






BRIEF COMMUNICATION

Gender Differences in Publication Authorship During COVID-19: A Bibliometric Analysis of High-Impact Cardiology Journals

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BACKGROUND: The purpose of this study was to examine gender differences in authorship of manuscripts in select high-impact cardiology journals during the early coronavirus disease 2019 (COVID-19) pandemic.

METHODS AND RESULTS: All manuscripts published between March 1, 2019 to June 1, 2019 and March 1, 2020 to June 1, 2020 in 4 high-impact cardiology journals (*Journal of the American College of Cardiology*, *Circulation*, *JAMA Cardiology*, and *European Heart Journal*) were identified using bibliometric data. Authors' genders were determined by matching first name with predicted gender using a validated multinational database (Genderize.io) and manual adjudication. Proportions of women and men first, co-first, senior, and co-senior authors, manuscript types, and whether the manuscript was COVID-19 related were recorded. In 2019, women were first authors of 176 (22.3%) manuscripts and senior authors of 99 (15.0%) manuscripts. In 2020, women first authored 230 (27.4%) manuscripts and senior authored 138 (19.3%) manuscripts. Proportions of woman first and senior authors were significantly higher in 2020 compared with 2019. Women were more likely to be first authors if the manuscript's senior author was a woman (33.8% for woman first/woman senior versus 23.4% for woman first/man senior; $P < 0.001$). Women were less likely to be first authors of COVID-19-related original research manuscripts ($P = 0.04$).

CONCLUSIONS: Representation of women as key authors of manuscripts published in major cardiovascular journals increased during the early COVID-19 pandemic compared with similar months in 2019. However, women were significantly less likely to be first authors of COVID-19-related original research manuscripts. Future investigation into the gender-disparate impacts of COVID-19 on academic careers is critical.

Key Words: academic cardiology ■ coronavirus disease 2019 ■ pandemic ■ productivity ■ publication ■ women

The coronavirus disease 2019 (COVID-19) pandemic has had far-reaching impacts on cardiovascular medicine. Beyond disruptions to clinical care and delivery, many researchers are working remotely while balancing competing household or community responsibilities. These responsibilities may fall disproportionately on women. Data from early in the COVID-19 pandemic showed that female authorship of manuscripts related to COVID-19 did not maintain the expected pace.^{1,2} An analysis of submitted preprints and registered reports demonstrated that the number

of submitted manuscripts with women as first authors declined precipitously during the early pandemic period, most notably in the medical field, suggesting an emerging disparity for early career researchers.² The purpose of this study was to examine gender differences in authorship of manuscripts in select high-impact cardiology journals during the COVID-19 pandemic. We hypothesized that women were less likely to be represented as first and senior authors of manuscripts published in these journals during the pandemic compared with a similar period in 2019.

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METHODS

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Manuscript Identification

We identified all manuscripts published between March 1, 2019 to June 1, 2019 and March 1, 2020 to June 1, 2020 in 4 high-impact cardiology journals: *Journal of the American College of Cardiology*, *Circulation*, *JAMA Cardiology*, and *European Heart Journal*, using a PubMed/MEDLINE query with the following limits: “create date” and journal name.

The following data were abstracted: (1) create date of the citation representing the earliest manuscript publication date, including online ahead of print; (2) first and co-first author first and last names; (3) senior and co-senior author first and last names; (4) manuscript type; and (5) whether the manuscript was COVID-19-related. Manuscript types included original research (including research letters, original investigations, systematic reviews, and meta-analyses), reviews, editorials (including editorials, commentaries, viewpoints, and letters), case reports (including image challenges, case reports including case series of up to 5 patients), and “other.” COVID-19-related manuscripts were designated if published in 2020 and article title or keywords mentioned any of the following: SARS-CoV; coronavirus; COVID-19; pandemic; or hydroxychloroquine. Citations associated with manuscript errors and corrections, journal highlights, editor’s notes, and committee or council reports, as well as manuscripts without authors listed, were excluded (n=40 for 2019, n=35 for 2020).

For the 2019 analysis, we identified a total of 788 first authors and 661 senior authors. For the 2020 analysis, we identified a total of 838 first authors and 716 senior authors. For the primary analysis (n=1627 manuscripts), first author designation was assigned to the first listed author name and senior author designation was assigned to the last listed author name for all manuscripts, including those with 2 or more first or senior authors. An exploratory analysis was performed for the subset of manuscripts with 2 co-first and/or 2 co-senior authors in which co-first and co-senior authors were assigned as noted by the journal. A similar analysis for manuscripts with more than 2 co-first (n=12 for 2019; n=12 for 2020) or 2 co-senior authors (n=4 for 2019; n=3 for 2020) was not performed. We performed a sensitivity analysis excluding manuscripts published in March 2019 and March 2020 (n=556) to more robustly identify scholarship conducted during the COVID-19 pandemic.

Author Gender Identification

Authors’ genders were determined by matching first name with predicted gender using a previously validated multinational database (Genderize.io).³ Gender was assigned if Genderize.io predicted the gender at a probability $\geq 95\%$, a higher threshold than has been previously used.^{4,5} Using this approach, 458 unique authors were categorized as “unknown” or not meeting the 95% probability threshold. These names were manually reviewed by E.M.D. and L.S. and matched with websites linking publications to authors to confirm gender and authorship. Particular attention was paid to the use of pronouns to be consistent with the self-identification of the authors. Those manuscripts for which first and senior author genders could not be manually adjudicated were excluded. Given that these data were publicly available, institutional review board approval was not required as per institutional policy.

Statistical Analysis

Summary statistics were used to describe the total numbers of manuscripts, types of manuscripts, and numbers of COVID-19-related manuscripts published, and genders of first and senior authors of these manuscripts during the 2019 and 2020 periods. Categorical variables were described as frequencies and percentages and were compared using χ^2 or Fisher exact testing, as indicated. An α -threshold of $P < 0.05$ was used for statistical significance. Analyses were performed using Stata, version 15.1/IC (College Station, TX).

RESULTS

The gender proportions of first and senior authorship, stratified by year, manuscript type, and COVID-19 relationship are shown in the Table. For 2019, a total of 837 manuscripts were abstracted from the 4 journals. After exclusion criteria were applied, the authorships of 797 manuscripts were reviewed. For 2020, a total of 885 manuscripts were abstracted, and the authorships of 849 manuscripts were reviewed. Nineteen additional manuscripts were excluded because of inability to identify first or senior author gender, leaving 1627 manuscripts for primary analysis.

Authorship Gender by Year

During the 2019 period, women were first authors of 176 (22.3%) manuscripts and senior authors of 99 (15.0%) manuscripts. In 2020, women first authored 230 (27.4%) manuscripts and senior authored 138 (19.3%) manuscripts. The proportions of woman first and senior authors were significantly higher in 2020 compared

Table 1. Gender Characteristics of First and Senior Authors of Manuscripts Published in High-Impact Cardiology Journals, Stratified by Chronological Period and by Relation to COVID-19

Manuscript Type	Year-to-Year Comparisons											
	First Author						Senior Author					
	2019			2020			2019			2020		
	M (%)	W (%)	P Value	M (%)	W (%)	P Value	M (%)	W (%)	P Value	M (%)	W (%)	P Value
Original Research	203 (72.5%)	77 (27.5%)	0.88	190 (73.1%)	70 (26.9%)	0.88	236 (84.3%)	44 (15.7%)	0.88	207 (79.6%)	53 (20.4%)	0.16
Case Report	41 (83.7%)	8 (16.3%)	1.00	58 (84.1%)	11 (15.9%)	1.00	43 (89.6%)	5 (10.4%)	1.00	61 (88.4%)	8 (11.6%)	1.00
Editorial	265 (83.1%)	54 (16.9%)	0.001*	260 (72.4%)	99 (27.6%)	0.001*	207 (87.3%)	30 (12.7%)	0.001*	225 (82.7%)	47 (17.3%)	0.15
Review	39 (79.6%)	10 (20.4%)	0.50	44 (73.3%)	16 (26.7%)	0.50	40 (83.3%)	8 (16.7%)	0.50	45 (80.4%)	11 (19.6%)	0.80
Other†	64 (70.3%)	27 (29.7%)	0.25	56 (62.2%)	34 (37.8%)	0.25	36 (75.0%)	12 (25.0%)	0.25	40 (67.8%)	19 (32.2%)	0.41
Overall	612 (77.7%)	176 (22.3%)	0.02*	608 (72.6%)	230 (27.4%)	0.02*	562 (85.0%)	99 (15.0%)	0.02*	578 (80.7%)	138 (19.3%)	0.04*
COVID-19-Era Comparisons (2020)												
Manuscript Type	First Author						Senior Author					
	Non-COVID-19-related			COVID-19-Related			Non-COVID-19-related			COVID-19-Related		
	M (%)	W (%)	P Value	M (%)	W (%)	P Value	M (%)	W (%)	P Value	M (%)	W (%)	P Value
	164 (71.0%)	67 (29.0%)	0.04*	26 (89.7%)	3 (10.3%)	0.04*	186 (80.5%)	45 (19.5%)	0.04*	21 (72.4%)	8 (27.6%)	0.33
Case Report	44 (84.6%)	8 (15.4%)	1.00	14 (82.4%)	3 (17.7%)	1.00	46 (88.5%)	6 (11.5%)	1.00	15 (88.2%)	2 (11.8%)	1.00
Editorial	220 (74.3%)	76 (25.7%)	0.09	40 (63.5%)	23 (36.5%)	0.09	186 (85.3%)	32 (14.7%)	0.09	39 (72.2%)	15 (27.8%)	0.03*
Review	36 (75.0%)	12 (25.0%)	0.72	8 (66.7%)	4 (33.3%)	0.72	35 (79.6%)	9 (20.5%)	0.72	10 (83.3%)	2 (16.7%)	1.00
Other†	33 (57.9%)	24 (42.1%)	0.37	23 (69.7%)	10 (30.3%)	0.37	20 (60.6%)	13 (39.4%)	0.37	20 (76.9%)	6 (23.1%)	0.27
Overall	497 (72.7%)	187 (27.3%)	0.88	111 (72.1%)	43 (27.9%)	0.88	473 (81.8%)	105 (18.2%)	0.88	105 (76.1%)	33 (23.9%)	0.12

P values correspond to χ^2 tests evaluating the difference in proportion of men (M) and women (W) authors by year. COVID-19 indicates coronavirus disease 2019.

*Statistically significant at the $\alpha < 0.05$ level.

†Other includes clinical guidelines, consensus documents, consensus statements, practice guidelines, scientific statements, white papers, and working group summaries. Because of rounding, percentages may not total 100%.

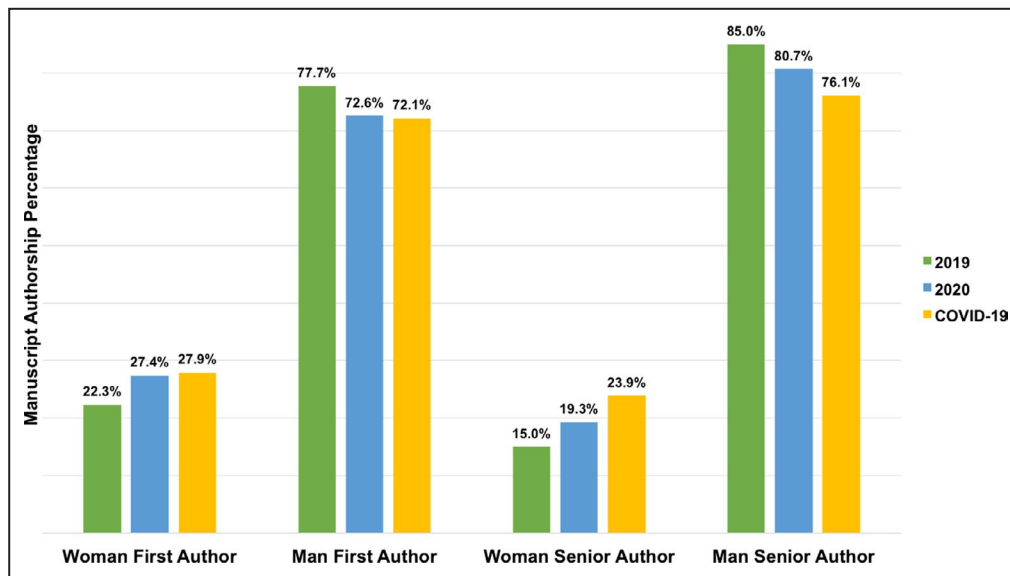


Figure. Trends in first and senior authorship of manuscripts published in high-impact cardiology journals.

Percentages of women and men first and senior authors in 2019, 2020, and of COVID-19-related manuscripts are displayed. COVID-19 indicates coronavirus disease 2019.

with 2019 ($P=0.02$ and $P=0.04$, respectively) (Figure). In aggregate, women were significantly more likely to be first authors if the manuscript's senior author was a woman (33.8% for woman first/woman senior versus 23.4% for woman first/man senior; $P<0.001$).

Authorship Gender by Manuscript Type

Women first authored a significantly higher proportion of editorials in 2020 compared with 2019 (27.6% versus 16.9%; $P=0.001$). There were no differences in the proportions of woman first or senior authors of original research, case reports, reviews, or other manuscript types in 2020 compared with 2019 (Table).

Authorship Gender of COVID-19-Related Manuscripts

During the 2020 period, 154 (18.4%) manuscripts were related to COVID-19. Of these manuscripts, 63 (40.9%) were editorials, 29 (18.8%) were original research, 17 (11.0%) were case reports, and 12 (7.8%) were reviews. Women were first authors on 43 (27.9%) and senior authors on 33 (23.9%) COVID-19-related manuscripts.

Of COVID-19-related manuscript types, women were most often the first and senior authors of editorials (36.5% and 27.8%, respectively). The proportion of woman senior authors of COVID-19-related editorials was higher compared with non-COVID-19-related editorials. Women were significantly less likely than men to be first authors of COVID-19-related original research manuscripts ($P=0.04$).

Exploratory Analysis

The genders of 119 co-first authors and 53 co-senior authors were determined; of these, 11 co-first authors' and 3 co-senior authors' genders were unable to be manually adjudicated. In the analysis of co-first authorship, the previously observed relative decline in woman first authorship of COVID-19-related original research was attenuated (25.7% COVID-19-related versus 29.6% non-COVID-19-related, $P=0.70$). All other comparisons were similar to those found in the primary analysis.

Sensitivity Analysis

The proportion of woman senior authors remained significantly higher in 2020 compared with 2019 ($P=0.04$), while the proportion of woman first authors was not significantly different ($P=0.06$). Women remained as first authors of editorials at a significantly higher proportion in 2020 compared with 2019 ($P=0.02$). There were no differences in the proportions of woman first or senior authors of other manuscript types in 2020 compared with 2019.

DISCUSSION

In this bibliometric analysis of high-impact cardiology journals, we examined the representation of women in principal authorship positions of manuscripts published during the beginning of the US COVID-19 pandemic compared with the prior year. Our key findings are as follows: (1) women comprise $\approx 25\%$ and 20% of first and senior authors published in leading cardiology

journals, respectively; (2) women were more frequently principal authors in the 2020 period compared with 2019; (3) women first authored fewer COVID-19-related original research manuscripts compared with men; and (4) women were more likely to be first authors on manuscripts if senior authors were women.

The proportions of women as first and senior authors in these major cardiology journals increased in 2020 compared with 2019. This is consistent with prior work demonstrating increasing women first authorships in high-impact journals, although these data also suggest a plateau in recent years.⁶ While our proportions of women in principal authorship positions are higher than the reported 17% of US female academic cardiologists,⁷ the women authors catalogued in our study may include noncardiologist physicians, other nonphysician health professionals, and those from non-US-based institutions. With respect to their academic careers, these women face many professional and personal obstacles similar to those of women cardiologists. At best, women cardiologists are exceeding academic expectations; however, it is likely that inequities persist in metrics regarded as among the most important for career advancement, and the need for increased representation of women in cardiology remains.

We show that women were first authors of COVID-19-related original research manuscripts significantly less often than men, corroborating recent demonstrations of the underrepresentation of women in COVID-19 research.⁸ Overall, these early findings herald a worrisome trend of the negative impact of COVID-19 on women in medicine.⁹ The first author position is often a designation for early career researchers, and our finding raises concern that early career female health professionals with less established careers and potentially more domestic responsibilities may face disproportionate barriers to career development during this time. Our exploratory analysis demonstrated an attenuation of this finding; however, the practice of assigning multiple co-authorship for principal positions may be a strategy used to mitigate the authorship disparity.

In our analysis, women were significantly more likely to be first authors if manuscript senior authors were women, a finding that aligns with previous work¹⁰ and supports the hypothesis that championing the careers of women in medicine may lead to increased mentorship of younger women and subsequently further opportunities for women's early career advancement.¹¹ Beyond the worthy goal of gender equity in publication authorship, female-led scholarship may introduce new approaches to research questions. It has been shown, for example, that female authors are more likely to report gender- and sex-disaggregated data,¹² highlighting underlying biological and societal differences in diseases and management.

Limitations of this analysis should be considered. First, we were unable to determine author genders of 1.1% of manuscripts. Second, gender misclassification may have occurred. We did not contact individual authors to confirm self-identified genders and were unable to identify individuals with nonbinary gender identities. Third, we recognize that some of the manuscripts published during these time periods do not necessarily reflect productivity during the March to June months and may represent work performed earlier. For this reason, we used the earliest date of online publication rather than the date of an issue for those articles that were assigned. Furthermore, the COVID-19-related manuscripts, given their content, should reflect academic productivity within the specified time period. Finally, because publications are trailing indicators of productivity, extended surveillance may be needed to capture emerging authorship patterns.

CONCLUSIONS

Representation of women as first and senior authors of manuscripts published in major cardiovascular journals increased during the beginning of the COVID-19 pandemic compared with similar months in 2019. However, women were significantly less likely to be first authors of COVID-19-related original research manuscripts. Overall, the number of cardiology publications with women in principal authorship positions remains low, and systematic implementation of strategies to support the academic careers of women is critical. As the many ramifications of the COVID-19 pandemic evolve, future studies to quantify its effects on women's academic productivity are imperative.

ARTICLE INFORMATION

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Disclosures

None.

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