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Gender Disparities in Authorships and Citations in Transplantation Research

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Background. Over the past decades, there has been a rapid change in the gender ratio of medical doctors, whereas gender differences in academia remain apparent. In transplantation research, a field already understaffed with female doctors and researchers, there is little published data on the development in proportion, citations, and funding of female researchers over the past years. **Methods.** To evaluate the academic impact of female doctors in transplantation research, we conducted a bibliometric analysis (01 January 1999 to 31 December 2018) of high-impact scientific publications, subsequent citations, and funding in this field. Web of Science data was used in combination with software R-Package "Gender," to predict gender by first names. **Results.** For this study, 15 498 (36.2% female; 63.8% male) first and 13 345 (30.2% female; 69.8% male) last author gender matches were identified. An increase in the percentage of female first and last authors is seen in the period 1999–2018, with clear differences between countries (55.1% female authors in The Netherlands versus 13.1% in Japan, for example). When stratifying publications based on the number of citations, a decline was seen in the percentage of female authors, from 34.6%–30.7% in the first group (≤10 citations) to 20.8%–23.2% in the fifth group (>200 citations), for first (P < 0.001) and last (P = 0.014) authors, respectively. From all first author name-gender matches, 6574 (41.6% female; 58.4% male, P < 0.001) publications reported external funding, with 823 (35.5% female; 64.5% male, P = 0.701) reported funding by pharmaceutical companies and 1266 (36.6% female; 63.4% male, P < 0.001) reporting funding by the National Institutes of Health. **Conclusions.** This is the first analysis of gender bias in scientific publications, subsequent citations, and funding in transplantation research. We show ongoing differences between male and female authors in citation rates and rewarded funding in this field. This requires an active approach to increase female representation in research reporting and funding rewarding.

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INTRODUCTION

Over the past decades, there has been a rapid change in the gender ratio of medical doctors, whereas gender differences in academia remain apparent.[1-6] Fifty years ago, only 9% of the medical students in the USA were female. Nowadays, the number of female students exceeds the number of male students.[7] This increase in female doctors is present in all medical specialties, including surgery. In 1980, almost one-quarter of the surgeons were female and since then it has increased up to 35%.[8] Despite this growth, the share of female surgeons in the field of transplantation remains low. To illustrate, in Germany the proportion of female transplant surgeons is approximately 13% and in the USA this is only 10%.[9,10] Recent research suggests ongoing gender bias in transplant surgery fellowship selections, with 92% of the letters of recommendation written by male surgeons and stronger recommendations for male candidates, which may contribute to the persistently low number of female transplant surgeons.[11]

Despite the fact that the number of female surgeons is steadily increasing, the number of female surgeons in academic positions is not increasing simultaneously.[12] Only 9% of full professors in academic surgery positions in the USA are female.[13] In general science, although the proportion of female first authors increased from 6% in 1970 to 29% in 2004, there are still almost 2 articles first-authored by men for every article with a female as first author.[2,5] A previous study in the field of surgery has established that, with only 23%, the proportion of female authors was even lower.[14] Another study

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All authors have made substantial contributions to conception and study design. S.B., L.B., and T.B. obtained the data and conducted the statistical analysis. S.B. and L.B. wrote the first draft of the manuscript. All authors worked on the final version of the manuscript.

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even found a negative relationship between journal impact factor and the proportion of female first and last authors.[15]

In terms of financial support, there are also differences between male and female. Regarding "first-time" principal investigators (PIs) across all grant types and institutions, female PIs received less funding than male PIs, respectively, \$126 615 versus \$165 721.[16] For the National Institutes of Health (NIH) funding scheme, less than one-third of the research grants are awarded to female applicants.[17] Although this could be explained by either lower rates of success for female applicants or fewer applications by female researchers, the difference is striking.

Females remain underrepresented in transplantation research, and there is little data concerning changes in the proportion of authorship, citation, and funding of female researchers over the past 20 y. To evaluate the academic impact of females in transplantation research, we conducted a bibliometric analysis of high-impact scientific publications, subsequent citations, and funding in this field.

MATERIALS AND METHODS

We focused on scientific publications in the field of solid organ transplantation, as previously described by our research group (Benjamens et al *Transplantation* Jan 2020).[18] Publications were selected using the Web of Science database, for which the search term "transplant*" was used in the period 01 January 1999 until 31 December 2018. Original articles and reviews were included, excluding editorials, letters to the editor, and conference abstracts. In the scientific fields "Transplantation," "Surgery," "Immunology," "Urology Nephrology," "Gastroenterology Hepatology," and "Medicine General Internal," high impact journals were selected. High impact journals are defined as the first-quartile (Q1) journals in a field. Figure 1 shows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowcharts of the inclusion and exclusion of publications. For each publication, we determined the gender of all listed authors, the number of citations, the institutional affiliation, and reported external funding. External funding was defined as reported funding acknowledgement and specified as funding from the NIH for the US-based first authors or funding from pharmaceutical companies for all authors globally.

All data were analyzed using R: A Language and Environment for Statistical Computing, version 3.5.2 (R Foundation for Statistical Computing, Vienna, Austria), with the software R-Package "bib2df," to parse Web of Science BibTeX files, and "Gender," to predict gender from names using historical data. With the "gender" package, a well-established method for first name gender extraction, names were predicted using international databases with name-gender matches: the US Social Security Administration baby name database; the US Census database; the North Atlantic Population Project; and the Kantrowitz corpus of male and female names.[19,20] Publications for which only initials of first names were published (n = 16 372) and publications for which authors' names were not included in the international databases were excluded from the analyses (n = 1265). The analyses were performed for first and last authors, with subanalyses for the USA and Europe, for authors from the top 10 countries based on scientific productivity, and for publications grouped by the number of citations. Data are expressed as median (interquartile range) for skewed variables and categorical data are expressed as n (%). Differences between gender groups were evaluated using Wilcoxon's rank-sum test for skewed variables and Chi-square for categorical variables. A $P < 0.05$ was considered statistically significant.

RESULTS

Based on first author gender matching, a total of 15 498 publications were included (Figure 1). From the identified first authors, 5605 (36.2%) were female and 9893 (63.8%) male. With gender matching for the last authors, 13 345 name-gender matches were identified, with 4032 (30.2%) female and 9313 (69.8%) male authors.

An analysis of the data according to year demonstrated an increase in the percentage of female first and last authors in the period 1999–2018 (Figure 2). Data for first authors based in the USA and Europe showed a similar trend, with an increase in the percentage of female authors in the past 20 y (Figure 3). When comparing the 10 countries with the most publications, clear differences in percentages of female first authors were seen, with a nearly equal contribution of female and male authors in The Netherlands (55.1% and 44.9%, respectively) and an unequal distribution in Japan (13.1% and 86.9%, respectively) (Figure 4).

Overall, female first authors received significantly fewer citations compared with their male colleagues, with median 13 (6, 29) and median 14 (6, 32) ($P < 0.001$) citations per single publication, respectively. Data for last authors showed a median of 14 (6, 29) citations for female authors and a median of 16 (6, 32) ($P = 0.002$) for male authors. For both female and male authors, the median citation rate was higher for older publications compared with more recent publications, with a median of 24 (12, 50), 22 (10, 42), 17 (9, 32), and 5 (2, 12), for, respectively, 1999–2003, 2004–2008, 2009–2013, and 2014–2018. When stratifying first author publications based on the number of citations, a decline was seen in the percentage of female authors, from 34.6% in the first group (≤10 citations) to 20.8% in the fifth group (>200 citations) ($P < 0.001$). A similar decline in the percentage of female authors was seen for last author name-gender matches ($P = 0.014$). Percentages for all groups are shown in Table 1.

From all first author name-gender matches, a total of 6574 (42.4%) publications reported external funding. From these publications, 2732 (41.6%) had female first authors and 3842 (58.4%) had male first authors ($P < 0.001$). A total of 823 (5.3%) reported funding by pharmaceutical companies, of which 292 (35.5%) by female first authors and 531 (64.5%) by male first authors ($P = 0.701$). From the US-based authors, 1266 reported funding by the NIH. From these publications, 463 (36.6%) had female first authors and 803 (63.4%) had male first authors ($P < 0.001$). Similar differences for external funding were seen for last author name-gender matches, as shown in Table 1.

DISCUSSION

The current study, the first publication focusing on gender disparities in transplantation research, shows that female authors remain underrepresented in transplantation research, with large differences in gender ratios between countries. While reporting less external funding, female first and last authors are especially underrepresented in the share of highly

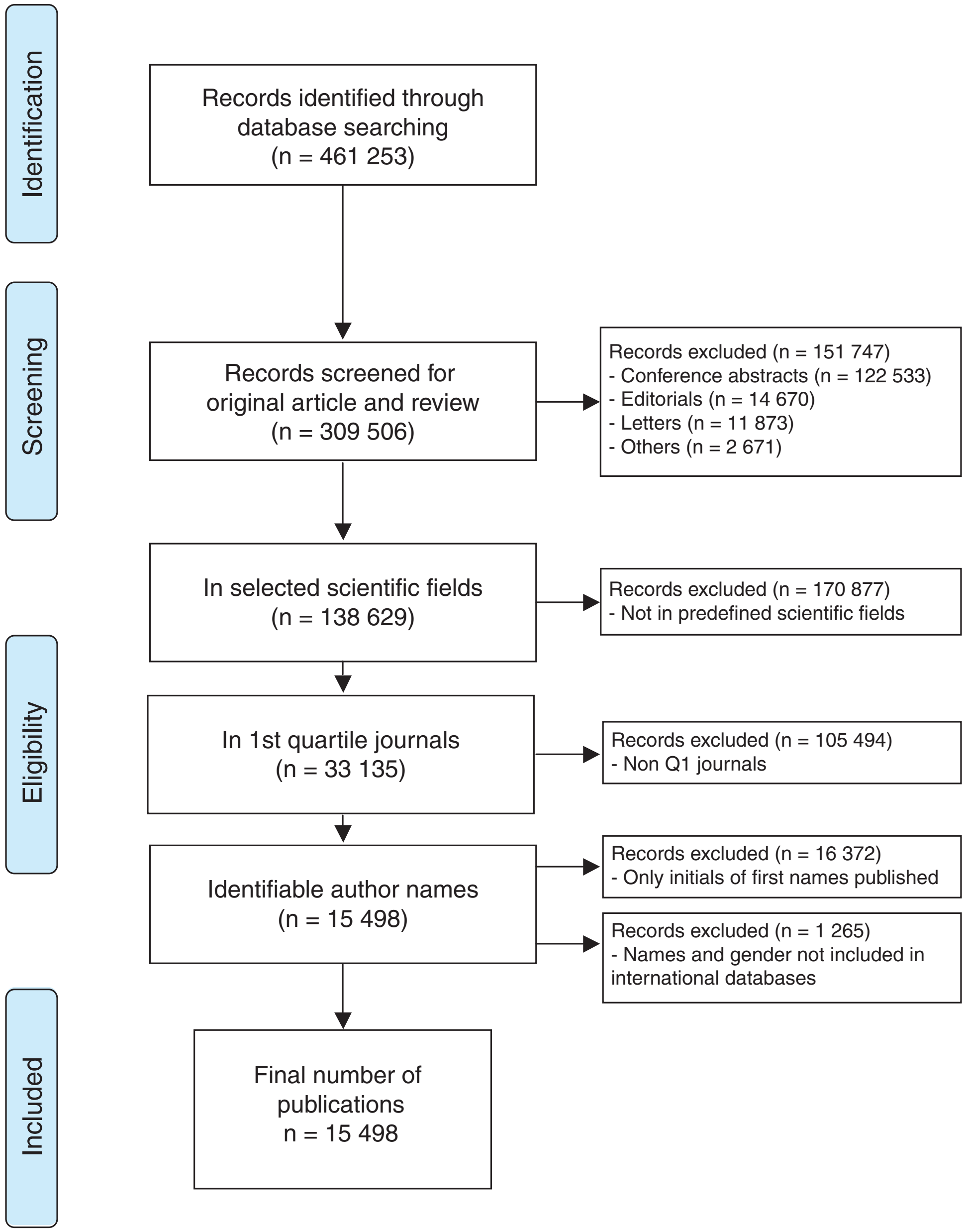

FIGURE 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart of the inclusion and exclusion of publications. Q1, first-quartile.

cited publications (>200 citations). These findings show the ongoing gender disparity in academic research, with an emphasis on gender disparity in the field of transplantation.

A recent survey by the American Society of Nephrology showed that nearly 40% of the Nephrologists and Nephrology residents are female and the Association of Women Surgeons reports that 19.2% of surgeons in the USA are female.[21,22] This same survey showed that early-career female nephrologists are more likely to work in an academic hospital compared with their male colleagues, with 53.8% working in academia and 38.7% working in private practice. However, several reports have shown that female talent is lost on the path toward a position as a medical specialist or academic researcher.[23] The Transplantation Society of Australia and New Zealand summarized several societal and academic factors contributing to the difficulties faced by females in academia, with a focus on transplantation research.[24] Earlier in their career, female students face a pervasive bias due to the undervaluation of their scientific capabilities.[25] This clear bias towards favoring male colleagues persists throughout their career, with less than a quarter of all professors in medical schools in the USA being female.[3] In a survey among members of the American Society of Transplant Surgeons, male transplant surgeons had a higher median number of total (83 versus 26) and first author (23 versus 16) publications. Regarding lifestyle factors, both genders reported the same amount of 70 work hours per week, with 14 d a month on call. The hours per week devoted to childcare differed substantially between the sexes (median 10 for females versus median 4 for males).[10] Over the past years, it became clear that a "controllable lifestyle," which means a "control of work hours," plays a major role in the career specialty preferences.[26] In the field of transplantation, there is

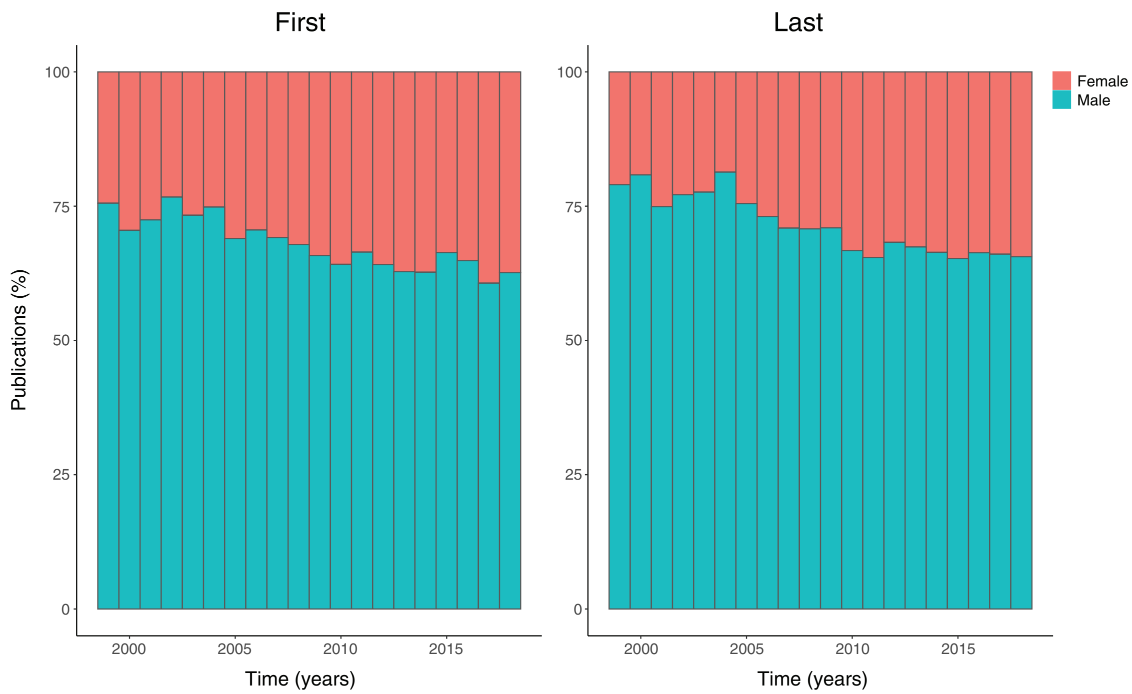

FIGURE 2. Percentage of first and last author publications by authors' gender for the y 1999 until 2018.

a so-called "incontrollable lifestyle" given the relatively high amount of on calls and work hours. Females are more likely to be impacted by lifestyle demands when making their career choice, as pregnancy and parenting hinder career development for females who desire both academic advancement and motherhood.[27,28] The combination of the above-mentioned factors can be a partial explanation for the continuous gender disparity in this field. One possible step towards resolution of these discrepancies lies in the leveling lifestyle demands of parents. In the example, as of 1 July 2020, male partners in The Netherlands receive 5 wk of paid parental leave.[29] This might help in leveling the favorability of hiring male over female candidates.

The gender ratio for authors presented in this study showed a higher percentage of female authors (35.9%) compared with previous studies in other fields of medicine. A previous analysis of female author representation in high impact medical journals showed a plateaued female representation

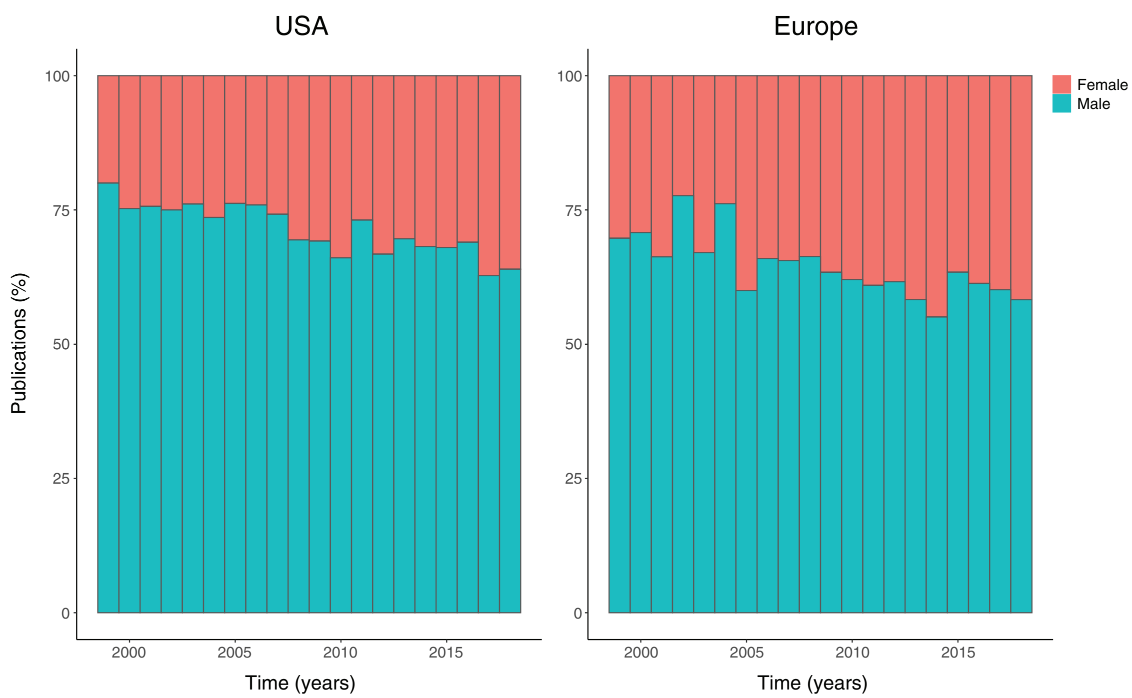

FIGURE 3. Percentage of publications by authors' gender in the USA and Europe, for the y 1999 until 2018.

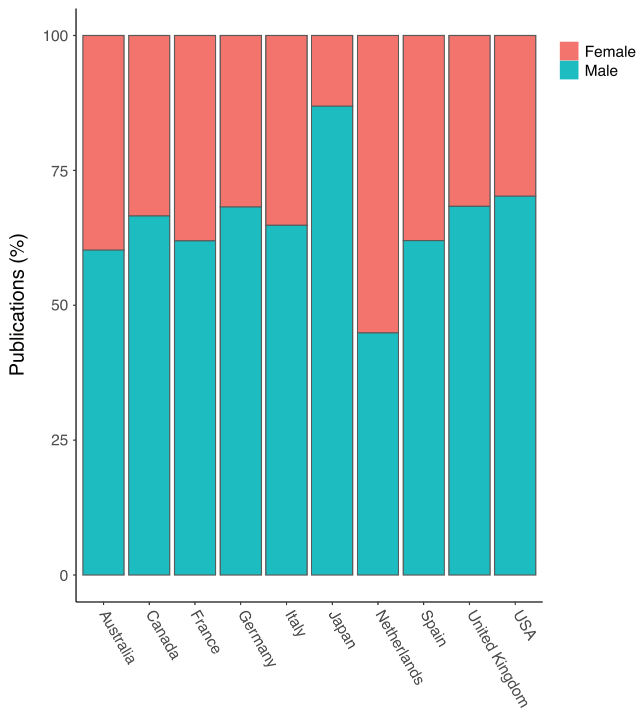

FIGURE 4. Percentage of publications by authors' gender for top 10 countries based on number of publications.

between 1994 and 2014, with even a decrease in some journals.[30]

The substantial differences in the share of female researchers among the various countries was another important finding and might be defined by cultural differences such as the amount of time women are spending on unpaid domestic work compared with men. Although women in The Netherlands spend twice the time on childcare, this study found almost no gender difference in publication rates. Whereas in Japan, the proportional difference between female and male was very broad (18.5% and 81.5%). This is, however, in accordance with the relatively low numbers of female doctors and surgeons in Japan. Especially in academic surgery, there are nearly no female professors and directors.[31,32] In Japan, the time women spend on household activities is nearly 5 times higher than the time men spend and therefore, women are less likely to be encouraged to pursue an academic career.[33]

Consistent with the literature, this study found that female researchers were less likely to receive external funding for their scientific work. A previous study, reporting on a cross-sectional database analysis of medical schools in the USA, showed that females received less NIH funding compared with their male colleagues (6.8% versus 11.3%).[3] A review of all Canadian Institutes of Health Research grant programs, showed a 0.9% lower success probability in traditional programs, with even a 4.0% gap in a new program focusing on PI caliber.[4] Whereas data on public and philanthropic cancer research funding awarded to UK institutions showed that female PIs received 31.0% of the funding budget compared with 69.0% for male PIs.[34]

This study supports earlier findings with regard to differences in citation rates between female and male authors. Female authors are especially underrepresented in the share of highly cited publications (>200 citations). The landmark publication by Larivière et al in "Nature" reported the results of a global,

TABLE 1.
Number of publications and citation by gender

	Total	Female	Citations	Male	Citations	*P*
First author						
Total	15 498	5605 (36.2)	13 (6, 29)	9893 (63.8)	14 (6, 32)	**<0.001**[a]
By citation groups						**<0.001**[c]
≤10	6135 (39.6)	2124 (34.6)	–	4011 (65.4)	–	
11–50	7483 (48.3)	2532 (33.8)	–	4951 (66.2)	–	
51–100	1415 (9.1)	416 (29.4)	–	999 (70.6)	–	
101–200	351 (2.3)	100 (28.5)	–	251 (71.5)	–	
>200	114 (0.7)	24 (20.8)	–	90 (79.2)	–	
External funding	6574 (42.4)	2732 (41.6)	–	3842 (58.4)	–	**<0.001**[b]
Funding by pharmaceutical companies	823 (5.3)	292 (35.5)	–	531 (64.5)	–	0.701[b]
Funding by NIH	1266 (8.2)	463 (36.6)	–	803 (63.4)	–	**<0.001**[b]
Last author						
Total	13 345	4032 (30.2)	14 (6, 29)	9313 (69.8)	15 (6, 32)	**0.002**[a]
By citation groups						**0.014**[c]
≤10	5289 (39.6)	1624 (30.7)	–	3,665 (69.3)	–	
11–50	6348 (47.6)	1946 (30.7)	–	4402 (69.3)	–	
51–100	1212 (9.1)	343 (28.3)	–	869 (71.7)	–	
101–200	384 (2.9)	93 (24.2)	–	291 (75.8)	–	
>200	112 (0.8)	26 (23.2)	–	86 (76.8)	–	
External funding	5546 (41.6)	1813 (32.7)	–	3733 (67.3)	–	**<0.001**[b]
Funding by pharmaceutical companies	688 (5.2)	195 (28.3)	–	493 (71.7)	–	0.292[b]
Funding by NIH	1306 (9.8)	352 (27.0)	–	954 (73.0)	–	**0.008**[b]

Numbers (%) and median (interquartile range).
[a]Statistical difference in number of citations by Wilcoxon's rank-sum test.
[b]Statistical difference number of male and female authors by Student's *t*-test.
[c]Statistical differences for citation group by chi-square test. $P < 0.05$ are significant (presented in bold).
NIH, National Institutes of Health.

cross-disciplinary bibliometric analysis, and provided first-time strong evidence of fewer citations for publications with female authors in dominant author positions.[5] A recent publication in "The BMJ" by Lerchenmueller et al provides a partial explanation for the dominance of male authors with regard to citation rates. With extensive bibliometric analysis, this study showed that male authors present their results with more positive terms and stronger statements, which was associated with higher citation rates.[6] Overall, the disparity in citations rates can be explained by differences in presentation of research findings, self-promotion, and underrepresentation of females in high impact research consortia.[5,6] Therefore, we propose an important role for scientific journals and scientific meeting committees to actively approach women to write invited commentaries, sit on panels during conferences, and lobby for equal pay and career opportunities. Diversity pledges from scientific journals, in which, that is, all-male panels are rejected and commitments to increase the representation of women among editorial staff, peer-review and authors are made, actively help in narrowing the gap.[35] Another example is "Women in Transplantation," an initiative of The Transplantation Society, raising awareness of ongoing gender inequity and whose mission, among others, is to get more female speakers in meetings, and more grants and awards toward female transplant professionals. Initiatives like these actively promote gender equity.

For the bibliometric analysis in this study, including the examination of authors' gender, the method was similar to those reported in related publications.[6,14,30] The systematic approach for publication extraction and gender prediction, with a relatively low number of publications with undefined author genders (n = 1265), resulting in a robust analysis. However, several limitations should be reported. At first, the large number of publications for which authors' gender could not be determined (n = 16 372), because of unpublished authors' first names, should be noted as a potential form of selection bias. There are no signs that this selection bias had any effect on the presented results, as reporting on authors' first names is not dependent on gender, but publishers' policy. Second, the presented data represent publications from 88 countries, but the vast majority of publications was written by authors from the USA, Canada, Japan, Australia, and European countries. By presenting the gender ratio for the top 10 countries based on publications rates, possible false interpretations due to the low number of cases were avoided. Third, part of the analyses focuses on the number of citations, a variable for which time is an important factor. When interpreting the results, one should keep in mind that changes in citation rates can be slower compared with preceding changes in author ratios. Furthermore, this study comprises a large dataset analysis. Boundaries had to be set for journal selection and included all major transplantation and general medicine Q1 journals. Some thoracic transplantation-related articles might be published in journals that were not selected since they were not present in these categories. Possibly, the differences might have been even more notable after adding these articles, given the known predominance of male surgeons in the field of cardiothoracic surgery.[36]

In conclusion, this study shows an ongoing gender disparity in transplantation research, confirming earlier findings in cross-disciplinary studies. In the 20-y study period, we show a clear increase in the percentage of female authors; however, with a plateau in the most recent years. The differences in citation rates and rewarded funding remain striking, requiring an active approach to eliminate potential bias in research reporting and funding rewarding. Opportunities to empower women in this field lie in raising awareness, leveling lifestyle demands between males and females, and a commitment of scientific journals and meeting committees to increase the representation of women.

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