

The gender gap in interventional cardiology research: insights from *Advances in Interventional Cardiology* journal (2015-2023)

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Introduction

Gender-related disparities in access to medical care, clinical presentation, therapy, and outcomes have been highlighted by numerous studies [1]. However, these disparities also extend into scientific research, affecting academic productivity and recognition [2–4]. As a result, female researchers are underrepresented in many scientific disciplines, including cardiology, which impacts their career advancement [1, 5]. A recent analysis of papers published in the *Polish Heart Journal (Kardiologia Polska)* confirmed the presence of a gender gap in leading author positions in cardiology papers in Poland [6]. To extend these findings, we focused on the field of interventional cardiology, examining gender representation among authors who published in another Polish cardiology journal, *Advances in Interventional Cardiology (Postępy w Kardiologii Interwencyjnej)*. Additionally, we assessed gender-related differences in rejection and citation rates.

Methods

All issues of *Advances in Interventional Cardiology* published from January 2015 to December 2023 were reviewed. Original papers, short reports, and images in intervention presentations that adhered to the new submission guidelines introduced in early 2015 were selected. Most review papers and editorials were solicited and thus excluded from the analysis. For each paper, we assessed the number of female authors and identified the presence of female first, last (senior), and corresponding authors. To determine the gender of foreign authors, we utilised NamSor.app API v2 (<https://namsor.app>), a web-based tool for name-based gender inference. Additional-

ly, all papers were categorised based on their prevailing theme into coronary interventions, structural/valvular interventions, peripheral interventions, electrotherapy, paediatric cardiology, and general cardiology. The assessment was conducted independently by 2 authors (AKO, BZ), and any discrepancies were resolved by a third author (AD). To evaluate the impact of author gender on rejection rates, data on rejected papers were retrieved from the journal's editorial system, although only the gender of the corresponding author was available. Citation counts for each paper were obtained from the Web of Science Core Collection (Clarivate Analytics, St. Helier, Jersey) using basic search.

Statistical analysis

Categorical variables are presented as frequencies (percentages), and differences between groups were evaluated using the χ^2 test or Fisher's exact test, as appropriate. Due to the non-normal distribution of all continuous variables, these are presented as medians with interquartile ranges (IQRs). Comparisons across groups were made using the Mann-Whitney *U* test for independent variables. Multivariable linear regression analysis was employed to identify factors associated with the number of citations of a given paper. The potential factors included the date of publication (2020–2023 versus 2015–2019), country of origin (Poland versus other countries), number of authors, number of female authors, percentage of female authors, and the presence of a female first, last (senior), or corresponding author. A stepwise approach was used to construct models for all papers, as well as separately for original papers, short reports, and

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images in intervention presentations. All statistical tests were two-tailed, and a p -value < 0.05 was considered statistically significant. Data analysis was performed using IBM SPSS Statistics version 29.0.0 (IBM Corp, Armonk, NY, USA).

Results

From 2015 to 2023, 36 issues of the *Advances in Interventional Cardiology* journal were published, featuring a total of 705 papers. Of these, 575 papers met the inclusion criteria, comprising 298 (51.8%) original papers, 97 (16.9%) short reports, and 180 (31.3%) images in intervention presentations. Most of these papers originated from Poland (73.6%). The most popular topics were coronary interventions, with 245 (42.6%) papers, followed by structural/valvular interventions (136 papers, 23.7%), peripheral interventions (86 papers, 15.0%), electrotherapy (29 papers, 5.0%), general cardiology (55 papers, 9.6%), and paediatric cardiology (24 papers, 4.2%).

On average, each paper had 6.7 ± 3.0 authors, with women comprising $20.8 \pm 19.4\%$ of all authors. At least one female author was identified in 393 (68.3%) of the papers. However, the representation of female authors was lower in specific roles: 131 (22.8%) as first authors, 73 (12.7%) as last (senior) authors, and 112 (19.5%) as corresponding authors. Interestingly, 86 (15.0%) papers had a female author serving as both the first and corresponding author, and 29 (5.0%) papers had a female author serving as both the last and corresponding author. For original papers, female first authors accounted for 68 (22.8%), for short reports 24 (24.7%), and for images in intervention presentations 39 (21.7%) ($p = 0.84$). There was no significant association between the type of paper and the frequency of last (senior) female authors (original papers: 41 [31.8%], short reports: 13 [13.4%],

images in intervention presentations: 19 [10.6%], $p = 0.58$). Similarly, female corresponding authors were represented as follows: 56 (18.8%) for original papers, 21 (21.6%) for short reports, and 35 (19.4%) for images in intervention presentations ($p = 0.83$). The frequency of first female authors was comparable between papers originating from Poland and those from other countries (24.6% vs. 17.8%; $p = 0.085$). There was significant variability ($p = 0.007$) in the frequency of first female authors among different topic categories, with the highest frequency observed in general cardiology at 43.6% (Figure 1). Similarly, a significant association ($p = 0.008$) between topic category and the frequency of last (senior) female authors was confirmed, but no such difference was observed for corresponding authors.

Temporal trend analysis revealed a significant increase in the percentage of first female authors across all papers ($p = 0.012$), original papers ($p = 0.012$), and short reports ($p = 0.048$). However, no similar trend was observed for images in intervention presentations ($p = 0.85$) (Figure 2 A). There were no significant trends for the last (senior) female authors and female corresponding authors, regardless of the type of paper (Figures 2 B, C). When comparing data from 2015–2019 to that from 2020–2023, there was an increase in the representation of first female authors across all papers, from 18.9% to 27.2% ($p = 0.022$). However, when the analysis was stratified by article type, the increases were of borderline significance for original papers ($p = 0.071$) and short reports ($p = 0.059$).

From 2015 to 2023, a total of 838 submissions, including original papers, short reports, or images in intervention presentations that fulfilled the new submission guidelines, were rejected. Available data on the gender of corresponding authors indicated no significant differ-

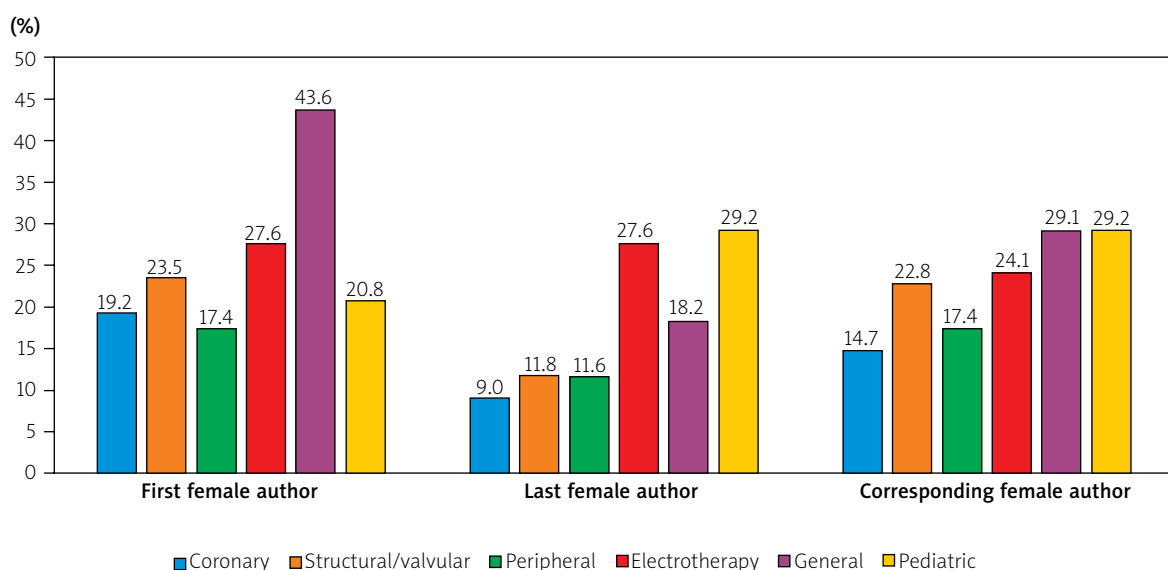


Figure 1. Frequency of first, last (senior), and corresponding female authors for all papers, stratified by topic categories

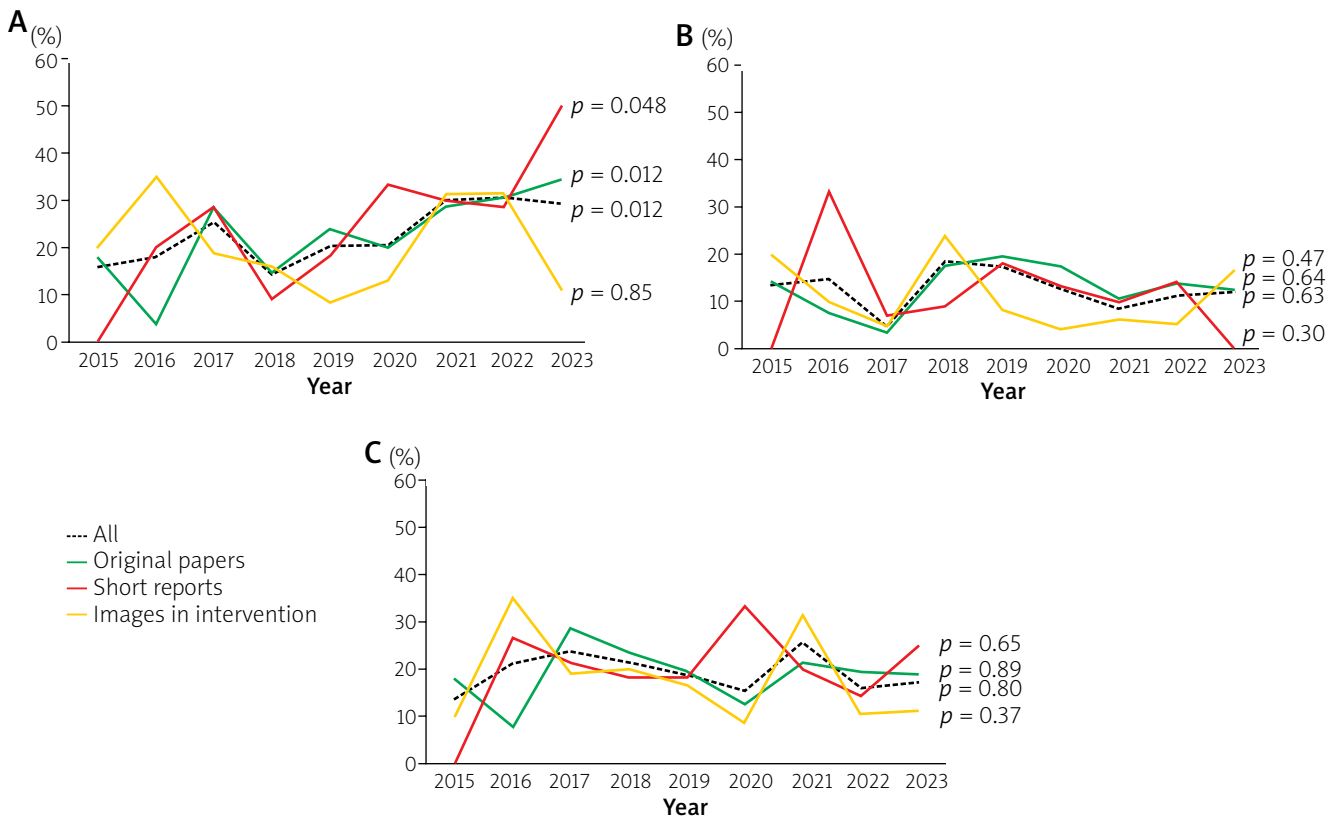


Figure 2. Trends in mean percentages of first (A), last (senior) (B), and corresponding female authors (C) stratified by article type

ence in the rejection rates between female and male corresponding authors (37.1% vs. 41.6%; $p = 0.16$). Data on the gender of the first and last (senior) authors were not available in this context.

The analysed papers were referred to 1953 times, with a median (IQR) citation rate of 2.0 (0.0, 5.0). Original papers were cited more frequently than short reports and images in intervention presentations (3.0 [1.0, 7.0] vs. 1.0 [0.0, 4.0] vs. 0.0 [0.0, 2.0], respectively; $p < 0.001$). Among all papers, those with a female first author tended to have a lower citation rate compared to those with a male first author (2.0 [0.0, 5.0] vs. 1.0 [0.0, 4.0]; $p = 0.09$). Citation rates were comparable for last (senior) authors (2.0 [0.0, 5.0] vs. 1.0 [0.0, 5.0]; $p = 0.45$) and corresponding authors (2.0 [0.0, 5.0] vs. 1.5 [0.0, 4.0]; $p = 0.53$) when comparing genders. For original papers, those with a female first author also tended to have lower citation rates (3.0 [1.0, 7.0] vs. 2.0 [1.0, 5.0]; $p = 0.06$), while rates were comparable for last (senior) (3.0 [1.0, 7.0] vs. 3.0 [1.0, 7.0]; $p = 0.95$) and corresponding (3.0 [1.0, 7.0] vs. 3.0 [1.0, 6.0]; $p = 0.86$) female authors. For short reports, papers with female first (2.0 [0.5, 4.0] vs. 0.5 [0.0, 3.0]; $p = 0.042$) and corresponding authors (2.0 [0.0, 4.0] vs. 1.0 [0.0, 2.5]; $p = 0.004$) had lower citation rates, whereas the last (senior) female author did not show a significant difference ($p = 0.12$). No significant impact of the first, last (senior), or corresponding female author on citation rates was observed for images in intervention presentations. When analysing all

papers and original papers only, no association between the first, last (senior), or corresponding female author and the number of citations was observed in linear regression models. For all papers, the only independent factors influencing citations were the number of authors (unstandardised $B = 0.409$; $p < 0.001$) and publication date from 2020 to 2023 versus from 2015 to 2019 (unstandardised $B = -3.611$; $p < 0.001$). Similarly, for original papers, the independent factors were the number of authors (unstandardised $B = 0.202$; $p = 0.047$) and publication date (unstandardised $B = -5.530$; $p < 0.001$). Conversely, for short reports, significant factors included the female corresponding author (unstandardised $B = -1.867$; $p = 0.027$), number of authors (unstandardised $B = 0.450$; $p = 0.024$), and publication date (unstandardised $B = -1.913$; $p = 0.008$). For images in intervention presentations, the only factors impacting citation rates were the publication date (unstandardised $B = -1.072$; $p < 0.001$) and Poland as the country of origin (versus other countries) (unstandardised $B = 0.736$; $p = 0.031$).

Discussion

There is growing awareness of the lack of gender parity in professional achievements within medical science, especially regarding the underrepresentation of women's research in high-impact journals [2]. Although more women are entering the medical field, they are less likely to author original research, particularly as first authors

[2]. This discrepancy can be attributed to the numerous barriers women face in academic medicine. For instance, Brown *et al.* [7] highlighted a gender disparity in orthopaedic literature, possibly due to a greater interest among men in this specialty. Similarly, Polanco *et al.* [8] found a significant difference between male and female first authors in hepatology publications, despite women more frequently choosing internal specialties. These findings underscore the dominance of men in scientific publications across various medical fields.

The underrepresentation of female authors is also evident in cardiology. A significant gender gap exists in cardiology and cardiology leadership positions across Europe [5]. Women physicians generally represent a minority among practicing cardiologists and the subspecialties of interventional cardiology and electrophysiology [9–11]. In Poland, even though the number of women cardiologists is similar to that of men, the representation of women among researchers and authors remains notably low. This gender difference in cardiology publications has been documented in numerous scientific papers [3, 12]. A recent paper by Konieczynska *et al.* [6] analysed trends over the past decade in the gender of authors publishing in *Polish Heart Journal*. Their analysis showed that only one-third of papers published between 2014 and 2023 had a female first author. This frequency was higher than observed in our study, which may be related to the primary focus of *Advances in Interventional Cardiology* on interventional cardiology. Konieczynska *et al.* [6] also confirmed that among original articles in *Polish Heart Journal*, 36.5% were authored by female first authors in non-interventional cardiology and 17.4% in the interventional field. Our analysis similarly found the lowest percentage of first female authors in articles related to coronary and peripheral interventions, probably because female interventional cardiologists are underrepresented in contemporary practice. According to data from the Polish National Registry of Percutaneous Coronary Intervention (ORPKI), women constitute only around 4% of all percutaneous coronary intervention operators in Poland [10].

In recent years, there has been a gradual increase in the number of female first authors. Our study confirms this trend, in line with the study by Konieczynska *et al.*, showing increased representation of female first authors across all publications in Poland. This aligns with the findings of Sharma *et al.* [12], who observed a rise in female first authors from 2005 to 2022. Okike *et al.* [13] reported a similar increase in female authors in orthopaedic journals, and Fishman *et al.* [14] noted a growing subset of female authors in paediatric journals.

It is important to note that articles written by men and women in academic medicine are cited differently. Consistent with our findings, Chatterjee *et al.* [15]

demonstrated that original research articles written by women as primary authors receive fewer citations compared to those authored by men. However, in our study, this association was not observed after correcting for the date of publication and the number of authors. Interestingly, a higher number of authors was suggested to increase the likelihood of a paper being cited. In our analysis, this effect was more pronounced for the analysis of all papers, which might be related to the limit on the number of authors (up to 6) for short reports and images in intervention presentations, which are less likely to be cited. On the other hand, this association was confirmed for original papers. These disparities in citation practices highlight the need for more equitable recognition of women's contributions in medical research.

Our study has some limitations. First, the analysis was limited to a single journal. Even though we used prespecified criteria and all authors participated in the assessment, there might be some bias in categorising the papers into specific topic categories, especially for multidisciplinary papers. The citation analysis was restricted to the total number of citations, without considering other bibliographic parameters related to the papers and authors. Additionally, while the assessment using NamSor.app might not be 100% accurate, previous studies have validated its use for gender identification based on name and origin [6]. The rejection rate analysis was limited to assessing the gender of the corresponding author. However, because reviewers are provided with a blinded version of the manuscript during the review process, the gender of the first, last, or corresponding authors does not appear to impact their decisions.

Conclusion

Our analysis revealed an increasing trend towards publishing papers led by female authors. However, these still account for only approximately one-fourth of all published papers. Comparable rejection and citation rates for male and female first authors suggest a similarly high scientific value of the published papers, regardless of gender. Thus, further efforts are needed to enhance scientific contributions from female cardiologists in Poland and other countries.

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Ethical approval

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Conflict of interest

The authors declare no conflict of interest.

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