No tickets for women in the COVID-19 race? A study on manuscript submissions and reviews in 2347 Elsevier journals during the pandemic

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Abstract

During the early months of the COVID-19 pandemic, the submission rate to scholarly journals increased abnormally (e.g., more than 90% in health & medicine Elsevier journals). Given that most academics have been forced to work from home, the competing demands for home-schooling, child and other care duties might have penalised the scientific productivity of women. To test this hypothesis, we looked at submitted manuscripts and peer review activities for all Elsevier journals between February and May 2018-2020, including data on almost 6 million academics. Results showed that women submitted proportionally fewer manuscripts than men during the COVID-19 lockdown months. This deficit was especially pronounced among women in more advanced stages of their career. The rate of the peer-review invitation acceptance showed a less pronounced gender pattern, with the exception of health & medicine, where women were also less keen to accept reviewing. Our findings indicate that the pandemic has already created cumulative advantages for men.

Keywords: COVID-19; gender penalties; gender; scholarly journals; manuscripts; peer review; Elsevier; science of science; gender bias; pandemic

1 Introduction

The recent pandemic has spurred a flood of COVID-related research publications (Vincent-Lamarre et al. 2020; Palayew et al. 2020). However, since from the onset of the pandemic, the governments of various countries have enforced severe lock-down measures, requiring most academics to work from home. While academics are used to working at a distance and with flexible times, it is plausible that during the pandemic competing demands from home-schooling, family obligations and other caring duties have affected the productivity of women and men differently (Staniscuaski et al. 2020; Collins et al. 2020; Viglione 2020). It is long known that women have more problematic academic careers and drop out more frequently from academia due to difficulties in reconciling work and family life (Penner 2015; Greider et al. 2019; Day et al. 2020; Huang et al. 2020). On the other hand, homeschooling and child care due to COVID-19 lock down regulations has also imposed a major shift in family schedules and routines, which has probably cemented ever more traditional gender roles (Wenham et al. 2020). For instance, a recent study in the U.S. showed that women with young children have reduced their working hours four to five times more than fathers during the pandemic (Collins et al. 2020). A recent surveys on 4,535 principal investigators in scientific projects in Europe and the U.S. indicated that women academics, those in the 'bench sciences' and, especially, scientists with young children, have experienced a substantial decline in research time. (Myers et al. 2020).

From the early onset of the pandemic, some journal editors began raising concerns over the fact that women were submitting fewer manuscripts to their journals (Flaherty 2020). This impression was confirmed by two recent studies using PubMed database to estimate the gender rate of authors publishing COVID-19 related papers during the pandemic (Andersen et al. 2020; Pinho-Gomes et al. 2020). Unfortunately, these studies did not have access to data to examine submissions to journals and could look only at publications. Furthermore, the lack of cross-journal data in various fields limited the analysis only to specific cases, e.g., biomedical publications on COVID-19 related research. Recent research has considered the authors' gender of preprints and found that women academics have posted fewer papers during the lockdown period (Vincent-Lamarre et al. 2020). However, understanding whether the COVID-19 race for publications has eventually benefited only men, requires accessing full individual data from different journals at least in a two-years time window to evaluate individual trends (Squazzoni et al. 2020).

To fill this gap, on 12 May 2020, we have established a confidential agreement with Elsevier to access manuscript and peer review metadata from all Elsevier journals. These included individual records of authors and referees in a fully comparable monthly time window — i.e., February-May 2018-2020, hereafter defined as the 'COVID-19 period'. This period covers most of the outbreak development in Asia, Europe and America during the first half of 2020, although China had restriction measures in place already in February (see Supplementary Materials and Methods). These data allowed us to compare time trends at an individual level for all areas of research before and

during the pandemic, allowing us to provide a systematic overview of the effect of the pandemic on academics' productivity. We also included data on referees to understand whether gender penalties could extend to peer review.

2 Results

The COVID-19 pandemic has caused a race for publication particularly in related topics with an abnormal rate of journal submissions. Our data from all Elsevier journals indicate that the number of manuscripts submitted to all Elsevier journals during the pandemic increased of 58% compared to the same period of the previous year (i.e., from 466,846 for February-May 2019 to 738,705 in 2020) (Tab. A1). Note that in health & medicine journals, this trend was even stronger with an increase of 92% (i.e., from 114,377 submissions from February-May 2019 to 219,552 in 2020). The absolute numbers of accepted review invitations for all disciplines increased by 45%, from 610,475 in 2019 to 788,053 in 2020. In case of health & medicine journals, the accepted invitations increased by 35% from 2019 to 2020 (i.e., 202,932 in 2019 against 273,871 in 2020) against an increase of submissions of 92%.

Our analysis shows that men submitted more manuscripts than women during the pandemic (Fig. 1A). The rate of accepted review invitations — i.e., the number of accepted invitations on the total number of invitations sent to potential referees — has been more constant around an average of ≈ 0.45 with only minimal differences between the acceptance rate of women and men (Fig. 1B).

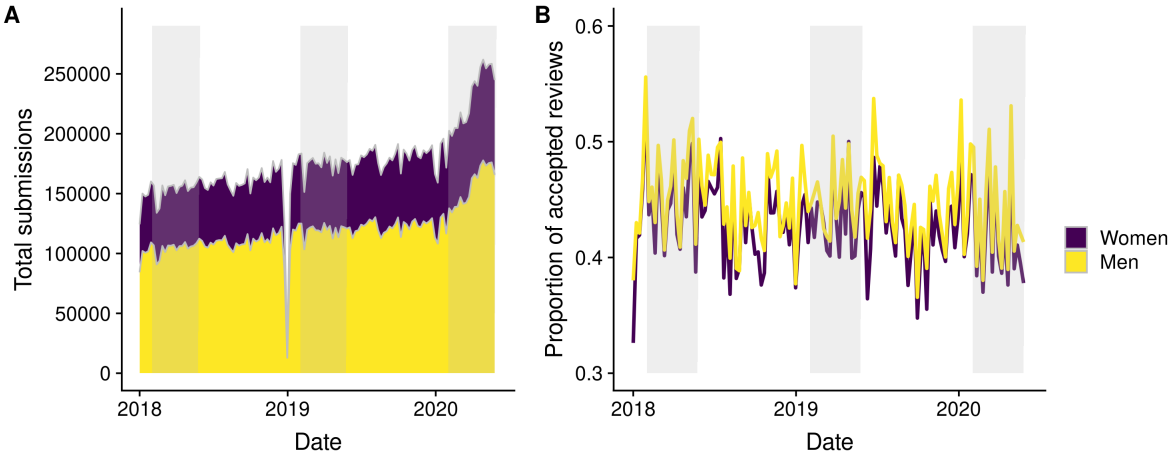

Figure 1: Total submissions (A) and proportion of accepted reviews (B) per week across the whole period covered by the dataset. The shaded areas indicate the February-May period of each year considered in the analysis. Note that in panel A co-authored submissions were reported multiple times depending on the number of co-authors. Each authors or referee whose gender was not assigned by our gender determination algorithm was excluded.

During the considered yearly periods (February-May 2018, 2019 and 2020), women submitted 1,960,973 manuscripts against 4,370,176 manuscripts by men (note that given that individual authors were our unit of analysis, co-authored submissions were counted multiple times here depending on the number of coauthors). Women agreed on performing 736,368 reviews while declining 568,415 invitations, with a proportion of 56.4% accepted invitations. Men accepted 2,233,801 review invitations while declining 1,694,489, with a similar acceptance proportion (56.9%) (see Table A2 for a summary of these descriptive statistics per area of research).

3 The effect of the pandemic on submissions

We calculated a submission difference index for each author (Δ_S) as the number of new submissions in the 2020 COVID-19 period minus the average number of submissions from the same author in the corresponding months of 2018 and 2019. The overall increase of submissions in 2020 led most authors to $\Delta_S \geq 0$. However, when considering different areas of research and seniority, we found that the Δ_S of men increased more than that of women (Fig. 2). This would suggest that women have been at least comparatively penalised in terms of opportunities of research and publication during the early months of 2020.

To check for the significance of these effects, we estimated a mixed effects model using authors' gender and seniority to predict Δ_S (Tab. A3). In order to control for the fact that authors were based in countries with different university systems and contagion-prevention policies, we included random effects for countries in the model. Results indicated a statistically significant negative effect for women in three of the four research areas, i.e., health & medicine, physical sciences and engineering, and social science and economics (Tab. A3). Note that with the exception of the area of social science and economics, we found a consistent negative interaction effect between gender and seniority, with women at intermediate or advanced stages of their career more penalised than PhD students and researchers without a PhD, possibly younger than the former.

In order to test the hypothesis that these gender and seniority differences were a side-effect of the different anti-contagious measures adopted by various countries, we included in the model a proxy of how lockdown and social distancing measures, such as the closure of schools, could have variously affected academics in different countries. We therefore used Google's COVID-19 Community Mobility Report (Google 2020), which tracks the amount of time spent by mobile-phone users in different places, including residential areas. Mobility reports are available at the country level (in some cases even at sub-national level) and are summarised in an index that calculates the different time rates spent in residential areas in a given day compared to the median value of January 2020.

We calculated the average values of the February-May 2020 period of the residential area index per country (Fig. A1) and included this variable in our model. Unfortu-

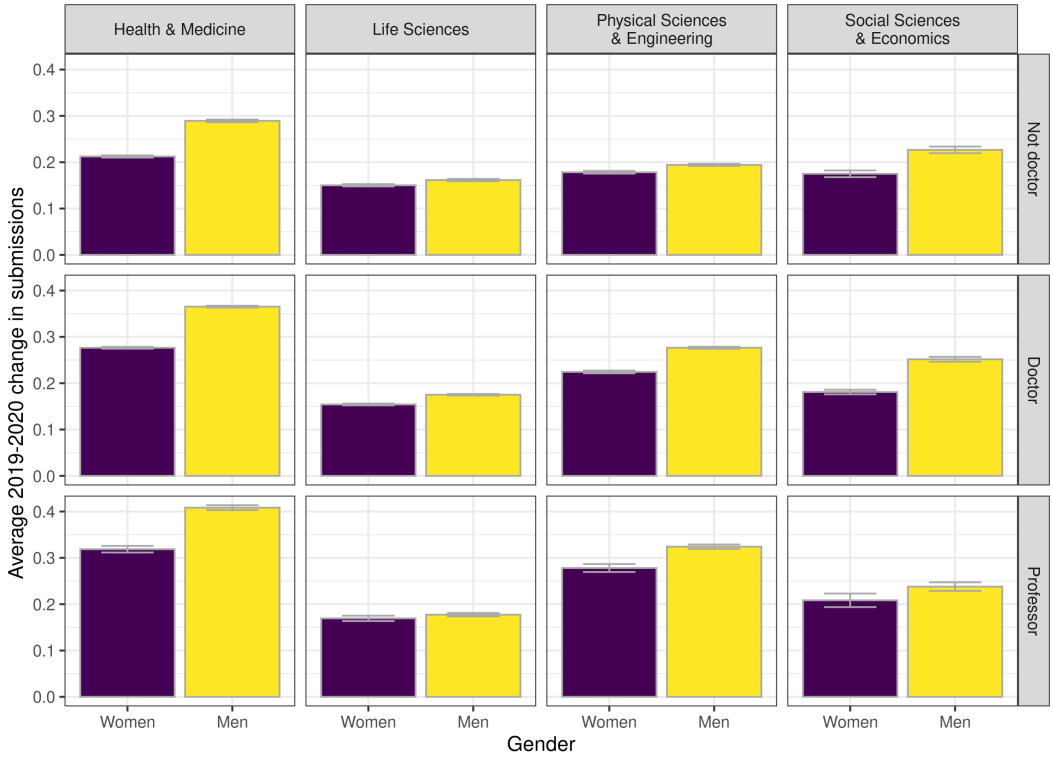

Figure 2: Average change in submissions by research area and seniority. Bars represent standard errors.

nately, certain countries (e.g., China and Iran) were not included in the mobility reports and so our analysis was performed on a restricted sample of academics, including between 20% and 30% fewer observations than the previous models depending on the area of research (Tab. A4). This would suggest that this new analysis is complementary to the previous one and more a robustness check of previous findings.

Results confirmed our hypothesis about a negative interaction between gender and time in residential areas, when considering authors of submissions to health & medicine, and physical science & engineering journals. We found neither a pure effect of gender nor any significant interaction when considering life science journals. We found a weakly significant pure effect of gender in case of social science and economics journals, but no significant interaction effects (Tab. A3). Note that, following (Benjamin et al. 2017), we considered any value of $0.05 < p < 0.005$ as being only weakly significant.

We then concentrated on 'COVID-related' manuscripts, i.e., manuscripts focusing on diseases caused by viruses of the *Coronaviridae* family (see Supplementary Materials and Methods). By using keywords similarity and internal classifications from Elsevier, we reconstructed the time trends of 'COVID-related' manuscripts submitted by academics to all Elsevier journals in the same period in 2018-2020, e.g., research on SARS-CoV-1. This also allowed us to focus on whether women doing research more directly relevant to COVID-19 were penalised during the pandemic.

Results confirmed that women submitted less COVID-19 related manuscripts in 2020, especially in health & medicine journals, with p-values above the more rigorous 0.005 level for life sciences, physical sciences and engineering (Tab. 1). Note that we could not estimate the model for social sciences and economics journals due to the small number of COVID-related manuscripts submitted to these journals prior to 2020. This also implied that we could not estimate models including mobility data.

	Health & Medicine	Life Sciences	Physical Sciences & Engineering
Women	−0.076	−0.053	−0.125
	(0.024)	(0.026)	(0.051)
	p = 0.002	p = 0.046	p = 0.014
Doctor	0.116	−0.018	−0.030
	(0.017)	(0.020)	(0.035)
	p = 0.000	p = 0.357	p = 0.387
Professor	0.242	−0.025	−0.009
	(0.022)	(0.026)	(0.045)
	p = 0.000	p = 0.334	p = 0.845
Women×Doctor	−0.036	−0.011	0.024
	(0.027)	(0.031)	(0.062)
	p = 0.188	p = 0.731	p = 0.693
Women×Professor	−0.058	0.005	0.057
	(0.042)	(0.047)	(0.089)
	p = 0.167	p = 0.914	p = 0.526
Intercept	0.888	0.659	0.858
	(0.035)	(0.039)	(0.056)
	p = 0.000	p = 0.000	p = 0.000
Observations	88448	23131	9127
Log Likelihood	−161853	−31444	−14137
AIC	323723	62905	28290

Table 1: Mixed effects models predicting February-May 2020 changes in the number of submissions of Covid-related manuscripts per area of research (Note that the area of social science and economics was not included due to the limited number of observations). Random intercepts included for countries.

3.1 The effect of the pandemic on academics' commitment to peer review

In order to measure the gender effect of the COVID-19 pandemic on academics' commitment to peer review, we calculated the proportion of accepted review invitations Δ_R

for each potential referee in February-May 2020 compared to the corresponding period in 2019. This proportion excluded individuals who did not receive any invitations for our period and the three-years time series would have lead us dropping the number of observations per individual excessively. We therefore decided to exclude the 2018 sample and restrict our analysis to February-May 2019-2020.

Besides an overall decline in the number of accepted invitations per individual (note the reversed y-axis), Figure 3 shows that the pandemic did not determine any significant gender differences in various areas of research and by seniority, the sole exception being health & medicine for academics with less seniority.

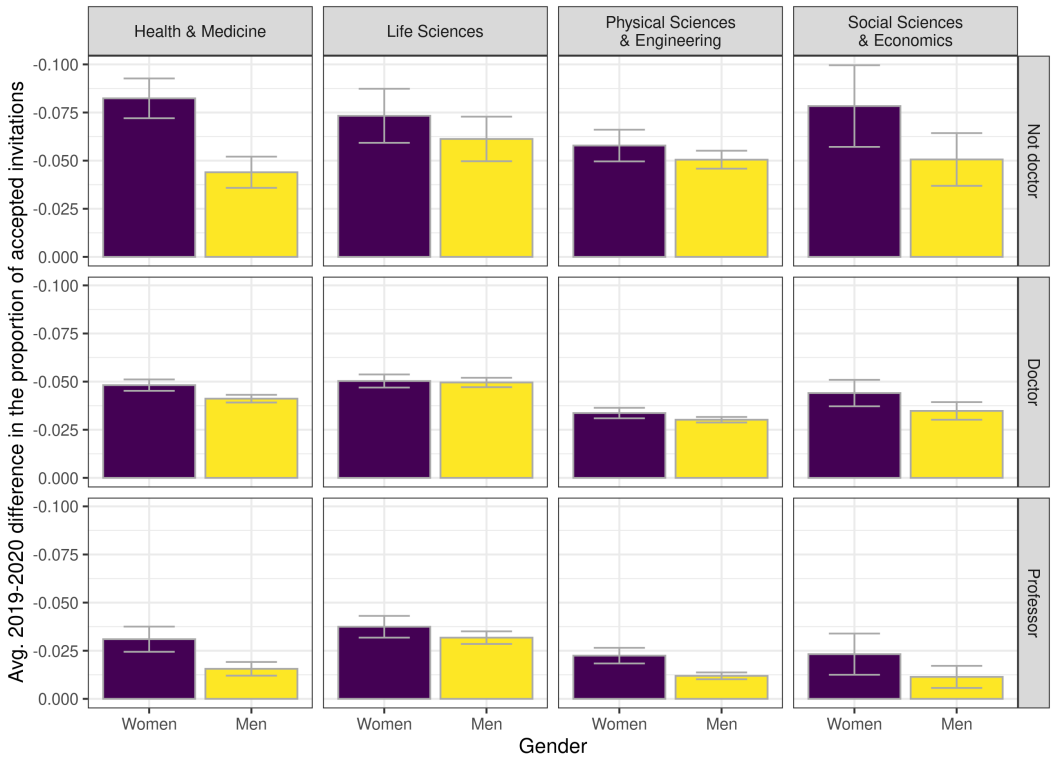

Figure 3: Average difference in the proportion of accepted invitations by research area and seniority. Bars represent standard errors. Note: the y axis is reversed.

We then estimated two mixed-effect models per research area (Tab. A5 and A6), controlling for the time spent in residential areas. Results confirmed that the relative decline in Δ_R was only greater for women in health & medicine, although even in this area we did not find any significant interaction with the time spent in residential areas. If we consider the proportional difference between the inflation of submissions (90%) and accepted reviews (35%) in health & medicine journals, the increasing pressure on the peer review system during the pandemic has probably implied a reduced ratio of referees per manuscript.

4 Discussion

The COVID-19 pandemic has generated unforeseen opportunities for fast publications as a collective response of the academic community to the pandemic. The inflated rate of scientific production during the early months of the COVID-19 pandemic has been about 1/3 the usual rate in all Elsevier journals, with peaks of 90% in health & medicine journals. This will probably continue over the following months, due to various factors, including the challenge of a possible resurgence of the virus, the global dimension of the pandemic crisis and the race for a vaccine. While the global crisis has increased demand for research, such opportunities have created inequalities and distortion in the scientific community (Myers et al. 2020).

Our complete data on all Elsevier journals indicate that the exceptional lock-down and social distancing measures imposed by the pandemic have penalised women academics and benefited men. This distortion has been especially prominent in the area of research where the academic production has been higher during the pandemic, i.e., health & medicine. Women at later stages of their career were penalised the most, which in principle could be explained by more intense family duties (Collins et al. 2020). While pressures on peer review is higher in this period, requiring also special arrangements by many journals — e.g., special fast-tracks (Eisen et al. 2020), our findings suggest that in health & medicine journals, the rate of referees per manuscript has declined and women have been less involved. This raises serious concern over the impact of the pandemic on the quality of peer review under increasing editorial pressures, which will require further investigations in the next months (Bauchner et al. 2020; Palayew et al. 2020).

Given the importance of publications and citations for academic career and prestige in the current hyper-competitive academic environment, these gender disparities could have important short- and longer-term effects, which need to be considered by academic institutions and funders. Indeed, those who have already benefited from this COVID-19 research inflation may have higher chances in the near future to receive prestigious grants and obtain tenures and promotion in prestigious institutions.

Therefore, it is important that funding agencies and hiring and promotion committees at national and international levels reconsider their policies. While voluntary disclosure of gender or gender quotas during journal submissions could lead to further biases (Pinho-Gomes et al. 2020), flagging, carefully pondering or even disregarding COVID-19 related publications and citations from applicants' assessment could also be considered. Given that the use of bibliometric indicators to assess applicants for funds and academic positions has been strongly criticised even in normal times (Hicks et al. 2015), one of the most important lessons from the pandemic could be to follow multi-dimensional criteria in any academic assessment, which truly reflect a variety of factors describing the potential of an applicant either for an academic job or a grant. This could include a COVID-19 impact statement where any candidate is required to explain the opportunities and constraints faced during the pandemic (Htun 2020). At the same time, improving career enhancement and retention by appropriate institu-

tional interventions, such as promoting a more diverse, inclusive, and equitable working environment and embracing a family-friendly leadership policy in the reopening plans of labs and institutes, could help moderate the distortions caused by the pandemic (Stepan-Norris and Kerrissey 2016; Kamerlin and Wittung-Stafshede 2020).

Obviously, considering the dynamic unfolding of the pandemic in different regions worldwide, and its possible resurgence in countries where the pandemic peaked early this year, journals and publishers should put more effort in internal assessment and monitoring (Berg 2019; Berenbaum 2019). Learned societies and journals have recently made progress in increasing the rate of gender diversity of their boards, yet still with certain obstacles and inertia (Fox et al. 2019). This study has paved the way for large-scale collaboration initiatives on data sharing between publishers and the scientific community (Squazzoni et al. 2020) and could be used as a template to map the evolution of the COVID-19 scientific landscape.

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Declaration of interest statement. BM is employee of Elsevier and organised the data sharing process.

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A Appendix

A.1 Material and methods

Data sharing agreement Data access required a confidential agreement to be signed on 12th May 2020 between Elsevier and each author of this study. The agreement was inspired by the PEERE protocol for data sharing and included anonymization, privacy, data management and security policies jointly determined by all partners (Squazzoni et al. 2017).

Dataset description Our dataset included complete information on manuscripts and reviews from 2347 Elsevier journals from January 2018 to May 2020. The sample included about 6 million academics listed as authors and/or referees. For the sake of our analysis, we defined the "COVID-19 period" as the months from February to May 2020 (more precisely, weeks 6-22, 2020). Besides covering large part of the outbreak during the first half of 2020, this choice was motivated by the fact that few countries had any lockdown measures in place during January 2020. In addition, Google COVID-19 Community Mobility Report used the first five weeks of 2020 as reference so that mobility data were only available starting from week 6, 2020. To ensure full comparability across years, we then limited our observations to the corresponding months of 2018 and 2019.

Tables A2 and A1 provide a complete overview on our data. Note that the same individuals could be counted twice (or more) in the Tables' totals whenever submitting or reviewing to journals in different research areas.

We used the e-mail (or the set e-mails) associated to each user account in the underlying submission systems (i.e., Editorial Manager, Elsevier Editorial System and EVISE) to track academics across all journals and constructed an auto-generated anonymous unique identifier. We controlled for multiple e-mail addresses and this allowed us to circumvent the incompleteness of other alternative identifiers, which were either available only for a partial sub-sample of academics (e.g., ORCID) or not unique (e.g., ScopusID).

To prevent de-anonymization of authors and referees, all observations from countries with less than 20 authors/referees were dropped from the dataset. This reduced our sample by 1876 authors and 2306 referees, i.e., less than 0.01% of the observations in the sample of authors and referees. In addition to the privacy issue mentioned above, removing observations from smaller countries increased the robustness of the analysis, as the maximum likelihood estimation of random intercepts with few observations for each category may have caused convergence and over-fitting problems, thereby making it difficult to control possible statistical biases. Finally, these countries were also not covered by the Google COVID-19 Community Mobility Report and so should have been excluded in any case.

Gender determination Our procedure for gender determination followed a two-step disambiguation algorithm inspired by previous research (Buljan et al. 2020; Bravo et al. 2019; Larivière et al. 2013; Karimi et al. 2016; Helmer et al. 2017) and already validated on several datasets of academics' names (Santamaría and Mihaljević 2018). First, we queried the Python package gender-guesser about the first names and countries of origin, if any. Gender-guesser allowed us to minimise gender bias and achieve the lowest misclassification rate (less than 3% for Benchmark 1 in (Santamaría and Mihaljević 2018)). For names classified by gender-guesser as 'mostly_male', 'mostly_female', 'andy' (androgynous) or 'unknown' (name not found), we

used GenderAPI[1], which ensures that the level of missclassification is around 5% (see Table 4 in (Santamaría and Mihaljević 2018)) and has the highest coverage on multiple name origins (see Table 5 in (Santamaría and Mihaljević 2018)). This procedure allowed us to determine the gender of 94.3% of academics in our sample, 45.1% coming from gender-guesser and 49.2% from GenderAPI. The remaining 5.7% of academics (i.e., all among the sample of referees) were assigned an unknown gender. Note that this level of gender determination is consistent with the non-classification rate for names of academics in previous research (Santamaría and Mihaljević 2018).

We checked the robustness of the analysis to variations of the gender determination algorithm by estimating further models using a more restrictive version of the algorithms. Results are reported as Supplementary Materials (Tab. A7 and A8).

COVID-19 related manuscripts Elsevier data allowed us to distinguish COVID related and non-related manuscripts through an internal Boolean flag from the manuscript submission systems used by journals. A manuscript was considered COVID-19 related when the following condition was met by its keywords or abstract: ["covid-19" OR "covid 19" OR "covid19" OR "corona virus" OR "coronavirus" OR "corona-virus" OR "corona viruses" OR "coronaviruses" OR "corona-viruses" OR "orthocoronavirinae" OR "coronaviridae" OR "coronavirinae" OR "2019-ncov" OR "2019ncov" OR "2019 ncov" OR "hcov-19" OR "sars-cov" OR "sars cov" OR "severe acute respiratory syndrome" OR "sars-cov-2" OR "sars-cov2" OR "mers-cov" OR "mers cov" OR "middle east respiratory syndrome" OR "middle eastern respiratory syndrome" OR ("angiotensin-converting enzyme 2" AND "virus") OR ("ace2" AND "virus") OR "soluble ace2" OR ("angiotensin converting enzyme2" AND "virus") OR ("ards" AND "virus") OR "acute respiratory distress syndrome" OR ("sars" AND "virus") OR ("mers" AND "virus") OR ("wuhan" AND "virus")]. We used this taxonomy to track COVID-related manuscripts (i.e., manuscripts focusing on diseases caused by the the same family of viruses) before the start of the pandemic.

Study limitations Though we achieved an observation scale never achieved previously in this type of research, our study is limited to only Elsevier journals. While Elsevier has one of the largest journal portfolios among publishers and sufficiently covers many areas of research, a desirable extension would be to re-run this analysis by including journals from other publishers. Although Elsevier and many commercial publishers have published COVID-19 related articles under open access licenses, including more open science journals could help to understand whether publication inflation has reflected certain publishers' specifications. When reconstructing the academic status of scholars, we used the fields title and degree (e.g. Prof., Dr., Mr., and Mrs.), which are optional in the registration form of Elsevier's three submission systems (i.e., EES, EVISE and EM). It is possible that self-declaration of academic titles could reflect culture-specific norms and conventions. For instance, the use of the title "Dr." could be different in certain communities and perhaps not allowing to clearly identify someone with a PhD title. On the other hand, the title "Prof." could be used more rarely among academic faculty members working in hospitals. However, the size of the sample and the large coverage of academics from different countries and areas of research could have reduced the effect of this possible bias on our outcomes.

[1]https://gender-api.com/

Finally, as mentioned above, unfortunately Google mobility data were not available in certain countries and regions, e.g., China and Iran. Therefore, we could not include our lock-down proxy (extra time spent in residential areas) for all observations in the sample and considered the models including mobility data as complementary and as a robustness check for our analysis.

A.2 Supplementary descriptive statistics

This section reports supplementary figures and other descriptive statistics to illustrate the findings presented in this manuscript.

	Feb-May 2018	Feb-May 2019	Feb-May 2020
HMS submissions	100216	114377	219552
LS submissions	63921	74330	113712
PS submissions	209653	236284	341477
SSE submissions	35486	41855	63964
Total submissions	409276	466846	738705
HMS review invitations	436010	509634	781349
LS review invitations	262817	277641	414836
PS review invitations	495022	542453	786749
SSE review invitations	163226	190863	259189
Total review invitations	1357075	1520591	2242123
HMS accepted invitations	179275	202932	273871
LS accepted invitations	108404	112708	143154
PS accepted invitations	204633	218096	279167
SSE accepted invitations	67338	76739	91861
Total accepted invitations	559650	610475	788053

Table A1: Total number of new submissions, review invitations, and accepted invitations per area of research during the COVID-19 period and corresponding months of 2018 and 2019. Note that the figures in this table differ from data presented in Table A2 (main text) because (i) several authors may submit the same manuscript, which is only counted once here, and (ii) submissions and reviews from academics whose gender was not recognised by our algorithm are considered here but not in Table A2.

A.3 Submission models

This section presents models predicting the number of submissions from each academic included in the dataset.

	Health & Medicine	Life Sciences	Physical Sciences & Engineering	Social Sciences & Economics	Total
N. of journals	896	417	770	264	2347
Submissions (women)	711612	416106	717655	115600	1960973
Submissions (men)	1319443	683948	2107877	258908	4370176
Accepted reviews (women)	208772	172193	297665	57738	736368
Declined reviews (women)	158645	138550	235137	36083	568415
Accepted reviews (men)	502672	368684	1228963	133482	2233801
Declined reviews (men)	382018	297592	934216	80663	1694489

Table A2: Overview of the main variables considered in the analysis by research area.

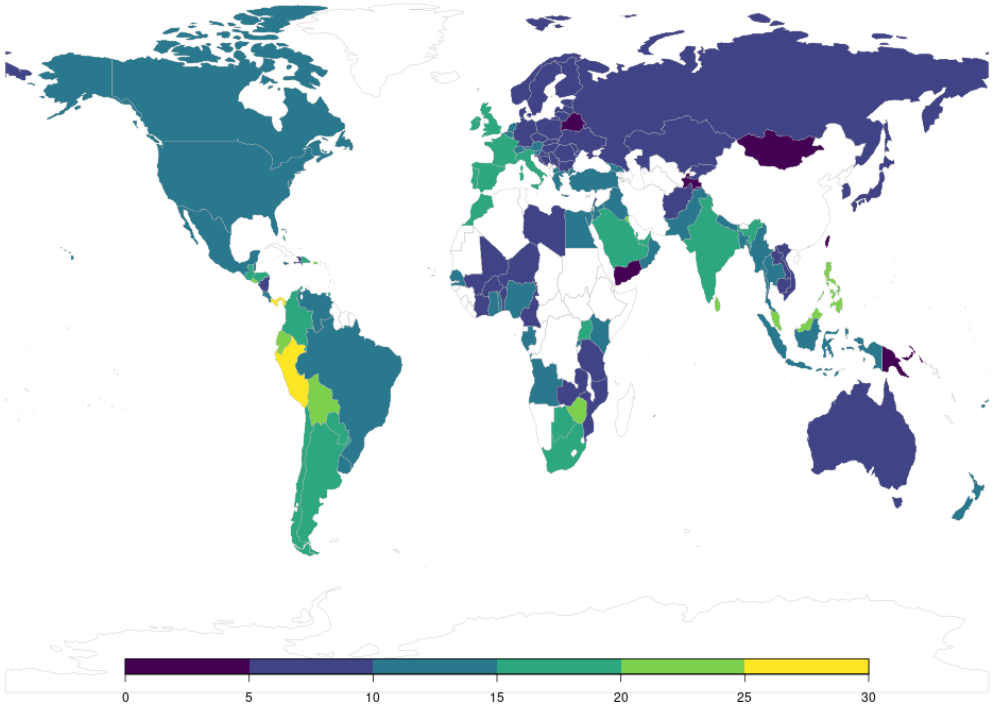

Figure A1: Average increase in the time spent in residential areas by country. The change was calculated as different rate from the baseline given by median value during the first five weeks of 2020. Data from Google COVID-19 Community Mobility Report (Google 2020). White areas indicate missing data.

	Health & Medicine	Life Sciences	Physical Sciences & Engineering	Social Sciences & Economics
Women	−0.057	−0.004	−0.015	−0.045
	(0.005)	(0.004)	(0.005)	(0.011)
	p = 0.000	p = 0.272	p = 0.002	p = 0.00005
Doctor	0.085	0.027	0.092	0.031
	(0.004)	(0.003)	(0.003)	(0.009)
	p = 0.000	p = 0.000	p = 0.000	p = 0.0003
Professor	0.129	0.035	0.147	0.014
	(0.005)	(0.004)	(0.005)	(0.011)
	p = 0.000	p = 0.000	p = 0.000	p = 0.194
Women×Doctor	−0.025	−0.012	−0.033	−0.019
	(0.005)	(0.005)	(0.006)	(0.013)
	p = 0.00001	p = 0.014	p = 0.00000	p = 0.161
Women×Professor	−0.026	−0.007	−0.035	0.019
	(0.009)	(0.007)	(0.009)	(0.020)
	p = 0.004	p = 0.336	p = 0.0003	p = 0.345
Intercept	0.213	0.141	0.163	0.209
	(0.012)	(0.008)	(0.011)	(0.011)
	p = 0.000	p = 0.000	p = 0.000	p = 0.000
Observations	1370391	1002232	1610850	358803
Log Likelihood	−2322432	−1424382	−3030575	−700798
AIC	4644879	2848780	6061167	1401612

Table A3: Mixed effects models predicting February-May 2020 changes in the number of submissions per area of research. The baseline is represented by the average of corresponding months in 2018 and 2019. Random intercepts included for countries.

	Health & Medicine	Life Sciences	Physical Sciences & Engineering	Social Sciences & Economics
Women	0.008	0.010	0.022	−0.046
	(0.010)	(0.009)	(0.011)	(0.023)
	p = 0.413	p = 0.263	p = 0.058	p = 0.043
Doctor	0.083	0.022	0.089	0.024
	(0.004)	(0.004)	(0.004)	(0.009)
	p = 0.000	p = 0.000	p = 0.000	p = 0.007
Professor	0.139	0.030	0.133	0.006
	(0.006)	(0.005)	(0.005)	(0.012)
	p = 0.000	p = 0.000	p = 0.000	p = 0.624
Residential	0.011	0.002	0.004	−0.00001
	(0.002)	(0.002)	(0.002)	(0.002)
	p = 0.00001	p = 0.128	p = 0.123	p = 0.997
Women×Doctor	−0.028	−0.013	−0.039	−0.021
	(0.006)	(0.005)	(0.007)	(0.014)
	p = 0.00001	p = 0.017	p = 0.000	p = 0.131
Women×Professor	−0.040	−0.006	−0.033	0.017
	(0.009)	(0.008)	(0.011)	(0.020)
	p = 0.00003	p = 0.460	p = 0.003	p = 0.408
Women×Residential	−0.006	−0.001	−0.003	0.0004
	(0.001)	(0.001)	(0.001)	(0.002)
	p = 0.000	p = 0.042	p = 0.0002	p = 0.786
Intercept	0.074	0.116	0.127	0.211
	(0.032)	(0.022)	(0.032)	(0.029)
	p = 0.020	p = 0.00000	p = 0.0001	p = 0.000
Observations	1086038	697566	1051848	291115
Log Likelihood	−1758775	−927617	−1875198	−546791
AIC	3517570	1855256	3750417	1093602

Table A4: Mixed effects models predicting February-May 2020 changes in the number of submissions per area of research. The baseline is represented by the average of corresponding months in 2018 and 2019. Models include time in residential areas from Google's COVID-19 Community Mobility Report (Google 2020). Random intercepts included for countries.

A.4 Peer review models

This section presents models predicting the proportion of accepted reviews for each academic included in the dataset.

	Health & Medicine	Life Sciences	Physical Sciences & Engineering	Social Sciences & Economics
Women	−0.038	−0.012	−0.007	−0.029
	(0.013)	(0.018)	(0.009)	(0.025)
	p = 0.004	p = 0.512	p = 0.457	p = 0.257
Doctor	0.006	0.011	0.021	0.015
	(0.009)	(0.012)	(0.005)	(0.015)
	p = 0.508	p = 0.349	p = 0.00002	p = 0.302
Professor	0.031	0.030	0.042	0.040
	(0.009)	(0.012)	(0.005)	(0.015)
	p = 0.001	p = 0.014	p = 0.000	p = 0.009
Women×Doctor	0.030	0.011	0.004	0.020
	(0.014)	(0.018)	(0.010)	(0.026)
	p = 0.028	p = 0.536	p = 0.701	p = 0.452
Women×Professor	0.021	0.007	−0.003	0.017
	(0.015)	(0.019)	(0.010)	(0.028)
	p = 0.159	p = 0.711	p = 0.752	p = 0.549
Intercept	−0.048	−0.065	−0.051	−0.051
	(0.009)	(0.012)	(0.005)	(0.014)
	p = 0.00000	p = 0.00000	p = 0.000	p = 0.0004
Observations	101750	82965	211525	28639
Log Likelihood	−64497	−53623	−130429	−20741
AIC	129011	107262	260875	41498

Table A5: Mixed effects models predicting February-May 2020 changes in the proportion of accepted review invitations per area of research. The baseline is represented by the average of the corresponding months in 2019. Random intercepts included for countries.

	Health & Medicine	Life Sciences	Physical Sciences & Engineering	Social Sciences & Economics
Women	−0.029	0.004	−0.0002	−0.066
	(0.018)	(0.023)	(0.014)	(0.036)
	p = 0.119	p = 0.878	p = 0.986	p = 0.064
Doctor	0.007	0.007	0.023	0.014
	(0.009)	(0.013)	(0.005)	(0.015)
	p = 0.455	p = 0.579	p = 0.00002	p = 0.373
Professor	0.033	0.026	0.043	0.039
	(0.009)	(0.013)	(0.006)	(0.016)
	p = 0.001	p = 0.053	p = 0.000	p = 0.015
Residential	0.002	0.001	0.001	−0.001
	(0.001)	(0.001)	(0.0005)	(0.001)
	p = 0.007	p = 0.199	p = 0.096	p = 0.625
Women×Doctor	0.027	0.015	0.0002	0.024
	(0.014)	(0.019)	(0.011)	(0.028)
	p = 0.047	p = 0.441	p = 0.983	p = 0.386
Women×Professor	0.022	0.010	−0.012	0.017
	(0.015)	(0.020)	(0.012)	(0.030)
	p = 0.148	p = 0.613	p = 0.289	p = 0.565
Women×Residential	−0.001	−0.002	−0.0003	0.003
	(0.001)	(0.001)	(0.001)	(0.002)
	p = 0.557	p = 0.144	p = 0.680	p = 0.183
Intercept	−0.074	−0.073	−0.063	−0.044
	(0.013)	(0.016)	(0.008)	(0.020)
	p = 0.000	p = 0.00001	p = 0.000	p = 0.030
Observations	97267	74828	167203	26359
Log Likelihood	−61479	−48316	−103270	−19213
AIC	122979	96653	206560	38446

Table A6: Mixed effects models predicting February-May 2020 changes in the proportion of accepted review invitations per area of research. The baseline is represented by the average of the corresponding months in 2019. Models included time in residential areas from Google's COVID-19 Community Mobility Report (Google 2020). Random intercepts included for countries.

A.5 Robustness check using a more restrictive gender determination algorithm

Tables A7 and A8 include models based on a more restrictive gender determination algorithm, which keeps the rate of miss-classified names resolved by GenderAPI under 5%. In order to follow the optimal values of these confidence parameters from previous research (Santamaría and Mihaljević 2018), we queried this name-to-gender inference service by requiring a minimum of 62 samples with at least 57% accuracy (Main text). Results confirmed those presented in the manuscript but at a cost of increasing the percentage of academics without an assigned gender to 31.6%.

	Health & Medicine	Life Sciences	Physical Sciences & Engineering	Social Sciences & Economics
Women	−0.060	−0.005	−0.011	−0.046
	(0.005)	(0.005)	(0.006)	(0.012)
	p = 0.000	p = 0.328	p = 0.047	p = 0.0003
Doctor	0.091	0.030	0.103	0.023
	(0.004)	(0.004)	(0.004)	(0.010)
	p = 0.000	p = 0.000	p = 0.000	p = 0.017
Professor	0.152	0.045	0.160	0.011
	(0.006)	(0.005)	(0.005)	(0.012)
	p = 0.000	p = 0.000	p = 0.000	p = 0.391
Women×Doctor	−0.032	−0.013	−0.044	−0.014
	(0.006)	(0.005)	(0.007)	(0.015)
	p = 0.00000	p = 0.016	p = 0.000	p = 0.351
Women×Professor	−0.045	−0.015	−0.056	0.020
	(0.010)	(0.008)	(0.011)	(0.022)
	p = 0.00001	p = 0.073	p = 0.00000	p = 0.364
Intercept	0.216	0.137	0.160	0.214
	(0.012)	(0.008)	(0.011)	(0.012)
	p = 0.000	p = 0.000	p = 0.000	p = 0.000
Observations	1092693	755932	1144129	273897
Log Likelihood	−1854662	−1073299	−2149346	−527983
AIC	3709340	2146613	4298709	1055983

Table A7: Mixed effects models predicting February-May 2020 changes in the number of submissions per area of research area. The baseline is represented by the average of corresponding months in 2018 and 2019. Random intercepts included for countries. Gender data based on the stricter version of the gender determination algorithm.

	Health & Medicine	Life Sciences	Physical Sciences & Engineering	Social Sciences & Economics
Women	−0.036	−0.010	−0.009	−0.005
	(0.014)	(0.020)	(0.011)	(0.029)
	p = 0.011	p = 0.596	p = 0.390	p = 0.873
Doctor	0.008	0.014	0.018	0.016
	(0.009)	(0.013)	(0.006)	(0.016)
	p = 0.402	p = 0.304	p = 0.002	p = 0.327
Professor	0.032	0.030	0.036	0.036
	(0.010)	(0.014)	(0.006)	(0.017)
	p = 0.002	p = 0.025	p = 0.000	p = 0.037
Women×Doctor	0.025	0.009	0.006	−0.006
	(0.014)	(0.020)	(0.011)	(0.031)
	p = 0.078	p = 0.652	p = 0.592	p = 0.832
Women×Professor	0.016	0.006	−0.004	−0.009
	(0.016)	(0.021)	(0.012)	(0.032)
	p = 0.318	p = 0.792	p = 0.719	p = 0.780
Intercept	−0.047	−0.066	−0.045	−0.046
	(0.010)	(0.013)	(0.006)	(0.016)
	p = 0.00001	p = 0.00000	p = 0.000	p = 0.005
Observations	89041	69478	159765	22825
Log Likelihood	−56322	−44727	−98844	−16658
AIC	112660	89471	197704	33333

Table A8: Mixed effects models predicting February-May 2020 changes in the proportion of accepted review invitations per area of research. The baseline is represented by the average of the corresponding months in 2019. Random intercepts included for countries. Gender data based on the stricter version of the gender determination algorithm.