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Female Authorship Trends in High Impact Academic Medicine Publications in a Canadian Context: A 10-year cross-sectional series, 2013-2023

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ABSTRACT

Importance

Women are underrepresented in senior roles within academic medicine, including authorship in high-impact journals.

Objective

This study investigates trends and predictors of female authorship in Canadian Medical Association Journal (CMAJ) as the only high-impact Canadian journal over a ten-year period to understand gender disparities in Canadian academic publishing.

Design

This cross-sectional study analyzed trends and predictors of female authorship in articles published in the Canadian Medical Association Journal (CMAJ) from January 1, 2013, to December 31, 2023.

Setting

The study was conducted using data extracted from PubMed, focusing on CMAJ, the only high-impact Canadian medical journal with an impact factor of 10 or higher. Data extraction utilized the RISmed package in R Studio.

Participants

The study included articles published in CMAJ within the specified period. First and last author gender was predicted using the validated Genderize.io software. Articles where the gender of the authors could not be predicted were excluded from analysis.

Main Outcomes and Measures

The co-primary outcomes were proportions of female first and last authors. Statistical analyses included chi-square tests comparing proportions, Jonckheere and linear regression models to evaluate trends, and logistic regression models to assess predictors of female authorship.

Results

From 5805 included articles, females comprised 47% of first authors and 42.9% of last authors ($p<0.001$), both significantly lower than males ($p<0.001$). Proportion of female first authors increased by 17.7%, while female last authors increased by 10.5% over the study period. Female authorship was higher during the tenure of female editors. Predictors of female last authorship included recent years and female editors, while female first authorship was more likely when there was a female last author (OR 1.98, 95% CI 1.71, 2.30).

Interpretation

Despite increases, women remain underrepresented in senior authorship roles. Female journal editors significantly promote female last authorship, and female last authors were associated with higher likelihood of female first authors. Transparent peer review oversight and mentorship are crucial for mitigating biases in academic publishing.

Strengths

- This is the first study to examine gender disparities in academic authorship in a Canadian context.
- A decade-long period was examined.

Limitations

- Although validated software was used for gender prediction, this may have lower accuracy for gender-neutral names or across different cultures.
- Predicted gender may not reflect an individual's self-identified gender or account for non-binary identities.
- This study did not examine the intersection of gender and race or ethnicity.

INTRODUCTION

Women remain underrepresented in science and academic medicine, comprising a minority of positions across the career spectrum, especially in senior roles[1]. Despite an increasing number of women entering the field, significant gender disparities persist, including in the realm of academic authorship – a key measure of academic success and leadership. Women are less likely to achieve senior authorship positions, receive lower research funding, and are underrepresented as editors, peer reviewers, grant panelists, or conference speakers[2-7]. These disparities not only hinder individual career progression but also limit the diversity of perspectives essential for innovative research. Although Canadian data is scarce, anecdotal evidence of this inequity was highlighted in a 2018 review by the Canadian Medical Association (CMA)[8].

Previous research has documented these gender disparities in publications across various scientific disciplines and regions[9-18]. Female-authored papers are less likely to be published in high-impact journals, take longer to get published, and receive fewer citations compared to their male counterparts[9,11,15,16,19-22]. Factors contributing to these disparities include unequal mentorship opportunities, biases in the peer review process, and the added burden of balancing professional and domestic responsibilities[23]. A review of selected publications in high-impact US and British journals from 1994 to 2014 reported an increase in female first authorship from 27% to 37%, which had plateaued and even declined in some journals, highlighting ongoing inequities[15]. A 2019 publication in JAMA described differential increases in female first and last authors across specialties in high-impact US and British journals from 2008 to 2018, with women experiencing slower transitions from first to last

author[9]. These temporal trends underscore efforts to improve equity while highlighting areas for further targeted improvement.

Highlighting the current state of gender balance in authorship is crucial to facilitate initiatives aimed at improving equity in academic medicine. A 2019 review of Lancet Global Health publications identified that female authors comprised between 22 to 42% of Canadian authors[24]. To our knowledge, there have been no studies to date that have characterized female academic authorship practice and trends within the Canadian publishing context. In Canada, the only high-impact journal is the Canadian Medical Association Journal (CMAJ), which employs a single-blinded peer review process where reviewers are not blinded to the submitting authors, thereby introducing potential for gender bias[25]. This study aims to investigate the trends and predictors of female academic authorship in a high-impact Canadian medical journal over a ten-year period.

METHODS

Search strategy and study selection

We abstracted all articles published from January 1st 2013 to December 31st 2023 in the Canadian Medical Association Journal (CMAJ), which represented the only Canadian medical journal with an impact factor of 10 or higher. The search was conducted on Pubmed on June 18th 2024 with the term "CMAJ" for the period of interest using the RISmed package in R Studio (version 2023.09.1+494). Articles were excluded if they were retracted or published in erratum. There were no other restrictions on article type to capture the broad

range of articles published in CMAJ. This study did not require Research Ethics Board approval as it analyzed public data. This study did not involve medical patients.

Outcomes

The co-primary outcomes were proportion of female (i) first and (ii) last authors. Last author was reported as this typically denotes the most senior author by convention. These outcomes were reported overall, temporally, and in relation to journal characteristics. Secondary outcomes were predictors of female first and last authors. In the case of single-authored publications, the author was considered as both first and last author. Gender was considered as a sociologic binary construct (i.e., female or male); biologic sex and non-binary gender could not be evaluated in this study design. First names of first and last authors were used to predict gender at a threshold of 60% using validated software (Genderize.io [https://genderize.io]), and publications where author gender could not be predicted were excluded from analysis[26].

Data extraction

Names of the first and last authors, article type, publication dates, and PMID were extracted from articles. Journal editor-in-chief name, impact factor, and details of the journal's review process were obtained from a web search including the journal website[27,28]. Gender of journal editor-in-chief was similarly predicted using Genderize.io [https://genderize.io][26].

Data analysis

All statistical analyses were performed using RStudio (version 2023.09.1+494).

The Wilcoxon rank sum test was used to compare number of articles published per year and across eras. Descriptive statistics included binomial proportion of female authors overall, per year, and during each journal editor's tenure. Chi square test was used to compare proportions of female authors overall, and by author type (first vs last), year, gender of journal editor, and within article types. Paired t-test was used to compare annual proportions of first versus last female authors within each year. Jonckheere-Terpstra test was used to evaluate temporal trends in number of articles and annual proportion of female authors over the 10-year period. Univariable linear regression models were used to evaluate associations between annual proportion of female first and last authors with year of publication and journal impact factor. Univariable logistic regression models examined potential predictors of female first or last authorship including year of publication or gender of journal editor. A subgroup of publications with more than one author was similarly analyzed and a univariable logistic regression model was used to determine whether a female last author was associated with odds of a female first author. P-values <0.05 were considered statistically significant.

RESULTS

The literature search identified 6024 articles, and 5805 articles were ultimately included after gender prediction was applied to author names. There was no difference in the total number of articles published annually, or before vs after 2019 at onset of the global COVID-19 pandemic. However, there was a trend to fewer annual publications in 2022-2023 compared to prior years (p=0.07). **[Supplemental Figure 1]**

Females comprised 47% of first authors and, less commonly, 42.9% of last authors (p<0.001) over the 10-year period, and these were significantly lower than male author counterparts (p<0.001). **[Figure 1]**

Temporal trends of female authorship

The proportion of female first and last authors each year is shown in **Figure 2**. The proportion of female first authors increased by 17.7%, and women last authors increased by 10.5% from 2013 to 2023. Females were less likely to author publications and less likely to be last versus first authors (p<0.001) in each year assessed. However, there appeared to be a very small but significant increases in annual proportion of female first (Jonckheere test p=0.009; linear regression estimate 0.01 (95% CI 0.004, 0.02), p=0.007) and last (Jonckheere test p=0.02; linear regression estimate 0.007 (95% CI 0.0005, 0.01), p=0.04) authors that followed similar trajectories over time. **[Figure 2]** Additionally, there was no difference in annual proportion of female first or last authors before or after 2019 at onset of the global COVID-19 pandemic. **[data not shown]**

Journal characteristics and female authorship

There were four journal editors during the period of interest, two of whom were female. The proportion of female first (p=0.002) and last (p=0.002) authors was higher during the tenure periods of female editors. **[Figure 3]**

The journal impact factor more than doubled from 8.3 in 2020 to 16.9 in 2021 and peaked most recently at 17.4 in 2022. There was a non-significant trend to slightly higher annual

proportion of female first authors (estimate 0.005 (95% CI -0.0002, 0.001), p=0.06), and no association with female last authors (p=0.37), when the journal impact factor was higher.

Article type and female authorship

There were 2185 articles with an indexed article type. Compared to male authors, female authors were significantly less likely to be first authors of practice guidelines (31%), observational studies (30%), case reports (36%), and comments (32%), and there was a trend to fewer randomized controlled trials (RCTs) (36%, p=0.06). Female last authors were also significantly less common in practice guidelines (28%), multicenter studies (33%), comparative studies (29%), case reports (29%), and comments (30%). Female authors were also less likely to be last authors compared to first authors for meta-analyses, comparative studies, and case reports (p<0.001). **[Table 1]**

Predictors of female authorship

When all articles were considered, the odds of female first authorship was lower in recent years (OR 0.96 (95% CI 0.94, 0.97), p<0.001) and when there was a female journal editor-in-chief (OR 0.85 (95% CI 0.77, 0.94), p=0.002), but the latter association was not observed after adjusting for publication year (p=0.17). Conversely, there was higher odds of female last authorship with increasing publication year (OR 1.03 (95% CI 1.01, 1.05), p=0.001) and when there was a female journal editor-in-chief (OR 1.18 (95% CI 1.06, 1.31), p=0.002) irrespective of publication year.

Subgroup analysis of articles with multiple authors

There were 3,134 articles with multiple authors and females comprised 42.4% of first authors and 34.9% of last authors (p<0.001). Analysis of this subgroup was unchanged from the primary analysis. Odds of female first author was higher when there was also a female last author (OR 1.98 (95% CI 1.71, 2.30), p<0.001).

DISCUSSION

This study investigated trends and predictors of female authorship in a high-impact Canadian medical journal over a ten-year period. Females were less likely to author publications and were less likely to be last versus first authors, although the annual proportion of female authors increased by 17.7% for first authors and 10.5% for last authors over the study period. Higher proportions of female first authors were observed during the tenure of female editors-in-chief. Female journal editors-in-chief were also associated with increased female last authorship. Moreover, having a female last author was associated with almost twofold higher odds of having a female first author, highlighting potential benefits of mentorship or support networks.

These findings align with previous research documenting gender disparities in academic authorship. Similar to studies in high-impact US and British journals, we observed an increased proportion of female first and last authorship, reflecting broader efforts to address gender equity in academia[9,15]. Notably, the increases we saw were larger than those reported in other studies[9,15]. Proportions of female authorship appeared robust to the COVID-19 pandemic's impacts, despite early studies showing lower submission and authorship rates for

females[29-32]. Nonetheless, female first and last authors overall remained less common than their male counterparts. This discordance, particularly pronounced for female last authors, suggests persistent barriers to senior authorship. Female authors were also underrepresented in more impactful publications, such as practice guidelines, RCTs, and comparative studies, which may result in fewer citations and is consistent with prior studies[33]. These imbalances may reflect ongoing workforce gender disparities at senior levels. At the same time, a 2018 US study found that publication-related productivity mitigated gendered differences in achieving full professor rank but not senior leadership positions[1]. Multifaceted approaches are clearly needed to target these intertwined domains.

The significant influence of journal editors' gender on female last authorship underscores the importance of leadership in fostering gender equity and highlights the need for innovative strategies in academic publishing. CMAJ's single-blind peer review process, where reviewers know the authors' identities, can introduce gender bias, as replicated by our study's gender prediction software. A 2022 systematic review found mixed results on the impact of double-blind versus single-blind peer review on publication decisions by perceived author gender[34]. Studies on gender balance would benefit from transparent reporting by journals of author gender at all stages from submission to publication. A recent Canadian review called for collecting and reporting gendered data, promoting voluntary gender disclosure during manuscript submission, and advocating for funding bodies to disclose funding success rates by gender[35]. These actions are essential to reduce bias and ensure diverse perspectives in academic publishing.

The increased odds of female first authorship with a female last author highlight the value of mentorship. Mentorship and sponsorship are crucial for launching independent research

careers, but the gender imbalance of senior academics in Canadian institutions may make it challenging to identify female mentors[36,37]. Establishing an independent research program often overlaps with childbearing and rearing years, creating additional barriers for women[23]. Limited grant funding for female researchers further restricts their ability to mentor junior trainees[2,3,38]. Female trainees may also struggle to develop effective mentor-mentee relationships due to fears of male mentors in the #MeToo era[39]. A Canadian structured training program with a gender-balanced award selection committee has shown benefits in promoting gender diversity and equity for early researchers[38]. A 2019 systematic review reported that mentorship programs for women led to high satisfaction, increased publications, promotion, and retention in medicine[40]. These findings support the need for formal mentorship programs targeted at women.

This study has several strengths. It provides a unique examination of gender disparities in academic authorship within the Canadian context, covering a decade-long period. The use of validated software for gender prediction enhances the reliability of our findings, enabling a robust analysis of trends and predictors of female authorship. However, there are also notable limitations. While the gender prediction software is validated, it is inherently limited and may not accurately identify gender, particularly for gender-neutral names or across different cultures. Additionally, it may not reflect an individual's self-identified gender or account for non-binary identities. Our analysis was restricted to published articles, and we could not assess gendered differences at the submission stage. Article types were classified based on PubMed indexing, which may not comprehensively capture all nuances, though we highlighted significant gender differences in first and last authorship as per available data. This study also did not examine the intersection of gender and race or ethnicity. Univariable statistical models are susceptible to confounders; however, the nature of the dataset precluded

adjustment for potential confounders. Lastly, we assumed a traditional first versus last author distinction of seniority, which may not always apply, potentially overlooking other collaborative dynamics within author teams.

In conclusion, this study highlights persistent gender disparities in academic authorship within a high-impact Canadian medical journal over a ten-year period. Despite increases in female first and last authorship, women remain underrepresented, particularly in senior authorship roles. The findings underscore the influence of female journal editors in fostering female authorship and the value of mentorship networks, with female last authors significantly increasing the likelihood of female first authors. Addressing gender bias in the peer review process and enhancing mentorship programs are critical steps toward achieving gender equity in academic publishing. Continued efforts to collect and report gendered data and transparent practices are essential to mitigate biases and promote diverse perspectives in research.

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DISCLOSURES

The author declares that she has no conflicts of interest.

ETHICAL APPROVAL

This study did not require Research Ethics Board approval as it analyzed public data.

DISCLAIMERS

None.

DATA SHARING

Data may be provided upon reasonable request.

AUTHOR CONTRIBUTIONS

CR: Study conception and design, data extraction, statistical analysis, results interpretation, manuscript preparation

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TABLES

Table 1. First and last author gender by article type.

Article type	Number of articles	Author type	Proportion of female authors (%)	Proportion of male authors (%)	Female vs male authors, p-value†	First vs last female authors, p-value‡
Case report	674	First	35.5	64.5	**<0.001**	**<0.001**
		Last	28.9	71.1	**<0.001**	
Comment	878	First	31.7	68.3	**<0.001**	1.0
		Last	30.3	69.7	**<0.001**	
Comparative study	34	First	41.2	58.8	0.30	**<0.001**
		Last	29.4	70.6	**0.02**	
Editorial	162	First	53.7	46.3	0.35	0.77
		Last	42.6	57.4	0.06	
Meta-analysis	21	First	38.1	61.9	0.28	**<0.001**
		Last	47.6	52.4	0.83	
Multi-centre study	36	First	50.0	50.0	1.00	0.78
		Last	33.3	66.7	**0.05**	
Observational study	30	First	30.0	70.0	**0.03**	0.29
		Last	33.3	66.7	0.07	
Practice guideline	29	First	31.0	69.0	**0.04**	0.67
		Last	27.6	72.4	**0.02**	
Randomized controlled trial	42	First	35.7	64.3	0.06	0.36
		Last	21.4	78.6	**<0.001**	
Review	279	First	40.1	59.9	**<0.001**	0.82
		Last	22.6	77.4	**<0.001**	

- There were 2185 articles with an indexed article type.
- Bolded values denote statistical significance.
- †Chi-square test was used to compare female vs male first and last author proportions.
- ‡Chi-square test was used to compare female first vs last author proportions.

FIGURE LEGENDS

Figure 1. Proportion of female first and last authors in CMAJ from 2013-2023.

Figure 2a. Proportion of female first authors each year from 2013-2023.

Figure 2b. Proportion of female last authors each year from 2013-2023.

Figure 2c. Proportions of female first and last authors each year from 2013-2023.

Figure 3a. Proportion of female first authors by journal editor and gender.

Figure 3b. Proportion of female last authors by journal editor and gender.

Figure 1. Proportion of female first and last authors in CMAJ from 2013-2023.

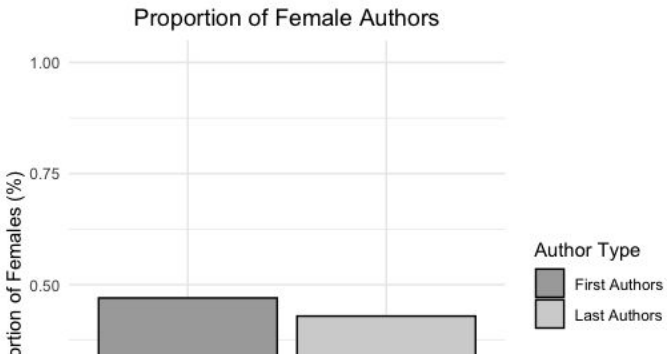


Figure 2a. Proportion of female first authors each year from 2013-2023.

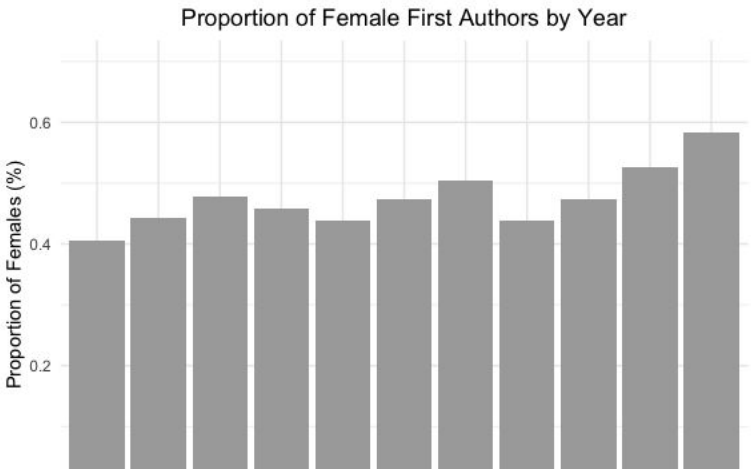


Figure 2b. Proportion of female last authors each year from 2013-2023.

Figure 2c. Proportions of female first and last authors each year from 2013-2023.

Figure 3a. Proportion of female first authors by journal editor and gender.

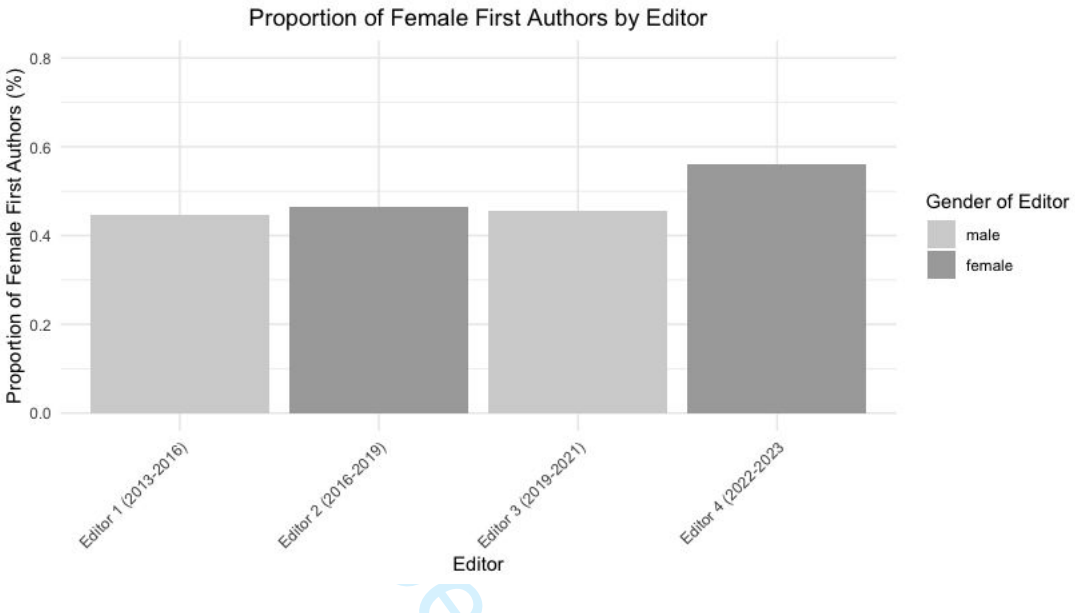
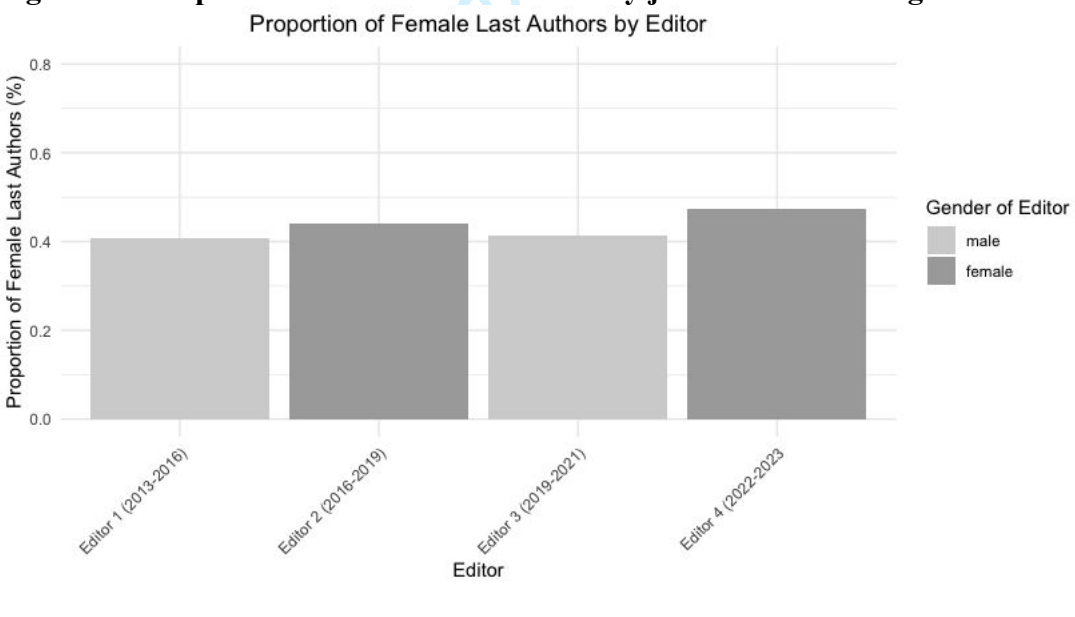


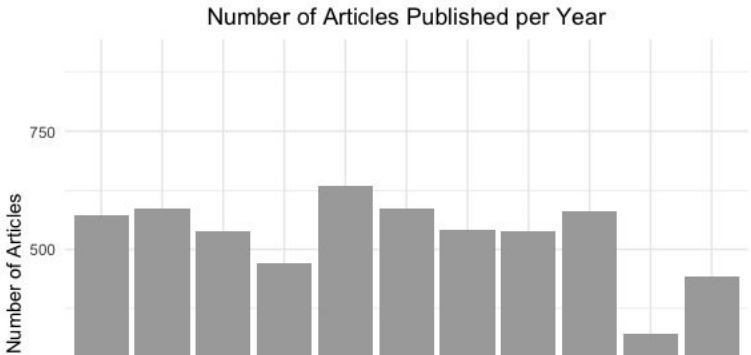
Figure 3b. Proportion of female last authors by journal editor and gender.



Supplemental Table 1. Annual journal impact factor for CMAJ.

Year	Impact factor
2013	5.808
2014	5.959
2015	6.724
2016	6.784
2017	6.21
2018	6.938
2019	7.744
2020	8.262
2021	16.869
2022	17.4

Supplemental Figure 1. Overall number of journal publications per year, 2013-2023.



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Female Authorship Trends in A High-Impact Canadian Medical Journal: A 10-year cross-sectional series, 2013-2023

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Female Authorship Trends in A High-Impact Canadian Medical Journal: A 10-year cross-sectional series, 2013-2023

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Keywords: Women; Female; Gender; Equity; Author; Canada

ABSTRACT

Importance

Women are underrepresented in senior roles within academic medicine, including as authors in high-impact journals.

Objective

To examine trends and predictors of female authorship in Canadian Medical Association Journal (CMAJ) as the only high-impact Canadian journal over a ten-year period to understand gender balances in Canadian academic publishing.

Design

This cross-sectional study analyzed trends and predictors of female authorship in articles published in CMAJ from January 1, 2013, to December 31, 2023.

Setting

Data were extracted from PubMed for CMAJ, the only high-impact Canadian medical journal (impact factor ≥10). Data extraction utilized the RISmed package in R Studio.

Participants

The study included articles published in CMAJ within the specified period. Author gender was predicted using the validated Genderize.io software. Articles where the gender of the authors could not be predicted were excluded from analysis.

Main Outcomes and Measures

The co-primary outcomes were proportions of female first and last authors. Statistical analyses included chi-square tests comparing proportions, Jonckheere and linear regression models to evaluate trends. Among multi-author articles, multivariable logistic regression models assessed predictors of female first and last authorship.

Results

From 5805 included articles, females comprised 47% of first authors and 43% of last authors ($p<0.001$), both significantly lower than males ($p<0.001$). Female first authorship increased by 17.7% and female last authorship by 10.5% over the study period (both $p<0.05$ for trend), reaching a majority (58%) and near parity (48%) in 2023, respectively. Female editor-in-chief and higher proportion of female co-authors were associated with higher odds of female first and last authors; female last authors were additionally associated with higher odds of female first authors.

Interpretation

Women were underrepresented in authorship overall, though female first and last authorship increased over time, with first authorship exceeding parity in recent years and last authorship nearing equal representation. Female editors-in-chief and a higher proportion of female co-authors were associated with greater female first and last authorship, while female last authorship was additionally associated with higher odds of female first authorship. These findings provide insight into authorship trends in a high-impact Canadian medical journal and may inform future efforts to support gender equity in academic publishing.

Strengths

- Analyzed a decade of publications in the only high-impact Canadian medical journal.
- Used validated software for gender prediction to systematically classify authorship.

Limitations

- Although validated software was used for gender prediction, this may have lower accuracy for gender-neutral names or across different cultures.
- Predicted gender may not reflect an individual's self-identified gender or account for non-binary identities.
- This study did not examine the intersection of gender and race or ethnicity.

INTRODUCTION

Women remain underrepresented in science and academic medicine, comprising a minority of positions across the career spectrum, especially in senior roles[1]. Despite an increasing number of women entering the field, significant gender disparities persist, including in the realm of academic authorship – a key measure of academic success and leadership. Women are less likely to achieve senior authorship positions, receive lower research funding, and are underrepresented as editors, peer reviewers, grant panelists, or conference speakers[2-7]. These disparities not only hinder individual career progression but also limit the diversity of perspectives essential for innovative research. Although Canadian data is scarce, evidence of this inequity was highlighted in a 2018 review by the Canadian Medical Association (CMA)[8].

Previous research has documented these gender disparities in publications across various scientific disciplines and regions[9-18]. Female-authored papers are less likely to be published in high-impact journals, take longer to get published, and receive fewer citations compared to their male counterparts[9,11,15,16,19-22]. Factors contributing to these disparities include unequal mentorship opportunities, biases in the peer review process, and the added burden of balancing professional and domestic responsibilities[23]. A review of selected publications in high-impact US and British journals from 1994 to 2014 reported an increase in female first authorship from 27% to 37%, which had plateaued and even declined in some journals, highlighting ongoing inequities[15]. A 2019 publication in JAMA described differential increases in female first and last authors across specialties in high-impact US and British journals from 2008 to 2018, with women experiencing slower transitions from first to last author[9]. These temporal trends underscore efforts to improve equity while highlighting areas for further targeted improvement.

Although gender disparities in academic publishing are well-documented, local evaluations are essential, as inequities vary by jurisdiction due to sociocultural, historical, and systemic factors. In Canada, women comprise 54% of physicians under 40 and are projected to reach overall parity by 2030, yet barriers persist for career advancement.[8] A 2019 Lancet Global Health review found that female represented only 22-42% of Canadian authors, highlighting ongoing inequities[24]. As Canada's leading and only high-impact medical journal, the Canadian Medical Association Journal (CMAJ) plays a key role in supporting local researchers, publishing regionally relevant findings, and informing national health policy.[25,26] A recent bibliometric review of leading medical journals observed that journals are more likely to publish studies from the country in which the journal is based, and authors are more likely to cite work from their own country.[27] Local journals can therefore shape academic opportunities within their countries, making CMAJ an important lens to assess gender equity in Canadian medical publishing.[28,29] To date, no study has examined female authorship trends within the Canadian publishing context. Notably, CMAJ employs a single-blinded peer review process, where reviewers know the authors' identities, thereby introducing potential for gender bias[30]. This study aims to investigate trends and predictors of female authorship in CMAJ over a ten-year period.

METHODS

Search strategy and study selection

We abstracted all articles published from January 1st 2013 to December 31st 2023 in the Canadian Medical Association Journal (CMAJ), which represented the only Canadian

medical journal with an impact factor of 10 or higher. The search was conducted on Pubmed on June 18th 2024 with the term "CMAJ" for the period of interest using the RISmed package in R Studio (version 2023.09.1+494). Articles were excluded if they were retracted or published in erratum. There were no other restrictions on article type to capture the broad range of articles published in CMAJ. This study did not require Research Ethics Board approval as it analyzed public data.

Outcomes

The co-primary outcomes were proportion of female (i) first and (ii) last authors. Last author was reported as this typically denotes the most senior author by convention. These outcomes were reported overall, temporally, and in relation to journal characteristics. Secondary outcomes were female composition of authorship teams, and predictors of female first and last authorship. In the case of single-authored publications, the author was considered as both first and last author. Gender was considered as a sociologic binary construct (i.e., female or male); biologic sex and non-binary gender could not be evaluated in this study design. First names of first and last authors were used to predict gender at a threshold of 50% using validated software (Genderize.io [https://genderize.io]), and publications where author gender could not be predicted were excluded from analysis[31].

Data extraction

Author names, article type, publication dates, and PMID were extracted from articles. Journal editor-in-chief name, impact factor, and details of the journal's review process were obtained from a web search including the journal website[32,33]. Gender of journal editor-in-chief was similarly predicted using Genderize.io [https://genderize.io][31].

Data analysis

All statistical analyses were performed using RStudio (version 2023.09.1+494).

The Wilcoxon rank sum test was used to compare number of articles published per year and across eras. Descriptive statistics included binomial proportion of female authors overall, per year, and during each journal editor's tenure. Chi square test was used to compare proportions of female authors overall, and by author type (first vs last), year, gender of journal editor, and within article types. Paired t-test was used to compare annual proportions of first versus last female authors within each year. Jonckheere-Terpstra test was used to evaluate temporal trends in number of articles and annual proportion of female authors over the 10-year period. Univariable linear regression models were used to evaluate associations between annual proportion of female first and last authors with year of publication and journal impact factor. Among a subcohort of publications with more than one author, multivariable logistic regression models examined potential predictors of female first or last authorship including female editor-in-chief, female composition of the authorship team, publication year, and journal impact factor; the model for female first authorship also included female last author as a predictor. All covariates were included as fixed effects. P-values <0.05 were considered statistically significant.

Patient and Public Involvement

None. This study did not involve medical patients.

RESULTS

The literature search identified 6024 articles, and 5805 articles were ultimately included after gender prediction was applied to author names. There was no difference in the total number of articles published annually, or before vs after 2019 at onset of the global COVID-19 pandemic. However, there was a trend to fewer annual publications in 2022-2023 compared to prior years (p=0.07). **[Supplemental Figure 1]**

Females comprised 2728/5805 (47%) of first authors and, slightly less commonly, 2491/5805 (42.9%) of last authors (p<0.001) over the 10-year period, and these were significantly lower than male author counterparts (p<0.001). **[Figure 1]** Females comprised about half of authorship teams (mean 0.46, SD 0.41).

Temporal trends of female authorship

The annual proportion of female first and last authors each year is shown in **Figure 2**. The proportion of female first authors increased by 17.7%, and female last authors increased by 10.5% from 2013 to 2023. Females comprised a slight majority of first authors in 2022 (53%) and 2023 (58%), and roughly half of last authors in 2023 (48%). There appeared to be a very small but significant increases in annual proportion of female first (Jonckheere test p=0.009; linear regression estimate 0.01 (95% CI 0.004, 0.02), p=0.007) and last (Jonckheere test p=0.02; linear regression estimate 0.007 (95% CI 0.0005, 0.01), p=0.04) authors that followed similar trajectories over time. **[Figure 2c]** Females were less likely to be last versus first authors in each year assessed (p<0.001). Additionally, there was no difference in annual proportion of female first or last authors before versus after 2019 at onset of the global COVID-19 pandemic. **[data not shown]**

Journal characteristics and female authorship

There were four journal editors during the period of interest, two of whom were female. The proportion of female first (p=0.002) and last (p=0.002) authors was higher during the tenure periods of female editors. **[Figure 3]**

The journal impact factor more than doubled from 8.3 in 2020 to 16.9 in 2021 and peaked most recently at 17.4 in 2022. **[Supplemental Table 1]** There was a non-significant trend to slightly higher annual proportion of female first authors (estimate 0.005 (95% CI -0.0002, 0.001), p=0.06), and no association with female last authors (p=0.37), when the journal impact factor was higher.

Article type and female authorship

There were 2185 articles with an indexed article type. Compared to male authors, female authors were significantly less likely to be first authors of practice guidelines (31%), observational studies (30%), case reports (36%), and comments (32%), and there was a trend to fewer randomized controlled trials (RCTs) (36%, p=0.06). Female last authors were also less common in practice guidelines (28%), multicenter studies (33%), comparative studies (29%), case reports (29%), and comments (30%). Female authors were also less likely to be last authors compared to first authors for meta-analyses, comparative studies, and case reports (p<0.001). **[Table 1]**

Predictors of female first and last authorship

There were 3,133 articles with multiple authors and females constitute 1330 (42.5%) of first authors and 1093 (34.9%) of last authors (p<0.001). Odds of female first author were higher when there was also a female last author (OR 1.49; 95% CI 1.15, 1.93), higher proportion of female authors in the team (OR 1.59; 95% CI 1.15, 2.20), and a female editor-in-chief (OR 1.18; 95% CI 1.00, 1.39). The odds of female last author were also higher with a higher proportion of female authors in the team (OR 2.38; 95% CI 1.94, 2.93) and female editor-in-chief (OR 1.25; 95% CI .05, 1.48). **[Table 2]** These findings were robust to data-driven adjustments of era effects before and after 2019 (COVID-19 pandemic onset) and 2022 (lower number of publications annually). **[data not shown]**

DISCUSSION

This study investigated trends and predictors of female authorship in a high-impact Canadian medical journal over a ten-year period. Females were less likely to be last versus first authors. The annual proportion of female authors increased by 18% for first authors and 11% for last authors over the study period, and females constituted a slight majority of first authors in recent years. Higher proportions of female first and last authors were observed during the tenure of female editors-in-chief. Odds of female first and last authors were higher with female editors-in-chief and higher proportion of female authors on the team. Moreover, having a female last author was associated with higher odds of having a female first author, highlighting potential benefits of mentorship or support networks.

We identified a lower proportion of female first and last authors overall, but crucially, temporal analyses showed increasing representation over time. The proportion of female first authors increased by 18% and female last authors by 11% over the study period, with females making up a slight majority of first authors and nearly half of last authors since 2022. This trend aligns with broader efforts to improve gender equity in academia and mirrors increases reported in high-impact US and British journals, though the magnitude of change in CMAJ appears greater than in prior studies of general medical journals[9,15]. However, improved gender parity was observed in more recent years in this contemporary CMAJ cohort; updated analyses of other medical journals would therefore be needed to examine whether these positive changes in gender balances were isolated or more widespread. Importantly, we found no significant decline in female authorship from onset of the COVID-19 pandemic, despite early studies showing lower submission and authorship rates for female scientists during the pandemic[34-37]. However, female last authorship remained lower than first authorship, suggesting persistent barriers to senior authorship, which has been reported in other studies. Additionally, female authors were underrepresented in more impactful publications, such as practice guidelines, randomized controlled trials, and comparative studies, which are more likely to be highly cited and influence clinical practice and policy[38]. These imbalances may reflect ongoing gender disparities at senior levels of the workforce and could reinforce barriers to academic promotion by skewing citation metrics. At the same time, a 2018 US study found that publication-related productivity helped mitigate gendered differences in achieving full professor rank but not senior leadership positions[1]. Multifaceted approaches are clearly needed to target these intertwined domains.

The increased odds of female first authorship when the last author was female highlight the role of mentorship and sponsorship in fostering gender equity in academic publishing. Our

study also found that a higher proportion of female co-authors was associated with greater odds of both female first and last authorship, suggesting that diverse authorship teams may create more supportive environments for female researchers. Prior research shows that gender-diverse teams produce more novel, high-impact work, reinforcing the broader benefits of diversity in academia.[39] A 2019 systematic review reported that mentorship programs for women led to high satisfaction, increased publications, promotions, and retention in medicine[40]. Strong female networks and diverse external connections are also associated with higher leadership success for women.[41] However, the gender imbalance among senior academics in Canada limits access to female mentors, particularly in fields where women remain underrepresented[42,43]. Establishing an independent research program often overlaps with childbearing years and limited grant funding for female researchers further restricts their ability to mentor junior trainees[2,3,23,44]. Female trainees may also struggle to develop effective mentor-mentee relationships due to fears of male mentors in the #MeToo era[45]. A Canadian training program with a gender-balanced award selection committee and structured mentorship has shown benefits in promoting gender diversity and equity for early researchers[44]. Having observed real-world improved gender parity for female authors in CMAJ, these findings support the need for future studies examining the identified factors associated with increased female authorship. Implementation studies should also explore potential roles of formal mentorship structures and diverse research teams to promote equitable opportunities for women in academic medicine.

The significant influence of female journal editors on female authorship underscores the importance of leadership in fostering gender equity. Our findings align with prior research showing that female peer reviewers and editors are associated with increased female authorship. However, editorial leadership remains predominantly male across academia.

Despite some progress, women still comprise less than one-third of journal editors, with even smaller proportions serving as editors-in-chief, particularly in male-dominated fields like Surgery.[17,46-50] This lack of representation in editorial leadership may contribute to the slower progression of female authors to senior authorship roles. CMAJ's single-blind peer review process, where reviewers know the authors' identities, creating the opportunity to potentially introduce gender bias, as replicated by our study's gender prediction software. A 2022 systematic review found mixed results on the impact of double-blind versus single-blind peer review on publication decisions by perceived author gender[51]. Studies on gender balance would benefit from transparent reporting by journals of author gender at all stages from submission to publication; ideally, studies such as this would not be needed. A recent Canadian review called for collecting and reporting gendered data, promoting voluntary gender disclosure during manuscript submission, and advocating for funding bodies to disclose funding success rates by gender[52]. Strengthening gender diversity in editorial leadership, alongside transparent peer review and authorship reporting practices, could help advance gender equity in academic publishing.

This study has several strengths. It provides a unique examination of gender disparities in academic authorship within the Canadian context, covering a decade-long period. The use of validated software for gender prediction enhances the reliability of our findings, enabling a robust analysis of trends and predictors of female authorship. However, there are also notable limitations. While the gender prediction software is validated, it is inherently limited and may not accurately identify gender, particularly for gender-neutral names or across different cultures. Additionally, it may not reflect an individual's self-identified gender or account for non-binary identities. This study also did not examine the intersection of gender and race or ethnicity. Our analysis was restricted to published articles, and we could not assess gendered

differences at the submission stage. Article types were classified based on PubMed indexing, which was not uniformly available and may not comprehensively capture all nuances, though we highlighted significant gender differences in first and last authorship as per available data. This study did not analyze manuscript content, which may be an important factor influencing publication patterns. Women are more likely to conduct research on female-focused health issues, which have historically received less recognition and funding. If such research is perceived as lower priority by journals or reviewers, it could partially explain disparities in authorship representation and impact. Future research should explore whether topic selection plays a role in gendered differences in academic publishing. Statistical models are susceptible to residual unmeasured confounding; however, the nature of the dataset precluded broad adjustment for potential confounders. Lastly, we assumed a traditional first versus last author distinction of seniority, which may not always apply, potentially overlooking other collaborative dynamics within author teams.

In conclusion, females were underrepresented as first and last authors overall, but we observed increasing female authorship in CMAJ over the past decade, with female first authors surpassing parity in recent years and female last authors achieving near-equal representation. Female journal editors were associated with greater female last authorship, underscoring the role of leadership in shaping authorship patterns. Additionally, a higher proportion of female co-authors was linked to increased odds of both female first and last authorship, while female last authors were associated with higher odds of female first authors, reinforcing the importance of diverse research teams and mentorship in supporting female career progression. These findings suggest that editorial leadership, team composition, and mentorship networks play a crucial role in advancing gender equity in academic publishing. Strengthening policies that promote gender-inclusive editorial boards, transparent

authorship tracking, and structured mentorship programs may help sustain progress toward equitable representation in medical research.

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DISCLOSURES

The author declares that she has no conflicts of interest.

ETHICAL APPROVAL

This study involves human participants but was not approved by an Ethics Committee(s) or Institutional Board(s). This study did not require Research Ethics Board approval as it analyzed public data. This study did not involve medical patients.

DISCLAIMERS

None.

DATA SHARING

Data may be provided upon reasonable request.

AUTHOR CONTRIBUTIONS

CR: Study conception and design, data extraction, statistical analysis, results interpretation, manuscript preparation.

CR is the guarantor.

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TABLES

Table 1. First and last author gender by article type.

Article type	Number of articles	Author type	Proportion of female authors (%)	Proportion of male authors (%)	Female vs male	First vs last female

					authors, p-value†	authors, p-value‡
Case report	674	First	35.5	64.5	**<0.001**	**<0.001**
		Last	28.9	71.1	**<0.001**	
Comment	878	First	31.7	68.3	**<0.001**	1.0
		Last	30.3	69.7	**<0.001**	
Comparative study	34	First	41.2	58.8	0.30	**<0.001**
		Last	29.4	70.6	**0.02**	
Editorial	162	First	53.7	46.3	0.35	0.77
		Last	42.6	57.4	0.06	
Meta-analysis	21	First	38.1	61.9	0.28	**<0.001**
		Last	47.6	52.4	0.83	
Multi-centre study	36	First	50.0	50.0	1.00	0.78
		Last	33.3	66.7	**0.05**	
Observational study	30	First	30.0	70.0	**0.03**	0.29
		Last	33.3	66.7	0.07	
Practice guideline	29	First	31.0	69.0	**0.04**	0.67
		Last	27.6	72.4	**0.02**	
Randomized controlled trial	42	First	35.7	64.3	0.06	0.36
		Last	21.4	78.6	**<0.001**	
Review	279	First	40.1	59.9	**<0.001**	0.82
		Last	22.6	77.4	**<0.001**	

- There were 2185 articles with an indexed article type.
- Bolded values denote statistical significance.
- †Chi-square test was used to compare female vs male first and last author proportions.
- ‡Chi-square test was used to compare female first vs last author proportions.

Table 2. Multivariable logistic regression models for female (i) first and (ii) last authors.

Predictor	Reference level	Odds ratio (95% CI)	p-value
Female first authors			
Female last author	Male	1.49 (1.15, 1.93)	**0.002**

Female proportion of authorship team (%)	Continuous	1.59 (1.15, 2.20)	**0.005**
Female editor-in-chief	Male	1.18 (1.00, 1.39)	**0.05**
Publication year	Continuous	0.99 (0.94, 1.04)	0.69
Journal impact factor	Continuous	1.02 (0.99, 1.05)	0.19
Female last authors			
Female proportion of authorship team (%)	Continuous	2.38 (1.94, 2.93)	**<0.001**
Female editor-in-chief	Male	1.25 (1.05, 1.48)	**0.01**
Publication year	Continuous	1.04 (0.99, 1.09)	0.11
Journal impact factor	Continuous	1.00 (0.97, 1.03)	0.79
• Bold values denote statistical significance.			

FIGURE LEGENDS

Figure 1. Proportion of female first and last authors in CMAJ from 2013-2023.

Figure 2a. Proportion of female first authors each year from 2013-2023.

Figure 2b. Proportion of female last authors each year from 2013-2023.

Figure 2c. Proportions of female first and last authors each year from 2013-2023.

Figure 3a. Proportion of female first authors by journal editor and gender.

Figure 3b. Proportion of female last authors by journal editor and gender.

Figure 1. Proportion of female first and last authors in CMAJ from 2013-2023.

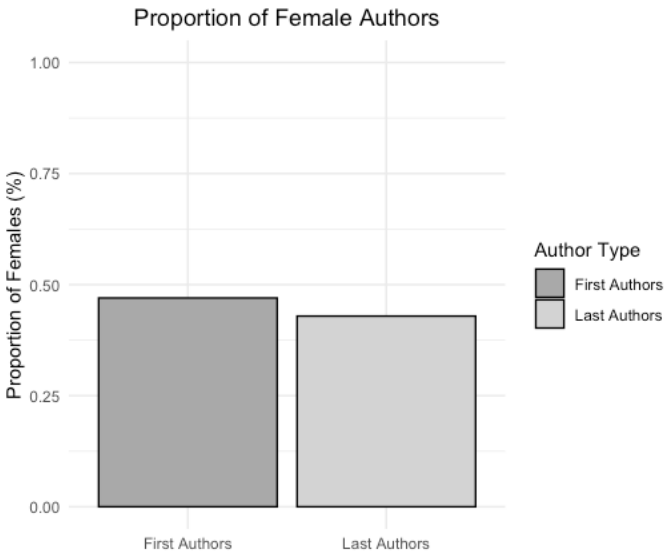


Figure 2a. Proportion of female first authors each year from 2013-2023.

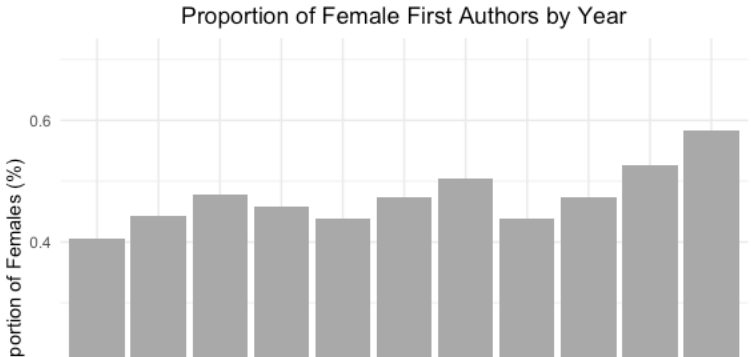


Figure 2b. Proportion of female last authors each year from 2013-2023.

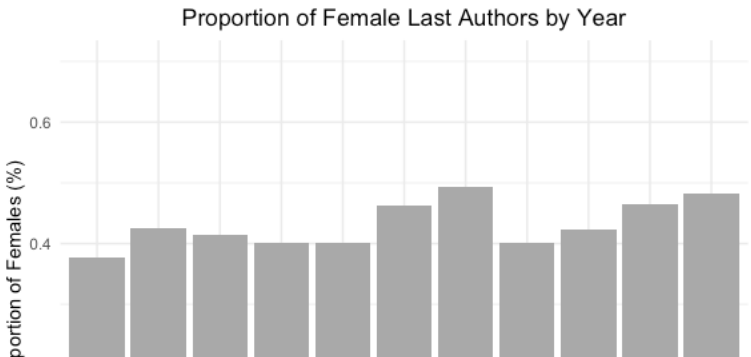


Figure 2c. Proportions of female first and last authors each year from 2013-2023.

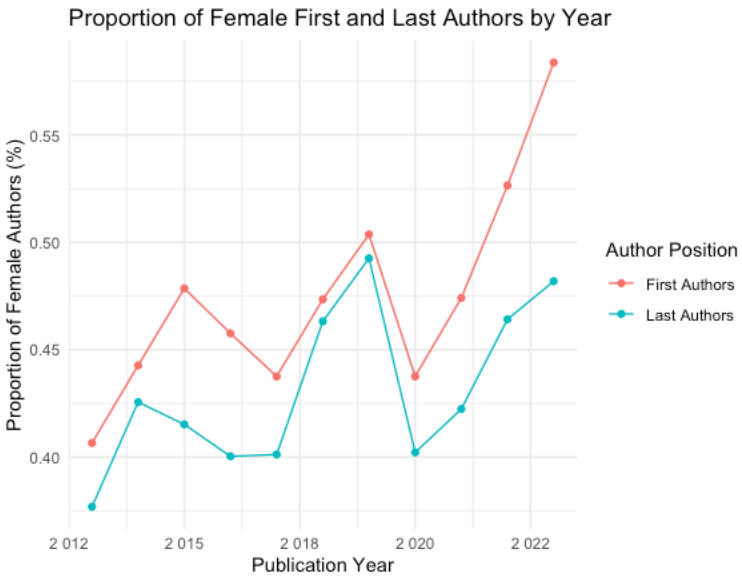


Figure 3a. Proportion of female first authors by journal editor and gender.

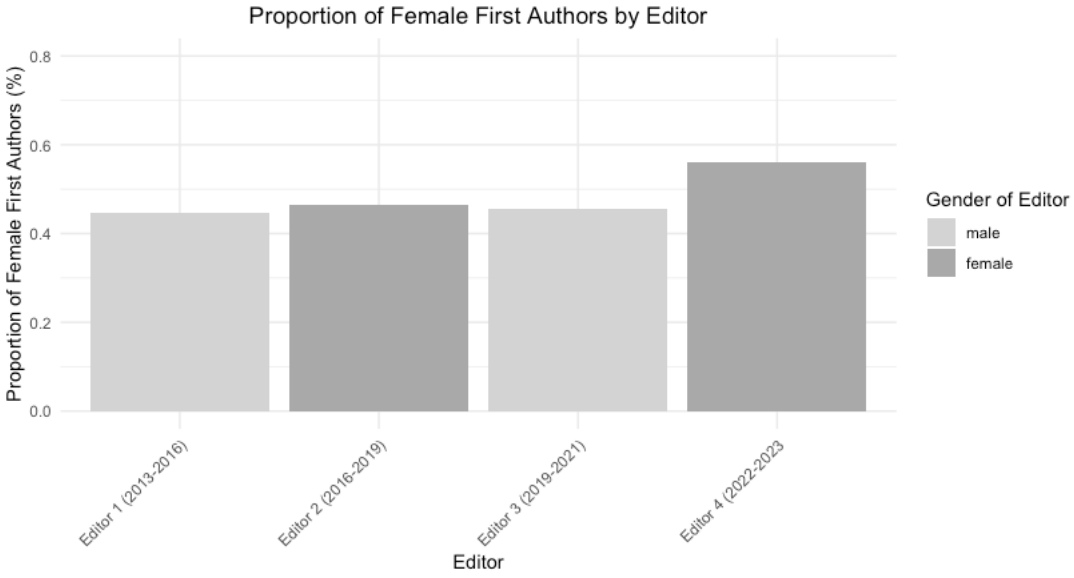
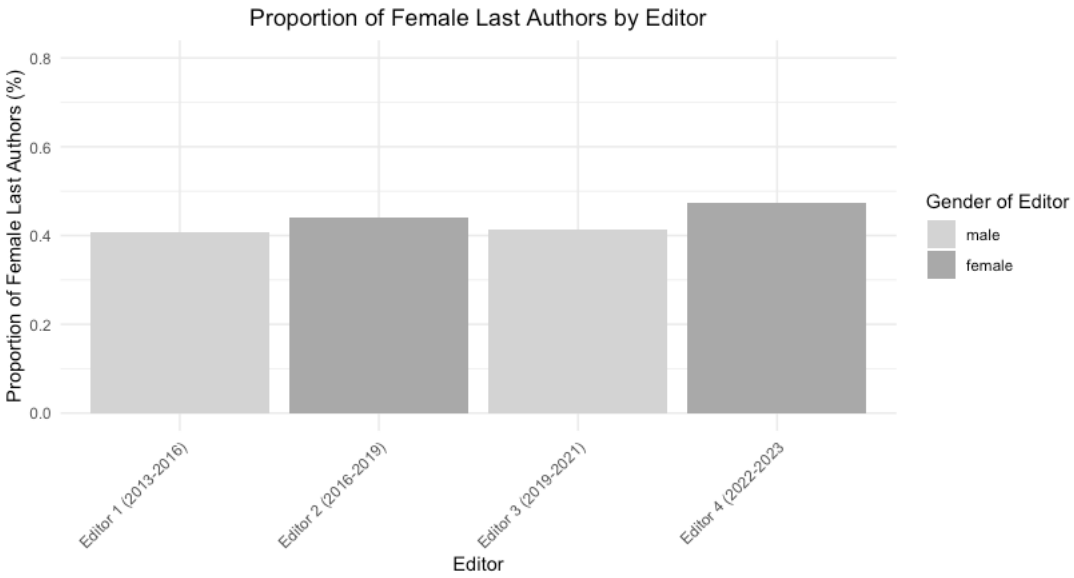


Figure 3b. Proportion of female last authors by journal editor and gender.



Supplemental Figure 1. Overall number of journal publications per year, 2013-2023.

Supplemental Table 1. Annual journal impact factor for CMAJ.

Year	Impact factor
2013	5.808
2014	5.959
2015	6.724
2016	6.784
2017	6.21
2018	6.938
2019	7.744
2020	8.262
2021	16.869
2022	17.4

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Female Authorship Trends in A High-Impact Canadian Medical Journal: A 10-year cross-sectional series, 2013-2023

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Supplemental Tables:	1
Supplemental Figures:	1
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Keywords: Women; Female; Gender; Equity; Author; Canada

ABSTRACT

Importance

Women are underrepresented in senior roles within academic medicine, including as authors in high-impact journals.

Objective

To examine trends and predictors of female authorship in Canadian Medical Association Journal (CMAJ) as the only high-impact Canadian journal over a ten-year period to understand gender balances in Canadian academic publishing.

Design

This cross-sectional study analyzed trends and predictors of female authorship in articles published in CMAJ from January 1, 2013, to December 31, 2023.

Setting

Data were extracted from PubMed for CMAJ, the only high-impact Canadian medical journal (impact factor ≥10). Data extraction utilized the RISmed package in R Studio.

Participants

The study included articles published in CMAJ within the specified period. Author gender was predicted using the validated Genderize.io software. Articles where the gender of the authors could not be predicted were excluded from analysis.

Main Outcomes and Measures

The co-primary outcomes were proportions of female first and last authors. Statistical analyses included chi-square tests comparing proportions, Jonckheere and linear regression models to evaluate trends. Among multi-author articles, multivariable logistic regression models assessed predictors of female first and last authorship.

Results

From 5805 included articles, females comprised 47% of first authors and 43% of last authors ($p<0.001$), both significantly lower than males ($p<0.001$). Female first authorship increased by 17.7% and female last authorship by 10.5% over the study period (both $p<0.05$ for trend), reaching a majority (58%) and near parity (48%) in 2023, respectively. Female editor-in-chief and higher proportion of female co-authors were associated with higher odds of female first and last authors; female last authors were additionally associated with higher odds of female first authors.

Interpretation

Women were underrepresented in authorship overall, though female first and last authorship increased over time, with first authorship exceeding parity in recent years and last authorship nearing equal representation. Female editors-in-chief and a higher proportion of female co-authors were associated with greater female first and last authorship, while female last authorship was additionally associated with higher odds of female first authorship. These findings provide insight into authorship trends in a high-impact Canadian medical journal and may inform future efforts to support gender equity in academic publishing.

Strengths

- Analyzed a decade of publications in the only high-impact Canadian medical journal.
- Used validated software for gender prediction to systematically classify authorship.

Limitations

- Although validated software was used for gender prediction, this may have lower accuracy for gender-neutral names or across different cultures.
- Predicted gender may not reflect an individual's self-identified gender or account for non-binary identities.
- This study did not examine the intersection of gender and race or ethnicity.

INTRODUCTION

Women remain underrepresented in science and academic medicine, comprising a minority of positions across the career spectrum, especially in senior roles[1]. Despite an increasing number of women entering the field, significant gender disparities persist, including in the realm of academic authorship – a key measure of academic success and leadership. Women are less likely to achieve senior authorship positions, receive lower research funding, and are underrepresented as editors, peer reviewers, grant panelists, or conference speakers[2-7]. These disparities not only hinder individual career progression but also limit the diversity of perspectives essential for innovative research. Although Canadian data is scarce, evidence of this inequity was highlighted in a 2018 review by the Canadian Medical Association (CMA)[8].

Previous research has documented these gender disparities in publications across various scientific disciplines and regions[9-18]. Female-authored papers are less likely to be published in high-impact journals, take longer to get published, and receive fewer citations compared to their male counterparts[9,11,15,16,19-22]. Factors contributing to these disparities include unequal mentorship opportunities, biases in the peer review process, and the added burden of balancing professional and domestic responsibilities[23]. A review of selected publications in high-impact US and British journals from 1994 to 2014 reported an increase in female first authorship from 27% to 37%, which had plateaued and even declined in some journals, highlighting ongoing inequities[15]. A 2019 publication in JAMA described differential increases in female first and last authors across specialties in high-impact US and British journals from 2008 to 2018, with women experiencing slower transitions from first to last author[9]. These temporal trends underscore efforts to improve equity while highlighting areas for further targeted improvement.

Although gender disparities in academic publishing are well-documented, local evaluations are essential, as inequities vary by jurisdiction due to sociocultural, historical, and systemic factors. In Canada, women comprise 54% of physicians under 40 and are projected to reach overall parity by 2030, yet barriers persist for career advancement.[8] A 2019 Lancet Global Health review found that female represented only 22-42% of Canadian authors, highlighting ongoing inequities[24]. As Canada's leading and only high-impact medical journal, the Canadian Medical Association Journal (CMAJ) plays a key role in supporting local researchers, publishing regionally relevant findings, and informing national health policy.[25,26] A recent bibliometric review of leading medical journals observed that journals are more likely to publish studies from the country in which the journal is based, and authors are more likely to cite work from their own country.[27] Local journals can therefore shape academic opportunities within their countries, making CMAJ an important lens to assess gender equity in Canadian medical publishing.[28,29] To date, no study has examined female authorship trends within the Canadian publishing context. Notably, CMAJ employs a single-blinded peer review process, where reviewers know the authors' identities, thereby introducing potential for gender bias[30]. This study aims to investigate trends and predictors of female authorship in CMAJ over a ten-year period.

METHODS

Search strategy and study selection

We abstracted all articles published from January 1st 2013 to December 31st 2023 in the Canadian Medical Association Journal (CMAJ), which represented the only Canadian

medical journal with an impact factor of 10 or higher. The search was conducted on Pubmed on June 18th 2024 with the term "CMAJ" for the period of interest using the RISmed package in R Studio (version 2023.09.1+494). Articles were excluded if they were retracted or published in erratum. There were no other restrictions on article type to capture the broad range of articles published in CMAJ. This study did not require Research Ethics Board approval as it analyzed public data.

Outcomes

The co-primary outcomes were proportion of female (i) first and (ii) last authors. Last author was reported as this typically denotes the most senior author by convention. These outcomes were reported overall, temporally, and in relation to journal characteristics. Secondary outcomes were female composition of authorship teams, and predictors of female first and last authorship. In the case of single-authored publications, the author was considered as both first and last author. Gender was considered as a sociologic binary construct (i.e., female or male); biologic sex and non-binary gender could not be evaluated in this study design. First names of first and last authors were used to predict gender at a threshold of 50% using validated software (Genderize.io [https://genderize.io]), and publications where author gender could not be predicted were excluded from analysis[31].

Data extraction

Author names, article type, publication dates, and PMID were extracted from articles. Journal editor-in-chief name, impact factor, and details of the journal's review process were obtained from a web search including the journal website[32,33]. Gender of journal editor-in-chief was similarly predicted using Genderize.io [https://genderize.io][31].

Data analysis

All statistical analyses were performed using RStudio (version 2023.09.1+494).

The Wilcoxon rank sum test was used to compare number of articles published per year and across eras. Descriptive statistics included binomial proportion of female authors overall, per year, and during each journal editor's tenure. Chi square test was used to compare proportions of female authors overall, and by author type (first vs last), year, gender of journal editor, and within article types. Paired t-test was used to compare annual proportions of first versus last female authors within each year. Jonckheere-Terpstra test was used to evaluate temporal trends in number of articles and annual proportion of female authors over the 10-year period. Univariable linear regression models were used to evaluate associations between annual proportion of female first and last authors with year of publication and journal impact factor. Among a subcohort of publications with more than one author, multivariable logistic regression models examined potential predictors of female first or last authorship including female editor-in-chief, female composition of the authorship team, publication year, and journal impact factor; the model for female first authorship also included female last author as a predictor. All covariates were included as fixed effects. P-values <0.05 were considered statistically significant.

Patient and Public Involvement

None. This study did not involve medical patients.

RESULTS

The literature search identified 6024 articles, and 5805 articles were ultimately included after gender prediction was applied to author names. There was no difference in the total number of articles published annually, or before vs after 2019 at onset of the global COVID-19 pandemic. However, there was a trend to fewer annual publications in 2022-2023 compared to prior years (p=0.07). **[Supplemental Figure 1]**

Females comprised 2728/5805 (47%) of first authors and, slightly less commonly, 2491/5805 (42.9%) of last authors (p<0.001) over the 10-year period, and these were significantly lower than male author counterparts (p<0.001). **[Figure 1]** Females comprised about half of authorship teams (mean 0.46, SD 0.41).

Temporal trends of female authorship

The annual proportion of female first and last authors each year is shown in **Figure 2**. The proportion of female first authors increased by 17.7%, and female last authors increased by 10.5% from 2013 to 2023. Females comprised a slight majority of first authors in 2022 (53%) and 2023 (58%), and roughly half of last authors in 2023 (48%). There appeared to be a very small but significant increases in annual proportion of female first (Jonckheere test p=0.009; linear regression estimate 0.01 (95% CI 0.004, 0.02), p=0.007) and last (Jonckheere test p=0.02; linear regression estimate 0.007 (95% CI 0.0005, 0.01), p=0.04) authors that followed similar trajectories over time. **[Figure 2c]** Females were less likely to be last versus first authors in each year assessed (p<0.001). Additionally, there was no difference in annual proportion of female first or last authors before versus after 2019 at onset of the global COVID-19 pandemic. **[data not shown]**

Journal characteristics and female authorship

There were four journal editors during the period of interest, two of whom were female. The proportion of female first (p=0.002) and last (p=0.002) authors was higher during the tenure periods of female editors. **[Figure 3]**

The journal impact factor more than doubled from 8.3 in 2020 to 16.9 in 2021 and peaked most recently at 17.4 in 2022. **[Supplemental Table 1]** There was a non-significant trend to slightly higher annual proportion of female first authors (estimate 0.005 (95% CI -0.0002, 0.001), p=0.06), and no association with female last authors (p=0.37), when the journal impact factor was higher.

Article type and female authorship

There were 2185 articles with an indexed article type. Compared to male authors, female authors were significantly less likely to be first authors of practice guidelines (31%), observational studies (30%), case reports (36%), and comments (32%), and there was a trend to fewer randomized controlled trials (RCTs) (36%, p=0.06). Female last authors were also less common in practice guidelines (28%), multicenter studies (33%), comparative studies (29%), case reports (29%), and comments (30%). Female authors were also less likely to be last authors compared to first authors for meta-analyses, comparative studies, and case reports (p<0.001). **[Table 1]**

Predictors of female first and last authorship

There were 3,133 articles with multiple authors and females constitute 1330 (42.5%) of first authors and 1093 (34.9%) of last authors (p<0.001). Odds of female first author were higher when there was also a female last author (OR 1.49; 95% CI 1.15, 1.93), higher proportion of female authors in the team (OR 1.59; 95% CI 1.15, 2.20), and a female editor-in-chief (OR 1.18; 95% CI 1.00, 1.39). The odds of female last author were also higher with a higher proportion of female authors in the team (OR 2.38; 95% CI 1.94, 2.93) and female editor-in-chief (OR 1.25; 95% CI .05, 1.48). **[Table 2]** These findings were robust to data-driven adjustments of era effects before and after 2019 (COVID-19 pandemic onset) and 2022 (lower number of publications annually). **[data not shown]**

DISCUSSION

This study investigated trends and predictors of female authorship in a high-impact Canadian medical journal over a ten-year period. Females were less likely to be last versus first authors. The annual proportion of female authors increased by 18% for first authors and 11% for last authors over the study period, and females constituted a slight majority of first authors in recent years. Higher proportions of female first and last authors were observed during the tenure of female editors-in-chief. Odds of female first and last authors were higher with female editors-in-chief and higher proportion of female authors on the team. Moreover, having a female last author was associated with higher odds of having a female first author, highlighting potential benefits of mentorship or support networks.

We identified a lower proportion of female first and last authors overall, but crucially, temporal analyses showed increasing representation over time. The proportion of female first authors increased by 18% and female last authors by 11% over the study period, with females making up a slight majority of first authors and nearly half of last authors since 2022. This trend aligns with broader efforts to improve gender equity in academia and mirrors increases reported in high-impact US and British journals, though the magnitude of change in CMAJ appears greater than in prior studies of general medical journals[9,15]. However, improved gender parity was observed in more recent years in this contemporary CMAJ cohort; updated analyses of other medical journals would therefore be needed to examine whether these positive changes in gender balances were isolated or more widespread. Importantly, we found no significant decline in female authorship from onset of the COVID-19 pandemic, despite early studies showing lower submission and authorship rates for female scientists during the pandemic[34-37]. However, female last authorship remained lower than first authorship, suggesting persistent barriers to senior authorship, which has been reported in other studies. Additionally, female authors were underrepresented in more impactful publications, such as practice guidelines, randomized controlled trials, and comparative studies, which are more likely to be highly cited and influence clinical practice and policy[38]. These imbalances may reflect ongoing gender disparities at senior levels of the workforce and could reinforce barriers to academic promotion by skewing citation metrics. At the same time, a 2018 US study found that publication-related productivity helped mitigate gendered differences in achieving full professor rank but not senior leadership positions[1]. Multifaceted approaches are clearly needed to target these intertwined domains.

The increased odds of female first authorship when the last author was female highlight the role of mentorship and sponsorship in fostering gender equity in academic publishing. Our

study also found that a higher proportion of female co-authors was associated with greater odds of both female first and last authorship, suggesting that diverse authorship teams may create more supportive environments for female researchers. Prior research shows that gender-diverse teams produce more novel, high-impact work, reinforcing the broader benefits of diversity in academia.[39] A 2019 systematic review reported that mentorship programs for women led to high satisfaction, increased publications, promotions, and retention in medicine[40]. Strong female networks and diverse external connections are also associated with higher leadership success for women.[41] However, the gender imbalance among senior academics in Canada limits access to female mentors, particularly in fields where women remain underrepresented[42,43]. Establishing an independent research program often overlaps with childbearing years and limited grant funding for female researchers further restricts their ability to mentor junior trainees[2,3,23,44]. Female trainees may also struggle to develop effective mentor-mentee relationships due to fears of male mentors in the #MeToo era[45]. A Canadian training program with a gender-balanced award selection committee and structured mentorship has shown benefits in promoting gender diversity and equity for early researchers[44]. Having observed real-world improved gender parity for female authors in CMAJ, these findings support the need for future studies examining the identified factors associated with increased female authorship. Implementation studies should also explore potential roles of formal mentorship structures and diverse research teams to promote equitable opportunities for women in academic medicine.

The significant influence of female journal editors on female authorship underscores the importance of leadership in fostering gender equity. Our findings align with prior research showing that female peer reviewers and editors are associated with increased female authorship. However, editorial leadership remains predominantly male across academia.

Despite some progress, women still comprise less than one-third of journal editors, with even smaller proportions serving as editors-in-chief, particularly in male-dominated fields like Surgery.[17,46-50] This lack of representation in editorial leadership may contribute to the slower progression of female authors to senior authorship roles. CMAJ's single-blind peer review process, where reviewers know the authors' identities, creating the opportunity to potentially introduce gender bias, as replicated by our study's gender prediction software. A 2022 systematic review found mixed results on the impact of double-blind versus single-blind peer review on publication decisions by perceived author gender[51]. Studies on gender balance would benefit from transparent reporting by journals of author gender at all stages from submission to publication; ideally, studies such as this would not be needed. A recent Canadian review called for collecting and reporting gendered data, promoting voluntary gender disclosure during manuscript submission, and advocating for funding bodies to disclose funding success rates by gender[52]. Strengthening gender diversity in editorial leadership, alongside transparent peer review and authorship reporting practices, could help advance gender equity in academic publishing.

This study has several strengths. It provides a unique examination of gender disparities in academic authorship within the Canadian context, covering a decade-long period. The use of validated software for gender prediction enhances the reliability of our findings, enabling a robust analysis of trends and predictors of female authorship. However, there are also notable limitations. While the gender prediction software is validated, it is inherently limited and may not accurately identify gender, particularly for gender-neutral names or across different cultures. Additionally, it may not reflect an individual's self-identified gender or account for non-binary identities. This study also did not examine the intersection of gender and race or ethnicity. Our analysis was restricted to published articles, and we could not assess gendered

differences at the submission stage. Article types were classified based on PubMed indexing, which was not uniformly available and may not comprehensively capture all nuances, though we highlighted significant gender differences in first and last authorship as per available data. This study did not analyze manuscript content, which may be an important factor influencing publication patterns. Women are more likely to conduct research on female-focused health issues, which have historically received less recognition and funding. If such research is perceived as lower priority by journals or reviewers, it could partially explain disparities in authorship representation and impact. Future research should explore whether topic selection plays a role in gendered differences in academic publishing. Statistical models are susceptible to residual unmeasured confounding; however, the nature of the dataset precluded broad adjustment for potential confounders. The structure of the data precluded the use of individual fixed effects, which may limit the ability to account for unmeasured author characteristics such as writing style, field of expertise, or reputation, that could contribute to observed gender differences in authorship. Lastly, we assumed a traditional first versus last author distinction of seniority, which may not always apply, potentially overlooking other collaborative dynamics within author teams.

In conclusion, females were underrepresented as first and last authors overall, but we observed increasing female authorship in CMAJ over the past decade, with female first authors surpassing parity in recent years and female last authors achieving near-equal representation. Female journal editors were associated with greater female last authorship, underscoring the role of leadership in shaping authorship patterns. Additionally, a higher proportion of female co-authors was linked to increased odds of both female first and last authorship, while female last authors were associated with higher odds of female first authors, reinforcing the importance of diverse research teams and mentorship in supporting

female career progression. These findings suggest that editorial leadership, team composition, and mentorship networks play a crucial role in advancing gender equity in academic publishing. Strengthening policies that promote gender-inclusive editorial boards, transparent authorship tracking, and structured mentorship programs may help sustain progress toward equitable representation in medical research.

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DISCLOSURES

The author declares that she has no conflicts of interest.

ETHICAL APPROVAL

This study involves human participants but was not approved by an Ethics Committee(s) or Institutional Board(s). This study did not require Research Ethics Board approval as it analyzed public data. This study did not involve medical patients.

DISCLAIMERS

None.

DATA SHARING

Data may be provided upon reasonable request.

AUTHOR CONTRIBUTIONS

CR: Study conception and design, data extraction, statistical analysis, results interpretation, manuscript preparation.

CR is the guarantor.

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TABLES

Table 1. First and last author gender by article type.

Article type	Number of articles	Author type	Proportion of female authors (%)	Proportion of male authors (%)	Female vs male	First vs last female

					authors, p-value†	authors, p-value‡
Case report	674	First	35.5	64.5	**<0.001**	**<0.001**
		Last	28.9	71.1	**<0.001**	
Comment	878	First	31.7	68.3	**<0.001**	1.0
		Last	30.3	69.7	**<0.001**	
Comparative study	34	First	41.2	58.8	0.30	**<0.001**
		Last	29.4	70.6	**0.02**	
Editorial	162	First	53.7	46.3	0.35	0.77
		Last	42.6	57.4	0.06	
Meta-analysis	21	First	38.1	61.9	0.28	**<0.001**
		Last	47.6	52.4	0.83	
Multi-centre study	36	First	50.0	50.0	1.00	0.78
		Last	33.3	66.7	**0.05**	
Observational study	30	First	30.0	70.0	**0.03**	0.29
		Last	33.3	66.7	0.07	
Practice guideline	29	First	31.0	69.0	**0.04**	0.67
		Last	27.6	72.4	**0.02**	
Randomized controlled trial	42	First	35.7	64.3	0.06	0.36
		Last	21.4	78.6	**<0.001**	
Review	279	First	40.1	59.9	**<0.001**	0.82
		Last	22.6	77.4	**<0.001**	

- There were 2185 articles with an indexed article type.
- Bolded values denote statistical significance.
- †Chi-square test was used to compare female vs male first and last author proportions.
- ‡Chi-square test was used to compare female first vs last author proportions.

Table 2. Multivariable logistic regression models for female (i) first and (ii) last authors.

Predictor	Reference level	Odds ratio (95% CI)	p-value
Female first authors			
Female last author	Male	1.49 (1.15, 1.93)	**0.002**

Female proportion of authorship team (%)	Continuous	1.59 (1.15, 2.20)	**0.005**
Female editor-in-chief	Male	1.18 (1.00, 1.39)	**0.05**
Publication year	Continuous	0.99 (0.94, 1.04)	0.69
Journal impact factor	Continuous	1.02 (0.99, 1.05)	0.19
Female last authors			
Female proportion of authorship team (%)	Continuous	2.38 (1.94, 2.93)	**<0.001**
Female editor-in-chief	Male	1.25 (1.05, 1.48)	**0.01**
Publication year	Continuous	1.04 (0.99, 1.09)	0.11
Journal impact factor	Continuous	1.00 (0.97, 1.03)	0.79
• Bold values denote statistical significance.			

FIGURE LEGENDS

Figure 1. Proportion of female first and last authors in CMAJ from 2013-2023.

Figure 2a. Proportion of female first authors each year from 2013-2023.

Figure 2b. Proportion of female last authors each year from 2013-2023.

Figure 2c. Proportions of female first and last authors each year from 2013-2023.

Figure 3a. Proportion of female first authors by journal editor and gender.

Figure 3b. Proportion of female last authors by journal editor and gender.

Figure 1. Proportion of female first and last authors in CMAJ from 2013-2023.

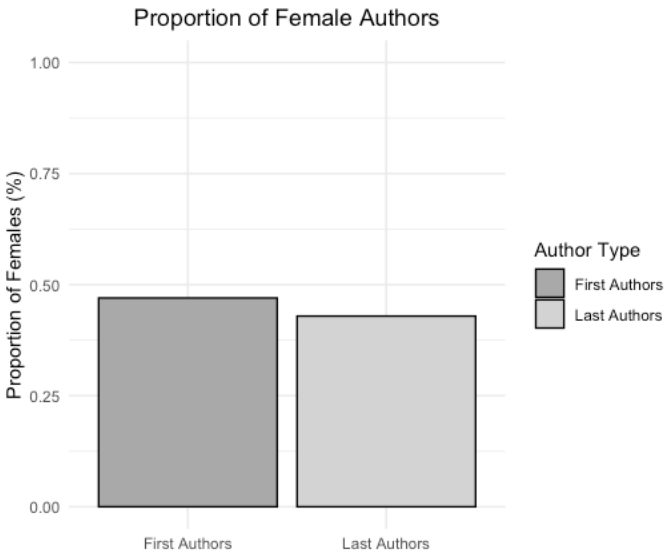


Figure 2a. Proportion of female first authors each year from 2013-2023.

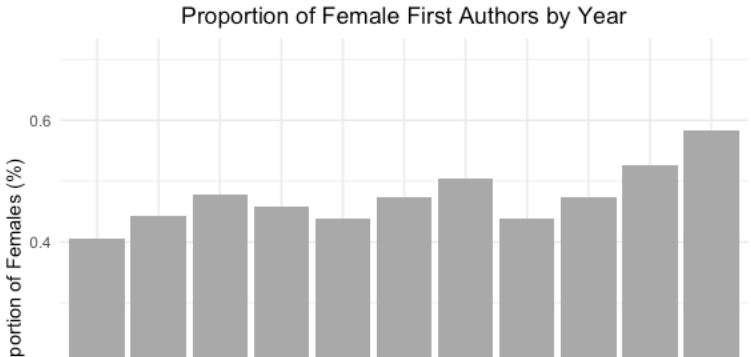


Figure 2b. Proportion of female last authors each year from 2013-2023.

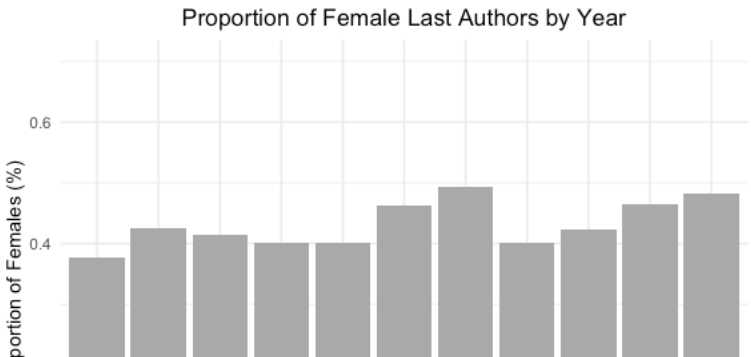


Figure 2c. Proportions of female first and last authors each year from 2013-2023.

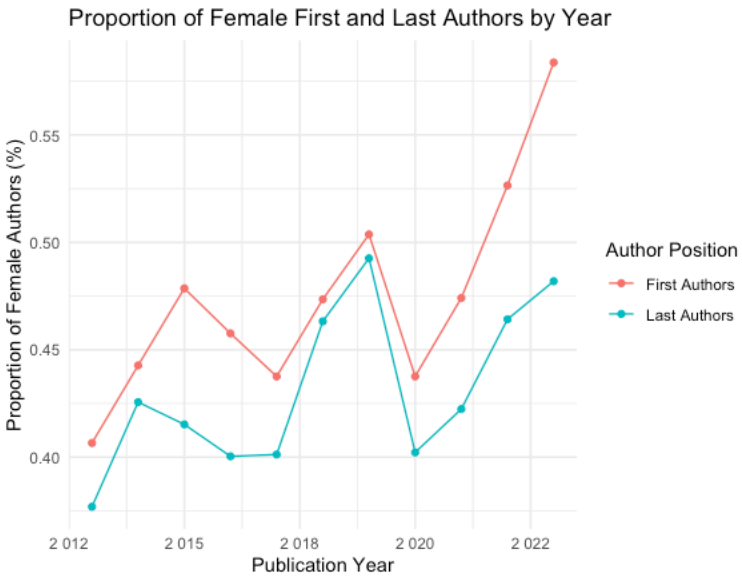


Figure 3a. Proportion of female first authors by journal editor and gender.

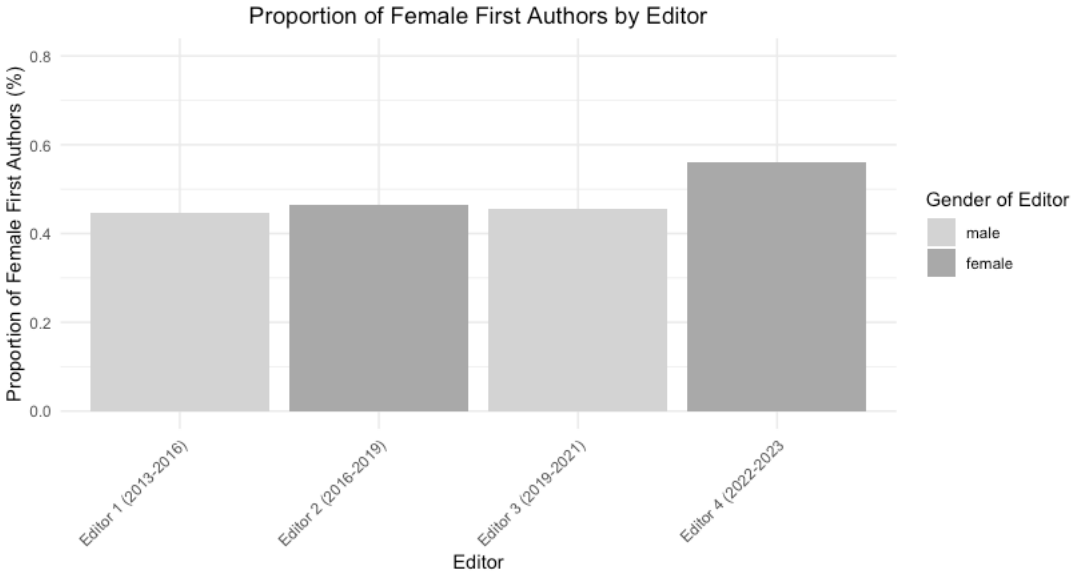
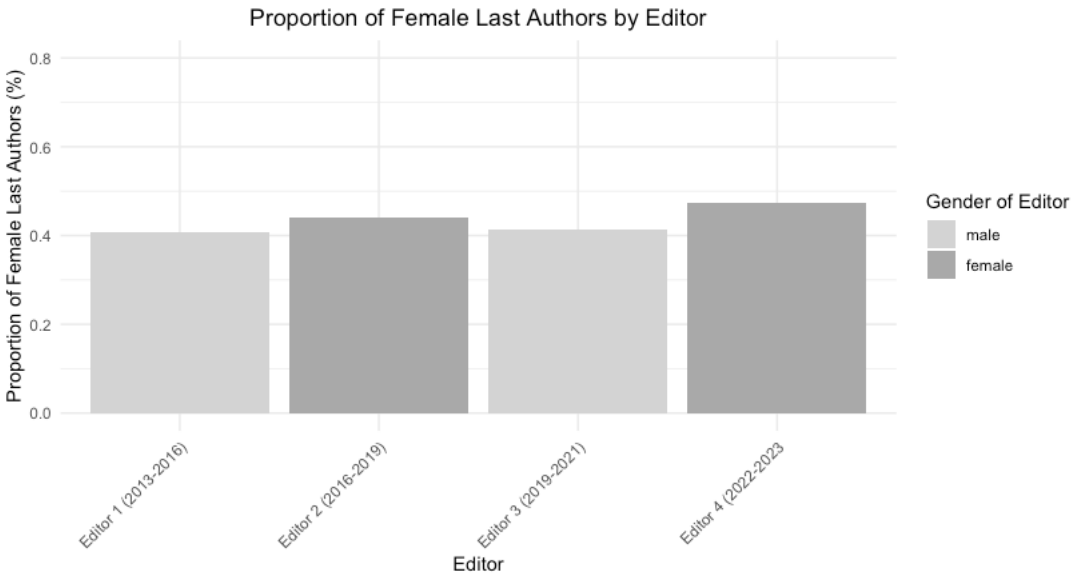


Figure 3b. Proportion of female last authors by journal editor and gender.



Supplemental Figure 1. Overall number of journal publications per year, 2013-2023.

Supplemental Table 1. Annual journal impact factor for CMAJ.

Year	Impact factor
2013	5.808
2014	5.959
2015	6.724
2016	6.784
2017	6.21
2018	6.938
2019	7.744
2020	8.262
2021	16.869
2022	17.4