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Impact of COVID-19 on gender gap in dental publications: a retrospective cohort with three Brazilian journals

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Abstract: This was a retrospective cohort study to investigate the impact of COVID-19 pandemic on the gender gap in articles submitted to three international dental journals based in Brazil. All submissions performed to Brazilian Dental Journal, Brazilian Oral Research, and Journal of Applied Oral Science before (2019) and during the pandemic (2020) were assessed. Gender of the first, last, and corresponding authors were collected. Other variables collected were journal, continent studied by authors and stage of their careers (classified according to authors' highest degree), and final decision reached in the article. Absolute and relative frequencies with 95% confidence intervals, Pearson's Chi-square tests, and Fisher's Exact test were used ($\alpha = 0.05$). In total, 4,726 unique submissions were analyzed. A higher proportion of early-career authors was observed during the pandemic (44.8% to 49.3%, $p = 0.021$). Most articles were rejected but without association with gender. Increased proportion of male first authors from before to during the pandemic was observed (39% to 42.1%, $p = 0.034$). Drop in the proportion of articles with women as first authors was observed for researchers in their early- (65.9% to 58.8%, $p = 0.02$) and mid-career stages (63% to 55.8%, $p = 0.014$). Reduction in women as first authors was observed during the pandemic in South and Central Americas (66.7% to 61.5%, $p = 0.010$), and when the last author was a female, or the corresponding author was a male. In conclusion, a disproportionate impact on female dental researchers in submitting articles in the period from before to during the pandemic was observed when considering first authorship, suggesting that the COVID-19 may have increased the gender inequality in dental science.

Keywords: Gender Equity; Publications; Peer Review.

Introduction

Precisely on March 13, 2020, the World Health Organization declared that the world was faced with a pandemic caused by an emerging coronavirus (SARS-CoV-2) with a high rate of contagion and the potential to collapse health systems.[1] The Coronavirus Disease 2019 (COVID-19) had a profound impact on people's lives, whether due to quarantine or social distancing measures, death of family and friends, or impact on work, family relationships, and socioeconomic issues.[2,3] As occurred

in other work environments, COVID-19 directly affected academia[4] as social distancing forced the move toward working from home and engaging in remote teaching and learning. The period of the day that was once exclusive to working was then mixed and confused with household chores, care of the elderly, and supervision of children in remote education and leisure activities.[4-6]

The pandemic may have led to a more precise distinction between gender roles and overburdened women with house and care work.[5,7] For example, female healthcare workers continued their workdays, often with additional exhausting work on the front line in response to the demands caused by COVID-19 and double or triple shifts at home.[7,8] In the same way, the pandemic impact on women's routine affected researchers.[9,10] A recent editorial suggested that the consequences of COVID-19 could negatively impact an entire generation of female researchers.[11] Among possible academic impacts, lower productivity could be exemplified by fewer articles submitted to peer-reviewed journals or preprint platforms.[11-13] In the first six months of the pandemic, a study observed a significant reduction in the position of female scientists as first authors in transfusion medicine journals.[14] Low application of COVID-19 grant proposals by female investigators also was reported.[15]

Two studies conducted with high-impact dental journals reported the observation that South American publications had higher proportions of women as first or last authors than North America and Europe.[16,17] A potential cause is the high number of women doing oral health work in South American countries, including Brazil.[17] In 2020, Brazil was considered one of the pandemic epicenters.[18] Other nations, including low- and lower-middle-income countries in South America, Asia, and Africa, also suffered from major COVID-19 outbreaks.[19] Furthermore, these countries have a social environment and, sometimes, legislation that is unfriendly to women and their fundamental human rights, such as gender and racial violence, different payment for work, division of household chores, maternal and reproductive rights.[20] This sum of circumstances may have significantly affected women researchers' scientific production in those regions.

Previous publications have addressed the influence of the pandemic on the gender gap in medical and health sciences journals.[12,14] However, to the best of our knowledge, the impact on articles submitted or published by women in dental journals has not been investigated. Since 2006, Brazil has been the country ranked second with most articles published in international dental journals.[21] Thus, it is a relevant scientific environment in which to investigate the possible impacts of the pandemic on gender inequality in authorship. Therefore, this study aimed to evaluate the impact of the COVID-19 pandemic on the gender gap and female participation in the authorship of articles submitted to or published in three international dental journals based in Brazil in the period before and during the pandemic.

Methodology

This study was reported following The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[22]

Study design, setting, and ethical aspects

This observational, retrospective cohort study evaluated articles submitted to three international dental journals based in Brazil: Brazilian Dental Journal (Braz Dent J), Brazilian Oral Research (Braz Oral Res), and Journal of Applied Oral Science (J Appl Oral Sci). In Scimago Journal Rank 2020, Braz Dent J is classified as Q2, Braz Oral Res and J Appl Oral Sci are classified as Q1 in the top quartiles of impact on dentistry.[23] According to Scopus data,[24] in 2017–2020 these journals published 1,226 articles, gathered 3,822 citations, and reached 2021 CiteScores between 2.4 and 3.5. As a characteristic, a smaller portion of the articles published in these journals have authorship from high-income countries.[25-27] The study protocol was submitted to and approved by the Research Ethics Committee of the Universidade Federal de Pelotas, Brazil (protocol #42177020.0.0000.5318). Submission data were provided by the journal editors, who signed a term of consent for sharing the data with the research team, and only one researcher (MCF), who signed a confidentiality form, had access to the complete data. An unidentifiable

dataset was available to the other authors. All data management was carried out in compliance with the Helsinki declaration.

Eligibility criteria

All papers submitted to the three journals during the years 2019 and 2020, were eligible for this study. To be included, articles had to have been submitted between January 1, 2019, and December 31, 2020. Articles were included in the sample irrespective of the submission stage (*e.g.*, original or revised resubmission). Papers identified as retractions were excluded from the sample. Records that did not have the date of submission and/or authors' names were excluded. Articles with more than one entry in the journals' editorial system, such as articles resubmitted after a major/minor review decision, had only the most recent entry considered. The study was conducted with the use of a sample that could be considered a type of convenience sampling.

Variables

Exposure and outcomes variables

The COVID-19 pandemic was considered the exposure whereas the author's gender (male or female) and authorship position (first, last, or corresponding author) were the outcomes. The gender of main authors for each article was determined by associating their first names with the probability of the name being held by a man or a woman using genderize.io (https://api.genderize.io/?name=). In cases where the researcher's gender was inferred with a probability below 90%, we also checked researchers' online curricula vitae (CVs) available in ORCID (https://orcid.org), ResearchGate (https://www.researchgate.net/), LinkedIn (https://www.linkedin.com/home/), or institutional websites. For Brazilian authors, we also checked the Brazilian Lattes CV Platform (https://lattes.cnpq.br/). Date of the submission was also collected. This variable was then categorized into periods: 'before the COVID-19 pandemic', encompassing studies submitted in 2019, and 'during the COVID-19 pandemic', which included studies submitted in 2020.

Covariates

For each article, the following information was collected: journal; first authors' country, which was categorized by continent (Africa, North America, South or Central Americas, Asia, Europe, or Oceania); and first authors' career stage, which was classified into early, mid, or senior categories. Central America was grouped with South America due to the very the low number of submissions from Central American countries. The career stage was assessed by checking the ORCID profiles and using data of authors' highest degree: early career (< 5 years from obtaining the highest degree), mid-career (5–10 years) or senior-career (> 10 years). This classification was the same as that used in previous publications.[28,29]. For authors who did not have career stage information on ORCID, the information was searched in other platforms: Lattes CV Platform, ResearchGate, LinkedIn, or institutional websites. When no data on the career stage was found, this was treated as missing data. The final decision about each submission was also collected: immediate rejection, rejected after peer review, accepted, minor review, major review, inappropriate, or resubmit. For statistical analysis, the categories resubmit, inappropriate, and rejected were grouped into "Rejected". A diagram of data extraction and sources of information is presented in Figure 1.

The protocol for searching for information about the authors was previously developed in other publications and adapted to the procedure for extracting data from the present study[16,28]. All data were extracted in Microsoft Excel 2016 (Microsoft, Redmond, Washington, USA) spreadsheets by three independent researchers (MCF, ABLQ, LRMS) who were previously trained in data collection.

Statistical methods

The statistical software RStudio 1.3 (R Core Team, RStudio, Inc., Boston, USA)[30] was used in all analyses, in addition to statistical packages dplyr,[31] Hmisc,[32] psych[33] and DescTools.[34] Missing data were deleted in all tests. Initially, descriptive analysis of variables was performed using absolute and relative frequencies with their respective 95% confidence

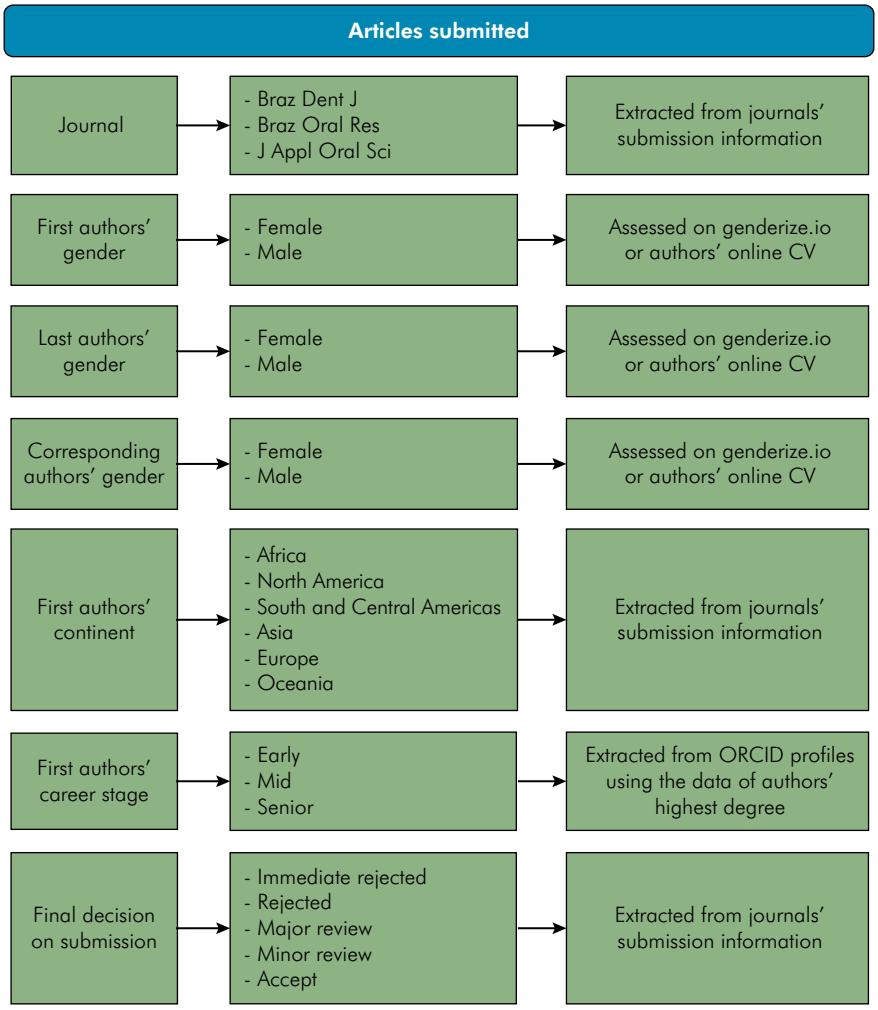

Figure 1. Diagram of data extraction and sources of information.

intervals, considering the period of submission. Then, Pearson's Chi-square test, Pearson's Chi-square test with Yate's continuity correction, and Fisher's Exact Test were used to evaluate changes according to the period of submission. Afterward, if significant associations were identified between the author's gender and the period of submission, we performed stratified analyses considering the author's gender as the outcome and the period of submission as the exposure. In addition, stratification was performed for confounders such as first author's career stage, first author's continent, last author's gender, and corresponding author's gender. No sensitivity analysis was carried out. All tests were performed considering a significance level of $\alpha = 0.05$.

Results

Out of the total number of 5,163 submissions (Figure 2), 385 submissions were excluded due to missing information about the author's gender and career stage, and 52 were duplicates, thus 4,726 individual submissions were analyzed. Considering the initial analyses presented in Table 1, there was a higher proportion of submissions to the Braz Oral Res when the periods before and during the COVID-19 pandemic (31.9% to 42.7%, $p < 0.001$) were compared. The majority of articles were immediately rejected or rejected and resubmitted after peer review. A significantly higher proportion of authors in their early career stages were observed in the submissions

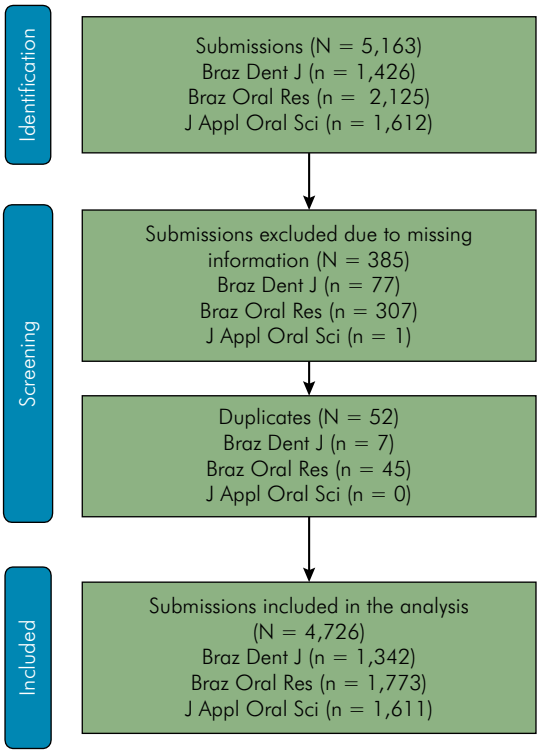

Figure 2. Flow diagram of article submissions included in the sample.

during the pandemic (44.8% before and 49.3% during the pandemic, p = 0.021). Although most of the submissions came from South or Central Americas, no significant differences were identified between the periods considering the first authors' continent. Considering the authors' gender, a significant difference was identified only for the first author, with an increased proportion of male first authors during the COVID-19 pandemic compared with the pre-pandemic period (3.1% increase, p = 0.021).

According to the stratified analysis performed to explore differences observed for first author gender (Table 2), women in the early-stage of their career showed a significant drop in the proportion of their article submissions as first authors during the pandemic (65.9% to 58.8%, p = 0.002). This drop was also significant for women in their mid-career stage: 63% and 56% as first authors before and during the pandemic, respectively (p = 0.014). In contrast, no differences were observed in the senior stage. Considering the first authors' continent in the stratification, a significant reduction of women in the first authorship position was observed in South and Central Americas from before to during the pandemic. Significant reductions in women as first authors were also observed when the last author was a female (70% before, 64% during the pandemic, p = 0.010). A reduction in the proportion of women as first authors was observed when a male was the corresponding author. Finally, an additional stratified analysis explored whether there were differences in gender and manuscript decisions in the period dating from before to during the pandemic, but no significant differences were observed, irrespective of the authorship position (data not shown here).

Discussion

This study showed that the COVID-19 pandemic was associated with a reduction in the submission of articles with female researchers in the position of first authors in three international dental journals based in Brazil. In the first authorship position, a decrease in submissions by female researchers in their early- and mid-career stages was observed during the pandemic, noticeably from South and Central Americas. Considering that the COVID-19 pandemic may have had a disproportionate effect relative to gender, the concern at present is that the already existent gender gap might have increased.[11] Unfortunately, findings of the present study appear to have provided evidence that the COVID-19 pandemic may have led to increasing the gender inequality in dental science.

The gender gap is present in dentistry.[16] An observatory study has shown that the vast majority of dental students are women, however this number decreases at each career step.[17] In the European Union, for instance, over 70% of graduate students are women, whereas the number decreases to 33% of women in the field of dental researchers.[17] Gender inequality is correlated with higher academic ranking and leadership positions in several countries, in addition to other gender disparities in the dental research sector.[17] For example, in a recent randomized controlled study with Brazilian dental scientists, male and female applicants for a scholarship had the

Table 1. Number of submissions according to journals, author variables, and period (before or during the pandemic), n = 4,726.

Variable/Categories[a]	n (%) [95%CI][b]		p-value
	Submissions before COVID-19	Submissions during COVID-19	
Journal (4,726)			
Braz Dent J	747 (32.9) [31.0–34.9]	595 (24.2) [22.5–25.9]	< 0.001*
Braz Oral Res	723 (31.9) [30.0–33.8]	1,050 (42.7) [40.7–44.7]	
J Appl Oral Sci	798 (35.2) [33.2–37.2]	813 (33.1) [31.2–34.9]	
Manuscript decision (4,726)			
Immediate rejected	913 (40.3) [38.5–42.3]	1,160 (47.2) [45.2–49.2]	< 0.001*
Rejected	1,073 (47.3) [45.3–49.4]	1,044 (42.5) [40.5–44.4]	
Major review	70 (3.1) [2.4–3.8]	73 (3.0) [2.4–3.7]	
Minor review	22 (0.9) [0.6–1.4]	8 (0.3) [0.16–0.6]	
Accept	190 (8.4) [7.3–9.6]	173 (7,0) [6.1–8.1]	
First author continent (4,489)			
Africa	54 (2.4) [1.9–3.2]	58 (2.5) [1.9–3.2]	0.737*
North America	51 (2.3) [1.8–3.1]	49 (2.1) [1.6–2.8]	
South or Central America	1,132 (51.9) [49.8–54.0]	1,178 (51.0) [48.9–53.0]	
Asia	824 (37.8) [35.8–39.8]	888 (38.4) [36.5–40.5]	
Europe	110 (5.0) [4.2–6.0]	131 (5.6) [4.8–6.75]	
Oceania	9 (0.4) [0.2–0.7]	5 (0.2) [0.09–0.5]	
First author career stage (3,625)			
Early	785 (44.8) [42.5–47.1]	923 (49.3) [47.0–51.5]	0.021*
Mid	590 (33.7) [31.5–35.9]	593 (31.7) [29.6–33.8]	
Senior	377 (21.5) [19.6–23.5]	357 (19.1) [17.3–20.9]	
First author gender (4,622)			
Female	1,355 (61.0) [58.9–62.9]	1,389 (57.9) [55.8–59.8]	0.034**
Male	867 (39.0) [37.0–41.1]	1,011 (42.1) [40.2–44.1]	
Last author gender (4,303)			
Female	1,036 (47.4) [45.3–49.5]	1,145 (48.0) [46.0–50.0]	0.709**
Male	1,149 (52.6) [50.5–54.6]	1,240 (52.0) [49.9–53.9]	
Corresponding author gender (4,612)			
Female	1,237 (56.0) [53.9–58.1]	1,319 (54.9) [52.9–56.9]	0.487**
Male	973 (44.0) [41.9–46.1]	1,083 (45.1) [43.1–47.1]	

[a]Number of entries varies from N due to missing data; [b]Column percentages. CI: confidence Interval. *Pearson's Chi-square test. **Pearson's Chi-square test with Yates' continuity correction.

exact same CV, but men received higher scores in all curriculum categories, namely scientific contribution, leadership potential, ability to work in groups, and international experience.[29] This result was observed irrespective of the gender of the assessor evaluating the candidates.[29] Additionally, under-representation of women in different academic environments has been shown, including undergraduate dentistry courses, leadership positions,[17] and as first or last authors in top-tier dental journals.[16,35] In this study,

Table 2. Stratified analysis by covariates between the period of submission and gender of the first author, n = 4,726.

Variable	First author gender, n (%)[a]		p-value
	Female	Male	
First author career stage (3,625)			
Early			0.002*
Before COVID-19	515 (65.9)	266 (34.1)	
During COVID-19	535 (58.8)	375 (41.2)	
Mid			0.014*
Before COVID-19	365 (63.0)	214 (37.0)	
During COVID-19	329 (55.8)	260 (44.2)	
Senior			0.253*
Before COVID-19	186 (50.1)	185 (49.9)	
During COVID-19	194 (54.6)	161 (45.4)	
First author continent (4,489)			
Africa			0.293*
Before COVID-19	36 (66.7)	18 (33.3)	
During COVID-19	32 (55.2)	26 (44.8)	
Asia			0.860*
Before COVID-19	443 (56.1)	346 (43.9)	
During COVID-19	447 (54.0)	381 (46.0)	
Europe			0.247*
Before COVID-19	53 (48.6)	56 (51.4)	
During COVID-19	52 (40.3)	77 (59.7)	
North America			0.898*
Before COVID-19	20 (40.0)	30 (60.0)	
During COVID-19	18 (36.7)	31 (63.3)	
South or Central America			0.010*
Before COVID-19	755 (66.7)	376 (33.3)	
During COVID-19	722 (61.5)	451 (38.5)	
Oceania			0.300**
Before COVID-19	4 (44.4)	5 (55.6)	
During COVID-19	4 (80.0)	1 (20.0)	
Last author gender (4,303)			
Female			0.008*
Before COVID-19	711 (69.5)	312 (30.5)	
During COVID-19	715 (64.0)	402 (36.0)	
Male			0.693*
Before COVID-19	599 (53.2)	526 (46.8)	
During COVID-19	636 (52.4)	579 (47.6)	

Continue

Continuation			
Corresponding author gender (4,612)			
Female			0.544*
Before COVID-19	1,058 (85.7)	176 (14.3)	
During COVID-19	1,105 (84.8)	198 (15.2)	
Male			0.028*
Before COVID-19	288 (29.8)	677 (70.2)	
During COVID-19	273 (25.5)	801 (74.5)	

[a]Number of entries varies from N due to missing data. Percentages refer to lines. *Pearson's Chi-square test with Yates' continuity correction; **Fischer's Exact Test.

researchers in their early and mid-career stages were more affected than senior researchers. This result was in line with the findings showing that female first authors were more affected by the pandemic than female corresponding authors, who generally were senior researchers. This was a relevant finding because it has been shown that the proportion of female workforce in dentistry was drastically reduced in senior career stages.[17] A possible hypothesis for this observation could be that pregnancy and raising children occurs more commonly in earlier career stages and may impact later career development. Moreover, further challenges may be imposed on early-career researchers by a critical workload and potential development of master's or doctoral courses in the meantime, for example.

An additional load on female researchers that needs to be considered in a pandemic scenario is that women are usually the primary persons responsible for taking care of children and the elderly in families.[10] With the closing of daycare centers and schools, associated with online classes and working from home, many women had to take care of their children simultaneously to teaching and doing administrative work in a completely new and challenging condition.[4-6] Besides taking care of the family, women are also the main persons responsible for household chores, resulting in doubling (or tripling) their usual working day.[4-6] If we add all of this extra work to the burden usually imposed on women to the entire sexist and patriarchal context in which we are socially inserted, on which the gender bias – implicit or not – interferes in the majority of daily actions of women's lives, this challenge becomes extremely disproportionate.[17,29,30] Another point that studies have shown is that women may be more psychologically affected by the pandemic effects and experience more anxiety and depression than men.[36] Mental problems may also arise from a greater burden of responsibilities imposed on women during the pandemic.[36] This may establish a cycle that favors an increase in the gender gap, manifesting as psychological illnesses that may impact women's productive capacity.[36]

Submissions by South and Central American female researchers in the position of first authors were reduced during the pandemic, whereas the same effect was not observed in other continents. It should be highlighted that South America had the highest proportion of female authors in the present sample. As the majority of submissions were from South America, the present sample did not have the power to detect differences in other continents, such as Africa. The result in South America could be related to differences in the proportions of men and women in the dental research workforce across the globe. In Brazil and South America, a higher fraction of female dental researchers has been reported when compared with countries in North America and Asia,[16,17] a finding that could be partly explained by the high proportion of women in healthcare professions in South America. The higher impact on South and Central American researchers could also be related to differences in the development of the pandemic across continents.

In Brazil, a general lack of COVID-19 control measures applied by the federal government was observed,[18,37] and up to now, spread of the virus has not been controlled. In this type of chaotic scenario that failed to follow guidelines based on scientific data and advice, the motivation for engaging in research and publications could be lower, especially when associated with overburdening household activities. The pandemic crisis may have long-term consequences for South and Central American science, including discouragement to follow a scientific career. This could be even more stressful in careers that involve working in a high-risk setting for exposure to contracting COVID-19, such as dentistry. Further investigation into the long-term impacts of the pandemic on the scientific careers of dental researchers is warranted.

To the best of the authors' knowledge, this is the first study to evaluate the effect of the pandemic on the submission of articles to dental journals and the participation of female researchers in these. The evaluation of all submissions to the three dental journals is a strong aspect of the study because it considered a broader environment of authorship than that of published articles alone. The evaluation of only articles that have been published could be affected by publication bias and timeliness between submission, peer review process, and publication. Despite the differences in authorship gender reported herein, there were no differences in the decisions relative to acceptance or rejection of the manuscripts between male and female authors. A limitation of the present study was that we considered the entire years of 2019 as 'before' and 2020 as 'during' COVID-19, and some overlapping between the periods may have been in place because the pandemic was declared in March, 2020. In addition, gender was a binary variable herein, which means that information on gender bias did not consider gender identity and gender-diverse persons. Another limitation was the evaluation of gender by an application programming interface. One study observed differences across name-to-gender inference services,[38] but also reported that genderize.io achieved less than 2% error for misclassifications. Future studies should also consider aspects related to the ethnicity, socioeconomic status, and family structure of the researchers as these may additionally affect the patterns of article submissions.

The observation that COVID-19 pandemic disproportionately affected female dental researchers raised questions that stakeholders need to reflect upon. Journal editors and publishers need to be aware of the gender gap to avoid reducing female participation in the dissemination of science, for example by ensuring double-blind peer reviewing practices. Universities and research funding agencies should be on the lookout to ensure support for female researchers and perhaps encourage gender equity practices. These may include the implementation of gender equality education and fostering practices to balance CVs from mothers of young children. Finally, researchers could investigate ways of mitigating the problems related to the gender gap in science and academia now and after the pandemic is over.

Conclusion

This study addressed the disproportionate impact on female dental researchers in articles submitted to three international dental journals based in Brazil in the period dating from before to during the COVID-19 pandemic. A reduction in the submission of articles with female researchers as first authors during the pandemic was observed, suggesting that the COVID-19 may have increased the gender inequality in dental science.

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