7% vs 38.7%; $p<0.001$). However, these limitations were associated with an increased risk of death in both sexes.

Conclusions This study highlights sex disparities in short-term mortality and ICU resource allocation among cardiac arrest patients, with women potentially facing disadvantages, in particular after OHCA. The limitations of ICU registry data, particularly the lack of detailed cardiac arrest-specific and comorbidity information, restrict definitive conclusions. Future research should prioritize prospective studies with more granular data to better understand and address these disparities.

Keywords Sex differences, Sex disparities, Gender differences, Cardiac arrest, ICU admission rate, Resuscitation, CPR

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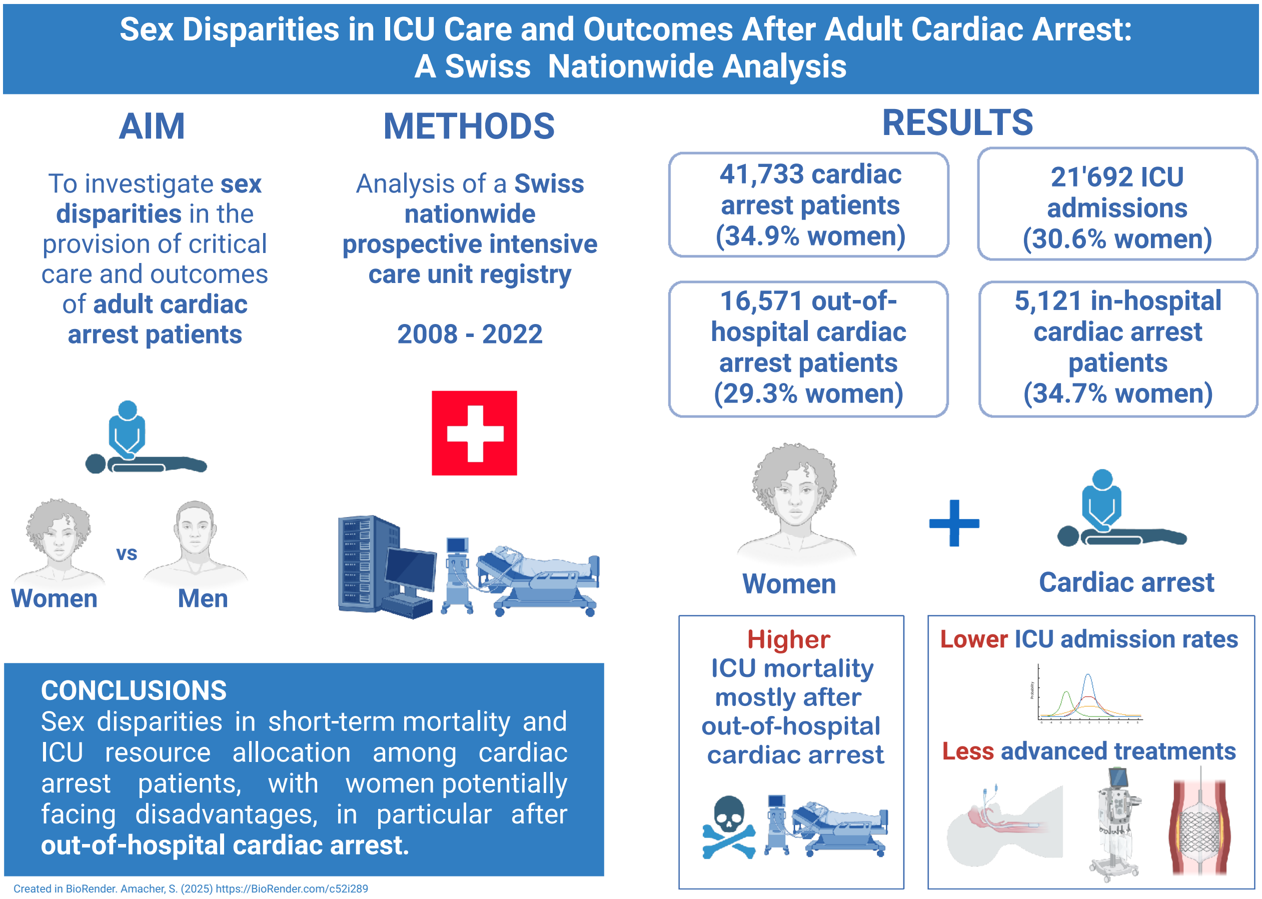
Graphical abstract



Introduction

Cardiac arrest is a leading cause of death worldwide despite many advances in cardiopulmonary resuscitation and intensive care [1–3]. Survivors frequently suffer from long-term disabilities and post-intensive care syndrome [4–7]. Sex and gender-related factors may impact out-of-hospital cardiac arrest (OHCA) outcomes, as factors associated with favourable outcomes, such as shockable initial rhythm or provision of bystander cardiopulmonary resuscitation (CPR) and defibrillation, are less frequently observed in women than in men [8–10]. Several recent observational studies provide an increasing body of evidence for worse short and long-term survival rates, neurological status, and quality of life in women successfully resuscitated from cardiac arrest [3, 7, 10–12]. In contrast, two recent systematic reviews with meta-analyses found no sex differences in survival to hospital discharge after adjusting for available confounders. However, these results must be interpreted cautiously due to the significant heterogeneity of included studies indicating potential sociocultural and geographical differences [13, 14]. For in-hospital cardiac arrest (IHCA) patients, data on sex differences in the provision of intensive care resources and survival is scarce [3, 15].

Sex and gender differences in admission to intensive care units (ICUs) and the provision of invasive and non-invasive treatments before and during intensive care (e.g., percutaneous coronary interventions (PCI), targeted temperature management) have been identified as potential mediators of the survival discrepancies observed in cardiac arrest patients [10, 16]. The disparity in outcomes might not be solely related to the provision of treatment but also to how decisions about end-of-life care are made, as women after cardiac arrest are more likely to undergo withdrawal from life-sustaining therapies [17]. Women are also more likely to have treatment limitations in place, such as do-not-resuscitate (DNR) orders, which may reflect different preferences for care or biases in medical decision-making [18]. Most studies regarding sex- and gender differences in cardiac arrest outcomes, provision of intensive care, and end-of-life care were conducted in North America, Asia, Australia, and Northern Europe, with only little data from Western Europe [13]. The present study aims to assess sex-specific differences and temporal trends in ICU mortality, ICU admission rates, critical care, and treatment limitations in short-term cardiac arrest survivors in a large nationwide ICU registry from Western Europe.

Methods

Databases and study population

The study used ICU data from the prospective Swiss ICU registry (MDSi-Minimal Dataset) of the Swiss Society of Intensive Care Medicine (SSICM). The registry constitutes a mandatory continuous data repository, including a minimal dataset for every patient admitted to officially accredited ICUs in Switzerland (81 to 86 ICUs over the 15-years study period). After validation and completeness check, the data is anonymized and incorporated into a centralized database, as outlined previously [19, 20]. Additionally, data on overall hospital admissions of adult patients with cardiac arrest admitted to any Swiss hospital during the study period were requested from the Swiss Federal Statistical Office (FSO). All patients aged ≥ 18 years who were admitted to a Swiss ICU between January 1, 2008, and December 31, 2022, with the primary diagnosis of cardiac arrest according to the MDSi dataset were included. The overall number of patients aged ≥ 18 years with a diagnosis of cardiac arrest admitted to any Swiss hospital was electronically identified and extracted from the FSO dataset. Supplementary Fig. 1 depicts patient selection from both datasets. Details regarding study reporting, assessed variables, and definitions are described in the Supplementary Material.

Outcome measures

The primary outcome was ICU mortality. The incidence of ICU admission after cardiac arrest and the provision of advanced treatments were assessed as key secondary outcome measures. Advanced treatments included interventions before ICU admission and treatments during the ICU stay. Further secondary outcomes included ICU length of stay and discharge destination. ICU mortality and the incidence of ICU admission were additionally assessed over time to gain insights into temporal trends.

Statistical analysis

Descriptive statistics are shown as mean ± Standard Deviation (SD) or median and interquartile range (IQR) for continuous variables, and numbers with proportions for categorical ones. Differences between sexes were assessed using the Chi-square test. Continuous variables were visually checked for normality. A multivariable Cox regression model was used to explore the association of sex differences with ICU mortality, adjusting for confounders such as age, in-hospital cardiac arrest, Nine Equivalents of Nursing Manpower Use Score (NEMS) score, pre-ICU interventions, ICU type, and level of care. ICU treatments (e.g., renal replacement therapy [RRT], invasive and non-invasive respiratory support, and vasoactive drugs were included as covariates to account for their impact on ICU mortality and potential differences in treatment allocation between sexes. Simplified Acute Physiology Score II [SAPS II] was excluded due to multicollinearity. Time to ICU death was the interval between ICU admission and death or discharge. Hazard ratios (HR) with 95% confidence intervals (95% CI) were reported. A second multivariable analysis (Model 2) included patients with information on treatment limitations available since 2016. Poisson regression was applied to estimate ICU admission and mortality trends, reporting incidence rate ratios (IRR) with 95% CIs to compare sexes. As less than 1% of data was missing and assumed random, no imputation was performed. All analyses were performed using Stata MP/18 (StataCorp, 2023).

Results

Baseline characteristics

During the 15-year study period, a total of 41,733 hospital admissions (14,558 [34.9%] women) with a diagnosis of cardiac arrest were identified, of whom 21,692 patients (6,626 [30.6%] women) were admitted to certified Swiss ICUs and included in the final analysis, Supplementary Fig. 1. The mean age was 65.8 ± 14.6) years, with women being older than men (67.0 years vs 65.2 years, $p < 0.001$). 16,571 (76.4%) patients were classified as OHCA (29.3% women) and 5,121 patients as IHCA (34.7% women). Mean overall illness severity at ICU admission estimated by the SAPS II score was higher in women (62.4 ± 23.1 vs 61.3 ± 23.1). The median overall NEMS was higher in women (103 [IQR 85–140] vs 100 [IQR 83–130]), Table 1. A subgroup analysis of IHCA and OHCA patients revealed higher SAPS II and NEMS scores in female OHCA patients only, Supplementary Table 1. Men were more frequently discharged to other ICUs or intermediate care (33.4% vs 28.9%, $p < 0.001$), while women were more often discharged to the regular ward (68.6% vs 63.9%, $p < 0.001$), Table 1.

Primary outcome—ICU mortality

Sex differences and outcomes (Model I)—overall

Overall, ICU death was reported in 8,228 (37.9%) of 21,692 patients and was higher in women compared to

Table 1 Baseline characteristics and outcomes stratified by sex category

	Total	Men	Women	*p*-value
N	21,692	15,066	6626	
Age (years)—Mean (SD)	65.7 (14.6)	65.2 (14.2)	67.0 (15.4)	< 0.001
Age categories				
Age < 45	1793 (8.3%)	1191 (7.9%)	602 (9.1%)	
Age 45–65	7889 (36.4%)	5836 (38.7%)	2053 (31.0%)	
Age > 65	12,010 (55.4%)	8039 (53.4%)	3971 (59.9%)	
Type of cardiac arrest				
In-hospital cardiac arrest	5121 (23.6%)	3346 (22.2%)	1775 (26.8%)	< 0.001
Out-of-hospital cardiac arrest	16,571 (76.4%)	11,720 (77.8%)	4851 (73.2%)	
Admission information				
Patient's pre-hospital origin				0.22
From home	14,983 (69.1%)	10,398 (69.0%)	4585 (69.2%)	
Other hospital	2903 (13.4%)	2010 (13.3%)	893 (13.5%)	
Nursing home	43 (0.2%)	24 (0.2%)	19 (0.3%)	
Other	3763 (17.4%)	2634 (17.5%)	1129 (17.0%)	
Patients' in-hospital origin				< 0.001
Emergency room	9474 (43.7%)	6503 (43.2%)	2971 (44.9%)	
Operating room/post-interventional	5891 (27.2%)	4340 (28.8%)	1551 (23.4%)	
Other ICU	1206 (5.6%)	877 (5.8%)	329 (5.0%)	
IMC/PACU	560 (2.6%)	369 (2.5%)	191 (2.9%)	
Ward	2959 (13.6%)	1888 (12.5%)	1071 (16.2%)	
Other	1602 (7.4%)	1089 (7.2%)	513 (7.7%)	
Illness severity and use of ICU resources				
SAPS-II—Mean (SD)	61.63 (23.11)	61.30 (23.10)	62.38 (23.11)	0.001
Sum NEMS of all nursing shifts—Median (IQR)	101 (83–133)	100 (83–130)	103 (85–140)	< 0.001
NEMS first nursing shift—Median (IQR)	12.22 (5.78–29.33)	11.49 (5.52–26.15)	14.21 (6.48–36.04)	< 0.001
NEMS last nursing shift—Median (IQR)	8.82 (3.56–23.94)	8.18 (3.30–21.60)	10.29 (4.21–30.00)	< 0.001
SAS > 4 points	6804 (31.4%)	5119 (34.0%)	1685 (25.4%)	< 0.001
Interventions and/or surgeries before ICU admission				
No intervention	10,597 (48.9%)	6933 (46.0%)	3664 (55.3%)	< 0.001
Percutaneous coronary intervention	6459 (29.8%)	5126 (34.0%)	1333 (20.1%)	
Cardiac surgery/other cardiovascular interventions	1879 (8.7%)	1282 (8.5%)	597 (9.0%)	
Non-cardiac surgery	2757 (12.7%)	1725 (11.5%)	1032 (15.6%)	
Treatments during ICU stay				
Intravenous medications	21,423 (98.8%)	14,888 (98.8%)	6535 (98.6%)	0.24
Mechanical ventilation	17,973 (82.9%)	12,494 (82.9%)	5479 (82.7%)	0.67
Additional respiratory support	12,695 (58.5%)	9052 (60.1%)	3643 (55.0%)	< 0.001
1 Vasoactive medication	15,340 (70.9%)	10,759 (71.6%)	4581 (69.3%)	< 0.001
> 1 Vasoactive medication	8234 (38.1%)	5849 (38.9%)	2385 (36.1%)	< 0.001
Renal replacement therapy	1666 (7.7%)	1213 (8.1%)	453 (6.8%)	0.002
Advanced Intervention in the ICU	11,227 (51.8%)	7910 (52.5%)	3317 (50.1%)	< 0.001
Advanced Intervention outside the ICU	10,044 (46.5%)	7129 (47.5%)	2915 (44.3%)	< 0.001
ICU type				
Medical ICU	3191 (14.7%)	2317 (15.4%)	874 (13.2%)	< 0.001
Surgical ICU	1116 (5.1%)	749 (5.0%)	367 (5.5%)	
Interdisciplinary ICU	17,197 (79.3%)	11,849 (78.7%)	5348 (80.7%)	
Other	188 (0.9%)	151 (1.0%)	37 (0.6%)	

Table 1 (continued)

	Total	Men	Women	*p*-value
Level of care				
Tertiary university hospital	8371 (38.6%)	6000 (39.8%)	2371 (35.8%)	< 0.001
Large hospital	5222 (24.1%)	3717 (24.7%)	1505 (22.7%)	
Regional hospital/no categorization	8099 (37.3%)	5349 (35.5%)	2750 (41.5%)	
Discharge information and outcomes				
Patient's discharge destination (patients discharged alive)				
Ward	8790 (65.29%)	6145 (63.94%)	2645 (68.63%)	< 0.001
Other ICU or IMC	4320 (32.09%)	3,208 (33.38%)	1112 (28.85%)	
Discharge to rehabilitation or home	105 (0.78%)	79 (0.82%)	26 (0.67%)	
Other	249 (1.85%)	178 (1.85%)	71 (1.84%)	
ICU length of stay—Median (IQR)	2 (1–5)	3 (1–6)	2 (1–5)	< 0.001
ICU mortality	8228 (37.9%)	5456 (36.2%)	2772 (41.8%)	< 0.001

Descriptive statistics are presented using mean and standard deviation (SD) or median and interquartile range (IQR: 25th–75th percentile) for continuous variables and numbers and proportions for categorical variables

ICU Intensive care unit, *IMC* Intermediate care unit, *IQR* Interquartile range, *NEMS* Nine equivalents of nursing manpower use score, *PACU* Post-anesthesia care unit SAS Sedation-agitation scale, *SAPS-II* Simplified Acute Physiology Score II, *SD* Standard deviation

men (41.8% vs 36.2%, p < 0.001), Table 1. Women experienced a higher ICU mortality as early as day 1 after ICU admission (ICU mortality day 1 men 14.1% [95% CI 13.6–14.7] vs. women 18.9% [17.9–19.9]), Supplementary Table 2. Survival analysis revealed an increased hazard for ICU death in women compared to men (unadjusted HR 1.31 [95% CI 1.25–1.37]) across the ICU stay, which was already evident in the first seven days after ICU admission (unadjusted HR 1.33 [95% CI 1.26–1.39]), Figs. 1 and 2, Supplementary Table 2. When estimating the incidence rate ratio (IRR) stratified for age and sex, women aged 50–69 years had a higher incidence rate for ICU death (IRR between 1.15 and 1.42) compared to men. In contrast, no sex differences were observed in the age groups < 50 years and ≥ 70 years, Fig. 4, Supplementary Table 3.

In the adjusted multivariable model, women exhibited a consistently higher risk of ICU death compared to men (adjusted HR [aHR] 1.14 [95% CI 1.09–1.20]), Supplementary Table 4. IHCA, in comparison to OHCA, was linked to an increased mortality risk only in men (aHR 1.19 [95% CI 1.11–1.27]). Age > 65 years was associated with an increased risk of dying in both sexes, which was more pronounced in men (ratio women:men aHR 0.88 [95% CI 0.79–0.97]), Fig. 3, Supplementary Table 4. All registered interventions before ICU admission were associated with a lower risk of ICU death in men and women, except for cardiac surgery/other cardiovascular interventions, which was not associated with a risk reduction for women (aHR 0.88 [95% CI 0.76–1.02], men: aHR 0.70 [95% CI 0.63–0.79]), Fig. 3, Supplementary Table 4.

Primary outcomes and sex differences stratified by in-hospital and out-of-hospital cardiac arrest

ICU death was reported in 2,063 of 5,121 (40.3%) IHCA patients and in 6,165 of 16,571 (37.2%) OHCA patients, Supplementary Table 1. In both groups, survival analysis revealed an increased hazard for ICU death in women compared to men across the ICU stay, which was more pronounced in OHCA patients: IHCA (unadjusted HR 1.14 [95% CI 1.04–1.25]); OHCA (unadjusted HR 1.35 [95% CI 1.28–1.43]), Fig. 1B, C.

The increased hazard for ICU death in women was already evident in the first seven days after admission and more prominent in OHCA patients: IHCA (unadjusted HR 1.15 (95% CI 1.04–1.26); OHCA (unadjusted HR 1.38 (95% CI 1.30–1.46), Fig. 2B, C. Along with that, women experienced a higher mortality at all time points in OHCA. Conversely, in IHCA patients, a significantly higher ICU mortality in women during the first 7 days was only observed on days 5 and 7, Supplementary Table 2.

In the multivariable analysis, female compared to male sex was linked to a higher risk of ICU death only in OHCA patients (aHR 1.19 [95% CI 1.12–1.25], Supplementary Table 5.

PCI was associated with a mortality risk reduction in both sexes, while cardiac surgery was connected to a lower risk of ICU death only in men independent of cardiac arrest type: IHCA (aHR 0.64 [95% CI 0.50–0.82]); OHCA (aHR 0.81 [95% CI 0.71–0.91]). Non-cardiac procedures were associated with a risk reduction in women with IHCA, while only men experienced a risk reduction after OHCA. Please refer to the Supplementary material

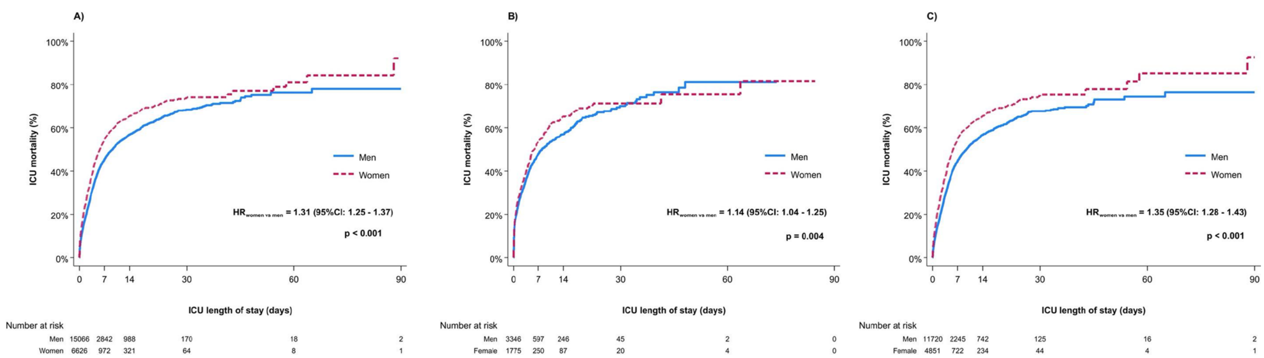


Fig. 1 Kaplan–Meier estimate of ICU mortality until 90 days after ICU admission. **A** Overall, **B** In-hospital cardiac arrest, **C** Out-of-hospital cardiac arrest. Abbreviations: CI Confidence interval; HR Hazard ratio; ICU Intensive care unit

(Supplementary Figs. 2 & 3, Supplementary Table 5) for further details.

Primary outcome and sex differences in the subgroup of patients with treatment limitations (model II)

We performed multivariable analysis (Model II) in a subgroup of 11,202 patients (30.4% women) with information regarding treatment limitations. Women had significantly more treatment limitations (46.7% vs 38.7%, $p < 0.001$), but the risk of dying did not differ between sexes. More details are available in the Supplementary material (Supplementary Results, Supplementary Fig. 4, Supplementary Tables 6 & 7).

Secondary outcomes

Sex differences in ICU admission rates

The incidence of ICU admission in patients after cardiac arrest was higher in men than in women, with women being 18% less likely to be admitted to ICUs compared to men (IRR 0.82 (95% CI 0.80–0.85), Figs. 4 and 5, Supplementary Table 8. Regarding age distribution, ICU admission incidence rates were higher in men ≥ 45 years compared to women of the same age (45–65 years [IRR = 1.12, 95% CI 1.06–1.18] and above 65 years [IRR = 1.24, 95% CI 1.19–1.29)], Supplementary Table 8 and Fig. 4. Further detailed information regarding sex differences and temporal trends of ICU admission rates and mortality is provided in the Supplementary results and Supplementary Table 8.

Sex differences in treatments before and during ICU stay

Interventions before ICU admission were less frequently performed in women than in men (44.7% vs 54.0%, $p < 0.001$). PCI was more common in men, while women more often underwent rescue cardiac surgery/other cardiovascular procedures (except PCI), and non-cardiac surgery. This pattern was also observed in the IHCA and OHCA subgroups, Table 1 and Supplementary Table 1.

During the ICU stay, mechanical ventilation (MV) was equally provided to both sexes, but men more frequently received non-invasive respiratory support, vasoactives, RRT, and advanced interventions, Table 1. The sex differences were more evident in OHCA patients (OHCA: all treatments except MV and intravenous medication more frequent in men; IHCA: only MV, additional respiratory support, and RRT more frequent in men), Supplementary Table 1. Further detailed information regarding treatments is provided in Supplementary Table 1, Fig. 3, Supplementary Fig. 3 & 4.

Sex differences in ICU length of stay

Median ICU LOS was shorter in women (2 days [IQR 1–5] vs 3 days [IQR 1–6], $p < 0.001$) and was shorter in ICU non-survivors (2 days [IQR 0–4] vs 3 days [IQR 1–6], $p < 0.001$). Women had a significantly shorter ICU LOS regardless of survival status: ICU survivors (women 3 days [IQR 1–6] vs men 3 days [IQR 1–7], $p < 0.001$) and ICU non-survivors (women 1 day [IQR 0–3] vs men 2 days [IQR 0–4], $p < 0.001$). These observations remained constant in the subgroup analysis of OHCA and IHCA patients, except for IHCA non-survivors, where ICU LOS did not differ between men and women ($p = 0.21$), Supplementary Table 9.

Discussion

This nationwide study, including 41,733 hospitalized individuals (21,692 ICU patients), identified important sex differences in ICU mortality rates, ICU admission rates, and provision of advanced treatments after successfully resuscitated in- and out-of-hospital cardiac arrest. Women were less frequently admitted to ICUs, received fewer advanced treatments, and had a higher risk of ICU mortality when compared to men. When analyzing subgroups of OHCA and IHCA patients, mortality differences were particularly pronounced in OHCA patients. In addition, women after cardiac arrest showed significantly shorter median ICU stays independent from ICU survival. When stratified for age and sex, women died more often in the age groups 50–69 years. Treatment limitations were more frequent in women and were associated with an increased risk of ICU mortality in both sexes.

In this study, women had higher ICU mortality than men, consistent with lower survival rates in women across most studies, despite a higher likelihood of achieving return of spontaneous circulation [9, 12]. As observed in our study, women tend to be older and suffer from more comorbidities at the time of cardiac arrest, which may partly explain their greater illness severity at ICU admission and the higher risk of ICU death [21]. Interestingly, the higher illness severity at ICU admission in women was only observed in the subgroup of OHCA patients. Although our study lacked detailed information on comorbidities, prior studies have shown greater disease severity in women with cardiovascular conditions [21, 22]. The higher incidence of ICU death in women aged 50–69 compared to age-matched men may be linked to the biological effects of the perimenopausal period [23], as studies suggest that declining estrogen levels increase the risk of cardiovascular (CV) disease, ischemic heart disease, and cardiac arrest in women [24, 25]. However, these sex differences in CV outcomes seem to diminish in older age groups. Evidence indicates that while menopause accelerates CV risk factors in women, chronological aging may dominate over hormonal effects in the elderly [26].

In our study, in-hospital cardiac arrest (IHCA) was more common in women, while OHCA was more frequent in men. Women experienced a higher risk of ICU mortality overall, with a more pronounced difference in OHCA patients compared to IHCA patients. Along with that, adjusted hazard ratios demonstrated that female sex was independently associated with a higher risk of ICU death in OHCA but not in IHCA. These findings align with previous studies showing that women are less likely to receive bystander CPR and experience delays in resuscitation during OHCA, which may contribute to their higher ICU mortality risk and illness severity observed in our study [8–10]. In contrast, IHCA occurs in monitored hospital environments, where standardized protocols and rapid response systems might mitigate pre-resuscitation differences [15, 27].

While sex differences in pre-ICU and ICU care may have contributed to the higher mortality observed in women, early withdrawal of life-sustaining therapy (WLST) could also play a role, particularly in OHCA patients, where women consistently showed higher mortality rates from the first day of ICU admission onwards. The shorter ICU LOS observed in female OHCA non-survivors compared to male OHCA non-survivors may suggest earlier withdrawal of life-sustaining therapy (WLST) in women. Current guidelines recommend postponing prognostication and WLST for at least 72 h after cardiac arrest [28]. However, previous studies have highlighted that unjustified early WLST after cardiac arrest is common, with women being particularly at risk [12, 29]. In contrast, the absence of significant LOS differences in IHCA non-survivors and a more equalized risk of ICU mortality between sexes suggests a more standardized ICU care in this subgroup, potentially minimizing sex-related variability. While early WLST cannot be entirely excluded as a contributing factor to the higher early ICU mortality observed in women, the shorter ICU LOS in female survivors indicates that factors beyond early WLST, such as differences in ICU care pathways or treatment escalation decisions, may influence outcomes, particularly in OHCA patients. Indeed, sex differences in the provision of ICU treatments were more pronounced in the OHCA subgroup. Given the limitations

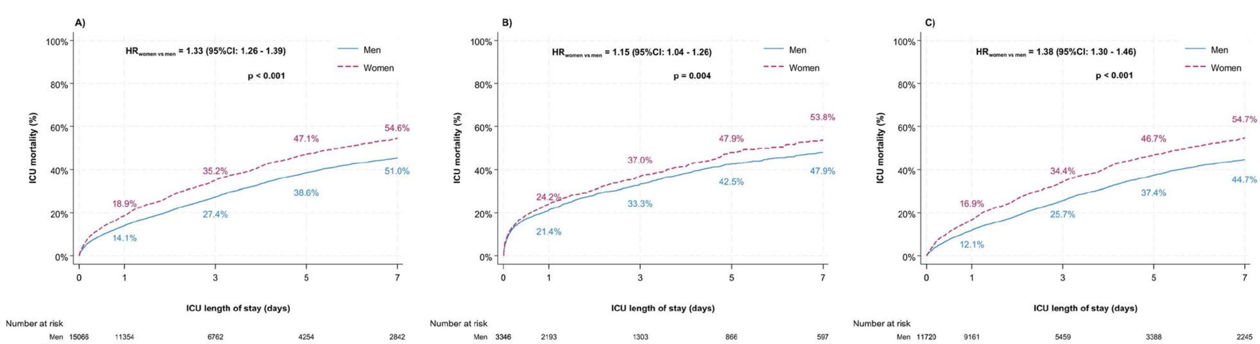


Fig. 2 Kaplan–Meier estimate of ICU mortality during the first 7 days after ICU admission. **A** Overall, **B** In-hospital cardiac arrest, **C** Out-of-hospital cardiac arrest. Abbreviations: CI Confidence interval; HR Hazard ratio; ICU Intensive care unit

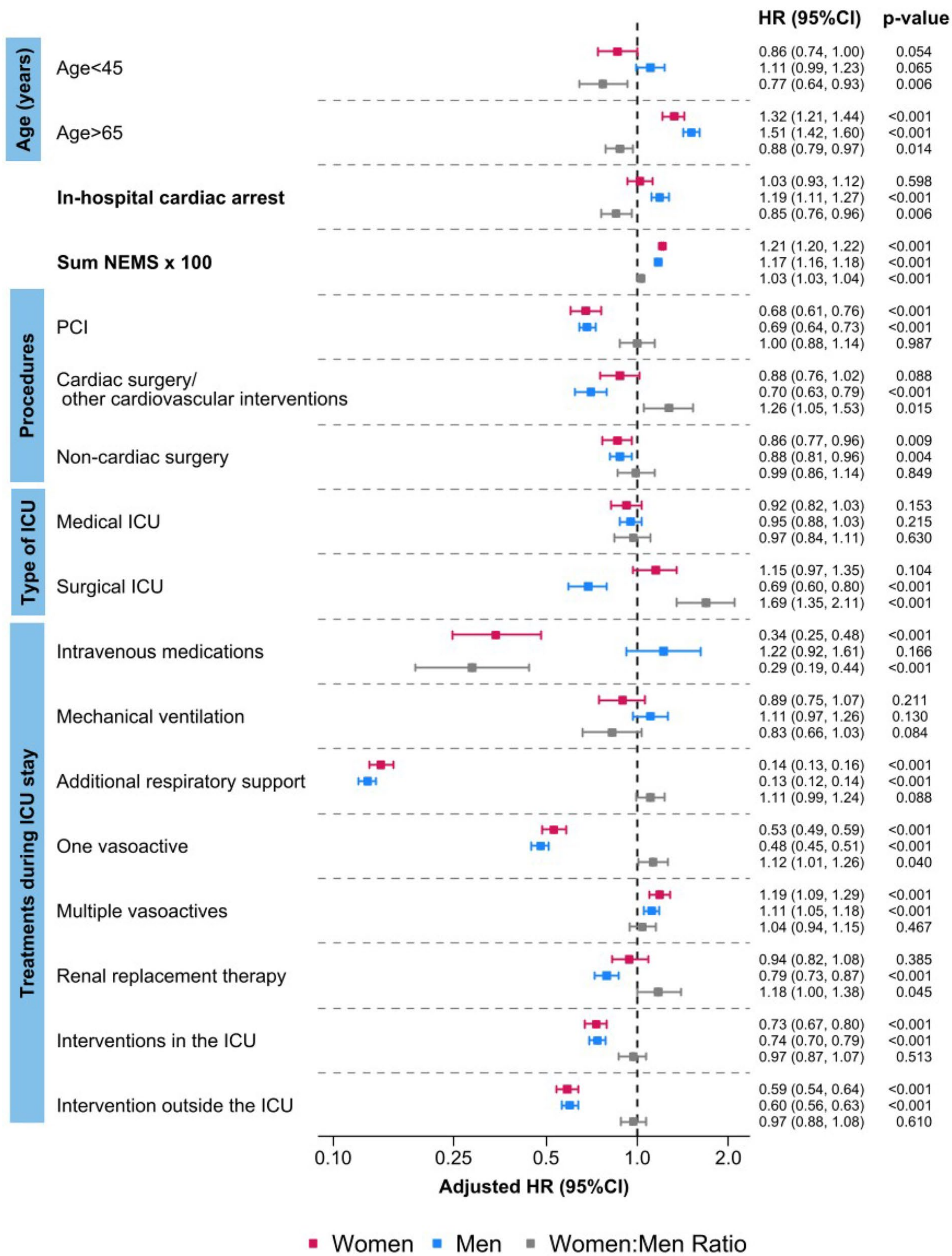


Fig. 3 Sex differences in ICU mortality risk from multivariable analysis. Abbreviations: HR Hazard ratio; ICU Intensive care unit; NEMS Nine equivalents of Nursing Manpower Use Score; PCI Percutaneous coronary intervention

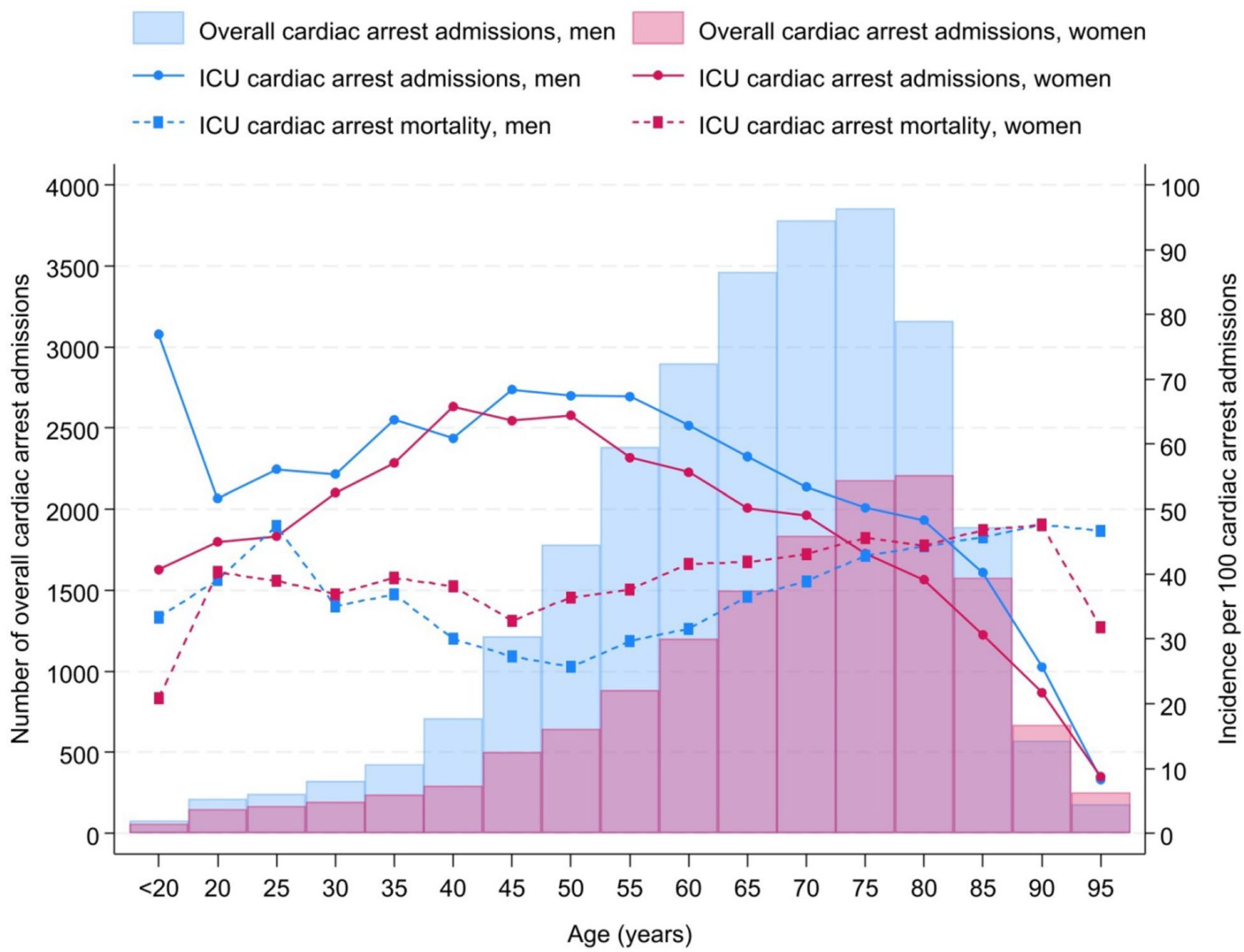


Fig. 4 Incidence rate ratios (IRR) of ICU admission and ICU death in women and men across age groups and overall number of cardiac arrest admissions. Abbreviations: ICU Intensive Care Unit

in WLST timing granularity within our dataset, we caution against the overinterpretation of these findings and emphasize the need for prospective studies with detailed WLST timing and decision-making data to validate our observations.

Pre-ICU interventions like acute PCI or rescue cardiac surgery improve outcomes after cardiac arrest. However, important sex differences in pre-ICU interventions were observed in our study. Women with cardiovascular conditions, including acute myocardial infarction (AMI) and cardiogenic shock, often receive less aggressive treatments than men, leading to poorer outcomes [22, 30, 31]. This is mirrored by our study, revealing that women less frequently received interventions (incl. PCI) before ICU admission, independent of cardiac arrest type, while rescue cardiac surgery was more frequently performed in women. PCI and non-cardiac surgery were associated with a reduced ICU death risk in both sexes. In contrast, cardiac surgery/other cardiovascular interventions were only associated with a reduced ICU death risk in men. A more severe disease state at presentation in women may result in worse conditions requiring emergent surgical revascularization. Misperception of symptoms, under- or misdiagnosed cardiovascular illness, and sociocultural factors, such as women's entrenchment in traditional gender roles and delayed healthcare-seeking behavior, have been linked to more advanced cardiovascular illness in women at presentation [32]. Additionally, older women may experience fewer witnessed OHCAs due to reduced social support or living alone, leading to a lower likelihood of receiving bystander CPR [33]. Delayed CPR and less frequent shockable initial rhythms are well-established mediators of higher rates of multiorgan failure and worse outcomes [9, 34]. These factors likely contribute to the higher mortality rate observed in female OHCA patients.

Most ICU treatments were more frequently applied to men, consistent with previous research [34]. While most

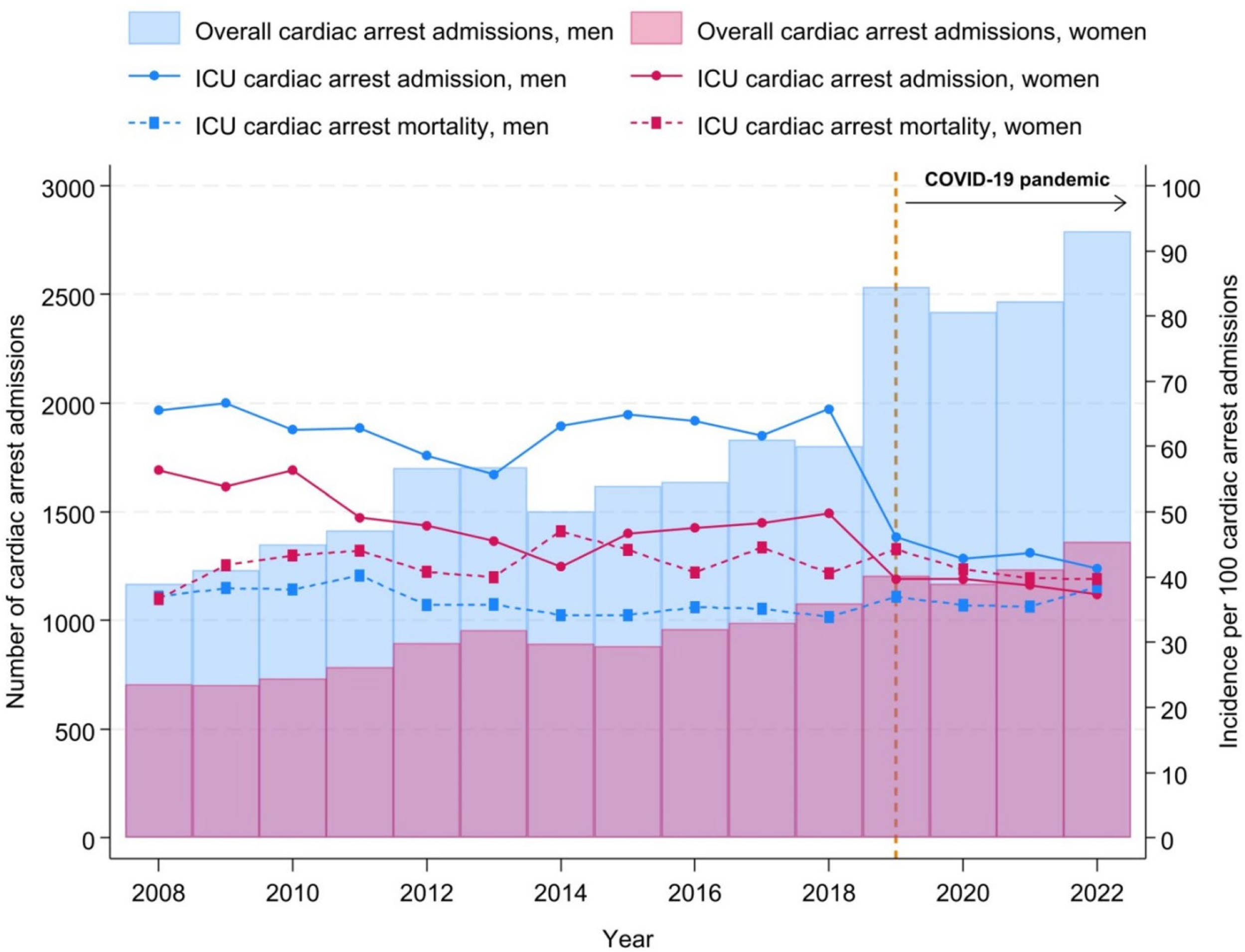


Fig. 5 Temporal trend of incidence rate ratios (IRR) of ICU admission and ICU death in women and men; overall number of cardiac arrest admissions over time. Abbreviations: COVID-19 Coronavirus disease—2019; ICU Intensive Care Unit

organ support measures were associated with decreased mortality risk in both sexes, RRT was only associated with a lower mortality risk in men, independent of cardiac arrest entity. The more frequent use of RRT in men may stem from an underestimation of acute kidney injury (AKI) in women, leading to delayed or even withheld RRT [20]. In addition, biological factors such as a decline of estrogen and its renoprotective effects may impact AKI and outcomes in elderly women [36].

We found that women had an 18% lower likelihood of ICU admission compared to men, particularly in those aged over 55 years, a trend consistent over the 15-year study period. This aligns with prior studies showing lower ICU admission rates for women, especially in cardiovascular cases [22, 31, 37]. Female sex and older age have been linked to life-sustaining treatment limitations, potentially influencing ICU resource allocation if clinicians assume that women might prefer less aggressive care [12, 39]. Although we were unable to assess how treatment limitations impacted decision-making before ICU admission, our data revealed that women had a higher prevalence of treatment limitations upon ICU admission, more withdrawal of life-sustaining therapy, and more decisions taken by the medical caregivers during ICU stay. Despite this, the increased hazard of ICU death in patients with treatment limitations was similar between sexes, a finding consistent with previous data [12]. Therefore, we propose that unaccounted factors, including unconscious biases related to race, ethnicity, ability, age, and sex, may influence ICU admission and treatment decisions in a discriminatory manner, potentially leading to limited or even denied care [39].

Interestingly, we observed a significant decline in ICU admissions for cardiac arrest patients across both sexes during the COVID-19 pandemic (2020–2022), with the reduction being more pronounced in men. However, ICU mortality remained higher in women. During COVID-19, scarcity of critical care resources and prognosis-based triage may have led to limited ICU provision in cardiac arrest patients, which might also have reduced the over-admission of men compared to women [40]. In addition, increased healthcare strain and lockdowns were linked to fewer bystander-witnessed OHCAs and excess deaths at home or delayed hospital admissions during the pandemic [40, 41].

Limitations and strengths

There are important limitations to consider. First, the FSO and the MDSi datasets comprise limited variables and lack detailed information on patient demographics, comorbidities, cardiovascular risk factors, cardiac arrest-specific information, and sociocultural factors. Second, the definition of OHCA versus IHCA was solely based on the origin of the patients before ICU admission, with a risk of misclassification for some patients. However, considering the large sample size, it is unlikely to have changed our findings. Third, data on decision-making during pre-hospital, pre-ICU, and ICU care were limited or unavailable. Specifically, the lack of WLST timing granularity may have influenced our results. Fourth, due to the limitations of the MDSi dataset, we were unable to include information regarding witnessed/unwitnessed cardiac arrest, no-flow time, low-flow time, provision of bystander CPR, initial rhythm of cardiac arrest, detailed cardiac arrest etiology, provision of eCPR and provision of targeted temperature management into our analysis. Lastly, despite our large nationwide dataset, the restriction of our data to Switzerland and a mainly Caucasian population may limit the generalizability of our results.

The study has notable strengths. The database includes all patients from certified Swiss ICUs since 2008, offering a high internal and external validity with a large sample size and minimal missing data (< 1%). Additionally, detailed information on treatment limitations provides valuable insights into sex-specific ICU outcomes.

Conclusions

This nationwide study highlights sex disparities in short-term mortality and ICU resource allocation among cardiac arrest patients, with women potentially facing disadvantages, in particular after OHCA. While our findings suggest multifactorial causes, including biological differences, sociocultural factors, and potential biases, the limitations of ICU registry data, particularly the lack of detailed cardiac arrest-specific and comorbidity information, restrict definitive conclusions.

Future prospective studies are essential to investigate these dynamics further, supported by enhanced administrative databases that enable detailed analyses of sex- and gender-related differences in post-cardiac arrest care.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13054-025-05262-5.

Additional file 1.

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During the preparation of this work, the authors used the grammar check Software Grammarly (Grammarly Inc., San Francisco, USA) to proofread and increase readability and the large language model ChatGPT-4o (OpenAI, San Francisco, USA) to paraphrase and summarize some of the manuscript's content. In addition, the large language model OpenEvidence (Cambridge, USA) to identify additional relevant literature in the field. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the publication's content. We thank Prof. Mark Kaufmann for providing expert advice about the data structure and for critically reviewing the manuscript. The authors thank the Federal Statistics Office for providing the hospital admission data and supporting data interpretation. They also thank the Swiss Society of Intensive Care Medicine for generously providing the MDSi—Minimal Dataset for Intensive Care Units, which formed the main body of the current analysis.

Author contributions

Simon A. Amacher and Caroline E. Gebhard planned and designed the study. Pimrapat Gebert performed the formal statistical analysis of the data provided by the Swiss Society of Intensive Care Medicine and the Federal Statistics Office. Simon A. Amacher, Pimrapat Gebert, and Caroline E. Gebhard interpreted the data. Caroline E. Gebhard and Simon A. Amacher wrote the inaugural draft of the manuscript. Simon A. Amacher, Tobias Zimmermann, Pimrapat Gebert, Pascale Grzonka, Sebastian Berger, Martin Lohri, Valentina Tröster, Ketina Arslani, Hamid Merdji, Catherine Gebhard, Sabina Hunziker, Raoul Sutter, Martin Siegemund and Caroline E. Gebhard interpreted the data, revised the final manuscript and substantially contributed to the inaugural draft. All authors approved the final submitted version of the manuscript.

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Availability of data and materials

This study is based on the MDSi dataset by the Swiss Society of Intensive Care Medicine (SSICM) and the Swiss Federal Statistical Office (FSO). Restrictions apply to the availability of this data and any requests must be made to the scientific committee of the SSICM (https://www.sgi-ssmi.ch) or/and the FSO (https://www.bfs.admin.ch/bfs/en/home.html).

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Committee of Northwestern and Central Switzerland (EKNZ UBE-15/47) and the scientific committee of the SSICM. It was carried out according to the principles of the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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