**Gender Trends in Authorship of Cardiology Academic Literature – A 40-Year Perspective**

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**Abstract**

**Background**: Despite advances in the representation of women in medical training, women continue to be underrepresented in cardiology, academic medicine, and senior positions within academic medicine. This study seeks to determine the representation of female physician-investigators in cardiology through review of published literature in three prominent cardiology journals over time. Understanding disparities in research productivity can highlight barriers to female representation in academic cardiology.

**Methods**: Authors of original research articles between 1980 and 2017 from three high impact cardiology journals (Journal of the American College of Cardiology, Circulation, and European Heart Journal) were extracted from PubMed. Author sex were determined and the proportion of female first and senior authors were calculated for consecutive time cohorts.

**Results**: We identified 78,558 unique authors of 55,085 primary research articles. Female authors accounted for 33.1% of all authors, however they represented only 26.7% of first authors and 19.7% of senior authors (p < 0.001 for both). Looking at the most prolific authors, female authors are also underrepresented, accounting for only 5% of the top 100 authors.

Female first authorship and senior authorship has increased over time, but senior authorship rates lag behind first authorship rates.

**Conclusions**: Using a large database of published manuscripts, we found that female representation in cardiology research has increased over the last four decades. However there is still disproportionate underrepresentation in first authorship, senior authorship and in authors with the most publications. In addition to recruiting more women into cardiology, further efforts should be made to identify and address barriers in advancement for female physician-scientists.

**Background**

Since 2015, women have represented more than 50% of all matriculating medical students in the United States, yet represent only 13% of the cardiology workforce. Even fewer women are choosing careers in academic cardiology. Among all American Council for Graduate Medical Education (ACGME) training programs, the subspecialty of interventional cardiology was the most underrepresented with only 8.4% female representation [1]. General cardiology fellowship, at 21.4% female representation, had less female representation than every other specialty with the exceptions of only neuroradiology, neurological surgery, orthopedic surgery, and interventional radiology [1].

The underrepresentation in senior roles has been thought to be multifactorial- attributable in part to fewer research and promotion opportunities [3-5].While gains have been made, women still compose a minority of the authors of published original research [2]. Both among trainees and practicing academic clinicians, female physicians report higher rates of gender discrimination and sexual harassment than male physicians, and these experiences are thought to negatively affect their career advancement [3-4]. Despite efforts to promote gender equality in academic medicine, significant progress must still be made in cardiology towards gender parity.

For academic clinicians, research productivity is often measured by peer-reviewed publications. In consideration for promotion, the number and impact of publications is frequently explicitly evaluated. In particular, first and senior authorship of publications is seen as a sign of organizing and leading research projects. This study seeks to determine trends in authorship of cardiology-related academic literature over the last 40 years. We hypothesize that although women are still less likely to be first or senior author in published research, the gender gap has decreased over time.

**Methods**

*Data Source*PubMed is an online database of over 27 million citations of medical literature developed and maintained by the National Center for Biotechnology Information (NCBI) at the US National Library of Medicine [6]. For this study, the top three impact factor cardiology journals were identified and articles published from 1980 to 2017 were extracted[7-9]. Articles were extracted from the Journal of the American College of Cardiology (JACC), Circulation, and European Heart Journal. Citation data such as PubMed ID, article type, article title, date of publication, and authorship list was obtained. After extracting all journal articles, editorials, comments, letters, news, and retractions were excluded from our analysis.

*Author identification*  
Authors were categorized as first, middle, or senior authorsbased on author list ordering. The first author, last author, and up to fifteen middle authors were identified. For all authors with a complete first name listed, sex was determined by matching first name using an online database containing 216,286 distinct namesacross 79 countries and 89 languages [10].

*Analysis*

The proportion of female first and senior authors were calculated for consecutive five year cohorts. Student’s t test, chi-square test, and Cox proportional hazards test were used to determine significant between groups. Statistical analysis was performed using R 3.4.2 (R Foundation, Vienna, Austria, [www.r-project.org](http://www.r-project.org)) and ggplot2 [11].

**Results**

We extracted a total of 72,362 articles published between 1980 and 2017. For our analysis, we excluded editorials, comments, letters, news, and retractions, and identified 55,085 primary research articles (Figure 1). Of 261,572 total authorships identified, 257,328 (93.7%) authorships were matched to sex. There were 71,345 unique authors, including 16,613 first authors and 11,160 senior authors.

In total, 23,629 (33.1%) authors were female. When looking at just first authors, only 4,434 (26.7%) of 16,613 first authors were female (p < 0.001, chi-square test). There was an even smaller proportion of female authors in senior authorships, accounting for 2,193 (19.7%) of 11,160 senior authors (p < 0.001, chi-square test).

In the queried journals, authors had a median of 1 article (IQR 1 - 3 articles), however the top 100 authors published a median of 130 articles each (IQR 114.8 - 161.2 articles). There were only five (5%) female authors in the top 100 most prolific authors (Figure 2, Supplemental Table 1). This trend was present at all levels of authorship as female authors more frequently had few or only one publication (Figure 3). In a univariate generalized linear model of productivity by the number of published manuscripts, female sex was statistically significant in having fewer publications (p < 0.001).

With increasing number of publications, there was a higher proportion of male authors (Figure 1).

**Discussion**

Paragraph 1 – summarize findings

Paragraph 2 – Findings in the context of current literature/data on women in medicine (doesn’t have to be just cardiology)

Paragraph 3 – why we think we found what we did. Some ideas

* Women are underrepresented in cardiology, particularly academic cardiology
* Women may be more likely to publish in lower impact journals
* Women are more likely to be middle authors, correlating to lower likelihood of being in a position of power. Any data on this?

Paragraph 4 – what our study adds to the literature. We are specifically looking at a direct metric of academic success as measured by high-impact publications over time. We did find that the sex-gap in authorship has narrowed but persists over the study period

Conclude with suggestions on how we can fix this important problem

* Improved mentorship
* Opportunities for promotions

Our analysis has a few limitations First, we only looked at three major cardiology journals to extrapolate trends in academic cardiology research. A significant body of literature exists outside of these three journals, however JACC, Circulation, and Euro Heart J are among the longest running cardiology journals and cover a breadth of topics of interest in cardiology. Additionally, publication in these high-impact journals often reflects academic success and productivity. Second, many conventional East Asian first names were not able to be algorithmically matched to sex. This analysis underestimates the representation of both male and female East Asian cardiologists, although we were still able to match 93.7% of all authorships.

Using over 4 decades of publication data from the three top impact cardiovascular medicine journals, we found persistent disparities in the number of first and senior author publications for women. Women were also less likely to be represented in the list of the top 100 most prolific authors

[1] https://www.aamc.org/data/workforce/reports/458766/2-2-chart.html

[2] <https://www.ncbi.nlm.nih.gov/pubmed/16855268>

[3]<https://www.ncbi.nlm.nih.gov/pubmed/10836916>

[4] https://jamanetwork.com/journals/jama/fullarticle/2521958

[5]https://medicine.yale.edu/owm/Inadequate%20Progress%20for%20Women%20in%20Academic%20Medicine\_214981\_284\_5\_v1.pdf

[6] <https://www.ncbi.nlm.nih.gov/pubmed/>

[7] <http://www.onlinejacc.org/>

[8] <http://circ.ahajournals.org/>

[9] <https://www.escardio.org/Journals/ESC-Journal-Family/European-Heart-Journal>

[10] [www.genderize.io](http://www.genderize.io)

[11] https://cran.r-project.org/web/packages/ggplot2/citation.html