PEER REVIEW HISTORY

ARTICLE DETAILS

TITLE (PROVISIONAL)	Longitudinal Analyses of Gender Differences in First Authorship Publications Related to COVID-19
AUTHORS	Lerchenmüller, Carolin; Schmallenbach, Leo; Jena, Anupam; Lerchenmueller, Marc

VERSION 1 – REVIEW

REVIEWER	Rosemary Morgan Johns Hopkins Bloomberg School of Public Health
REVIEW RETURNED	15-Dec-2020

GENERAL COMMENTS	This study addresses an important topic and is well written overall. The findings presented are interesting and compelling. Be careful about conflating sex and gender. Female/male is used to denote sex, while women/men is used to denote gender. Admittedly it can make writing a little awkward, but the distinction is important. What you have done is a gender disaggregated analysis, however, you had to infer the author's gender as you have no way to know whether their biological sex is the same as their gender. This is common practice as the alternative would have been impossible, however, it would be good to see this acknowledged. By its nature, this analysis leaves us those who are non-binary, and transgender men and women are being grouped together, when their experiences are likely to be very difference. I would also like to see some reflection on intersectional vulnerabilities, and how not all men's and women's experiences are will be same despite the fact you are looking at the aggregated level. Page 5, lines 49-54 you state: "Second, COVID publications are mainly produced in the life sciences and medicine where long-standing authorship standards reserve the first author position to early career investigators, which allows estimating the effect for this group in particular." I work in public health/ health systems and there has been a lot of COVID publications. This is not common practice in the field, and as a result makes me think that the data cannot therefore be used a proxy for this group. If this is common practice in life sciences and medicine, then I would make it clear that this analysis only pertains to this group. Although I'm still not convinced that this analysis can be done without explicitly knowing the career stage of the first authors. In addition, there are disciplines outside of life sciences and medicines which have been publishing on COVID, including within the social sciences. I would recommend making it clear that your study is focusing on specific disciplines and some have been missed, otherwise the paper gives the impression that it is only life sciences and medicine that matters.

	Page 6, line 22: please explain what the Genderize database is and how it works. Within the findings section you state country affiliation, stating that "productivity goes down in relation to their male peers across all continents." You then go on to list countries and continents – Brazil, Europe, Canada, and the US. I think this is an important analysis, however, I would caution about the examples provided which indicate a Western essentialism. I would recommend providing a rationale for the countries chosen (and focus on either countries or continents not both) and make sure they are geographically and economically diverse. Including a point about countries with no data would also help to demonstrate disparities between regions. In addition, what about the countries in green? Are these outliers? Page 8, lines 5-8 states: "Our results provide the largest and latest systematic evidence for the COVID pandemic's effect on women's publishing productivity across disciplines worldwide." I would caution against making such hyperbolized statements as some disciplines are missing which are also publishing on COVID, especially those which are not health related, and data from many countries are missing. Page 8, lines 42-45 states: "the disproportionate impact of COVID-19 on early career women investigators needs serious consideration." I would argue all women not just early career. While it is true early and mid career will likely have more long lasting repercussions. Page 8, lines 47-51 states: "pre-existing inequities must be evaluated, and a long-term strategy has to be established to support equity and inclusion in science". Please provide examples of 'pre-existing inequities'. In addition, equity and inclusion is much more than just gender equity – please make it clear that you are focusing on gender equity here. Great recommendations are provided. I would also like to see recommendations related to the systemic and structural issues within academia. References: there has been a lot written about the gendered impacts of the pandemic, it would be great to see some of this reflected in the paper. Within this work these impacts are referred to a long-term secondary impacts as opposed to short term primary impacts. No limitations are provided. There are distinct limitations in relation of the ability to assess gender by an author's name. See: https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(19)30342-0/fulltext

REVIEWER	Ana-Catarina Pinho-Gomes King's College London, UK
REVIEW RETURNED	18-Dec-2020

GENERAL COMMENTS	Overall, this is an interesting article. It adds to the evidence that has been mounting on the widening of the gender inequalities during the COVID-19 pandemic in authorship of research papers. Overall, the gap between women and men increased by 18% for COVID-19 papers in comparison with papers published in the same journals in

	the previous year. In addition, there was substantial variation in the extent of the relative reduction in publications with women as first author between countries and scientific fields. The findings, albeit relevant, are not new and there are important limitations that should be acknowledged and addressed, if possible. 1. In my view, the design of this study could be reconsidered. What is it that authors are trying to illustrate? If the point to make is that women's voices are not being heard in COVID-19 research, then restricting the analysis to COVID-19 papers makes sense. On the other hand, if the aim is to investigate the impact of the COVID-19 pandemic and associated measures on women's publications, then all papers regardless of topic should be included. For instance, is the gender gap explained by the fact that women are publishing more non-COVID research in those scientific fields? Evidence from elsewhere does not favour this, but the truth is that this study mixes both research questions, which, albeit completely different, are often confused. I would suggest that the authors review their question and adopt the most appropriate approach to answer their study question. 2. The introduction does not accurately summarise the current knowledge. There are key articles missing that clearly illustrate the disproportionate impact of COVID-19 on female authors. The authors paint the picture that there is no evidence about the impact of COVID-19 on gender inequalities in authorship of published papers. This is definitely not true and should be acknowledged. This paper adds to the pool of evidence that compellingly demonstrate the widening of the gender gap in academia associated with COVID-19. This does not mean that this study has less merit, but it puts it into perspective. It is not novel, but it reinforces the message that action needs to be taken if we are to avoid losing hard-won gains in gender equality over the last decades. A few examples: https://jamanetwork.com/journals/jamasurgery/fullarticle/2769186 https://gh.bmj.com/content/5/7/e002922 https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)31412-4/fulltext https://www.nature.com/articles/d41586-020-01294-9 https://ajph.aphapublications.org/doi/10.2105/AJPH.2020.305975 3. Why did the authors restrict the analysis to first authors? I do understand the interest of looking at the career of young researchers but combining this with analysis of last authorship would add value to the study. 4. Why did the authors not provide a temporal analysis of the gender gap? As COVID-19 measures were introduced and lifted at different times across the world, this could provide useful insight into the effect of COVID-19 control measures on gender inequalities? For instance, was the effect more marked during initial lockdowns and then gradually improved as restrictions were eased throughout Summer in the Northern hemisphere? 5. Restrictions have been minimal in Australia, but the gender gap widened to a similar extent to European countries where much more

	severe restrictions were in place for a long time. This argues against author's point that the observed exacerbation of gender inequality is explained by caring responsibilities. A broader discussion of the myriad factors underpinning gender imbalance in published papers is clearly required. 6. The authors mention that the widening of the gender gap may be due to childcare and household responsibilities. However, there are many other reasons and those should be explored in the discussion (please see https://pubmed.ncbi.nlm.nih.gov/32527733/). For instance, COVID-19 is a "trendy" subject, and it is likely that those in positions of power, who are commonly men, led COVID-related research themselves. Women may simply side-lined and denied the opportunity to take up COVID-related projects, as they are highly competitive. 7. There is also some evidence suggesting that men may be more likely to get papers accepted than women, which is seriously concerning. Although authors cannot explore this in their study, it is certainly worth discussing (please see https://ajph.aphapublications.org/doi/10.2105/AJPH.2020.306028?url_ver=Z39.88-2003&rfr_id=ori%3Arid%3Acrossref.org&rfr_dat=cr_pub++0pubmed). 8. There is no mention in the discussion about limitations. This is, though, very important. Could the key limitations be outlined in the paper so that readers understand how to interpret the findings and conclusions? 9. The software used to determine gender of authors is far from perfect and a degree of misclassification is expected. This is particularly an issue for Asian authors who often have only initials as first names. Bearing this in mind, how generalisable are this study findings globally? 10. Also, there is no mention about what was done with collective authorship, which happens in some papers. 11. About half of the eligible articles were excluded and there is no reason to assume that those would be similar to those that were included. This may have introduced significant selection bias and should be acknowledged. 12. The conclusion is very limited in scope and does not appropriately reflect the key messages of the paper. I would suggest (1) emphasising the main finding of this study, which is that the gender gap in first authors of published papers widened during the pandemic, and (2) calling for action to address those longstanding gender inequalities that are detrimental to women and men alike and compromise our ability to respond to and recover from the pandemic.

VERSION 1 – AUTHOR RESPONSE

Reviewer: 1

Dr. Rosemary Morgan, Johns Hopkins University
Comments to the Author:

This study addresses an important topic and is well written overall. The findings presented are interesting and compelling.

Be careful about conflating sex and gender. Female/male is used to denote sex, while women/men is used to denote gender. Admittedly it can make writing a little awkward, but the distinction is important. What you have done is a gender disaggregated analysis, however, you had to infer the author's gender as you have no way to know whether their biological sex is the same as their gender. This is common practice as the alternative would have been impossible, however, it would be good to see this acknowledged. By its nature, this analysis leaves us those who are non-binary, and transgender men and women are being grouped together, when their experiences are likely to be very difference.

We have revised the manuscript throughout using gender in lieu of sex (women/men instead of male/female) to address this very important distinction. We additionally expanded our limitations section in the discussion. to acknowledge inferential limitations

I would also like to see some reflection on intersectional vulnerabilities, and how not all men's and women's experiences are will be same despite the fact you are looking at the aggregated level.

In the revised version of our manuscript we now include explicit statements about the fact that we cannot disaggregate individual level experiences due to the large scale, aggregate nature of our study.

Page 5, lines 49-54 you state: "Second, COVID publications are mainly produced in the life sciences and medicine where long-standing authorship standards reserve the first author position to early career investigators, which allows estimating the effect for this group in particular." I work in public health/ health systems and there has been a lot of COVID publications. This is not common practice in the field, and as a result makes me think that the data cannot therefore be used a proxy for this group. If this is common practice in life sciences and medicine, then I would make it clear that this analysis only pertains to this group. Although I'm still not convinced that this analysis can be done without explicitly knowing the career stage of the first authors. In addition, there are disciplines outside of life sciences and medicines which have been publishing on COVID, including within the social sciences. I would recommend making it clear that your study is focusing on specific disciplines and some have been missed, otherwise the paper gives the impression that it is only life sciences and medicine that matters.

We have now clarified the predetermined and unbiased criteria underlying the selection of included scientific disciplines, especially the requirement that included disciplines must have

contributed at least 50 articles in service of estimation accuracy. We have also included a more precise description and discussion to clarify our approach analyzing first (and now also last) authorships and included a section about the limitation in evaluating individual career stages, as well as individual level experiences, in large archival studies.

Page 6, line 22: please explain what the Genderize database is and how it works.

We have now extended the methods section in the main manuscript to give more details on the Genderize database and existing external validation. We also included a clearer referral to the more detailed online methods supplement that offers additional details and analyses.

Within the findings section you state country affiliation, stating that "productivity goes down in relation to their male peers across all continents." You then go on to list countries and continents – Brazil, Europe, Canada, and the US. I think this is an important analysis, however, I would caution about the examples provided which indicate a Western essentialism. I would recommend providing a rationale for the countries chosen (and focus on either countries or continents not both) and make sure they are geographically and economically diverse. Including a point about countries with no data would also help to demonstrate disparities between regions. In addition, what about the countries in green? Are these outliers?

We have adjusted our manuscript throughout to address this very helpful point. We now describe the change in the gender gap across different countries and grouped in continents/geographical area over time. In an unbiased approach, we included countries and continents based on prespecified inclusion criteria, mainly a certain level of publishing activity to allow for precise estimation, that we describe in the methods section. In the revised version of the manuscript we now include as many data points in the text as possible without sacrificing readability and focused specifically on countries/continents with the most publication activity in addition to countries/continents for which we felt that results warranted explicit discussion.

Page 8, lines 5-8 states: "Our results provide the largest and latest systematic evidence for the COVID pandemic's effect on women's publishing productivity across disciplines worldwide." I would caution against making such hyperbolized statements as some disciplines are missing which are also publishing on COVID, especially those which are not health related, and data from many countries are missing.

We have softened the language throughout the manuscript. We have also clarified prespecified inclusion criteria for disciplines, countries and geographic areas to underline the unbiased approach of our analyses.

Page 8, lines 42-45 states: "the disproportionate impact of COVID-19 on early career women investigators needs serious consideration." I would argue all women not just early career. While it is true early and mid career will likely have more long lasting repercussions.

We have now included a more detailed description and discussion about why we focus on first authorships, including an additional analysis showing the change in the gender gap in last authorships. We also added a discussion of the likely long-lasting repercussion of this pandemic for women in other career stages, and in other research fields (unrelated to COVID research) that were not subject of the present study.

Page 8, lines 47-51 states: "pre-existing inequities must be evaluated, and a long-term strategy has to be established to support equity and inclusion in science". Please provide examples of 'pre-existing inequities'. In addition, equity and inclusion is much more than just gender equity – please make it clear that you are focusing on gender equity here.

We have now clarified that the focus of our study was on gender equity but highlight that the issues discussed here are broader than just gender and likely also impact other underrepresented populations in the academic life sciences.

Great recommendations are provided. I would also like to see recommendations related to the systemic and structural issues within academia.

We have now included examples of possible measures addressing the systemic and structural problems within academia in general and refer to more extensive reviews in the discussion section of the revised manuscript.

References: there has been a lot written about the gendered impacts of the pandemic, it would be great to see some of this reflected in the paper. Within this work these impacts are referred to a long-term secondary impacts as opposed to short term primary impacts.

We acknowledge that we failed to introduce important related publications and were not able to cite some of the emerging literature because our manuscript was submitted earlier on. We now elaborate on these studies in the introduction of the revised manuscript, highlighting our contribution with respect to longitudinal data across disciplines and regions.

No limitations are provided. There are distinct limitations in relation of the ability to assess gender by an author's name.

See: https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(19)30342-0/fulltext

We have now included a more detailed discussion of the limitations of our study, including potential limitations associated with associating gender by an author's forename.

Reviewer: 2

Dr. Ana Pinho-gomes, The George Institute for Global Health
Comments to the Author:

Overall, this is an interesting article. It adds to the evidence that has been mounting on the widening of the gender inequalities during the COVID-19 pandemic in authorship of research papers. Overall, the gap between women and men increased by 18% for COVID-19 papers in comparison with papers published in the same journals in the previous year. In addition, there was substantial variation in the extent of the relative reduction in publications with women as first author between countries and scientific fields. The findings, albeit relevant, are not new and there are important limitations that should be acknowledged and addressed, if possible.

1. In my view, the design of this study could be reconsidered. What is it that authors are trying to illustrate? If the point to make is that women's voices are not being heard in COVID-19 research, then restricting the analysis to COVID-19 papers makes sense. On the other hand, if the aim is to investigate the impact of the COVID-19 pandemic and associated measures on women's publications, then all papers regardless of topic should be included. For instance, is the gender gap explained by the fact that women are publishing more non-COVID research in those scientific fields? Evidence from elsewhere does not favour this, but the truth is that this study mixes both research questions, which, albeit completely different, are often confused. I would suggest that the authors review their question and adopt the most appropriate approach to answer their study question.

In the revised manuscript, we updated the introduction, included a clarified methods section and discussed the limitations of our study in more detail to underline the strengths and limitations of our design as well as the research question addressed. In brief, we ask whether gender differences in productivity (i.e., rate of publication) exist that can be attributed to the COVID pandemic. Addressing this question invariably involves trade-offs. Considering women's authorships across all research areas and topics, for example, could lead us to understate the effect of the pandemic on women scholars because many research projects that were published in (early) 2020 were likely executed months or even years before the pandemic. Our design limits our findings to gender differences in productivity with respect to COVID-research relative to research in the same (or highly similar) fields a year earlier. Besides offering evidence on the extent to which women were able to inform society's response to the pandemic relative to a baseline expectation, we submit that our design can provide early evidence for women's productivity drain in science more broadly.

2. The introduction does not accurately summarise the current knowledge. There are key articles missing that clearly illustrate the disproportionate impact of COVID-19 on female authors. The authors paint the picture that there is no evidence about the impact of COVID-19 on gender inequalities in authorship of published papers. This is definitely not true and should be acknowledged. This paper adds to the pool of evidence that compellingly demonstrate the widening of the gender gap in academia associated with COVID-19. This does not mean that this study has less merit, but it puts it into perspective. It is not novel, but it reinforces the message that action needs to be taken if we are to avoid losing hard-won gains in gender equality over the last decades.

A few examples:

https://jamanetwork.com/journals/jamasurgery/fullarticle/2769186

https://gh.bmj.com/content/5/7/e002922

https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)31412-4/fulltext

https://www.nature.com/articles/d41586-020-01294-9

https://ajph.aphapublications.org/doi/10.2105/AJPH.2020.305975

We acknowledge that we failed to introduce important related publications and were not able to cite some of the emerging literature because our manuscript was submitted earlier on. We have now updated our literature review and elaborate more on these studies on this topic in the introduction of the revised manuscript.

3. Why did the authors restrict the analysis to first authors? I do understand the interest of looking at the career of young researchers but combining this with analysis of last authorship would add value to the study.

In the revised manuscript, we now clarified the focus of our study and elaborate more on our hypothesis that the pandemic disproportionally affected routines and work arrangements of early career stage women scientists (e.g. with family responsibilities) relative to senior, established scholars. Additionally, we now have supplemented our analysis of the overall effect of the pandemic on gender differences in first authorships with a corresponding analysis of last authorships.

4. Why did the authors not provide a temporal analysis of the gender gap? As COVID-19 measures were introduced and lifted at different times across the world, this could provide useful insight into the effect of COVID-19 control measures on gender inequalities? For instance, was the effect more marked during initial lockdowns and then gradually improved as restrictions were eased throughout Summer in the Northern hemisphere?

As mentioned in our response to point 2, we submitted this study for review at an earlier timepoint in the pandemic but in the revised manuscript, we have now included temporal analyses of the gender gap by disciplines and by continent/geographical area. Given the time lag between local restrictions and publication dates as well as the heterogeneity of restrictions across and within countries, states, and continents we refrain from interpreting the immediate effect of countermeasures.

5. Restrictions have been minimal in Australia, but the gender gap widened to a similar extent to European countries where much more severe restrictions were in place for a long time. This argues against author's point that the observed exacerbation of gender inequality is explained by caring responsibilities. A broader discussion of the myriad factors underpinning gender imbalance in published papers is clearly required.

We have now included a more detailed discussion of several key factors potentially underpinning the gender gap in publishing related to the pandemic. We have also included time trend analysis for different geographical regions and point to suggestive evidence that the representation of women first authors in Oceania, i.e. Australia and New Zealand, has reverted to the baseline level faster than in other regions.

6. The authors mention that the widening of the gender gap may be due to childcare and household responsibilities. However, there are many other reasons and those should be explored in the discussion (please

see https://pubmed.ncbi.nlm.nih.gov/32527733/). For instance, COVID-19 is a "trendy" subject, and it is likely that those in positions of power, who are commonly men, led COVID-related research themselves. Women may simply side-lined and denied the opportunity to take up COVID-related projects, as they are highly competitive.

We have now more explicitly discussed reasons for the widening of the gender gap during the pandemic.

7. There is also some evidence suggesting that men may be more likely to get papers accepted than women, which is seriously concerning. Although authors cannot explore this in their study, it is certainly worth discussing (please

see https://ajph.aphapublications.org/doi/10.2105/AJPH.2020.306028?url_ver=Z39.88-2003&rfr_id=ori%3Arid%3Acrossref.org&rfr_dat=cr_pub++0pubmed).

In the revised manuscript, we have now included a more detailed discussion of the potential mechanisms underlying the increased gender gap especially early during the pandemic (see also our response to point 6 and 7), including the potential of gender differences in manuscript acceptance rates.

8. There is no mention in the discussion about limitations. This is, though, very important. Could the key limitations be outlined in the paper so that readers understand how to interpret the findings and conclusions?

We have now detailed the limitations of our study in the discussion of the revised manuscript.

9. The software used to determine gender of authors is far from perfect and a degree of misclassification is expected. This is particularly an issue for Asian authors who often have only initials as first names. Bearing this in mind, how generalisable are this study findings globally?

We have now included a more detailed description of the algorithm used to designate gender and also included a discussion about the limitations of our study, including the potential limitations associated with associating gender by an author's forename and differences in the accuracy depending on geographic area. In the supplementary material we further provide sensitivity analyses for the accuracy with which gender is assigned and find very similar results across different accuracy thresholds (Table S6, Model 1-2).

10. Also, there is no mention about what was done with collective authorship, which happens in some papers.

We have now included a robustness check in the supplementary material (Table S6, Model 3) showing that exclusion of articles with collective authorship does not affect the results. We identified collective authorships through the associated tag in the PubMed XML data structure.

11. About half of the eligible articles were excluded and there is no reason to assume that those would be similar to those that were included. This may have introduced significant selection bias and should be acknowledged.

We now provide additional descriptive statistics in the supplementary material (Table S7) comparing the articles included in the analysis to those excluded for not fulfilling a certain quality threshold, i.e. not being indexed in Clarivate's Journal Citation Report. However, we show in a robustness check that the increase in the gender gap during the COVID pandemic persists if these articles are included in the analysis (Table S6, Model 4).

12. The conclusion is very limited in scope and does not appropriately reflect the key messages of the paper. I would suggest (1) emphasising the main finding of this study, which is that the gender gap in first authors of published papers widened during the pandemic, and (2) calling for action to address those longstanding gender inequalities that are detrimental to women and men alike and compromise our ability to respond to and recover from the pandemic.

We have now expanded the conclusions and summarize key findings as well as most important policy implications in more detail.

VERSION 2 – REVIEW

REVIEWER	Ana-Catarina Pinho-Gomes King's College London, UK
REVIEW RETURNED	02-Mar-2021

GENERAL COMMENTS	The paper has improved markedly. It reads very well. It clearly demonstrates the prejudice that women have experienced throughout the pandemic. It's a wake up call to all the scientific community about the widening gender gap that may have serious long-term consequences for junior women in academia. Thanks for doing this valuable piece of research! As a minor comment, I would just ask the authors to proof-read the manuscript as there are some typos and also to use British spelling consistently.