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Gender and Authorship in Annals of Surgery

A nineteen-year review including the pandemic

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Objective: We examined article submission data from the Annals of Surgery to assess gender bias in publishing.

Background: Medicine has long been a male-dominated practice, particularly in surgical fields. A key criterion for promotion in academic medicine is the publication record. Thus, it is critical to understand the extent to which there are gendered disparities in access to publishing which may contribute to differences in career advancement, especially given the exacerbation of these disparities in the early part of the COVID-19 pandemic.

Methods: Working with Annals of Surgery submission data (2005–2023), we assigned author genders using genderize.io. Primary outcomes were final decision on the article (acceptance or rejection) and time to decision. Differences were examined between first-author gender, last-author gender, and first-author/last-author gender pairs using regression and chi-squared analyses.

Results: Men submit more articles than women. This gap widened until the number of submissions peaked in 2020, after which submissions from men appeared to decrease at a faster rate than those from women. Acceptance rates and time to decision have generally declined over time, but articles by women experienced, on average, higher acceptance rates and longer time to decision during recent years compared with those by men.

Conclusions: Our data from a single journal suggest that the widening gender gap in submissions that existed before the pandemic may be narrowing, and overall research productivity of academic surgeons may be declining. Further work is needed to examine the long-term productivity and career trajectories of academic surgeons by gender accounting for the ongoing pandemic.

Keywords: academic surgery, bias, disparities, gender bias, gender equity, publication bias

INTRODUCTION

After 2 decades of near gender parity in medical schools in the United States, the majority of medical students in the United States today are women.[1,2] Historically, though, medicine has been a male-dominated field and continues to be so, particularly at senior levels. Despite gender parity at the medical student level, women represent just 29% of full professors, 25% of department chairs, and 27% of medical school deans.[2]

Within general surgery, the proportion of women trainees has more than doubled from 18%[3] to 46%[4] from 1994 to 2022, while the proportion of women full professors in the same period rose from 4% to 10%.[5] At such a slow rate of improvement, it will take over 100 years to close the gender gap in academic surgery.[3]

Multiple factors, such as gender discrimination, lack of visible role models, insufficient mentorship and sponsorship, and family/lifestyle challenges,[6–12] contribute to women's underrepresentation in senior and leadership roles. One key criterion for promotion in academic medicine is the publication record. Prior studies examining different academic journals demonstrate that women's work spends more time in review,[13–15] and women's work may be held to a higher standard.[16,17] Multiple studies have shown men's academic productivity increased more during the early part of the pandemic than did women's, thus exacerbating these disparities.[18,19] Here, we examine submission data from a leading surgical journal, Annals of Surgery, to determine to what extent, if any, differences exist in acceptance rates of women and men authors. Our data span periods before and including the COVID-19 pandemic, allowing us to examine the prepandemic baseline and pandemic-related changes.

METHODS

We obtained data for all submissions to Annals of Surgery from 2005 to 2023, including authors' names, article title, submission date, final decision date, and final decision (accept or reject).[20] We did not have information on the number or timing of revisions.

After deleting duplicate articles, we applied the commonly used genderize.io function to assign genders to authors.[21] Taking the conservative approach of Buda et al[22], only gender assignments with the likelihood of 90% or more were retained. For each analysis, we included all articles where gender was identified for the author position(s) of interest: when analyzing first authors, we considered all articles where first-author gender was successfully assigned (regardless of whether last-author genders were successfully assigned), and analogously for our analyses of last authors. For analyses involving first-author and last-author gender pairs, we restricted the data to submissions where both author genders were identified.

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Primary outcomes were final article decision (acceptance or rejection) and time to decision. We used linear and logistic regression to assess differences in time to decision or acceptance rates based on first-author and last-author gender as well as the first-author/last-author gender pairings. We used linear regression to compare changes in the numbers of submissions and acceptances over time by author gender; because the proportions of men and women changed over the study period, we also used linear regression to compare these changes normalized by the number of board-certified surgeons of each gender per year.[23] We applied chi-squared tests to examine over- and under-representation of first- and last-author gender pairs, comparing the observed number of each pairing with the expected number if the genders of first- and last-author pairs were left to random chance.

When evaluating changes in the numbers of submissions and acceptances by year, we defined 2005 to 2019 as prepandemic and 2020 to 2022 as pandemic (we did not have access to the full year of submissions for 2023, so 2023 data was omitted here) and included an indicator for prepandemic *versus* pandemic interacted with author gender. Due to a discontinuity observed in time to decision around January 1, 2014, we included indicators for 3 distinct periods (prepandemic before discontinuity, prepandemic after discontinuity, and pandemic) that interacted with author gender in the models for final decision and time to decision described above. We used March 24, 2020, to define prepandemic and pandemic periods for submitted articles, based on the date of the first pandemic-related submission. For the chi-squared tests, we ran separate analyses for articles submitted during each period. Except when modeling changes in the numbers of submissions and acceptances by year, which only incorporate years with a full year of data (2005–2022), all analyses included all data that was made available to us.

Because the same author can submit multiple articles, submissions may not be fully independent. Therefore, we used clustered standard errors when assessing significance and reporting confidence intervals based on regression results. As a sensitivity check, we performed the same chi-squared test on the subset of the data that only includes submissions from the first and last authors with one submission.

We applied the Benjamini-Hochberg procedure to all reported *P* values, controlling the false discovery rate at 0.05.[24] The code repository is: https://github.com/janewliang/Annals_of_Surgery_Gender.

Further details can be found in the supplement. This study was determined exempt by the institutional review board at University Hospitals Cleveland Medical Center.

RESULTS

Annals of Surgery received 40,276 submissions from 2005 to 2023 and accepted 8847 of them (overall 22% acceptance rate) (Supplemental Table 1, http://links.lww.com/AOSO/A402). Annual acceptance rates dropped during the study period from 25.6% to 12.8%. Additional results are provided in the supplement.

Prepandemic Period

Gender and Submission Rates

During the prepandemic period (2005–2019), the annual number of total submissions nearly tripled from 972 to 2735, with an average of 134.3 additional articles submitted per year. However, the rate of increase in first-author submissions was significantly lower for women than for men (35.5 per year *vs* 67.4 for men; t = −6.58, *P*-adj = 2.96 x10^{-6}). Similarly, the number of submissions from women last authors increased at a significantly lower rate compared with men (21.5 more per year *vs* 80.6 more per year for men; t = −11.97, *P*-adj = 2.94 x 10^{-11}) (Figs. 1A,B), resulting in a widening gap in the number of submissions over time by author gender. In general, despite submissions from men increasing at a faster rate than submissions from women, the proportion of articles authored by women increased over the period, from 14.0% to 31.9% for first and 8.9% to 20.0% for last authors (Supplemental Table 2, http://links.lww.com/AOSO/A402).

Primary Outcome: Acceptance Rates and Time to Decision

Over the prepandemic period and before the discontinuity in review times, there were no statistically significant differences in acceptance rates by first-author gender or last-author gender (first authors: women 27.4%, men 27.8%, *P*-adj = 0.868; last authors: women 26.8%, men 25.5%, *P*-adj = 0.554). After the 2014 discontinuity (and before the pandemic), differences in acceptance rates by first-author gender remained nonsignificant (22.6% for women *vs* 23.2% for men, *P*-adj = 0.671), but the average acceptance rate was significantly higher for women last authors than for men (24.6% *vs* 21.0%, *P*-adj = 0.0258).

Unlike the widening gender gap for submissions, there was no statistically significant difference in the rate of change in the number of accepted articles per year by gender of first authors during this period. The number of accepted articles from women first authors increased at a rate of 7.0 per year compared with 10.7 for men (t = −1.31, *P*-adj = 0.337) (Fig. 1D). However, the number of accepted articles from women last authors increased at a significantly lower rate than for men (4.7 per year for women *vs* 11.7 for men; t = −2.70, *P*-adj = 0.0304) (Fig.1E).

In the period before the discontinuity, there were no significant differences in time to decision by gender of first (75.2 days for women *vs* 71.0 days for men, *P*-adj = 0.118) or last author (70.5 days for women *vs* 72.1 days for men, *P*-adj = 0.632). However, the average time shrank considerably after the discontinuity before the pandemic, and it took significantly longer for women authors, compared with men, to receive a response (first authors: 42.9 days for women *vs* 36.3 days for men, *P*-adj = 1.03 x 10^{-7}; last authors: 43.2 days for women *vs* 38.3 days for men, *P*-adj = 2.27 x 10^{-3}).

Gender of Authorship Pairs

Women last authors were significantly more likely to submit work with women first authors and less likely to submit work with men first authors than would be expected by chance alone during both prepandemic periods (Supplemental Table 3A,B, http://links.lww.com/AOSO/A402). After the discontinuity, woman-man pairs were less likely to work with each other. When restricting to accepted articles only, the same patterns held, but differences for man-woman pairs before the discontinuity and woman-man pairs after the discontinuity were no longer significant.

The rate of increase in the number of submissions over time for the prepandemic period was significantly different among all pairwise combinations of author gender pairs, except for man-woman *vs* woman-woman (Fig. 1C, Supplemental Table 4a, http://links.lww.com/AOSO/A402), with pairs involving men authors tending to have higher rates. The largest gap was between the man-man and woman-woman author pairs, with the former increasing their submission rate by an additional 35.4 articles per year more than the latter. The rate of increase for accepted articles was significantly higher for woman-man compared to man-woman and woman-woman pairings (Fig. 1F, Supplemental Table 5A, http://links.lww.com/AOSO/A402).

Rate of Acceptance and Time to Decision for Authorship Pairs

There were no statistically significant differences in acceptance rates by first- and last-author gender pairings before the

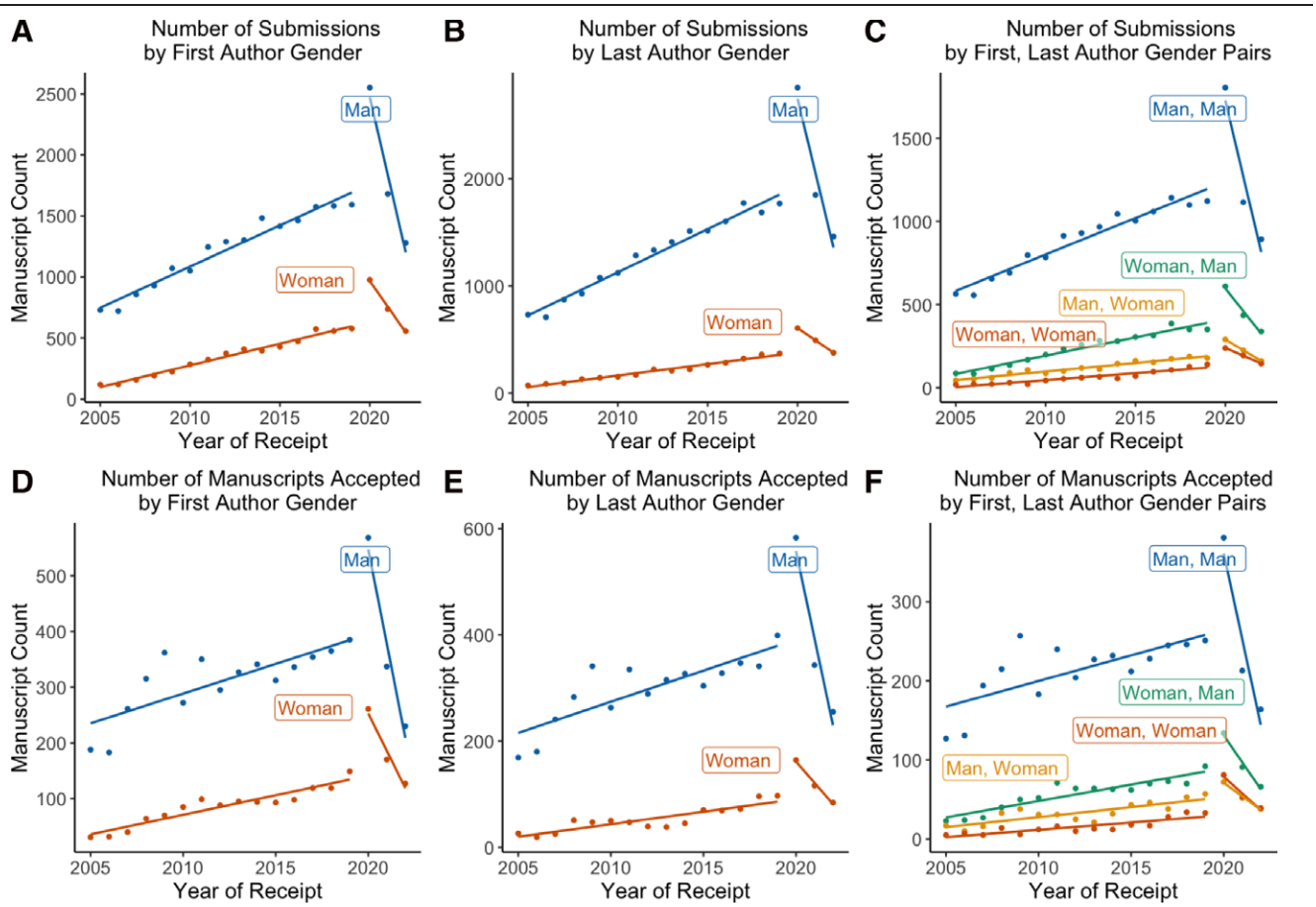

FIGURE 1. Number of submissions and acceptances over time by author gender. The raw number of articles for each year and author gender/author gender pair is plotted as points, along with the linear regression fit for 2005–2019 and 2020–2022, given as follows. A, Man (2005–2019): y = 67x – 134475; (2020–2022): y = –636x + 1287193. Woman (2005–2019): y = 36x – 71165; (2020–2022): y = –211x + 426177. B, Man (2005–2019): y = 81x – 160822; (2020–2022): y = –695x + 1406648. Woman (2005–2019): y = 21x – 42980; (2020–2022): y = –115x + 232907. C, Man, Man (2005–2019): y = 44x – 87244; (2020–2022): y = –456x + 921836. Woman, Man (2005–2019): y = 22x – 43949; (2020–2022): y = –136x + 275317. Man, Woman (2005–2019): y = 10x – 20527; (2020–2022): y = –65x + 130580. Woman, Woman (2005–2019): y = 8x – 16759; (2020–2022): y = –47x + 94169. D, Man (2005–2019): y = 11x – 21140; (2020–2022): y = –169x + 341927. Woman (2005–2019): y = 7x – 14013; (2020–2022): y = –67x + 135593. E, Man (2005–2019): y = 12x – 23293; (2020–2022): y = –164x + 331838. Woman (2005–2019): y = 5x – 9404; (2020–2022): y = –40x + 80961. F, Man, Man (2005–2019): y = 6x – 12829; (2020–2022): y = –109x + 219531. Woman, Man (2005–2019): y = 4x – 8279; (2020–2022): y = –34x + 68811. Man, Woman (2005–2019): y = 3x – 5048; (2020–2022): y = –17x + 34411. Woman, Woman (2005–2019): y = 2x – 3707; (2020–2022): y = –21x + 42499.

discontinuity. After the discontinuity, articles with a man first author and a woman last author had the highest acceptance rate (26.8%), which was statistically significantly higher than for man-man and woman-man pairings (22.1% and 21.8%, respectively; woman-woman acceptance rate was 23.9% but not significantly different) (Fig. 2, Supplemental Table 6, http://links.lww.com/AOSO/A402).

Before the discontinuity, time to decision was not significantly different for any pairwise combination of author pairings (Fig. 3, Supplemental Table 7, http://links.lww.com/AOSO/A402), with average times ranging from 72.1 days for man-woman pairings to 77.3 days for woman-man. However, after the discontinuity, man-man pairings received a decision in statistically significantly less time than any of the other pairings: it only took a mean of 38.0 days for man-man pairings to receive a decision, compared with 43.1 days for woman-man, 43.3 days for man-woman, and 45.5 days for woman-woman pairs.

Pandemic Period

Gender and Submission Rates

Submission numbers skyrocketed in 2020 for all authors but fell rapidly in subsequent years (Figs. 1A,B). We observed that this 2020 peak was much higher for men than women. The subsequent rate of decline in submissions appears sharper for men, but the difference in rates of decrease by gender was not statistically significant (211 fewer per year for women *vs* 636 fewer per year for men first authors, t = 1.28, *P*-adj = 0.340; 115 fewer per year for women *vs* 695 fewer per year for men last authors, t = 1.34, *P*-adj = 0.331).

Primary Outcome: Acceptance Rates and Time to Decision

During the pandemic period, articles submitted by women were accepted at significantly higher rates than for men for both first (22.9% *vs* 19.2%, *P*-adj = 2.40 x 10^{-3}) and last (22.8% *vs* 18.0%, *P*-adj = 2.99 x 10^{-3}) authors.

There was no difference in the rate of change in number of acceptances by first- or last-author gender. Since 2020, there has been a decrease in acceptances for both men and women, mirroring the trend with submissions. The number of accepted articles from women first authors in this period decreased at a rate of 67 per year compared with 169 for men (t = 1.09, *P*-adj = 0.387), and the number of accepted articles from women last authors decreased at a rate of 40 per year compared with 164 for men (t = 1.15, *P*-adj = 0.374).

However, it took significantly longer for women, compared with men, to receive a response during the pandemic period (first

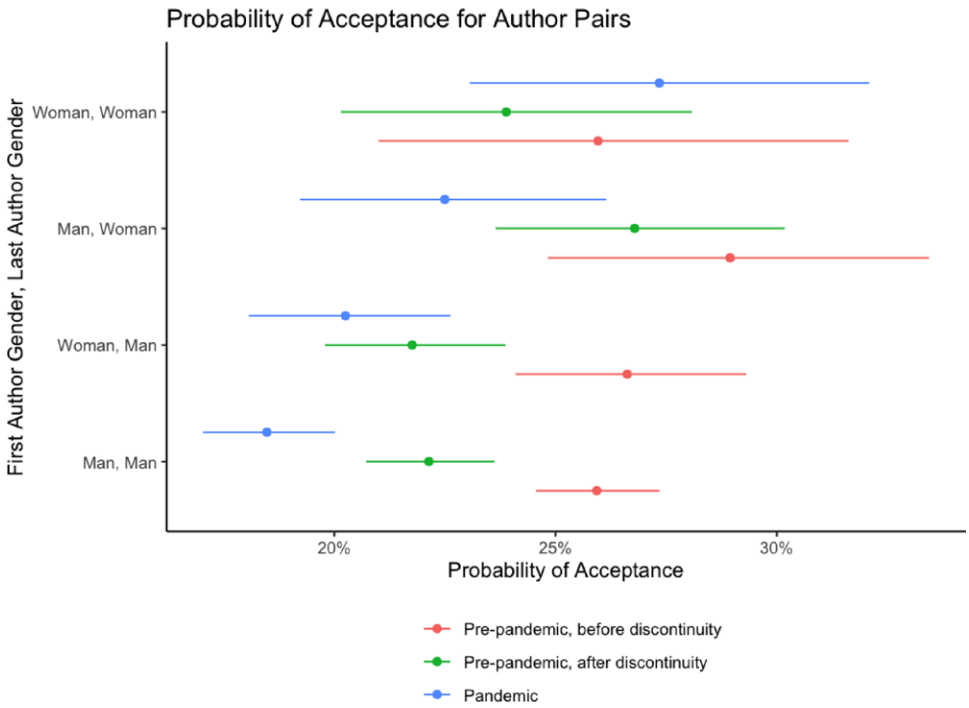

FIGURE 2. Mean probability of acceptance by first- and last-author gender pairs and period (prepandemic, before discontinuity; prepandemic, after discontinuity; or pandemic). Comparison of mean probability of acceptance by paired (first, last) author and period, with a 95% confidence interval constructed using cluster-robust standard errors. Prepandemic, before discontinuity (articles submitted before January 1, 2014): Man, Man: 25.9% (24.6%, 27.3%); Woman, Man: 26.6% (24.1%, 29.3%); Man, Woman: 28.9% (24.8%, 33.4%); Woman, Woman: 26.0% (21.0%, 3.16%). Prepandemic, after discontinuity (articles on or after January 1, 2014, and before March 24, 2020): Man, Man: 22.1% (20.7%, 23.6%); Woman, Man: 21.8% (19.8%, 23.9%); Man, Woman: 26.8% (23.6%, 30.2%); Woman, Woman: 23.9% (20.1%, 28.1%). Pandemic (articles submitted on or after March 24, 2020): Man, Man: 18.5% (17.0%, 20.0%); Woman, Man: 20.3% (18.1%, 22.6%); Man, Woman: 22.5% (19.2%, 26.1%); Woman, Woman: 27.3% (23.1%, 32.1%).

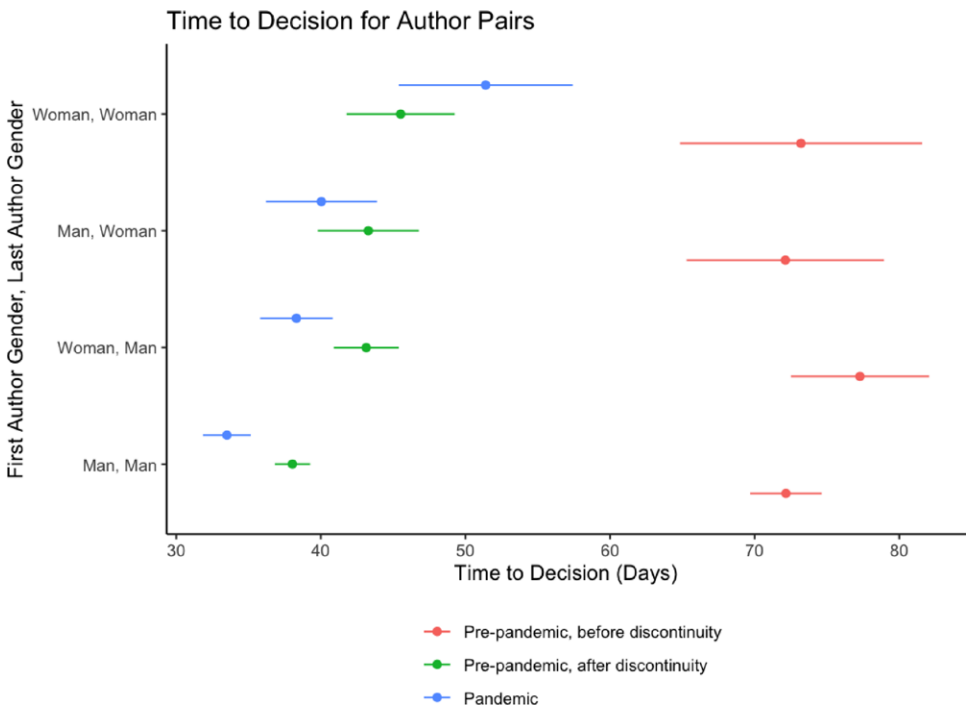

FIGURE 3. Mean time to decision by first- and last-author gender pairs and period (prepandemic, before discontinuity; pre-pandemic, after discontinuity; or pandemic). Comparison of mean time to decision by paired (first, last) author and period, with a 95% confidence interval constructed using cluster-robust standard errors. Prepandemic, before discontinuity (articles submitted before January 1, 2014): Man, Man: 72.2 (69.7, 74.6); Woman, Man: 77.3 (72.5, 82.1); Man, Woman: 72.1 (65.3, 79.0); Woman, Woman: 73.2 (64.8, 81.6). Prepandemic, after discontinuity (articles on or after January 1, 2014, and before March 24, 2020): Man, Man: 38.0 (36.8, 39.3); Woman, Man: 43.1 (40.9, 45.4); Man, Woman: 43.3 (39.8, 46.8); Woman, Woman: 45.5 (41.8, 49.3). Pandemic (articles submitted on or after March 24, 2020): Man, Man: 33.5 (31.8, 35.2); Woman, Man: 38.3 (35.8, 40.8); Man, Woman: 40.0 (36.2, 43.9); Woman, Woman: 51.4 (45.4, 57.4).

authors: 41.0 days for women *vs* 32.6 days for men, *P*-adj = 1.11 x 10^{-8}; last authors: 42.6 days for women *vs* 33.6 days for men, *P*-adj = 7.10 x 10^{-6}).

Gender of Authorship Pairs

Just as in the prepandemic period, women and men last authors were significantly more likely to work with first authors of the same gender (and less likely to work with authors of the opposite gender) than would be expected by chance alone during the pandemic (Supplemental Table 3C, http://links.lww.com/AOSO/A402). The same pattern was observed when considering accepted articles only.

The only statistically significant difference in the rates of change in submissions and acceptances by authorship pairs during this period was that man-woman submissions (–65 articles/year) decreased significantly faster than woman-woman submissions (–47 articles/year) (Figs. 1C,F; Supplemental Tables 4B and 5B http://links.lww.com/AOSO/A402).

Rate of Acceptance and Time to Decision for Authorship Pairs

During the pandemic period, articles with first and last authors who were both women had significantly higher acceptance rates than man-man and woman-man pairings, but no other comparisons by authorship pair were statistically significant (27.3% *vs* 18.5% and 20.3%, respectively; acceptance rate for man-woman was 22.5% but not statistically significantly different) (Figure 2, Supplemental Table 6, http://links.lww.com/AOSO/A402). However, man-man pairings received a decision in significantly less time than all other authorship pairs (33.5 days on average *vs* 38.3 for woman-man, 40.0 for man-woman, and 51.4 for woman-woman) and decisions for woman-woman pairings took significantly longer than any of the other pairings (Fig. 3, Supplemental Table 7, http://links.lww.com/AOSO/A402).

Sensitivity Analyses

Sensitivity analyses restricting to unique authors and normalizing submissions/acceptances by gender per year to the number of certified surgeons of the same gender in that year were generally consistent with our main findings (Supplemental Figure 1, and Supplemental tables 3-5, http://links.lww.com/AOSO/A402). However, when restricting to unique authors, the prepandemic change in the number of acceptances by last-author gender was not statistically significant, and the findings for the gender of authorship pairs among acceptances were no longer significant in the periods following the discontinuity.

DISCUSSION

We examined all submissions to Annals of Surgery over 19 years and had 3 major findings: (1) before the pandemic, there was a widening gap in the number of submissions by author gender, with submissions from men increasing at a faster rate than those by women; (2) this gap appeared to narrow during the pandemic; and (3) in recent years, women's articles spent longer in review but were more likely to get accepted.

Given the increasing number of women in surgery, it is surprising that the rate of increase in submissions from men outpaced that of women during the prepandemic period. This finding is particularly interesting for the first authors, given recent increases in the proportion of women trainees. Between 2005 and 2019, the percentage of certified general surgeons who are women rose from 23.5% to 38.5%.[23] While we did not see a significantly widening gap in the number of accepted articles before the pandemic, we also did not see the narrowing of this gap that might be expected given the increasing number of women surgeons. In addition, the slow rate of growth for submissions from women last authors before the pandemic implied widening disparities over the course of women's careers.

This widening gap in submissions before the pandemic was likely multifactorial. Whether women were spending more time on teaching and other service activities,[25,26] with patients,[25,27] or developing collaborative relationships with other healthcare workers,[28–30] many different demands on women's time may have reduced their opportunities for scholarship compared with male colleagues. In addition, asymmetrical pressures women may feel to invest more time and effort in preparing submissions in anticipation of criticism may negatively impact the number of submitted articles and observable research productivity.[3,31]

The number of submissions and acceptances peaked for all authors in 2020, observed to a greater degree for men compared with women. This is consistent with other research on academic productivity during the early parts of the pandemic. Others have shown that preprint submissions from women first authors to medRxiv decreased significantly from December 2019 to spring 2020.[18] In US medical journals, women were less represented as authors of COVID-19-related articles than as authors of research in the same journals in 2019.[19] Many have written about how the COVID-19 pandemic has threatened the careers of women, particularly women of color, in academic medicine.[19,32] Women's careers were often disproportionately interrupted to bear the asymmetrical burden of added responsibilities.

To our knowledge, we are the first to examine data beyond 2021, which enabled us to identify a later decline in submissions. Our ability to detect statistical significance by author gender here is somewhat limited by the relatively few years that have passed since the onset of the pandemic. Although not statistically significant, we observed a striking difference in the rates of decline, with men first and last authors' submissions declining faster year over year compared with women in the pandemic period after the initial spike in 2020. It is possible the increased productivity of men in the early part of the pandemic was simply not sustainable, especially as clinical obligations increased when elective surgeries were later no longer put on hold. Whatever the reason, the gap in submissions from women *vs* men appeared to narrow considerably, if not statistically significantly, by 2022. It remains to be seen if this pattern will hold in future years. It is unclear whether gendered trends, particularly the recent narrowing of the gap in submissions and acceptances, observed among surgeons generalize to other disciplines or academic physicians overall. If the narrowing of the gap is consistent across other journals this could be very promising, but the steep decline in submissions for all suggests a continued need to support the research productivity of all authors in the coming years. This is especially important as many departments may be increasingly relying on financial support from clinical productivity at the expense of academic productivity.

It is reassuring that articles from women authors do not seem to be at a disadvantage in terms of the likelihood of publication. While acceptance rates have generally decreased over time (even before the pandemic), women are more likely to have their work accepted, compared with men, in recent years, which may contribute to improving gender equity among authors of published articles. Data from economics may explain this trend. In a review of articles submitted to 4 economics journals, Hengel concluded women authors may spend more time on article preparation before submission to preempt anticipated critical reviews.[31] This is consistent with data from Lim et al[33] who looked at the perspectives of female surgeons and found they reported increased scrutiny of their work and felt they had to do more work than their male colleagues to be perceived as equally competent.

On the other hand, articles authored by women have spent more time in review over the past 10 years. As with the diverging trends for acceptance rates among men and women

authors, this phenomenon may have been exacerbated by the COVID-19 pandemic, but our findings suggest that the trend emerged before 2020. These differing outcomes in the review process may reflect differences in article types or subject matter for articles submitted by women *vs* men, differences in the types of reviewers sought for said articles, or other broader trends.

One limitation of this study is the inability to assess the time or effort put into each submission or otherwise assess the quality of submissions. Other limitations of this study include using an algorithm to assign gender and only having data from 1 journal. Thus, we cannot assess whether the observed narrowing gender gap in submissions is driven, for example, by competition from other surgery journals that may have had a significant focus on COVID-related work, leading to fewer submissions from men to Annals of Surgery. As we lack sufficient information to distinguish authors with intersectional identities, we are unable to assess their potentially differential outcomes and the implications for how to best support these individuals in academic surgery. In addition, due to the nature of the data available, we were only able to classify individuals into 1 of 2 genders despite knowing this binary construct is inadequate. Finally, we do not know the reason for the discontinuity in review times noted around 2014.

Our data suggest that the widening gender gap in submissions that existed before the pandemic may be narrowing and that trends in acceptance rates by author gender at this journal are now such that articles by women authors are more likely to be accepted than articles written by men. However, our data also suggest both men and women are submitting fewer articles now than they were before the pandemic. The steep rise seen in 2020 was followed by a steep decline that ultimately appeared to narrow the gender gap in submissions compared with the prepandemic 2019 baseline. This should be concerning to all leaders in academic surgery and affirms that faculty likely need more support for research endeavors than what they currently receive.[34] In light of recent data showing[35,36] better patient outcomes for patients treated by women (compared with men) surgeons, it is more critical than ever to support women's careers to obtain optimal patient outcomes. Intentional efforts should be made at the level of journals, professional societies, departments, and institutions to support women's retention and promotion.

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