

Gender differences in authorship prior to and during the COVID-19 pandemic in research submissions to Occupational and Environmental Medicine (2017–2021)

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ABSTRACT

Objective To explore whether the COVID-19 pandemic has impacted productivity of female academics in the field of occupational and environmental health, by examining trends in male and female authorship of submissions during and prior to the COVID-19 pandemic in Occupational and Environmental Medicine.

Methods Administrative data on submissions between January 2017 and November 2021 were obtained through databases held at BMJ journals. Author gender was identified using an existing algorithm based on matching names to social media accounts. The number and proportion of female and male primary (first) and senior (last) authors were examined for each quarter, and the average change in share of monthly submissions from male authors in the months since the pandemic compared with corresponding months prior to the pandemic were identified using regression models estimating least squares means.

Results Among 2286 (64.7%) and 2335 (66.1%) manuscripts for which first and last author gender were identified, respectively, 49.3% of pre-pandemic submissions were from male first authors, increasing to 55.4% in the first year of the pandemic (difference of 6.1%, 95% CI 1.3% to 10.7%), before dropping to 46.6% from April 2021 onwards. Quarterly counts identified a large increase in submissions from male authors during the first year after the onset of the pandemic, and a smaller increase from female authors. The proportion of male last authors did not change significantly during the pandemic.

Conclusions These findings suggest that there has been an increase in male productivity during the COVID-19 pandemic within the field of occupational and environmental health research that is present to a lesser extent among women.

INTRODUCTION

The COVID-19 pandemic has impacted work in a variety of ways, driving many to work remotely and eradicating traditional sources of support, including childcare, forcing many to balance work, household and caregiving responsibilities. Despite decades of progress, women continue to experience greater work–family conflict and perform a greater share of unpaid labour compared with men.^{1,2} Emerging research suggests that COVID-19-related increases in household and caregiving responsibilities have disproportionately fallen on women.^{3–5}

As a result of these imbalances, working women, including those in academia, may face more substantial impacts on their productivity and performance, and be less able to take advantage of new opportunities. An increasing number of studies have observed that the share of women authors has declined during the pandemic, with the gender difference in authorship particularly notable among COVID-19-related papers.^{6–9} Some research has found that the change in authorship share appears to be due to reduced production among female academics, while in others, it is primarily due to increased production by male academics. Declining productivity among female academics relative to male academics during the pandemic may have longer-term impacts on career progression among women, a risk for both female representation and influence on academic research and innovation.⁸

It is less clear how COVID-19 has impacted productivity among women and men in the field of occupational and environmental health research. As such, the

aim of this report is to describe the number and share of submissions from primary and senior women and men authors during, and prior to the COVID-19 pandemic in Occupational and Environmental Medicine (OEM).

METHODS

Data were obtained through administrative databases held by BMJ journals on all submissions to OEM between January 2017 and November 2021, including

Key messages

What is already known about this subject?

⇒ An increasing number of studies have identified a widening or emerging gender gap in academic productivity since the onset of the COVID-19 pandemic. Gender differences in productivity since the onset of the pandemic among academics in the field of occupational and environmental health have not been well explored.

What are the new findings?

⇒ We observed an increase in productivity, as determined through numbers of submissions to Occupational and Environmental Medicine, among male academics at the onset of the pandemic that was not echoed to the same extent among female academics.

How might this impact on policy or clinical practice in the foreseeable future?

⇒ This study provides evidence of a gender disparity in productivity during the pandemic, potentially due to differences in the involvement of male versus female academics in pandemic-related research and non-research-related responsibilities. More supports are required to allow female academics to engage in work related to new and rapidly emerging situations, and to prevent any differential longer-term impacts of the pandemic on career progression between women and men.

administrative information on authors and manuscripts. Original research, systematic reviews, short reports or letters that were submitted between 2017 and 2021 were included. Other types of publications that

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require less intensive work, including abstracts, editorials and position statements were excluded (n=38).

The first names of first (primary) and last (senior) authors were extracted and the ‘Genderize’ R package was used to determine gender through comparing first names to an existing database of names compiled through social media accounts.¹⁰ The genderize algorithm determines gender based on proportion of matched names, if over 50% of matched names have self-identified as female, gender is assigned as female, whereas if over 50% were male, gender is assigned as male. Probability or credibility of the assigned gender is indicated by the proportion of matched names in the database that are either female or male. In the case of multiple first names, the name with the highest ‘credibility’ or probability of a specific gender, is selected. To ensure a high degree of certainty in author gender identification, author first names that matched with fewer than 10 names in the database were excluded, as were those for whom the probability was less than 95%. As names are used as a binary measure of gender, we are most likely capturing a mixture of gender identity and presentation at the time when information was captured, however sex at birth is likely highly correlated with these factors. A logistic regression was run to examine whether factors including submission after the onset of the pandemic, submitting author region and manuscript type were linked to likelihood of gender identification using the algorithm.

The number and proportion of first and last authors who were female were subsequently examined by month across the study years, to account for seasonal variation. A marker for the onset of the COVID-19 pandemic was defined as 1 April 2020. Using this, the average monthly submissions prior to the pandemic, during the first 12 months of the pandemic, and during the following 7 months of the pandemic (between April and November 2021) were calculated and compared. The average monthly share of submissions from male first and last authors was examined for each of these time periods and the change in share of submissions across corresponding months in each of the three time periods were identified using regression models estimating least squares means. To examine whether any identified changes in submission from male and female authors were due to changes in other factors since the onset of the pandemic, additional analyses

were performed adjusting for submitting author’s region and manuscript type. A sensitivity analysis was also performed with less strict criteria for inclusion, of 75% rather than the prespecified 95% certainty and 1 or more matched names rather than 10 matched names in the database to examine the impact on results. Additional analyses examined differences in male/female authorship among accepted papers and for COVID-19-specific papers by identifying related keywords in the titles of each submission (available in online supplemental files).

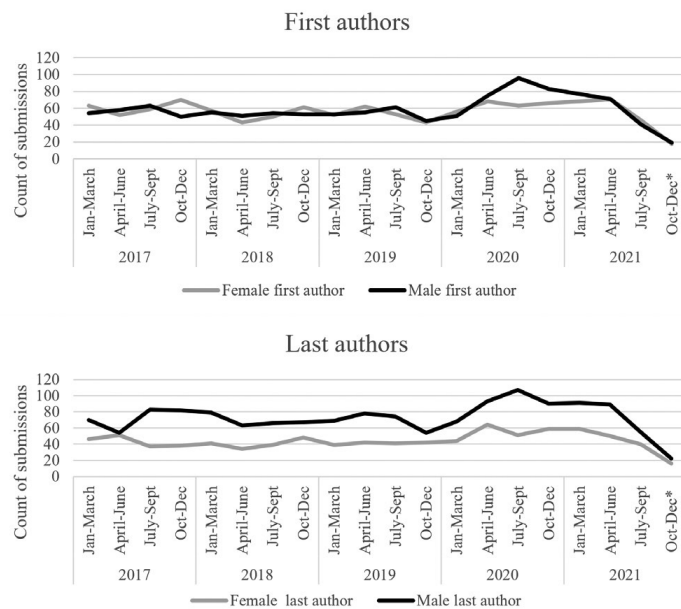
RESULTS

Overall, there were 3531 eligible submissions within the study period. Of these submissions, gender was identified for 2286 (64.7%) first authors and 2335 (66.1%) last authors using the prespecified criteria. Of the excluded, 102 (8.2%) first authors and 118 (9.9%) last authors had a first name that matched with fewer than 10 names in the database, 988 (79.4%) and 829 (69.3%) were identified with lower than 95% certainty, and 155 (12.4%) and 249 (20.8%) met neither criterion. Logistic regression models determined that manuscripts by first and last authors from regions outside of Europe exhibited a decreased odds of gender identification using these criteria, compared with manuscripts by authors from regions within Europe. This was particularly marked for authors from

Asian and Pacific regions. Submission after the onset of the pandemic compared with before, did not significantly impact odds of author gender identification. First authors of short reports were found to have a slightly increased odds of identification than those of original research.

During the COVID-19 pandemic, submissions to OEM increased substantially, between January 2017 and March 2020 OEM received on average 55 submissions per month. In the first year of the pandemic (April 2020–March 2021) this increased to 79.2 submissions per month, dropping to an average of 59.4 submissions per month from April 2021 to October 2021. However, this increase was not consistent between male and female authors. Among approximately two-thirds of the submissions for which author gender could be identified, prior to the pandemic 49.3% of submissions were from male first authors. This proportion increased to 55.4% in the first year of the pandemic (difference of 6.1%, 95% CI 1.3% to 10.7%), dropping to prepandemic levels from April 2021 onwards (46.6% of submissions from male authors). The proportion of male last authors did not change significantly during the pandemic, with 62.5% of submissions having a male last author prior to the pandemic, 61.8% in the first year of the pandemic, and 60.9% from April 2021 onwards.

Figure 1 displays the absolute number of submissions by author gender by quarter



*Data available only until November for this quarter

Figure 1 Submissions by author gender between January 2017 and November 2021

between 2017 and 2021. As displayed, more submissions included a male last author compared with a female last author prior to the pandemic, whereas there is little difference in submissions from male versus female first authors. There is a notable increase in the gap between male and female authorship beginning in April 2021 for both first and last authors, that appears to reduce back to prepandemic levels by the third quarter of 2021.

Identified differences in the increase of male and female first authored submissions following the onset of the pandemic persisted after adjusting for submitting author regions and manuscript types, however, the differences were non-significant for last authors. Making inclusion criteria less strict to include manuscripts with authors whose names were matched to at least one other name in the database and assigned a gender with 75% probability according to the 'Genderize' algorithm, increased the sample size of manuscripts to 2935 (83.1%) for first author names and 2955 (83.7%) for last author names. Repeating the analyses with these relaxed criteria did not meaningfully change the results (results available in online supplemental materials).

Among submissions that had been accepted for publication at the time of analysis (November 2021), 44% had a male first author prior to the pandemic, which rose to 48% post-pandemic, while 65% had a male last author pre-pandemic, reducing to 58% post-pandemic. Using a set of search terms within titles, we found that almost one in four papers submitted since the onset of the pandemic are COVID-19 related, and of these papers, 57.8% and 65.3% were first and last authored by men, compared with 50.2% and 61.9% of non-COVID-19-related submissions. This differed by year; in 2020, 67.5% and 71.5% of COVID-19-related papers were first and last authored by men, compared with 47.8% and 59.2% in 2021.

CONCLUSIONS

Research article submissions are an indicator of productivity in academic settings. Among submissions to OEM, we observed a gender gap in authorship of submissions over the first year of the COVID-19 pandemic, largely driven by a sharp increase in research productivity among male authors that did not occur to the same extent among female authors.

The divergence in primary (first) authorship for men and women was present even after adjustment for geographical region and types of articles submitted and was present among accepted papers as well as submitted papers.

These findings suggest that the identified gender gap in academic authorship during the COVID-19 pandemic observed elsewhere, is also present within the field of occupational and environmental health research.^{6 7 9 10} Yet, by examining the absolute number of submissions prepandemic and postpandemic, it becomes clearer that, in this context, the gap was not due to a hypothesised decline in female productivity, but rather a larger increase in male productivity. The sharp increase among male primary authors may in part represent COVID-19-related work, as evidenced by the fact that a higher proportion of this work was authored by men, aligning with estimates obtained in other research examining COVID-19-related academic publications.⁹ This gender gap in COVID-19-related work could be because men have more robust networks for collaboration that are not as impacted by remote work, or may be more able to take on additional work due to higher pay or financial stability, and differences in household responsibilities and caregiving.^{12 11}

There is early evidence that this divergence between men and women is reducing in the latter half of 2021, primarily due to a reduction in submissions from male authors. Yet, this decline does not appear to be due to reduced COVID-19-related work, which continues to account for around one in four submissions to OEM. Instead, it may be that male academics have now substituted COVID-19-related work for part of their regular research, as opposed to completing this work in addition to regular research. In addition, female representation in this work does appear to be increasing. This may indicate that the greater household and caregiving responsibilities placed on women during the pandemic have alleviated as pandemic restrictions have lifted. Or that due to carrying added responsibilities outside of work, women have a reduced capacity to take on additional work and have therefore needed time to shift their focus away from their regular research towards COVID-19-related work. The true reasons for these patterns are likely complex and require further investigation.

The pandemic appeared to have a greater impact for primary authors compared with senior (last) authors,

potentially due to the pandemic impacting those in different career and life stages differently, combined with the greater level of work associated with primary authorship. However, we identified a gender gap prior to the pandemic for senior authors, suggesting longer-term gender disparities in the production of research among more senior academics that may be explored in future research.

Strengths of this report include the fact that we examined article submissions, not article acceptances, to better understand the impacts of COVID-19 on research productivity between male and female occupational health researchers. We were also able to examine differences prior to the pandemic, compared with during the pandemic to better understand the impact of the pandemic on article submissions. Limitations of this work include the fact that the algorithm used to capture gender is not as effective among Asian and Pacific countries, meaning that we were only able to include just over one in three authors from these regions (equating to almost 20% of overall submissions). However, sensitivity analyses in which we broadened inclusion criteria captured around two-thirds of authors from Asian and Pacific regions and did not meaningfully change our findings (results available in online supplemental materials). In addition, while submissions may be a closer marker of productivity, accepted publications are potentially a better indicator of success and career impact for female academics. When exploring this, we found some evidence to suggest that the male/female divergence in primary authorship was also present among published papers at OEM.

This report offers a novel set of descriptive findings on male/female differences in primary authorship and senior authorship in OEM submission. These findings should be explored in more depth using either quantitative or qualitative methods to better understand modifiable factors associated with these inequalities.

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REFERENCES

- 1 Cerrato J, Cifre E. Gender inequality in household Chores and Work-Family conflict. *Front Psychol* 2018;9:1330.
- 2 McMunn A, Bird L, Webb E, *et al*. Gender divisions of paid and unpaid work in contemporary UK couples. *Work Employ Soc* 2020;34:155–73.

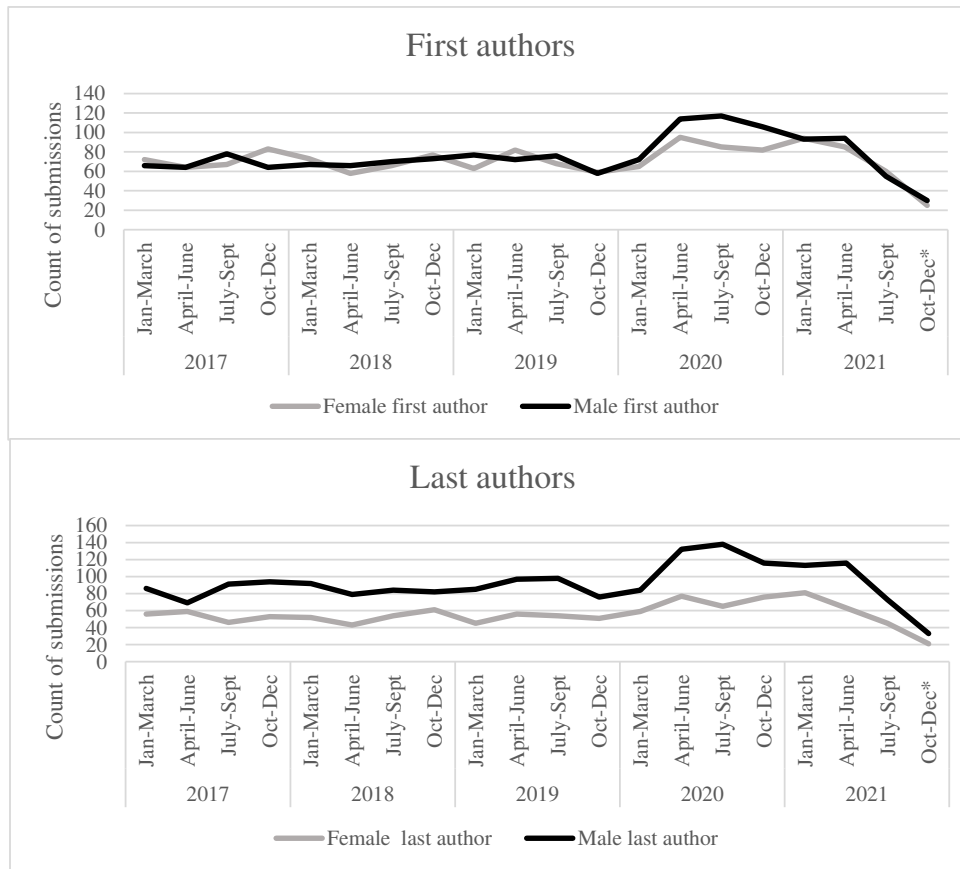
- 3 Milliken FJ, Kneeland MK, Flynn E. Implications of the COVID-19 pandemic for gender equity issues at work. *J Manag Stud* 2020;57:1767–72.
- 4 Fisher J, Languilaire J-C, Lawthom R, *et al*. Community, work, and family in times of COVID-19. *Community Work Fam* 2020;23:247–52.
- 5 Shockley KM, Clark MA, Dodd H. *Work-family strategies during COVID-19: examining gender dynamics among dual-earner couples with young children*. US: American Psychological Association, 2021: 15–28.
- 6 Andersen JP, Nielsen MW, Simone NL, *et al*. COVID-19 medical papers have fewer women first authors than expected. *Elife* 2020;9:e58807.
- 7 Bell ML, Fong KC. Gender differences in first and corresponding authorship in public health research submissions during the COVID-19 pandemic. *Am J Public Health* 2021;111:159–63.
- 8 King MM, Frederickson ME. The pandemic penalty: the gendered effects of COVID-19 on scientific productivity. *Socius* 2021;7:237802312110069.
- 9 Pinho-Gomes A-C, Peters S, Thompson K, *et al*. Where are the women? gender inequalities in COVID-19 research authorship. *BMJ Glob Health* 2020;5:e002922.
- 10 Wais K. Gender prediction methods based on first names with genderizeR. *R J* 2016;8:17 <https://journal.r-project.org/archive/2016-1/wais.pdf>
- 11 Elsevier. *Gender in the global research landscape*, 2020.

Supplementary table 1 - Average monthly change in male submissions following pandemic using 75% certainty for gender identification

		Before April 1 st 2020	April 1 st 2020-March 31 st 2021	April 1 st 2021-November 30 th 2021
First Author	Proportion male	50.1%	54.6%	49.3%
	Average monthly % change (95% CI*)	(ref)	4.5% (0.3 to 8.7%)	-0.8% (-7.0% to 5.3%)
Last Author	Proportion male	61.9%	62.4%	62.6%
	Average monthly % change (95% CI*)	(ref)	0.5% (-3.5 to 4.6%)	0.7% (-5.3 to 6.6%)

*CI = Confidence interval

Supplementary figure 1: Submissions by author gender between January 2017 and November 2021 – 75% certainty of gender identification



*Results only available up until November in this quarter

Supplementary materials: COVID-19 related search terms

To identify COVID-19 related papers we did a text search for the following strings in the title of the submission: ‘SARS-COV-2’, ‘COVID’, ‘Pandemic’, ‘Coronavirus’, ‘Corona’.