



Effect of the SARS-CoV-2 Pandemic on Authorship Gender Disparities in the Ophthalmology Literature

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Abstract

Background Studies in several fields of medicine have found that women published less during the COVID-19 pandemic, potentially due to an increase in domestic responsibilities. This study examines whether a similar pattern exists for female authorship in ophthalmology.

Purpose To compare the proportions of female authorship published in high-impact ophthalmology journals before and during the COVID-19 pandemic.

Methods A cross-sectional study analyzing authorship gender of articles published during the COVID-19 pandemic (between July and September 2020) compared with matched articles published in the same journals before the COVID-19 pandemic (between July and September 2019). Gender of the first and last authors was analyzed using an online gender determination tool.

Results A total of 577 articles and 1,113 authors were analyzed. There was no significant difference in the average number of publications by male and female authors before and during the COVID-19 pandemic. There was a significant increase in the percentage of female first authorship from the prepandemic period (32%) to during the COVID-19 pandemic (40%; $p=0.01$), but no significant increase in the last authorship ($p>0.05$). When analyzing only research articles, a similar increase in female first authorship was noted when comparing the publications before (31%) and during the COVID-19 pandemic (43%; $p=0.02$). No significant differences were noted when analyzing the editorials ($p>0.05$).

Conclusion While disparities continue to exist between male and female authorship, an increase in female first authorship was noted during the COVID-19 pandemic for overall articles as well as research articles.

Keywords

- ▶ publications
- ▶ gender disparities
- ▶ authorship
- ▶ COVID-19

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Precis During the COVID-19 pandemic, female authorship as first and last authors of peer-reviewed articles in high-impact ophthalmology journals was below 50%. However, while the overall rates of female authorship were unchanged, female first authorship significantly increased during the pandemic. These results differ from studies published in other medical fields that demonstrated a decrease in female authorship during the COVID-19 pandemic.

The novel coronavirus, SARS-CoV-2 (COVID-19), pandemic has had major ripple effects on the day-to-day life of physicians in the United States. Specifically within the field of ophthalmology, a drastic decline was seen in terms of the number of ocular surgeries performed during the height of the pandemic compared with the same time period the year prior.¹ With fewer clinical and surgical responsibilities, ophthalmic physicians involved in academia were inadvertently provided more time to dedicate toward their research. Many medical students also had increased time to dedicate to research as previously in-person commitments such as rotations and interviews were transitioned to a virtual medium.

Beyond changes in clinical demands when the pandemic hit the United States in early 2020, mandatory shutdowns transformed American homes into simultaneous workplaces, schools, and daycares. For many physicians, this resulted in an increased balancing of both childcare and workplace responsibilities.² It is well established that women often take on more childcare responsibilities and household tasks than men, including in dual-academic households.³ Even before the COVID-19 pandemic, female physicians were thought to disproportionately make adjustments to their professional roles to adjust for their personal roles, potentially sacrificing career progression and advancement when compared with men.² Stay-at-home orders during the pandemic increased childcare and elderly care responsibilities, thus potentially impacting females more than their male counterparts.

Authorship trends have previously been used as a proxy for assessing the environment with regard to academic gender equality, allowing researchers to draw conclusions regarding research collaborations, mentor-mentee gender pairings, and productivity in academia.⁴⁻⁶ In the context of the pandemic, studies in other medical specialties have noted a significant decrease in the proportion of female authorship during the pandemic as compared with before the pandemic.^{7,8} As a result, while the proportion of female authorship has been improving in ophthalmology in recent years,⁴ this study specifically looks at the impact COVID-19 had on female authorship within the ophthalmology literature.

Methods

All manuscripts published online between July and September 2020 from three high-impact ophthalmology journals (*Ophthalmology*, *JAMA Ophthalmology*, and *American Journal*

of Ophthalmology) were included. For a matched comparison, these articles were compared with manuscripts published between July and September 2019 in the same three journals. Since at-home orders were instituted in late March 2020, we examined articles published in July through September 2020 to capture articles that were likely to be written after at-home orders were set in place. While we were not able to determine the average review timelines for *Ophthalmology*, *JAMA Ophthalmology*, and *American Journal of Ophthalmology (AJO)*, these journals have self-reported review timelines ranging anywhere from 6 to 12 weeks from submission to second decision/acceptance.^{9,10} Once the articles were identified, the first and last names of the first and last authors, manuscript type, initial acceptance date (if available), and publication date were noted. Manuscript types were broken down into two types: type 1 (research articles), which included original investigations, brief reports, research letters, research articles, special communications, American Ophthalmology Society (AOS) thesis/research articles, short communications, review articles, commentaries, and reports, and type 2 (editorials), which included commentaries, editorials, correspondences, and invited commentaries.

Author names were analyzed for gender with Gender API (Munich, Germany, found at <https://gender-api.com/>), a gender inference tool that returns gender assignments based on first names. Gender API returns an accuracy value based on the name. Names returning a score of less than 90% were manually verified in conjunction with the author's institution via an exhaustive Google search (Google Inc., Mountain View, CA). Authors with unknown genders were excluded.

Matlab R 2020a (MathWorks, Natick, MA) and SAS version 9.4 software (SAS Institute, Cary, NC) were used to perform statistical analysis. Pearson's chi-squared test was used to compare authorship by gender for pandemic versus prepandemic for each journal and subgroup. Fisher's exact test was used to identify gender associations between the first and last authors.

Results

Manuscripts Published Online COVID-19 vs. Pre-COVID-19: All Articles

Overall, we included 577 articles and 1,113 authors, 971 of whom were unique authors. For the pandemic group, there was no significant difference between the average number of publications per unique male and female

authors for all authors, first authors, or last authors (all $p > 0.05$). For the prepandemic group, there was no significant difference between the average number of publications per unique author between males and females for all authors or first authors, but male last authors published more articles per author than female last authors (males: 1.14, females: 1.02; $p = 0.03$). There was no significant change in the number of articles per male or female first, last, or all authors during and before the pandemic (all $p > 0.05$; ► **Table 1**).

Prior to the COVID-19 pandemic, females made up 32% of first authors and 26% of last authors. During the COVID-19 pandemic, females made up 40% of first author publications and 26% of last author publications (► **Fig. 1** ► **Table 2**). While there was no statistically significant difference between female first and last author publications prepandemic ($p = 0.21$), women published significantly more first author publications than last author publications during COVID-19 ($p < 0.001$). There was a significant increase in the percentage of female first authorship prior to the pandemic when compared with during the COVID-19 pandemic ($p = 0.01$). There was no significant increase in the percentage of female last authors or all authors ($p = 0.92$ and 0.08 , respectively; ► **Table 2**). Both during the COVID-19 pandemic and pre-pandemic, there were no significant gender associations between the genders of the first and last authors (pre-COVID-19: odds ratio [OR] = 1.5 [0.78–2.88]; COVID-19: OR = 1.01 [0.61–1.69]; ► **Table 3**).

Manuscripts Published Online during COVID-19 vs. pre-COVID-19: Research Articles

When examining only research articles, there were 366 articles and 652 unique authors. Both prepandemic and during the pandemic, there was no significant difference between the average number of publications per unique male and female authors for all authors, first authors, or last authors (all $p > 0.05$). There was no significant change in the number of articles per male or female first, last, or all authors during and prior to the pandemic (all $p > 0.05$; ► **Table 1**).

Prior to the COVID-19 pandemic, females made up 31% of first author publications and 25% of last author publications. During the COVID-19 pandemic, females made up 43% of first author publications and 25% of last author publications (► **Table 2**). While there was no statistically significant difference between female first and last author publications prior to the COVID-19 pandemic ($p = 0.30$), women published significantly more first author publications than last author publications during COVID-19 ($p < 0.001$; ► **Table 2**). There was a significant increase in the percentage of female first authorship prior to the pandemic compared to during the COVID-19 pandemic ($p = 0.02$). However, there was no significant change in the last authors or all authors (both $p > 0.05$; ► **Table 2**). Both during the COVID-19 pandemic and before the pandemic, there were no significant gender associations between the first and last authors (pre-COVID-19: OR = 1.57 [0.67–3.69]; COVID-19: OR = 1.24 [0.68–2.27]; ► **Table 3**).

Manuscripts Published Online during COVID-19 vs pre-COVID-19: Editorials

When examining only editorials, there were 126 articles and 208 unique authors. During the COVID-19 pandemic and prior to the pandemic, there was no significant difference between the average number of publications per unique male and female authors for all authors, first authors, or last authors (all $p > 0.05$; ► **Table 1**).

Prior to the COVID-19 pandemic, females made up 31% of first author editorials and 24% of last author editorials. During the COVID-19 pandemic, females made up 27% of first author editorials and 23% of last author editorials (► **Table 2**). There were no statistically significant differences between female first and last author editorials both before and during the COVID-19 pandemic (both $p > 0.05$). There were no significant increases in the percentage of female first, last, or all authorship when comparing the publications prepandemic to during the COVID-19 pandemic (all $p > 0.05$). Additionally, both during the COVID-19 pandemic and prior to the pandemic, there were no significant gender associations with the first and last authors (pre-COVID-19: OR = 0.8 [0.12–5.21]; COVID: OR = 0.47 [0.09–2.42]; ► **Table 3**).

Discussion

In this study, we examined whether the gender gap in ophthalmology authorship was magnified during the COVID-19 pandemic. While we found that overall authorship and last authorship did not significantly change, female first authorship increased during the pandemic. Furthermore, we found that the number of publications per author did not increase, suggesting that the increase in first authorship may be due to new authors who had not previously published. First authors tend to be ophthalmologists-in-training or early-career physicians, potentially highlighting an increased research focus in this population in the setting of decreased elective procedures within ophthalmology, increased virtual rotations, and more time off clinical duties.

One possible explanation for the rise in female first authorship during the pandemic is an increase in dedicated research capacity given the time without in-person activities, particularly for younger ophthalmologists. While the COVID-19 pandemic resulted in increased hospital duties for certain specialties, specialties such as ophthalmology, which has a larger proportion of elective procedures, saw a large reduction in case volume.¹ Notably, surgical volumes in ophthalmology were down roughly 90% during April 2020 as compared with April 2019.¹ Similarly, for third- and fourth-year medical students, rotations and interviews were transitioned to a virtual format. Submissions overall in Elsevier, particularly for health and medicine titles, rose 92% in 2020 compared with 2019, likely due to increased time to publish research.¹¹ Combined with the rising rate of female trainees,¹² this may explain the specific rise in female first authorship. Furthermore, given that first authors tend to be younger and/or earlier in their career compared with last authors who are generally more senior, it is plausible that

Table 1 Number of publications per male and female authors for research articles (type 1), editorials (type 2), and all articles

	First		Last		p value comparing 2019 to 2020 average no. of publications	2019	2020	p value comparing 2019 to 2020 average no. of publications	2019	2020	p value comparing 2019 to 2020 average no. of publications
	2019	2020	2019	2020							
Type 1 (research articles)	Unique male authors	92.00	129.00			86.00	161.00				
	Unique female authors	41.00	96.00			30.00	58.00				
	No. of total male publications	93.00	132.00			94.00	179.00				
	No. of total female publications	41.00	100.00			31.00	61.00				
	Average no. of publications/unique male author	1.01	1.02		0.49	1.09	1.11				0.69
	Average no. of publications/unique female author	1.00	1.04		0.19	1.03	1.05				0.70
	Unique male authors	33.00	56.00			22.00	46.00				
	Unique female authors	15.00	20.00			7.00	13.00				
	No. of total male publications	33.00	57.00			22.00	47.00				
	No. of total female publications	15.00	21.00			7.00	14.00				
Type 2 (editorials and commentaries)	Average no. of publications/unique male author	1.00	1.02		0.45	1.00	1.02				0.49
	Average no. of publications/unique female author	1.00	1.05		0.39	1.00	1.08				0.48
	Unique male authors	150.00	204.00			133.00	223.00				
	Unique female authors	71.00	134.00			53.00	79.00				
	No. of total male publications	154.00	211.00			151.00	246.00				
	No. of total female publications	72.00	140.00			54.00	85.00				
		1.03	1.03		0.69	1.14	1.10				0.41

(Continued)

Table 1 (Continued)

	First		Last		p value comparing 2019 to 2020 average no. of publications
	2019	2020	2019	2020	
Average no. of publications/unique male author					
Average no. of publications/unique female author	1.01	1.04	1.02	1.08	0.15

first authors may have fewer domestic responsibilities compared with senior authors.

Another contributing factor to the rise in first authorship for female trainees may be an increased catalyst to conduct research. The transition to a virtual learning format likely made it more difficult for medical students to stand out while applying to residency as opportunities for clinical shadowing, course honors and recommendation letters were limited. To offset this disadvantage, more students may have participated in research to distinguish themselves. One study looking at JAMA internal medicine articles found that medical student first authorship has steadily increased and medical students made up roughly 25% of first authors and were involved in 58% of articles in 2018.¹³ Furthermore, the pandemic resulted in a rise in COVID-19-related publications. Approximately 6% of PubMed articles in 2020 involved COVID-19, and preprints on COVID-19 were found to be published in half the time of preprints on other topics.¹¹ Conducting research in a highly sought-after topic may have increased the incentive to publish, leading to increased gender representation. While overall, significant disparities persisted between proportions of male and female authors in both first and last authorship, seeing an increase in female first authorship is encouraging as early-career ophthalmologists arguably have the most to gain given that research and scholarship is a key component of academic promotion decisions.¹⁴

Overall, we found that female senior authorship did not increase during the pandemic, mirroring the results of similar studies in other specialties.¹⁵ We also found that while first authorship increased overall, when specifically studying first authorship in editorials and commentaries, female first authorship did not rise. Generally, most editorials and commentaries are solicited by the editor-in-chief and thus are written by more senior authors. The lack of increase in editorial female first authorship supports the finding that there was no increase in female senior authorship during the pandemic. Interestingly, while a large study on preprints found that female authorship did not rise at the same rate of male authorship, both men and women received and accepted invitations to evaluate peer-review publications at similar rates.^{8,16} This finding suggests that men and women may have had similar bandwidth for academic responsibilities during the pandemic, but other factors such as unidentified implicit biases may result in decreased publication rates. For example, in one experimental study, investigators manipulated author genders in author bylines and found that male-sounding names were rated more highly than female-sounding names.¹⁷ Other manifestations of these implicit biases may be the reason for longer review times for female first and last authors and fewer female reviewers appointed by male editors compared with female editors.^{18,19}

The current study has several limitations. First, although we deliberately specified the inclusion criteria to begin a few months after stay-at-home orders were instated, there was no way of guaranteeing that the included manuscripts were worked on exclusively after stay-at-home orders were put in place. On the other hand, we were able to catch the output of researchers who did complete projects during the stay-at-

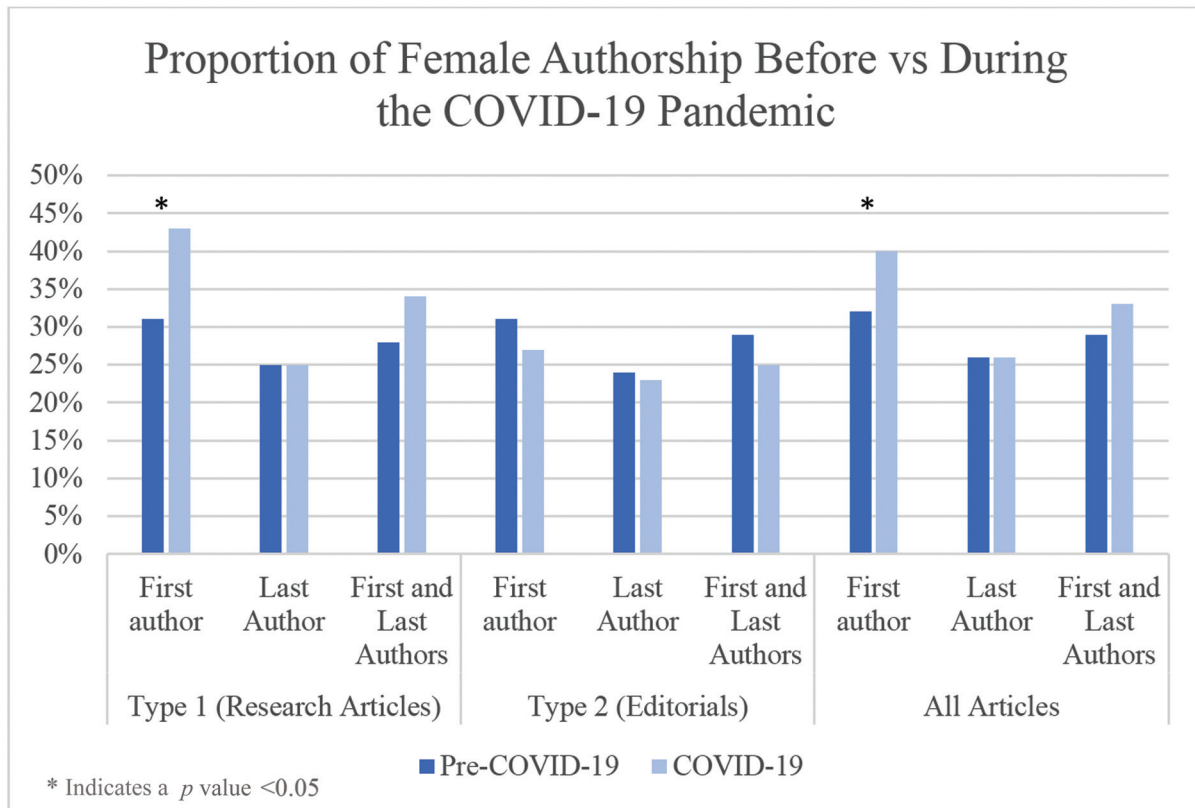


Fig. 1 Proportion of female authorship before versus during the COVID-19 pandemic for research articles, editorials, and all articles.

Table 2 Proportion of male and female authors pre-COVID-19 compared with the COVID-19 pandemic for research articles (type 1), editorials (type 2), and all articles

	Type 1 (research articles)		
	First author	Last author	<i>p</i> value comparing first author to last author
Pre-COVID-19	41 (31%)	31 (25%)	0.3
COVID-19	100 (43%)	61 (25%)	<0.001
<i>p</i> values comparing pre-COVID-19 to COVID-19	0.01786138	0.89754725	

home period, whether through finishing long-term projects or starting and completing new projects. Next, to determine the genders of the authors, a gender-predicting software was used (Gender API). This software was validated in a similar study on longitudinal gender authorship, but still has the risk of misidentifying names and also excludes nonbinary people.⁴ Furthermore, all three of the journals analyzed in this paper were based in the United States. However, these trends may not be mirrored in international-based journals given that cultural differences exist in the role of women in households in other countries. Another limitation is that subspecialty journals were not studied. While the three journals we selected theoretically span all the subspecialties of ophthalmology, the distribution of each specialty is unknown. Given that each subspecialty has a different proportion of females,²⁰ it is possible that COVID-19 could have impacted each subspecialty in different ways. Finally, while the goal was to compare similar time periods for each

journal, we analyzed articles that were published online during COVID-19 and articles that were published in print for pre-COVID-19, as many of the COVID-19 articles were not yet published in print. Therefore, in this study, we compared the proportions rather than absolute numbers. Finally, the sample size of the study was relatively small given the time span defined by the dates of the pandemic.

This study found that there was an increase in female first authorship during the COVID-19 pandemic, but not in female last authorship. While these findings are encouraging compared with other studies evaluating gender disparities in authorship during the pandemic, further work to minimize the gender gap in authorship is necessary. The rise in female first authorship is likely driven by an increase in female trainees, ophthalmologists-in-training who have an incentive to further differentiate themselves in the context of virtual rotations/interviews, increased opportunities for research, and more dedicated time for research due to the cancellation of in-person activities.

Table 3 Likelihood of same-gender mentorship pre-COVID-19 and during the COVID-19 pandemic

Last author	First author			OR (95% CI)	p value
		Female	Male		
AJO pre-COVID-19	Female	4	15	1.64 (0.41–6.67)	0.479
	Male	6	37		
AJO COVID-19	Female	8	41	0.53 (0.22–1.29)	0.2066
	Male	24	65		
JAMA pre-COVID-19	Female	10	17	1.14 (0.43–3.03)	0.807
	Male	17	33		
JAMA COVID-19	Female	8	17	2.16 (0.6–7.79)	0.3393
	Male	5	23		
Ophthalmology pre-COVID-19	Female	7	13	1.97 (0.61–6.41)	0.3526
	Male	9	33		
Ophthalmology COVID-19	Female	16	33	1.29 (0.59–2.82)	0.5514
	Male	21	56		
All journals	Female	53	136	1.17 (0.78–1.76)	0.4672
	Male	82	247		
Pre-COVID-19	Female	21	45	1.5 (0.78–2.88)	0.236
	Male	32	103		
COVID-19	Female	32	91	1.01 (0.6–1.7)	1
	Male	50	144		

Abbreviations: CI, confidence interval; OR, odds ratio.

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Conflict of Interest

None declared.

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