Scientometrics
https://doi.org/10.1007/s11192-024-05212-y

The impact of the virtualization of scholarly conferences on the gender structure of conference contributors

Agnieszka Olechnicka[1] · **Adam Ploszaj**[1] · **Ewa Zegler-Poleska**[1]

Received: 17 July 2024 / Accepted: 19 November 2024

Abstract
The underrepresentation of women in academic conferences is an underexplored aspect of gender disparity in science. This study aims to expand knowledge on this issue by investigating whether the virtualization of academic conferences in the wake of the COVID-19 pandemic changed the gender structure of conference participants. We explored this question utilizing authorship data from the Web of Science Conference Proceedings Citation Index for 180 conferences in 30 conference series held between 2017 and 2023, with a total number of 88,384 papers and 404,295 authors. At least one edition of each analyzed conference series was launched in a virtual or hybrid form. This sample enables a comparison of differences in the gender participation of conference authors while controlling for heterogeneity among conference series. Using linear and logistic regression models, we identified a positive difference in women's involvement in virtual and hybrid conferences compared to onsite events. However, this effect was due less to the increased participation of women in virtual and hybrid conferences than to the decreased participation of women in the onsite editions of the analyzed conference series.

Keywords Academic conferencing · Virtual conferences · Inequalities in academia · Gender diversity

Introduction

Gender disparity in academia remains evident. Women generally publish fewer papers, achieve lower citation rates, and face more challenges in disseminating their research (Song et al., 2024; Sugimoto et al., 2015; Vásárhelyi et al., 2021). Despite the gradual increase in the representation of women in research staff and grant awards, the gender gap in research output has persisted over the past two decades (Elsevier, 2024). The underrepresentation of women extends to academic conferences, where women remain less visible, particularly as speakers and in high-status roles (Blumen & Bar-Gal, 2006; Braun et al., 2023; Falk & Hagsten, 2022). This further undermines their position because scholarly conferences are

✉ Adam Ploszaj
a.ploszaj@uw.edu.pl

[1] Science Studies Lab & Centre for European Regional and Local Studies EUROREG, University of Warsaw, Warsaw, Poland

critical for scientific discussion, communication, and networking – essential components for career development (Hansen & Budtz Pedersen, 2018; Jacobs & McFarlane, 2005; Leon & McQuillin, 2020; Teplitskiy et al., 2024).

The COVID-19 pandemic significantly disrupted scholarly activities. It led to a surge in journal publications, albeit with unequal impacts across academic groups (García-Costa et al., 2024; Ioannidis et al., 2022; Kwon et al., 2023; Madsen et al., 2022). The literature confirms the gender gap in number of publications across disciplines (Jemielniak et al., 2023), the intensity of new project initiation (Gao et al., 2021), and available time for scientific work (Esquivel et al., 2023; Myers et al., 2020).

At the same time, the shift to virtual platforms transformed scholarly communication and networking practices (Waltman et al., 2021). The impact of virtual conferences on gender inequality remains a subject of debate, with mixed findings (Olechnicka et al., 2024). For example, while certain studies indicate positive changes in gender composition among conference participants due to the online transition (Biermann, 2024; Skiles et al., 2022; Walton et al., 2022), while others report that gender disparities persist or even worsen (Falk & Hagsten, 2022; Jarvis et al., 2023; Standaert & Thunus, 2022; Zhang et al., 2023). These inconsistent findings highlight the need for comprehensive studies that analyze gender participation over a more extended period and across multiple conference formats, using reliable and objective data of high credibility.

This study seeks to address this gap by exploring how the virtualization of academic conferences due to the COVID-19 pandemic has influenced the gender structure of participants. The study addresses the research question: How has the virtualization of academic conferences due to the COVID-19 pandemic altered the gender structure of conference participants? The hypothesis tested in this paper is that virtual and hybrid modes of academic conferences are associated with higher participation of women scholars than onsite conferences.

Conducting research in this area is crucial to assess the scale of changes in women's participation in academic conferences due to shifts in their format and highlight virtualization as a potential driver for increasing women's presence in academia. This study contributes to the broader discourse on the positive impact of gender diversity on scientific innovation, research productivity, and the visibility of academic work (Hofstra et al., 2020; Mulders et al., 2024).

The paper is structured as follows. It begins with a review of the literature on gender disparity in academia particularly in scholarly conferences, and its evolution during the COVID-19 pandemic. Detailed descriptions of the data sampling, methods, and results follow. The paper finishes with a discussion and conclusions drawn from the study.

Literature review

However, the share of female researchers globally has approached parity (47% in 2022), and 37% of research grants are now awarded to women, the gender gap in research output and outreach as well as career progression persists (Astegiano et al., 2019; Elsevier, 2024; Halevi, 2019). Women generally publish fewer papers and have lower citation rates than men, but these differences vary by field and country (Boekhout et al., 2021; Huang et al., 2020). Men continue to dominate fields like mathematics, physics, and software engineering, while women are more productive and highly cited in the female-dominated field of nursing but not in psychology (Sá et al., 2023). Additionally, there remains significant

underrepresentation of women in STEM disciplines and patent creation (Elsevier, 2024). Furthermore, altmetric studies indicate that women are less successful in disseminating their research online (Song et al., 2024; Vásárhelyi et al., 2021). Factors contributing to this disparity include differences in career length, dropout rates, institutional support, and stereotypes relating to gender (Duch et al., 2012; Huang et al., 2020; Jadidi et al., 2018; Nielsen et al., 2017). Country-level development indicators also play a role. Lower human development and higher gender inequality correlate with reduced female participation in academia (Elsevier, 2024; Larivière et al., 2013).

Gender disparity in scholarly conferences

The issue of gender disparity extends beyond research output and recognition. Studies of participation in conferences and other academic meetings consistently reveal a persistent underrepresentation of women, particularly in prestigious roles. This disparity is evident across various disciplines, highlighting the widespread nature of the problem. As one example, despite increased overall participation, women remain underrepresented in high-status positions at the annual meetings of the Israeli Geographical Society (Blumen & Bar-Gal, 2006). This trend is also evident in the fields of academic tourism, hospitality, leisure, and events, where gender inequality persists among keynote speakers and members of honorary committees (Walters, 2018). In evolutionary biology, and gambling studies women are less frequently represented as invited speakers at conferences, However, the proportion of invited women tends to be higher when there are more women among the organizers (Débarre et al., 2018; Monson et al., 2023). Similarly, gender and geography significantly influence author representation at the Association for Information Science and Technology Annual Meeting (Buchanan & McKay, 2022). In critical care, despite some progress, gender disparity remains, with male speakers still outnumbering female speakers at conferences (Dymore-Brown et al., 2024). Women are also underrepresented in computer science as colloquium speakers at top universities, but having female colloquium chairs increases the likelihood of female speakers (Nittrouer et al., 2018). On average, women accounted for less than one-third of the speakers at medical conferences held between 2017 and 2018 in Australasia, Canada, Europe, the UK, and the US, but the proportion varied significantly, ranging from 5.8 to 74.5% (Arora et al., 2020). In economic conferences, paper submissions authored solely by women are 3.3% less likely to be accepted, largely due to gender stereotypes in the review process (Hospido & Sanz, 2021).

The findings discussed above can be disturbing because academic conferences are essential for scientific work and scholarly communication, serving as vital spaces in which scientific knowledge is scrutinized, debated, and refined (Hansen & Budtz Pedersen, 2018; Jacobs & McFarlane, 2005). Gender disparities in participation and recognition at these events not only impede equitable career advancement for women but also limit the diversity of perspectives that are critical for driving innovation in science and scientific progress (Hofstra et al., 2020; Mulders et al., 2024; Nielsen et al., 2017). Addressing this imbalance is essential to ensuring conferences foster inclusivity and maximize the potential of the scientific community.

Finally, it should be noted that gender disparities intersect with geographic location and socio-economic conditions, creating additional barriers to participation for scholars from underrepresented regions (Mickey & Smith-Doerr, 2022). Women from countries with lower gender equality indices or fewer economic resources may face compounded challenges, even in virtual formats, due to digital exclusion and lack of institutional support.

Efforts to enhance inclusivity at conferences must address not only gender but also these broader intersectional factors (Kozlowski et al., 2022). However, as a recent review (Robinson-García et al., 2024) highlights, advances in scientometric tools enable nuanced analyses of diversity, yet many aspects, including socio-economic background, are difficult to measure.

Gender disparity in scientific productivity amidst COVID-19

Academic work has been disrupted by the COVID-19 pandemic. The increasing demand for research due to the COVID-19 pandemic and anti-contagion public measures impacted academic productivity positively. Interestingly, although the abnormal peak of submissions was dominated by health and medical researchers during the early stages of the pandemic, submissions to social science and economics journals later increased (García-Costa et al., 2024). However, the so-called "covidisation of research" did not affect all academic groups equally, and the citation impact for COVID-19 publications far exceeded that of works in other fields, significantly influencing the citation profiles of scientists and shaping the scientific elite (Ioannidis et al., 2022).

In addition, the positive impact was not equal. During the first wave of the pandemic, junior women scientists submitted proportionally fewer manuscripts than men (García-Costa et al., 2024; Madsen et al., 2022). This was even more prominent for junior women working in less prestigious academic organizations located in less gender-equal countries (Kwon et al., 2023). Even though some studies did not observe a decline in the number of manuscripts submitted by women, they indicated that the pre-pandemic rise in manuscript submissions had subsided and that authors in all journals, countries, and fields were overwhelmingly men before, during, and after the pandemic (Son & Bell, 2022).

Significant differences in publication patterns between genders were reported in different disciplines, although there were no significant differences between men and women in overall publication patterns between 2019 and 2021 (Jemielniak et al., 2023). The pandemic negatively impacted many female scholars' work habits and routines due to higher competing demands from family obligations, such as home-schooling and parental care (Esquivel et al., 2023; European Commission: Directorate-General for Research & Innovation, 2023). Female scientists, especially those with young children, experienced a decline in the rate of new project initiation (Gao et al., 2021) and a substantial drop in time devoted to research (Myers et al., 2020).

The virtualization of scientific conferences and the gender gap

Scholarly communities responded to pandemic-related restrictions by moving research communications to the virtual space (Waltman et al., 2021). Virtual conferences have been lauded for their inclusiveness, allowing women, early-career scientists, people with disabilities, and researchers from less affluent countries to participate by reducing costs and eliminating travel barriers. Still, the transition to remote or hybrid formats introduced several challenges that limited potential inclusiveness, such as digital exclusion, reduced networking opportunities, and lower conference engagement of attendees with caregiving responsibilities, particularly women (Olechnicka et al., 2024).

Several empirical studies reported reduced gender disparity resulting from transitioning scholarly conferences to an online format. For instance, the transition to a virtual mode in 2020 for three scientific conferences—the International Conference on Learning

Representations (ICLR), the American Astronomical Society (AAS), and the North American Membrane Society (NAMS)—increased the number of attendees compared to traditional in-person meetings, with higher rises in female participation (60–260%) than in male participation (Skiles et al., 2022). Similarly, the shift to remote presentations for economics seminars held by 270 institutions worldwide between 2018 and 2021 led to a significant increase in the number of women leading seminars (Biermann, 2024). The shift to online formats during the pandemic further increased women's participation, even in conferences where they were already highly represented, such as the Agriculture, Nutrition & Health Academy Week in 2021, where women made up 65% of attendees (Walton et al., 2022), and the International Communication Association, where female participation rose from 52% in 2005 to 59% in 2022 (Braun et al., 2023).

Nonetheless, other studies indicate that virtual meetings have exacerbated gender inequalities in academic settings. For instance, an online survey distributed to 542 academic researchers from five Belgian universities one month into the COVID-19 lockdown revealed that the overall number of meetings increased from 5.50 to 6.08 per week during the pandemic. Although men experienced a significant increase in meetings, the increase for women was not substantial, widening the gender gap. Additionally, 31% of women, particularly women in lower hierarchical ranks, reported greater difficulty speaking up in virtual meetings compared to 20% of men (Standaert & Thunus, 2022). Several studies also highlight the persistence of gender inequalities in virtual academic environments, but they can serve more as background points than primary references for the proposed research. For instance, Jarvis and colleagues (2023) found that men continued to dominate question-and-answer sessions in virtual conferences; Zhang et al. (2023) observed that although gender parity was achieved in the audience, women asked half as many questions as men; Falk and Hagsten (2022) found that the facilitation of participation through the online format did not significantly increase the proportion of women among keynote speakers.

The findings from recent studies indicate that while virtual conferences have lowered entry barriers and increased women's access to scientific events, they have not resolved the gender disparities in active participation and visibility. The rise in female participation in virtual conferences in quantitative terms has not been accompanied by a corresponding improvement in the qualitative dimension, such as delivering keynote lectures or engaging actively in discussions. This indicates that, despite the potential of online conferences to facilitate greater inclusivity, structural gender inequalities remain deeply entrenched and require further investigation and targeted interventions.

This study addresses the existing research gaps by contributing to the understanding of the long-term effects of virtual and hybrid conference modes on gender equality in academia. While previous studies have often focused on short-term impacts or individual events during the peak of the pandemic, this study provides a comprehensive analysis that examines gender participation over a longer period and across multiple conference formats, using reliable and objective data of high credibility. This approach offers valuable insights for advancing the discussion on gender equality in academic participation.

Data and methods

Whereas prior studies primarily relied on conference registration data (Skiles et al., 2022; Zhang et al., 2023), conference programs (Falk & Hagsten, 2022; Jarvis et al., 2023), survey results (Standaert & Thunus, 2022), in-depth interviews, focus groups, and video

recordings of virtual events (Walton et al., 2022), our approach utilizes a different source: conference proceedings indexed in the Web of Science database (WoS, Clarivate). In May 2024, we searched for conference proceedings indexed in the Conference Proceedings Citation Index (CPCI), including both the Conference Proceedings Citation Index-Science (CPCI-S) and the Conference Proceedings Citation Index-Social Science & Humanities (CPCI-SSH), which we accessed through the University of Warsaw Library. Our searches were deliberate and targeted, rather than random, as the latter would have been unfeasible. We aimed to identify international conferences from different disciplines, occurring regularly, and resulting in proceedings with data enabling a gender analysis of the authors' names. The resulting set of conferences does not meet the criteria for a truly random sample. However, we believe that it avoids biases other than those resulting from the database's characteristics.

In the first step, we limited the search in WoS CPCI to the years 2017–2023 to collect proceedings data covering seven years, with the pandemic year 2020 serving as a midpoint. Next, we inspected the search results using the "Conference Titles" filter and further refined the results using other available WoS filters. We used "Conference Titles" and not "Publication Titles" because the proceedings of different conferences may be published in the same publication series (such as Lecture Notes in Computer Science). A notable issue we encountered was inconsistency in conference titles. For example, the titles of the conference editions varied slightly, so the proceedings were indexed under several different titles rather than one consistent title.

In the next step, we focused on the conferences whose titles seemed relevant to our study, specifically those indicating that the conferences were held regularly (titles containing words such as "annual meeting") and had an international scope ("international conference"). We then checked whether proceedings were available for 2017–2023. We aimed to cover the entire timespan, but it proved difficult. Finally, we inspected the details of the proceedings to verify whether the full first names were provided. If the verification was positive, we included the conference for analysis and downloaded the proceedings' full records from WoS as Excel files. Nevertheless, we also encountered inconsistencies in WoS data because some editions of the same conference did not feature full first and last names.

We collected data for all document types and did not exclude any type of document indexed in CPCI. However, we decided early on to exclude large medical conference proceedings for two main reasons. First, we aimed to cover various disciplines in our data. Second, on a more practical level, medical conference proceedings tended to provide only the initials of the authors' first names rather than the full names, making it impossible to conduct a gender analysis. We acknowledge that such conferences might warrant a separate study due to their specific characteristics and the existing literature addressing gender issues in the field of medicine. Overall, this process resulted in the selection of 30 conference series encompassing 180 individual events, in which 88,384 papers were presented, with a total number of 404,295 authors. The list of the full names of the conferences selected for the analysis is presented in Table 6 in the Appendix. Additionally, Table 7 in the Appendix shows disciplines (defined as Web of Science research areas) covered by each selected conference.

We defined four conference modes: onsite, virtual, hybrid, and switched. The onsite mode is the traditional meeting in a physical location where participants gather in person, while the virtual mode is an online event that allows participants to attend from anywhere in the world. The hybrid mode combines the two previous modes. Finally, the switched mode refers to a meeting that was initially planned as onsite but was subsequently

"switched" to a virtual one. In our study, the switched mode occurred only in 2020 and is analyzed together with the onsite mode because participants registered assuming that it would be onsite.

Web of Science provides information on the locations of conferences, including online events, designated as "ELECTR NETWORK." However, it does not include information on hybrid events. To address this gap, we conducted internet searches for each edition of each conference, consulting the official conference websites and other available sources, such as calls for papers published on external websites, to verify the location and assign a mode to the event. We encountered some difficulties in classifying editions into a specific mode. For instance, the website of the 2023 edition of the Conference on AI, Ethics, and Society (AIES), stated that "the virtual option is not for presenting authors," so we classified it as an "onsite" event. In another example, the International Conference on Artificial Neural Networks (ICANN) website indicated that its 2020 conference had been canceled, but the proceedings were published and appeared in WoS CPCI; thus, we classified this edition as "onsite."

Table 1 presents the abbreviated names of the conferences and their modes. Blank cells indicate that no proceedings data was available in the Web of Science database. With proceedings data for only 15 conferences, 2023 features the most gaps, 2021 was dominated by the virtual mode, and the hybrid mode prevailed in 2022. Overall, after the virtual boom in 2021, there was a gradual return to the onsite mode.

For the purposes of this research, we treat gender as a binary variable, including only men and women, but we acknowledge that there are other gender identities, such as non-binary or trans (Lindqvist et al., 2021). The collected proceedings data was processed using a custom R script to extract authors' first and last names and affiliations. The gender of the conference contributions' authors was identified based on their first and last (family) names as well as the country of their academic affiliation. To do so, we used NamSor gender detection tool. The effectiveness of this tool has been verified in independent empirical tests, the results of which indicate a very high accuracy of the tool compared to other available solutions (Sebo, 2021). A gender was assigned to 99.7% of the authors of the analyzed conference contributions.

The number of women authoring conference papers between 2017 and 2023 was relatively stable, with the average percentage of women authors ranging from 29.4 to 34.1%. In the analyzed set, an upward trend in the share of women among the authors of the analyzed conference contributions is visible (Table 2). At the same time, there is also a very large variation in the participation of women in individual conferences, which is reflected in the large difference between the minimum and maximum values (full data on the participation of women in the individual editions of the analyzed conference series are presented in Table 10 in the Appendix).

The analysis carried out in this study had two variants associated with different ways of calculating the explained variable: OLS and Logit. In the first analysis, the explained variable was the percentage of women authors in the proceedings of the analyzed conferences. Because this is a continuous variable, the appropriate analytical method is simple linear regression. The second approach estimated the probability that a presentation's author was a woman. Since this variable is binomial, the appropriate analytical method is logistic regression. The main difference between the two approaches is the level of analysis and the related number of observations. In the first approach, the level of analysis is the conference; in the second approach, it is the conference participant. Performing an analysis at the level of conference participants allowed us to control the covariates describing individual participants. In this analysis, we considered the country of affiliation of the

Table 1 Modes of the analyzed conference series

Conference series abbreviation	2017	2018	2019	2020	2021	2022	2023
ACHEMS		o	o		v	v	o
ACL	o	o	o	v	v	h	h
AEA	o	o	o	o	v	v	o
AIED	o	o	o	s	h	h	
AIES		o	o	o	v	h	o
BIOPHYS	o	o	o	o	v	o	
CHI	o	o	o	s	v	h	h
COMPNET	o	o	o	s		h	o
CSEDU	o		o	s	v	v	
DGO	o	o	o			v	o
ECGBL	o	o	o		v		
ECKM	o	o	o	s	h		
EDUCON	o	o	o	s	v	h	
EUCAP	o		o	s	v	h	o
GLOBECOM	o	o	o	v	h	h	
HEAD	o	o	o	s	v	h	
ICANN	o	o	o	o	v	h	h
ICIP	o	o	o	s	v	h	h
ICML		o	o	v	v	h	
IJCNN	o	o	o	s	v	o	o
INTER	o	o	o	s	h	h	
IUS	o	o	o	s	v	h	
JCDL	o	o	o		v	h	
KDD	o	o	o	s	v	o	o
MME	o	o	o	s	h	h	
NENE	o	o	o	h	h		
ROMAN	o	o	o	s	v	h	h
SMART	o	o	o	v	v		
WACV	o	o	o	o	v	o	o
WEBCONF	o	o	o	s	v	h	o

Legend

o	onsite
s	switched
v	virtual
h	hybrid

Table 2 Share of women among the authors of the analyzed conference contributions (%)

	2017	2018	2019	2020	2021	2022	2023
Average	29.4	30.3	31.2	30.7	34.1	33.4	33.0
Standard deviation	9.0	8.4	9.8	8.5	9.3	8.4	7.4
Min	13.0	14.6	12.6	14.4	16.9	18.0	16.6
Max	54.0	54.4	60.7	54.4	56.4	56.7	45.8

conference participant and the participant's country GDP per capita (which was impossible in the analysis at the conference level) (Table 3).

In both analyses, the primary variable of interest was the type of conference, a binary variable taking the value of 1 for conferences held in virtual or hybrid mode and 0 for

Table 3 Variables employed in the analyses

Type of variable	Variable	OLS	Logit
Explained variables	Share of women among the authors of conference contributions	✓	
	Gender of the authors of conference contributions (1 = women, 0 = men)		✓
Explanatory variable	Conference mode (1 = virtual or hybrid; 0 = onsite or switched from onsite to virtual/hybrid)	✓	✓
Control variables	Conference year	✓	✓
	Conference series (dummy)	✓	✓
	Number of papers presented (log)	✓	✓
	Conference host country (dummy)	✓	✓
	Participant country (dummy)		✓
	Participant's country GDP per capita (log)		✓

conferences held in onsite mode or planned as onsite but changed to virtual or hybrid mode (switched). The switched type appeared only in the pandemic year of 2020. The control variables used in both analyses were conference series, year of conference organization, host country of the conference, and the total number of papers presented at a given conference. Moreover, the Logit analysis used a country of the participant affiliation and the participant's country GDP per capita to account for between country differences. In both the OLS and Logit variants, several specifications were estimated with a smaller or larger range of control variables (for details, see the results section).

Importantly, individual editions in the conference series could not be treated as independent observations, primarily because regular conferences usually attract the same participants and have their own rules and customs—all of which may affect the explained variable we are interested in. To mitigate this presumed observation dependence, the model used robust errors clustered by conference series. This approach allowed us to estimate the correct standard errors and significance levels despite violating the requirement of independence of observation.

Results

Between 2017 and 2019, the participation of women in analyzed onsite conferences slightly increased, from 29.4% to 31.2%. The year 2020 stands out because women's participation in onsite and switched conferences was at 32.4%, maintaining the previous trend, while their participation in virtual and hybrid conferences was low, around 23.4%. However, 2020 was unique in that only five conferences in our dataset were categorized as virtual or hybrid because most events had been planned as onsite and were switched at the last minute. The shift to entirely virtual and hybrid conference formats after 2020 had a positive impact on women's participation, which reached 34.1% in 2021 and 2022, and 35.2% in 2023. In 2022 and 2023, a noticeable difference in women's participation between onsite and virtual or hybrid conferences was observed: 34.1 vs. 29.3% in 2022 and 35.2 vs 31.8% in 2023 (see Fig. 1). This suggests that the gender disparity in conference participation was primarily driven by a decrease in women's participation in onsite conferences rather than an increase in virtual conference participation.

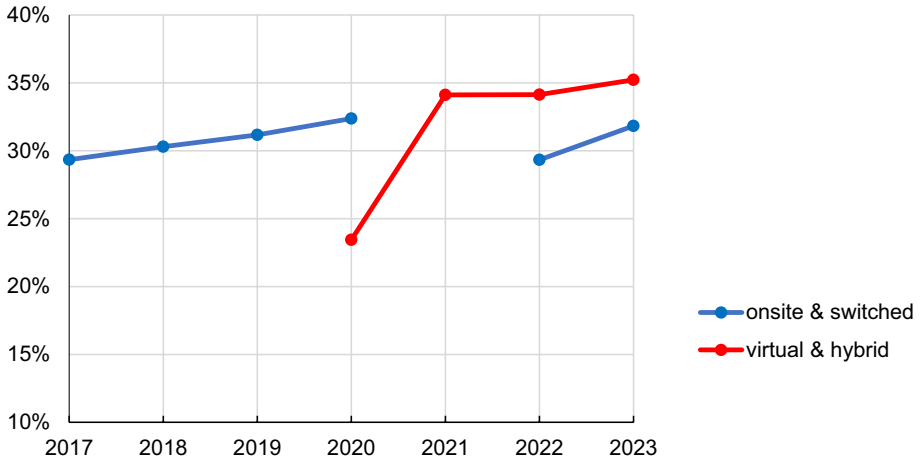

Fig. 1 Percentage of women among the authors of conference contributions by conference mode

The results of the statistical modeling are presented in Tables 4 and 5. Table 4 displays the results of the linear model (OLS), in which the explained variable was the percentage of women among the authors of conference contributions. The analysis was performed for two specifications that differ only in including the host country dummy (i.e., information about the country where the conference was held). Both specifications had a very high value of the R-squared statistic, which resulted from the use of a conference series dummy. Both specifications provided consistent results indicating a relationship between conference mode and the percentage of women participating. The effect had quite good statistical significance (p-value = 0.016 in Specification 1 and p-value = 0.02 in Specification 2), especially considering the relatively small sample (180 observations). At the same time, this observed effect, although statistically significant, was relatively modest in its scale. The parameter estimates of 0.013 in Specification 1 and 0.021 in Specification 2 mean that the expected difference in the percentage of women among the authors of conference contributions between onsite conferences and virtual

Table 4 Effect on the percentage of women among the authors of conference contributions, OLS results

	(1)	(2)
Virtual or hybrid	0.013**	0.021***
	(0.005)	(0.007)
Conference year	0.006***	0.006***
	(0.002)	(0.002)
Number of papers (log)	0.028	0.029
	(0.018)	(0.021)
Conference series (dummy)	✓	✓
Host country (dummy)		✓
Observations	180	180
R-squared	0.924	0.939

Errors in parentheses (robust, clustered by conference series)

Significance levels: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 5 Effect on the likelihood that the author of a conference contribution is a woman, Logit results, odds ratio

	(1)	(2)	(3)	(4)
Virtual or hybrid	1.054***	1.043**	1.095***	1.071***
	(0.017)	(0.018)	(0.026)	(0.023)
Conference year	1.032***	1.025***	1.034***	1.028***
	(0.006)	(0.004)	(0.005)	(0.004)
Number of papers (log)	1.049*	1.023	1.045*	1.021
	(0.030)	(0.022)	(0.026)	(0.021)
GDP per capita (log)	0.857***	0.819**	0.858***	0.814**
	(0.025)	(0.075)	(0.025)	(0.078)
Conference series (dummy)	✓	✓	✓	✓
Participant country (dummy)		✓		✓
Host country (dummy)			✓	✓
Observations	356,089	356,056	356,089	356,056

Errors in parentheses (robust, clustered by conference series)

Significance levels: ***$p<0.01$, **$p<0.05$, *$p<0.1$

or hybrid conferences was circa 1.3 percentage points (Specification 1) or 2.1 percentage points (Specification 2).

In the variant using logistic regression, the variable was explained by the gender of the conference contribution author, operationalized as 1 for women and 0 for men. The results show the relationship between the examined independent variables and the probability that the gender of the conference participant was a woman. Modeling was performed for four specifications differing in whether the host country dummy and participant country dummy were included. This analysis used a large number of observations: 356,089 for Specifications 1 and 3, and 356,056 for Specifications 2 and 4. The smaller number of observations in Specifications 2 and 4 was the result of the inclusion of the participant country dummy variable. In the case of several countries, this resulted in perfect separation, so these observations had to be excluded for the maximum likelihood estimation algorithm to work correctly. Excluding these observations should not significantly impact the analysis because they constitute only 0.01% of the initial sample.

All presented specifications produced similar results. The virtual or hybrid conference mode (including switched conferences in 2020) was associated with a statistically significant increase in the probability that the author of a conference contribution was a woman compared to the onsite mode. The effect was estimated at 1,043–1,095. The statistical significance of the result was high: 0.001 for Specification 1, 0.013 for Specification 2, below 0.000 for Specification 3, and 0.002 for Specification 4. It is worth emphasizing that specifications including the host country dummy variable provided higher statistical significance of the examined independent variable and indicated a more substantial effect (parameter estimate of 1.071–1.095 in Specifications 3 and 4 compared to an estimate of 1.043–1.054 in Specifications 1 and 2).

The logistic regression results translated into predicted probabilities, specifically the predicted difference in the percentage of women participants between onsite and virtual conferences, largely align with the OLS result. Predicted differences based on logistic models vary between 0.9 and 1.9 percentage points (1.1 for specification, 0.9 for specification

2, 1.9 for specification 3, and 1.4 for specification 4). As we remember, the OLS values were 1.3 and 2.1 percentage points, depending on the specification. The major difference is that logistic regression results have noticeably higher statistical significance statistics, mostly because logistic models are based on a much larger number of observations than the OLS models.

Moreover, it is worth noting that in all presented specifications, there was an observable relationship between the year of the conference and the participation of women. Over the years—even in the short seven-year period we studied—there has been a gradual, although slight, increase in the share of women among the authors of conference contributions. These results were statistically significant in all specifications, both in OLS and logistic models.

Discussion and conclusions

In this article, we analyzed the relationship between conference mode and the participation of women as authors in scientific conferences in 2017–2022. Our results demonstrate that the virtual and hybrid conference mode is associated with a greater involvement of women scientists than the onsite mode. Although this effect is statistically significant in our sample, it must be emphasized that its scale is not very large, between circa 1 and 2 percentage points. Furthermore, the distribution of raw data suggests that this should be attributed not to the increased participation of women in virtual and hybrid conferences but to their decreasing participation in onsite editions of the analyzed conference series.

These findings imply that transitioning to virtual and hybrid environments could be an effective strategy for enhancing gender inclusivity in academic conferences, which supports findings from other recent studies (Braun et al., 2023). However, it is important to consider that although virtual and hybrid formats may increase participation, they could also diminish the networking opportunities facilitated by face-to-face interactions during onsite events. This may make virtual events and virtual participation in hybrid events less beneficial for career development, knowledge exchange, and the establishment of collaborative relationships (Campos et al., 2018). It should also be emphasized that participation in virtual conferences requires appropriate infrastructural resources, which may result in the emergence of other dimensions of inequality in scientific communication, perhaps less in the context of gender and more in the context of access to resources and financing. Another factor that may have unintended negative consequences is time zone differences and the resulting inconvenience for peripheral centers having to adjust to the conference time set by privileged centers.

Furthermore, the collected data indicate that virtual scientific conferences may have seen a one-off boom and bust during the pandemic. In 2021, all editions of the analyzed conference series were held in virtual or hybrid mode (with a predominance of virtual); in 2022, the hybrid mode dominated, but several conferences were held in the onsite mode. However, in 2023, there was a clear return to the onsite mode. This may suggest that we are witnessing a return to pre-pandemic patterns of gender participation in conferences. Thus, repeating our study in the future may be impossible due to a lack of virtual conferences. From the point of view of the possibility of conducting further research, this is an unfavorable situation. Nonetheless, the negative aspects of virtual academic conferences (Olechnicka et al., 2024) and virtual fatigue (Nesher Shoshan & Wehrt, 2022) should be acknowledged.

Our analysis is based on a relatively small sample, and a larger sample size would be beneficial. However, our research approach assumed that we analyzed only cyclical conferences whose individual editions were held in different modes. This made it possible to analytically control the features of individual conference series and, as a result, separate the effect that may be attributed to the change in conference mode from other features. It would be worth repeating this analysis in the future, including at least another year of the conference series we analyzed, even if they all return to the onsite mode.

Our study addresses the need for tools to monitor gender gaps at academic conferences (Corona-Sobrino et al., 2020). This work should be continued in several dimensions, one of the most promising of which would be to consider the conference participants' roles. Our analysis encompassed all authors of conference proceedings without differentiation based on their specific roles. Future research could benefit from examining the position of authors in the conference contribution byline, such as first or last authors, to better understand the roles of men and women as lead authors and any other potential changes over time. This approach could provide deeper insights into gender disparity in conference contribution authorship and help identify further avenues for research.

Appendix

See Tables 6, 7, 8, 9, 10, and 11.

Table 6 Conferences selected for the analysis

Short name	Full name
ACHEMS	Association for Chemoreception Sciences
ACL	Annual Meeting of the Association for Computational Linguistics
AEA	Annual Meeting of the American Economic Association
AIED	International Conference on Artificial Intelligence in Education
AIES	AAAI ACM Conference on AI, Ethics, and Society
BIOPHYS	Annual Meeting of the Biophysical Society
CHI	ACM CHI Conference on Human Factors in Computing Systems
COMPNET	International Conference on Complex Networks and their Applications
CSEDU	International Conference on Computer Supported Education
DGO	Annual International Conference on Digital Government Research
ECGBL	European Conference on Games Based Learning
ECKM	European Conference on Knowledge Management
EDUCON	IEEE Global Engineering Education Conference
EUCAP	European Conference on Antennas and Propagation
GLOBECOM	IEEE Conference on Global Communications
HEAD	International Conference on Higher Education Advances
ICANN	International Conference on Artificial Neural Networks
ICIP	IEEE International Conference on Image Processing
ICML	International Conference on Machine Learning
IJCNN	International Joint Conference on Neural Networks
INTER	International Speech Communication Association Annual Conference INTERSPEECH
IUS	IEEE International Ultrasonics Symposium
JCDL	ACM IEEE Joint Conference on Digital Libraries
KDD	ACM SIGKDD Conference on Knowledge Discovery and Data Mining
MME	International Conference on Mathematical Methods in Economics
NENE	International Conference Nuclear Energy for New Europe
ROMAN	IEEE International Conference on Robot & Human Interactive Communication
SMART	IEEE International Smart Cities Conference
WACV	IEEE CVF Winter Conference on Applications of Computer Vision
WEBCONF	The Web Conference

Table 7 Conferences and their research areas (as determined in the Web of Science)

Short name	Research areas
ACHEMS	Behavioral Sciences; Food Science & Technology; Neurosciences & Neurology; Physiology
ACL	Computer Science; Linguistics
AEA	Business & Economics
AIED	Computer Science; Education & Educational Research
AIES	Computer Science; Social Sciences—Other Topics
BIOPHYS	Biophysics
CHI	Computer Science; Computer Science; Robotics
COMPNET	Computer Science; Mathematics; Mathematical Methods In Social Sciences
CSEDU	Computer Science; Education & Educational Research
DGO	Computer Science; Public Administration; Social Issues
ECGBL	Computer Science; Education & Educational Research
ECKM	Business & Economics
EDUCON	Education & Educational Research; Engineering
EUCAP	Engineering; Telecommunications
GLOBECOM	Engineering; Telecommunications
HEAD	Education & Educational Research
ICANN	Computer Science; Computer Science; Radiology, Nuclear Medicine & Medical Imaging
ICIP	Computer Science; Engineering; Imaging Science & Photographic Technology; Computer Science; Engineering; Imaging Science & Photographic Technology
ICML	Computer Science; Computer Science; Engineering
IJCNN	Computer Science
INTER	Computer Science; Engineering
IUS	Engineering; Engineering; Physics; Acoustics; Engineering; Acoustics; Engineering; Radiology, Nuclear Medicine & Medical Imaging
JCDL	Computer Science; Information Science & Library Science
KDD	Computer Science
MME	Business & Economics; Mathematics; Mathematical Methods In Social Sciences
NENE	Environmental Sciences & Ecology; Nuclear Science & Technology
ROMAN	Computer Science; Engineering; Robotics
SMART	Automation & Control Systems; Computer Science; Transportation
WACV	Computer Science; Imaging Science & Photographic Technology; Computer Science
WEBCONF	Computer Science

Table 8 Number of conference contributions (conference papers) by conference series and year

	2017	2018	2019	2020	2021	2022	2023
ACHEMS		631	488		198	334	302
ACL	323	405	719	511	1113	1096	1133
AEA	15	117	113	118	121	149	43
AIED	88	155	131	127	125	211	
AIES		76	91	76	114	115	101
BIOPHYS	1007	3428	2883	3052	1765	2647	
CHI	599	1214	1300	1321	873	1128	879
COMPNET	65	103	123	161		137	104
CSEDU	155		148	134	144	164	0
DGO	89	132	72			69	86
ECGBL	125	116	126		112		
ECKM	156	140	145	119	116		
EDUCON	291	292	239	303	263	318	
EUCAP	837		882	934	604	709	876
GLOBECOM	1017	988	1086	913	900	1086	
HEAD	161	189	161	163	161	163	
ICANN	191	219	323	139	265	259	457
ICIP	927	837	943	695	779	844	705
ICML		621	774	561	1185	1234	
IJCNN	620	755	798	1122	1180	1244	969
INTER	839	791	951	1031	987	1121	
IUS	578	592	682	542	559	614	
JCDL	73	102	115		72	59	
KDD	244	306	374	431	478	534	564
MME	150	112	98	103	90	66	
NENE	117	105	90	112	121		
ROMAN	231	188	187	209	191	236	355
SMART	94	122	127	90	84		
WACV	152	232	253	402	429	486	707
WEBCONF	445	572	617	379	487	357	291

Table 9 Number of authors of conference contributions by conference series and year

	2017	2018	2019	2020	2021	2022	2023
ACHEMS		3014	2221		1061	1907	1698
ACL	1317	1722	3295	2566	5940	6189	6934
AEA	23	383	345	386	411	465	162
AIED	402	653	489	565	609	871	
AIES		249	292	260	459	347	327
BIOPHYS	4433	15,716	12,993	14,543	8404	12,669	
CHI	2691	5423	5809	6403	4027	5508	4475
COMPNET	236	371	435	594		531	375
CSEDU	561		567	536	509	602	
DGO	287	462	249			227	310
ECGBL	405	368	355		356		
ECKM	411	365	383	298	286		
EDUCON	987	1084	845	1110	1042	1183	
EUCAP	3639		3866	4074	2759	3189	4222
GLOBECOM	4287	4328	4889	4019	4049	5169	
HEAD	493	568	511	482	494	505	
ICANN	740	897	1436	623	1217	1151	2159
ICIP	3821	3498	4083	3022	3299	3758	3290
ICML		2773	3495	2577	5774	6483	
IJCNN	2433	3143	3394	4837	5276	5561	4469
INTER	3624	3541	4549	5016	5164	5804	
IUS	3177	3356	3760	2904	3017	3364	
JCDL	247	355	379		297	209	
KDD	1118	1450	1904	2229	2894	3162	3500
MME	290	214	180	200	190	128	
NENE	479	415	301	449	444		
ROMAN	957	801	845	1000	855	1038	1735
SMART	398	456	625	397	354		
WACV	605	960	1077	1814	2052	2247	3444
WEBCONF	1978	2356	2666	1796	2496	1854	1441

Table 10 Share of women among the authors of conference contributions by conference series and year

	2017 (%)	2018 (%)	2019 (%)	2020 (%)	2021 (%)	2022 (%)	2023 (%)
ACHEMS		43.7	41.9		47.9	47.4	45.8
ACL	26.8	26.6	31.2	28.1	31.9	33.2	33.4
AEA	13.0	27.4	29.9	37.0	42.1	37.1	33.8
AIED	38.7	36.1	36.7	34.7	36.5	37.0	
AIES		27.9	30.4	33.3	36.9	43.1	39.4
BIOPHYS	32.2	32.9	34.3	34.2	35.9	35.5	
CHI	35.5	36.2	37.3	39.3	40.8	41.8	40.6
COMPNET	24.9	23.5	22.5	25.2		23.4	24.5
CSEDU	35.8		36.7	35.2	41.4	38.9	
DGO	33.2	36.6	37.2			33.3	40.8
ECGBL	38.6	34.4	46.5		46.8		
ECKM	48.8	49.7	45.6	46.6	49.4		
EDUCON	29.5	33.6	34.2	38.7	34.9	36.6	
EUCAP	17.2		18.6	18.8	16.9	18.0	16.6
GLOBECOM	28.6	27.7	27.9	28.9	29.4	29.5	
HEAD	54.0	54.4	60.7	54.4	56.4	56.7	
ICANN	21.8	23.8	22.1	25.8	31.3	32.0	37.3
ICIP	28.8	27.5	30.4	26.1	29.2	26.3	30.3
ICML		17.9	16.1	19.2	21.4	22.7	
IJCNN	23.5	24.1	27.4	25.3	30.8	29.2	32.7
INTER	27.0	28.0	27.4	28.5	29.8	27.8	
IUS	23.6	25.1	24.4	26.1	31.4	26.8	
JCDL	29.8	27.2	30.9		26.8	27.6	
KDD	26.3	30.3	30.7	30.4	32.4	30.7	32.5
MME	37.1	32.5	40.4	36.5	42.1	40.8	
NENE	13.5	14.6	12.6	14.4	17.5		
ROMAN	27.1	31.0	28.4	30.5	33.7	37.9	34.5
SMART	27.0	26.9	24.5	26.7	29.7		
WACV	25.7	22.0	18.6	21.0	21.5	22.0	21.7
WEBCONF	24.6	26.7	29.6	32.3	30.6	32.9	30.5

Table 11 Share of women among the authors of conference contributions in the sample by country of affiliation (only the top 60 countries with the highest number of authors are presented)

Country	Share of women (%)
Arab Emirates	26.3
Argentina	46.4
Australia	32.1
Austria	29.3
Bangladesh	29.8
Belgium	24.6
Brazil	23.0
Canada	29.4
Chile	22.0
China	40.5
Colombia	38.7
Croatia	27.4
Cyprus	23.0
Czech Republic	26.9
Denmark	27.6
Ecuador	43.3
Egypt	26.2
Estonia	37.8
Finland	21.7
France	26.0
Germany	22.5
Greece	16.5
Hungary	25.8
India	24.7
Iran	25.5
Ireland	28.5
Israel	23.6
Italy	28.4
Japan	15.2
Lithuania	40.9
Luxembourg	28.0
Malaysia	41.7
Mexico	35.9
Morocco	31.0
Netherlands	30.5
New Zealand	30.4
Norway	27.2
Pakistan	19.2
Peru	19.5
Poland	25.5
Portugal	33.4
Qatar	15.0
Romania	32.1
Russia	29.4

Table 11 (continued)

Country	Share of women (%)
Saudi Arabia	18.2
Singapore	31.8
Slovakia	30.3
Slovenia	12.1
South Africa	35.7
South Korea	22.0
Spain	30.0
Sweden	31.2
Switzerland	22.4
Taiwan	47.4
Thailand	35.5
Tunisia	37.5
Turkey	33.2
United Kingdom	28.8
USA	32.9
Vietnam	60.9

Acknowledgements We would like to thank Eliasz Czułada, also known as Ilya Alipau, for his contribution to developing the algorithm for processing Web of Science data and determining the gender of authors.

Author contributions Conceptualization: AP, AO, EZP. Methodology and Formal analysis: AP. Software and Data curation: AP, EZP. Writing—original draft and Writing—review & editing: AP, EZP, AO. Funding acquisition: AO.

Funding The University of Warsaw supported this publication under Priority Research Area V of the "Excellence Initiative—Research University" program.

Data availability This work uses proprietary Web of Science data provided by the University of Warsaw Library.

References

Arora, A., Kaur, Y., Dossa, F., Nisenbaum, R., Little, D., & Baxter, N. N. (2020). Proportion of female speakers at academic medical conferences across multiple specialties and regions. *JAMA Network Open, 3*(9), e2018127. https://doi.org/10.1001/jamanetworkopen.2020.18127

Astegiano, J., Sebastián-González, E., & Castanho, C. D. T. (2019). Unravelling the gender productivity gap in science: A meta-analytical review. *Royal Society Open Science, 6*(6), 181566. https://doi.org/10.1098/rsos.181566

Biermann, M. (2024). Remote talks: Changes to economics seminars during COVID-19. *European Economic Review, 163*, 104677. https://doi.org/10.1016/j.euroecorev.2024.104677

Blumen, O., & Bar-Gal, Y. (2006). The academic conference and the status of women: The annual meetings of the Israeli Geographical Society*. *The Professional Geographer, 58*(3), 341–355. https://doi.org/10.1111/j.1467-9272.2006.00572.x

Boekhout, H., van der Weijden, I., & Waltman, L. (2021). Gender differences in scientific careers: A large-scale bibliometric analysis. Zenodo. https://doi.org/10.5281/zenodo.5006283

Braun, M., Heintz, L., Kruschinski, S., Trepte, S., & Scharkow, M. (2023). Gender diversity at academic conferences—The case of the International Communication Association. *Journal of Communication, 73*(6), 601–615. https://doi.org/10.1093/joc/jqad032

Buchanan, G., & McKay, D. (2022). You oughta know: Examining author geography and gender in information science. *Proceedings of the Association for Information Science and Technology, 59*(1), 32–43. https://doi.org/10.1002/pra2.602

Campos, R., Leon, F., & McQuillin, B. (2018). Lost in the storm: The academic collaborations that went missing in hurricane ISSAC. *The Economic Journal, 128*(610), 995–1018. https://doi.org/10.1111/ecoj.12566

Corona-Sobrino, C., García-Melón, M., Poveda-Bautista, R., & González-Urango, H. (2020). Closing the gender gap at academic conferences: A tool for monitoring and assessing academic events. *PLoS ONE, 15*(12), e0243549. https://doi.org/10.1371/journal.pone.0243549

de Leon, F. L. L., & McQuillin, B. (2020). The role of conferences on the pathway to academic impact: Evidence from a natural experiment. *Journal of Human Resources, 55*(1), 164–193. https://doi.org/10.3368/jhr.55.1.1116-8387R

Débarre, F., Rode, N. O., & Ugelvig, L. V. (2018). Gender equity at scientific events. *Evolution Letters, 2*(3), 148–158. https://doi.org/10.1002/evl3.49

Duch, J., Zeng, X. H. T., Sales-Pardo, M., Radicchi, F., Otis, S., Woodruff, T. K., & Nunes Amaral, L. A. (2012). The possible role of resource requirements and academic career-choice risk on gender differences in publication rate and impact. *PLoS ONE, 7*(12), e51332. https://doi.org/10.1371/journal.pone.0051332

Dymore-Brown, L.-A., Ahluwalia, A., Dangoisse, C., Zaman, F., Sereeyotin, J., Mehta, S., & Metaxa, V. (2024). An update on gender disparity in critical care conferences. *Critical Care Explorations, 6*(4), e1075. https://doi.org/10.1097/CCE.0000000000001075

Elsevier. (2024). *Progress toward gender equality in research & innovation—2024 review*. Retrieved from https://elsevier.digitalcommonsdata.com/datasets/bb5jb7t2zv/1/files/b9a2901e-50d7-41ba-96ec-63998c820981

Esquivel, A., Marincean, S., & Benore, M. (2023). The effect of the Covid-19 pandemic on STEM faculty: Productivity and work-life balance. *PLoS ONE, 18*(1), e0280581. https://doi.org/10.1371/journal.pone.0280581

European Commission: Directorate-General for Research and Innovation. (2023). *COVID-19 impact on gender equality in research & innovation: Policy report*. Publications Office of the European Union. Retrieved from https://data.europa.eu/doi/10.2777/171804

Falk, M. T., & Hagsten, E. (2022). Gender diversity of keynote speakers at virtual academic conferences. *Journal of Policy Research in Tourism, Leisure and Events.* https://doi.org/10.1080/19407963.2022.2066684

Gao, J., Yin, Y., Myers, K. R., Lakhani, K. R., & Wang, D. (2021). Potentially long-lasting effects of the pandemic on scientists. *Nature Communications, 12*(1), Article 1. https://doi.org/10.1038/s41467-021-26428-z

García-Costa, D., Grimaldo, F., Bravo, G., Mehmani, B., & Squazzoni, F. (2024). The silver lining of COVID-19 restrictions: Research output of academics under lockdown. *Scientometrics, 129*(3), 1771–1786. https://doi.org/10.1007/s11192-024-04929-0

Halevi, G. (2019). Bibliometric studies on gender disparities in science. In W. Glänzel, H. F. Moed, U. Schmoch, & M. Thelwall (Eds.), *Springer handbook of science and technology indicators* (pp. 563–580). Springer. https://doi.org/10.1007/978-3-030-02511-3_21

Hansen, T. T., & Budtz Pedersen, D. (2018). The impact of academic events—A literature review. *Research Evaluation, 27*(4), 358–366. https://doi.org/10.1093/reseval/rvy025

Hofstra, B., Kulkarni, V. V., Munoz-Najar Galvez, S., He, B., Jurafsky, D., & McFarland, D. A. (2020). The diversity-innovation paradox in science. *Proceedings of the National Academy of Sciences, 117*(17), 9284–9291. https://doi.org/10.1073/pnas.1915378117

Hospido, L., & Sanz, C. (2021). Gender gaps in the evaluation of research: Evidence from submissions to economics conferences. *Oxford Bulletin of Economics and Statistics, 83*(3), 590–618. https://doi.org/10.1111/obes.12409

Huang, J., Gates, A. J., Sinatra, R., & Barabási, A.-L. (2020). Historical comparison of gender inequality in scientific careers across countries and disciplines. *Proceedings of the National Academy of Sciences, 117*(9), 4609–4616. https://doi.org/10.1073/pnas.1914221117

Ioannidis, J. P. A., Bendavid, E., Salholz-Hillel, M., Boyack, K. W., & Baas, J. (2022). Massive covidization of research citations and the citation elite. *Proceedings of the National Academy of Sciences, 119*(28), e2204074119. https://doi.org/10.1073/pnas.2204074119

Jacobs, N., & McFarlane, A. (2005). Conferences as learning communities: Some early lessons in using 'back-channel' technologies at an academic conference—Distributed intelligence or divided attention? *Journal of Computer Assisted Learning, 21*(5), 317–329. https://doi.org/10.1111/j.1365-2729.2005.00142.x

Jadidi, M., Karimi, F., Lietz, H., & Wagner, C. (2018). Gender disparities in science? Dropout, productivity, collaborations and success of male and female computer scientists. *Advances in Complex Systems, 21*(03n04), 1750011. https://doi.org/10.1142/S0219525917500114

Jarvis, S. N., Nguyen, C. Q., Zhu, M., Ebersole, C. R., & Kray, L. J. (2023). Do virtual environments close the gender gap in participation in question-and-answer sessions at academic conferences? In search of moderation by conference format. *Sex Roles, 89*(11), 818–833. https://doi.org/10.1007/s11199-023-01388-4

Jemielniak, D., Sławska, A., & Wilamowski, M. (2023). COVID-19 effect on the gender gap in academic publishing. *Journal of Information Science, 49*(6), 1587–1592. https://doi.org/10.1177/01655515211068168

Kozlowski, D., Larivière, V., Sugimoto, C. R., & Monroe-White, T. (2022). Intersectional inequalities in science. *Proceedings of the National Academy of Sciences, 119*(2), e2113067119. https://doi.org/10.1073/pnas.2113067119

Kwon, E., Yun, J., & Kang, J. (2023). The effect of the COVID-19 pandemic on gendered research productivity and its correlates. *Journal of Informetrics*. https://doi.org/10.1016/j.joi.2023.101380

Larivière, V., Ni, C., Gingras, Y., Cronin, B., & Sugimoto, C. R. (2013). Bibliometrics: Global gender disparities in science. *Nature, 504*(7479), Article 7479. https://doi.org/10.1038/504211a

Lindqvist, A., Sendén, M. G., & Renström, E. A. (2021). What is gender, anyway: A review of the options for operationalising gender. *Psychology & Sexuality, 12*(4), 332–344. https://doi.org/10.1080/19419899.2020.1729844

Madsen, E. B., Nielsen, M. W., Bjørnholm, J., Jagsi, R., & Andersen, J. P. (2022). Author-level data confirm the widening gender gap in publishing rates during COVID-19. *eLife, 11*, e76559. https://doi.org/10.7554/eLife.76559

Mickey, E. L., & Smith-Doerr, L. (2022). Gender and innovation through an intersectional lens: Re-imagining academic entrepreneurship in the United States. *Sociology Compass, 16*(3), e12964. https://doi.org/10.1111/soc4.12964

Monson, E., Ng, K., Sibbick, H., Berbiche, D., & Morvannou, A. (2023). Gender disparity in prestigious speaking roles: A study of 10 years of international conference programming in the field of gambling studies. *PLoS ONE, 18*(6), e0286803. https://doi.org/10.1371/journal.pone.0286803

Mulders, A. M., Hofstra, B., & Tolsma, J. (2024). A matter of time? Gender and ethnic inequality in the academic publishing careers of Dutch Ph.D.s. *Quantitative Science Studies, 5*(3), 487–515. https://doi.org/10.1162/qss_a_00306

Myers, K. R., Tham, W. Y., Yin, Y., Cohodes, N., Thursby, J. G., Thursby, M. C., Schiffer, P., Walsh, J. T., Lakhani, K. R., & Wang, D. (2020). Unequal effects of the COVID-19 pandemic on scientists. *Nature Human Behaviour, 4*(9), 880–883. https://doi.org/10.1038/s41562-020-0921-y

Nesher Shoshan, H., & Wehrt, W. (2022). Understanding "Zoom fatigue": A mixed-method approach. *Applied Psychology, 71*(3), 827–852. https://doi.org/10.1111/apps.12360

Nielsen, M. W., Alegria, S., Börjeson, L., Etzkowitz, H., Falk-Krzesinski, H. J., Joshi, A., Leahey, E., Smith-Doerr, L., Woolley, A. W., & Schiebinger, L. (2017). Gender diversity leads to better science. *Proceedings of the National Academy of Sciences, 114*(8), 1740–1742. https://doi.org/10.1073/pnas.1700616114

Nittrouer, C. L., Hebl, M. R., Ashburn-Nardo, L., Trump-Steele, R. C. E., Lane, D. M., & Valian, V. (2018). Gender disparities in colloquium speakers at top universities. *Proceedings of the National Academy of Sciences, 115*(1), 104–108. https://doi.org/10.1073/pnas.1708414115

Olechnicka, A., Ploszaj, A., & Zegler-Poleska, E. (2024). Virtual academic conferencing: A scoping review of 1984–2021 literature—Novel modalities vs long standing challenges in scholarly communication. *Iberoamerican Journal of Science Measurement and Communication, 4*(1), 1–31. https://doi.org/10.47909/ijsmc.93

Robinson-García, N., Corona-Sobrino, C., Chinchilla-Rodriguez, Z., Torres-Salinas, D., & Costas, R. (2024). The use of informetric methods to study diversity in the scientific workforce: A literature review. Zenodo. https://doi.org/10.5281/zenodo.13880355

Sá, C., Cowley, S., Shahrin, B., Stevenson, C., & Su, A. (2023). Disciplinary gender balance, research productivity, and recognition of men and women in academia. *PLoS ONE, 18*(12), e0293080. https://doi.org/10.1371/journal.pone.0293080

Sebo, P. (2021). Performance of gender detection tools: A comparative study of name-to-gender inference services. *Journal of the Medical Library Association: JMLA, 109*(3), 414. https://doi.org/10.5195/jmla.2021.1185

Skiles, M., Yang, E., Reshef, O., Muñoz, D. R., Cintron, D., Lind, M. L., Rush, A., Calleja, P. P., Nerenberg, R., Armani, A., Faust, M., & K., & Kumar, M. (2022). Conference demographics and footprint changed by virtual platforms. *Nature Sustainability, 5*(2), 149–156. https://doi.org/10.1038/s41893-021-00823-2

Son, J.-Y., & Bell, M. L. (2022). Scientific authorship by gender: Trends before and during a global pandemic. *Humanities and Social Sciences Communications, 9*(1), 1–10. https://doi.org/10.1057/s41599-022-01365-4

Song, Y., Wang, X., & Li, G. (2024). Can social media combat gender inequalities in academia? Measuring the prevalence of the Matilda effect in communication. *Journal of Computer-Mediated Communication, 29*(1), zmad050. https://doi.org/10.1093/jcmc/zmad050

Standaert, W., & Thunus, S. (2022). Virtual meetings during the pandemic: Boon or bane for gender inequality. *ECIS 2022 Research-in-Progress Papers*. Retrieved from https://aisel.aisnet.org/ecis2022_rip/3

Sugimoto, C. R., Ni, C., & Larivière, V. (2015). On the relationship between gender disparities in scholarly communication and country-level development indicators. *Science and Public Policy*. https://doi.org/10.1093/scipol/scv007

Teplitskiy, M., Park, S., Thompson, N., & Karger, D. (2024). Intentional and serendipitous diffusion of ideas: Evidence from academic conferences. *Papers*, Article 2209.01175. Retrieved from https://ideas.repec.org//p/arx/papers/2209.01175.html

Vásárhelyi, O., Zakhlebin, I., Milojević, S., & Horvát, E. -Á. (2021). Gender inequities in the online dissemination of scholars' work. *Proceedings of the National Academy of Sciences, 118*(39), e2102945118. https://doi.org/10.1073/pnas.2102945118

Walters, T. (2018). Gender equality in academic tourism, hospitality, leisure and events conferences. *Journal of Policy Research in Tourism, Leisure and Events, 10*(1), 17–32. https://doi.org/10.1080/19407963.2018.1403165

Waltman, L., Pinfield, S., Rzayeva, N., Oliveira Henriques, S., Fang, Z., Brumberg, J., Greaves, S., Hurst, P., Collings, A., Heinrichs, A., Lindsay, N., MacCallum, C. J., Morgan, D., Sansone, S.-A., & Swaminathan, S. (2021). Scholarly communication in times of crisis: The response of the scholarly communication system to the COVID-19 pandemic [Report]. Research on Research Institute. https://doi.org/10.6084/m9.figshare.17125394.v1

Walton, E., Yates, J., Blake, L., Waage, J., & Kadiyala, S. (2022). Virtual academic conferences: A mixed-methods study of equitable participation according to gender and country-income level. https://doi.org/10.21203/rs.3.rs-2250662/v1

Zhang, J., Torchet, R., & Julienne, H. (2023). Gender-based disparities and biases in science: An observational study of a virtual conference. *PLoS ONE, 18*(6), e0286811. https://doi.org/10.1371/journal.pone.0286811