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Short title: Women in Polish interventional cardiology

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INTRODUCTION

Gender-related disparities persist across multiple domains of medicine, affecting not only access to medical care, clinical presentation, and therapeutic approaches, but also scientific research participation [1, 2]. While numerous global initiatives, including networking opportunities, mentoring programs, and Women in Cardiology working groups, strive to address these disparities, significant challenges remain. For instance, recent studies have examined gender gaps in leading author positions within Polish cardiology publications [3, 4]. Although opportunities for women's medical education are increasingly promoted, the path to becoming a successful specialist remains challenging. Female physicians face unique obstacles in balancing personal and professional responsibilities, while societal expectations and gender biases impede career advancement. Still, women in medicine continue to be underrepresented in managerial positions, receive lower compensation, face higher rates of workplace discrimination, including mobbing and nepotism [5, 6].

Given the ongoing relevance of these gender-based disparities in cardiology, our study aims to examine two specific aspects within the Polish medical community: women's participation in interventional cardiology and their scientific achievements.

METHODS

Data from the Polish National Registry of PCI (ORPKI) were analyzed for all operators who performed at least one coronary angiography or percutaneous coronary intervention (PCI) between 2014 and 2023. After reviewing for completeness and duplicates, operator gender was determined by given name. The database was enriched with information on work experience and scientific achievements. Professional experience was calculated from medical license obtainment to 2024 or date of death, using the central register of medical doctors (https://rejestr.nil.org.pl/). For missing data, dates were estimated based on specialty certification. Scientific degree information was collected from the central register of medical doctors and https://ludzie.nauka.gov.pl/. Publication metrics were gathered manually from two sources: PubMed (https://pubmed.ncbi.nlm.nih.gov/) for total publications and first/last author positions, and Web of Science Core Collection (Clarivate Analytics) for publication count, citations, and H-index. Papers outside cardiology and multicenter trials without direct authorship were excluded.

Categorical variables are presented as frequencies (percentages), with group differences assessed by χ^2 test or Fisher's exact test. Continuous variables, all non-normally distributed, are shown as medians with interquartile ranges and compared using Mann–Whitney U test. Independent predictors of procedure volumes and publication counts (Web of Science data)

were identified using nonparametric kernel density multivariable regression models. Bootstrap resampling was employed to calculate standard errors and confidence intervals. Variables showing significant correlation were excluded from the final multivariable model. Statistical significance was set at P <0.05. Analyses were performed using IBM SPSS Statistics version 29.0.0 and Stata version 18.5.

RESULTS

Among 1005 invasive cardiology operators in the ORPKI database (2014–2023), 56 (5.6%) were women. The proportion of female PCI operators showed a non-significant increase from 3.3% (2014) to 5.2% (2023) (P = 0.10, Supplementary material, *Figure S1*). Women had shorter median work experience (20.0 years [13.5–28.5] vs. 23.0 years [17.0–30.0]; P = 0.006).

Of 2 777 511 total procedures (1 762 295 coronary angiographies, 1 015 216 PCIs), women performed fewer median procedures across all categories: total procedures (1909.0 [581.0–2946.5] vs. 2628.5 [1095.0–4314.5]; P <0.001), coronary angiographies (1256.0 [352.0–2073.5] vs. 1634.5 [730.5–2792.0]; P <0.001), and PCIs (497.0 [210.0–1077.5] vs. 923.0 [363.0–1668.5]; P = 0.006). Female operators conducted 3.4% of all procedures, with increases observed over time (P <0.001; Supplementary material, *Figure S2*). The multivariable regression model (Supplementary material, *Table S1*) indicated that work experience positively and significantly affects the number of all procedures performed, with an estimated increase of 66.9 procedures per additional year of experience. Gender differences were also significant, with women showing 955.45 fewer procedures than men, even after controlling for other factors. Other variables, such as academic title and number of publications, did not significantly influence the outcome. Across all levels of work experience, male operators consistently perform more procedures than their female counterparts (Supplementary material, *Figure S3*).

Scientific grade distribution was similar between genders (Figure 1). Based on the PubMed data, the median number of papers published by a given operator (3.0 [0.0–11.5] vs. 4.0 [0.0–17.5]; P = 0.30) as well as those published as the first (0.0 [0.0–2.0] vs. 0.0 [0.0–2.0]; P = 0.86) and the last author (0.0 [0.0–1.0] vs. 0.0 [0.0–1.0]; P = 0.76) was comparable between women and men. Similarly, the median number of papers listed for a given operator in the Web of Science database did not differ between genders (2.5 [0.0–15.5] vs. 4.0 [0.0–20.0]; P = 0.51). Papers from women and men gained a similar number of citations (9.0 [0.0–124.5] vs. 13.0 [0.0–137.0]; P = 0.51) and citations after exclusion of self-citations (8.5 [0.0–122.0] vs. 12.0 [0.0–132.0]; P = 0.52), resulting in comparable H-index of 1.0 (0.0–4.5) vs. 2.0 (0.0–6.0); P = 0.52. The multivariable regression model (Supplementary material, *Table S2*) confirmed that

first- and last-author publications significantly positively impacted the total number of publications, contributing 4.07 and 3.87 additional publications, respectively. Work experience was also a marginally significant predictor, with an increase of 0.24 publications per year. Gender differences and academic titles did not show a statistically significant effect on publication count.

DISCUSSION

Our findings align with global trends regarding women's underrepresentation in cardiology, particularly in interventional cardiology [7, 8]. The data demonstrate that female operators perform significantly fewer interventional procedures compared to their male counterparts and tend to handle more cases involving single vessel disease [8]. This gender disparity extends beyond Poland's borders. Wang et al. reported that in the United States, women constitute only 4% of interventional cardiologists and perform merely 3% of all PCI procedures, figures that closely parallel our observations [9]. However, encouragingly, our data show an annual increase in PCI procedures performed by female interventionalists. Importantly, studies have found no difference in periprocedural complications between patient-operator gender concordant and discordant pairs [10].

The underrepresentation of women extends beyond clinical practice into academic leadership and research. Despite increasing numbers of women entering medical school, they remain underrepresented in leadership positions within organized medicine and academia, and as principal investigators in major research initiatives [5, 6, 11, 12]. Most female leaders specialize in non-interventional cardiology and have fewer scientific publications compared to their male colleagues [12], although the proportion of women authors has shown an upward trend over time [3, 4].

The barriers facing women in medicine stem from deep-rooted structural and systemic inequalities. These challenges include gender bias, disproportionate domestic and parental responsibilities, work-life integration difficulties, and career interruptions related to pregnancy and child-rearing [5]. Nevertheless, our data reveal comparable scientific achievements between genders in terms of academic degrees. The median number of total publications, first-author and last-author positions, citation counts, and H-indices showed no significant gender differences among Polish interventional cardiologists. However, it is noteworthy that most scientific output among women was concentrated among a few highly productive female PCI operators and authors (Supplementary material, *Figure S4*), suggesting the need for initiatives to encourage broader scientific engagement across both genders.

Study limitations include potential underestimation of procedures due to incomplete ORPKI registry reporting and possible discrepancies in public data sources regarding academic achievements. These limitations affect both gender groups equally. While surveys might provide more detail, low response rates (exemplified by the 15.1% rate in a Polish Cardiac Society survey [5]) present alternative challenges.

In conclusion, the narrowing gender gap in interventional cardiology shows promising progress. By highlighting existing disparities and increasing female participation, we aim to encourage more women to pursue this subspecialty and advance cardiovascular medicine.

Supplementary material

Supplementary material is available at https://journals.viamedica.pl/polish_heart_journal.

Article information

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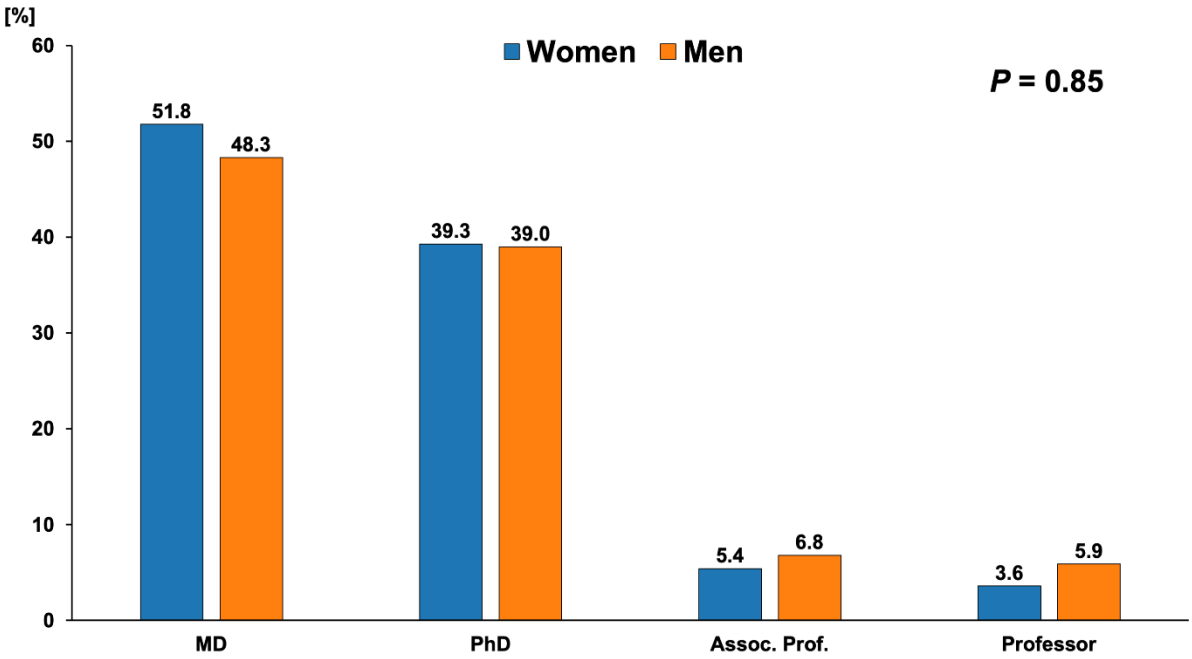

Figure 1. Distribution of academic degrees among female and male interventional cardiologists

Abbreviations: MD, Medical Doctor; PhD, Doctor of Philosophy; Assoc. Prof., Associate Professor