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Gender disparities among United States academic pediatric ophthalmologists: an analysis of publication productivity, academic rank, and NIH funding

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Abstract

PURPOSE—To investigate gender disparitie among pediatric ophthalmologists in academic rank, publication productivity, and National Institutes of Health (NIH) funding.

METHODS—In this cross-sectional analysis of pediatric ophthalmologists at 113 US academic programs, data on gender, residency graduation year, and academic rank were obtained from institutional websites between January 2019 and March 2019. The Scopus database was used to calculate h-indices and m-quotients. The NIH Research Portfolio Online Reporting Tool was used to determine NIH funding.

RESULTS—We identified 389 pediatric ophthalmologists: 194 women (49.9%) and 195 men (50.1%). A binomial logistic regression model, which included career length as an independent variable, showed proportions of women to men were similar across all academic ranks (assistant professor, 64.4% vs 46.2% [$P = 0.738$]; associate professor, 21.7% vs 19.0% [$P = 0.357$]; full professor, 13.9 vs 34.9% [$P = 0.119$]). Women had a lower median h-index (5.0 vs 8.0 [$P = 0.008$]) and a shorter median career duration (12.5 vs 25.0 years [$P < 0.001$]), but a similar median m-quotient (0.5 vs. 0.5; $P = 0.525$). Among pediatric ophthalmologists who received NIH funding (20 women vs. 27 men; $P = 0.826$), the overall median grant-funding total for women was $804K (interquartile range (IQR) 5.0M, mean $3.8M) compared to men, $2.2M (IQR, 4.0M; mean, $3.7M; $P = 0.328$).

CONCLUSIONS—The shorter career duration for women likely contributes to the difference in overall h-indices between genders, as m-quotients were similar. The m-quotient should be used over the h-index when comparing academic productivity across genders when disparities in career length exist.

Women currently represent 25% of all ophthalmologists in the United States and nearly 40% of pediatric ophthalmologists.[1,2] The proportion of women in ophthalmology is expected to increase, because they make up 44% of graduating ophthalmology residents.[3] Despite the increasing representation of women in ophthalmology, previous studies have shown that

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women faculty continue to be disproportionately underrepresented in leadership positions within and outside their own academic institutions.[4-7]

The h-index has been used as a tool to assess scholarly impact and is often positively correlated with increasing academic rank.[8] It has also been positively correlated with National Institutes of Health (NIH) funding.[9] The h-index, however, fails to account for individual career durations,[10] which is not ideal when comparing bibliometric markers in a field such as ophthalmology, where differing career durations exist between groups. For instance, in a prior study assessing academic productivity and gender disparities in ophthalmology, the h-index was higher in mid-career male ophthalmology faculty but higher in women when assessing faculty with a career duration longer than 20 years.[11] These findings support evaluating productivity metrics within the context of career duration when studying gender disparities. The m-quotient is a tool that helps to average scholarly achievements over the duration of an individual's career[8] and may thus be an alternative outcome measure used to study gender disparities when a difference in career duration between genders exists, as is the case across medicine.

Although the number of women in ophthalmology is lower than that of men, pediatric ophthalmology is a unique subspecialty in that women and men are represented in roughly equal numbers as physicians. The purpose of the current study was to investigate gender disparities among pediatric ophthalmologists with respect to academic rank, publication productivity, and NIH funding.

Methods

This study was approved by the Penn State College of Medicine Institutional Review Board as a cross-sectional analysis. A search of all ophthalmology residency programs participating in the 2019 SFMatch (sfmatch.org) yielded a total of 114 programs. One program was excluded because data could not be obtained from its institutional website or direct email communications, leaving 113 US academic ophthalmology programs for analysis.

Official institutional websites were accessed between January and March 2019 to obtain data on gender, year of graduation from residency, and academic rank of all full-time academic pediatric ophthalmology faculty. When necessary, confirmation of gender was accomplished through evaluation of photographs, physician profiles, or gender-indicating pronouns accessed through additional online searches.

The Scopus database (Elsevier, https://www.scopus.com) was accessed between March 1 and March 31, 2019, to determine the total number of publications (including all first, middle, and last coauthorships) by each faculty member and the total number of times that an author's papers were cited. The database was also searched in alphabetical order using author last names, so as not to bias the query results toward one gender. Attempts were made to determine any alternative names that faculty had used prior to their current name (such as maiden names). Online searches for curriculum vitae and Scopus website profiles were performed to include publications under different last names. These data from

Scopus were then used to determine each faculty member's h-index, defined as the highest number of an author's publications that received at least *h* number of citations. The h-index serves as a measure of both author productivity and citation impact. Each faculty member's m-quotient, which accounts for varying lengths of an academic career, was also calculated by dividing the h-index by the number of years between date of residency graduation and 2019. Analyses were performed to determine whether h-index or m-quotient differed between genders at each academic rank (assistant, associate, and full professor) as well as in three career intervals: 0-15 years, 16-28 years, and 29+ years.

NIH funding data, including total dollar amount of funding and number of projects funded, were collected from the NIH Research Portfolio Online Reporting Tool Expenditures and Results (RePORTER, https://report.nih.gov) between March 1 and March 31, 2019. This data tool captures NIH funding from 1985 to the present. All years of available data for each faculty member were included for analysis. All listed and alternative names were queried.

Statistical analysis was performed using SAS version 9.4 (SAS Institute, Cary, NC). The cut-off for statistical significance was set at $P = 0.05$. The distribution of career duration was analyzed by the Anderson-Darling test for normality. Academic ranks as binary response variables were compared in terms of percentages between genders using a binomial logistic regression model that included career length as an independent variable for adjustment; career duration was compared between genders within each academic rank using Wilcoxon rank-sum tests and medians (Table 1). Overall median comparisons of academic productivity metrics by gender were made using a Wilcoxon rank-sum tests for the h-index and m-quotient (Table 2). These same comparisons were also made within subgroup categories of career length and within academic ranks using the Wilcoxon rank-sum test (Table 2).

Results

A total of 389 full-time pediatric ophthalmology faculty members were identified from the 113 US allopathic academic institutions: 194 (49.9%) were women, and 195 (50.1%) were men. The academic ranks of these individuals are summarized in Table 1. Academic pediatric ophthalmologists also represented 6.0% of all department chairs (11/113), of whom 2.7% (3/113) were women and 7.1% (8/113) were men ($P = 0.419$). The median career duration among the pediatric ophthalmology department chairs was statistically similar between genders (females 23.0 vs males years [$P = 0.142$]).

Career duration was found to be skewed based on the Anderson-Darling test for normality ($P < 0.005$). Overall, women had a shorter median career duration compared to men (12.0 years vs 25.0 years [$P < 0.001$]). Analyzed by academic rank, women had a significantly shorter median career duration at both the assistant (9.0 vs 16.5 years [$P < 0.001$]) and associate (16.0 vs 22.0 [$P = 0.004$]) level positions compared to their male colleagues, but there were similar median career durations between genders at the full professor level (29.0 vs 32.0 years [$P = 0.132$]). See Table 1.

The median number of publications for women was 10.0 (range, 0-298), compared to 20.5 (range, 0-467) for men ($P < 0.001$). When analyzed by career length, women providers had a median of 0.9 publications per year in practice compared to men, who had a median of 1.2 publications per year ($P = 0.029$). Women were cited a median of 100.0 times (range, 0-8324) compared to men, who averaged 343.5 citations (range, 0-13064; $P < 0.001$). Analyzed by career length, females had a median citation record of 7.8 per year compared with their male colleagues, who had a median citation record of 18.1 per year ($P < 0.001$).

The aforementioned scholarly activity data was used to calculate h-index and m-quotient values by gender (Table 2). Women had a lower median h-index compared to men (5.0 vs 8.0 [$P = 0.008$]). However, women had similar median m-quotients (0.5 vs 0.5 [$P = 0.525$]). Box-and-whisker plots of h-indices and m-quotients by gender are illustrated in Figure 1. The h-indices and m-quotients were equivalent for women and men at all academic ranks (Table 2). Comparison of the h-index and m-quotient over the three predefined career length intervals, however, showed men to have significantly higher h-indices and m-quotients at years 16-28 but similar values to women at years 0-15 and >29 years (Table 2).

A total of 47 principal investigators receiving NIH grant funding were identified from the 389 pediatric ophthalmology faculty. Of these, 20 women and 27 men received NIH grant funding between 1985 and 2019 ($P = 0.826$). The overall median grant funding total for women was $804K (interquartile range [IQR], 5.0M; mean, $3.8M) compared with $2.2M for men (IQR, 4.0M; mean, $3.7M; $P = 0.328$). Women had a similar median number of NIH projects compared to men (1.5 vs 2.0 [$P = 0.459$]). During their early career (0-15 years), women had lower median NIH grant values compared with their male colleagues ($430k [n = 9] vs $2.2M [n = 2]), although findings were not statistically significant ($P = 0.724$). In the middle of their careers (16-28 years), women continued to have lower median NIH grant values ($540k [n = 5] vs $2.8M [n = 6]) compared with men ($P = 0.036$]). This trend changed by late career (>29 years), at which time women had significantly larger median NIH grants ($11.7M [n = 6] vs $1.4M [n = 19]) compared with men ($P = 0.017$).

Discussion

Previous studies have raised concerns over the underrepresentation of female ophthalmology faculty in positions of higher academic rank.[3,4,11] For instance, Lopez and colleagues[11] published in 2014 that 13% of female compared to 34% of male ophthalmologists had achieved the rank of full professor. A more recent study by Tuli[12] also found that the gender ratio at each academic rank had not changed significantly from 2003 to 2017. Dotan and colleagues[13] found that only 4% of academic chairs within ophthalmology were women in 2007. In 2018 this had only increased to 10%.[13] On a national scale, previous studies have shown that women ophthalmologists are less likely to be editor-in-chief of a top journal and/or president of an influential society.[5,6]

On the surface, one might conclude that our study draws similar conclusions for pediatric ophthalmologists, namely, that men were more than twice as likely as women to be ranked full professor. However, our study highlights how these observations must be interpreted within the context of career duration. When this is taken into account, no difference between gender and rank of full professor is observed among pediatric ophthalmologists ($P = 0.119$). Thus, the disparity seen when solely considering the proportion of women and men with the rank of full professor is likely secondary to the shorter mean career duration of women pediatric ophthalmologists. With more women entering the field of ophthalmology, we may well see a close in this gender gap at various academic ranks.

It is also noteworthy that women with the rank of assistant and associate professor had a significantly shorter median career length than men in pediatric ophthalmology. It may be that, among academic pediatric ophthalmologists, women are promoted more quickly than men; however, the present study lacks sufficient data to conclude this definitively, because information regarding timing of faculty promotion is not available. Longitudinal studies are warranted to investigate this further.

Gender disparities observed in upper academic ranks must also be evaluated in the context of relative productivity. Both the h-index and m-quotient are measures designed to help assess this. Prior studies have shown that the h-index and m-quotient increase with academic rank.[11,13,14] Of note, Thiessen and colleagues[15] reported higher h-indices in men versus women ophthalmologists but equivalent m-quotients between genders. Our study confirms these findings in the pediatric ophthalmologist subgroup. However, it is important to note that evaluating only the h-index, raw publication numbers, or raw citation numbers is an oversimplification of productivity, because these metrics do not take into account career duration. These measures provide an advantage to individuals later in their career. On the other hand, a lower raw number of publications and citations for women versus men did not translate to a difference in the overall m-quotient. The m-quotient may thus be a better indicator of publication productivity when comparing groups of varying career lengths, as is the case for men and women in pediatric ophthalmology.

In the current study, we investigated associations between the h-index and m-quotient with academic rank but also career length intervals and found that women and men in their early (0-15 years) and late (>29 years) careers have similar h-indices and m-quotients. However, midcareer (16-28 years) women have lower publication productivity by both measures compared with their male colleagues, as seen in the box-and-whiskers plots (Figure 1). We did not investigate the reasons for this gender disparity in productivity during mid-career years; future studies that investigate the significance of specific gender characteristics, such as career path decisions and home versus work responsibilities, may help to elucidate such differences.

The NIH is the largest funder of biomedical research across the globe, and women represent 34% of all NIH grant recipients.[9,16] In our study, men and women pediatric ophthalmologists were equally represented as recipients of NIH funding ($P = 0.826$). Women, however, achieved lower NIH funding values compared to men in the early and mid-career intervals (0-15 and 16-28 years) and surpassed them in late career (>29 years). Differing responsibilities for women and men outside of work might explain some of these findings, but addressing this hypothesis is beyond the scope of this study. It is also important to note that the small number of women (20) and men (27) in this subgroup of pediatric ophthalmologists and principal investigators limits conclusions on the association between gender and grant funding status.

There are several important limitations to this study. Although we attempted to merge the scholarly product and NIH grant data that occurred under alternate (ie, maiden) names for the same individual, it is possible that alternative names were not identified and remained unmerged. This study also did not take into account how a specific faculty member's career years from residency to 2019 were spent and thus any time off for health or family reasons, which may be higher among women, could adversely affect the timeline to achievement in publication or other scholarly activities. Such omissions might disproportionately under-report the scholarly productivity of women and result in lower bibliometric profiles. This study also did not directly investigate the total career length in which each individual faculty member remained within his or her subspecialty. A recent publication by Hedden and colleagues[17] noted that when averaged over all medical specialties, women physicians seem to retire earlier than their male colleagues. If this same retirement trend were true for ophthalmology, the trend may limit gender-based data comparisons in the later career years. Further studies on gender and retirement are warranted.

Second, there are inherit limitations in the Scopus database and the NIH RePORTER. For example, Scopus results primarily include PubMed-indexed articles, which may result in inaccurate author productivity data, particularly as it pertains to a research-oriented medical profession such as ophthalmology, where research is published in a diverse array of journals. The NIH RePORTER is also limited, because it only captures NIH funding dating back to 1985. In addition, and as mentioned above, the low number of individuals with NIH funding in this study (n = 47) limits the statistical power to make strong conclusions.

Third, it is important to point out that there are inherent limitations in the h-index and m-quotient as it pertains to an assessment of the quality of academic achievement. The h-index is one of the most widely used parameters to measure scholarly productivity; however, it has not been validated specifically within the field of pediatric ophthalmology. The h-index also does not take into account details of an author's contribution in multiauthor publications.[18] Future studies investigating the h-index as it relates to specific author contributions (first, middle, or last author) may be helpful to further investigate gender disparities.

Lastly, it is important to note that the results of this study, which investigated gender disparities, cannot be used to imply gender discrimination. To investigate such a charged topic, demographically equivalent cohorts of women and men would have to be compared. This was beyond the scope of the current study.

To our knowledge, this is the first study to investigate gender disparities among academic pediatric ophthalmologists with respect to academic rank, publication productivity, and NIH funding. This study revealed similar academic productivity between genders on multiple levels. We believe that the career duration of women faculty versus their male colleagues must be considered when comparing academic productivity between genders. Our study highlights the m-quotient as an appropriate measure of academic productivity in the setting of gender disparities that exist within medicine at present. It is important to highlight, however, that the h-index and m-quotient alone do not fully summate publication quality or its relevance to the scientific community at large and thus should not be used as a sole measure for comparison of faculty applicants for promotion.

Literature Search

PubMed MEDLINE, OVID MEDLINE, and Clinical Key were searched without date restriction in January 2020 using the following search/MESH terms: *physicians* AND *women*; *education* AND *medical* AND *graduate*; *faculty, medical, authorship, female, male, sex factors, sexism, peer review, research,* and *ophthalmology*. Articles cited in other reference lists of articles were also researched. Foreign literature was considered when applicable to the topic.

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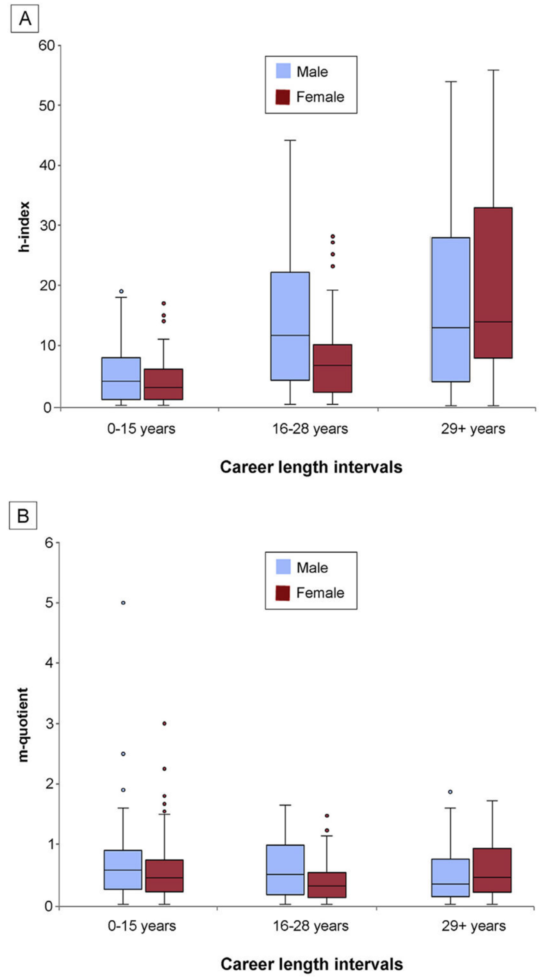

FIG 1.

Box-and-whiskers plots of h-index (A) and m-quotient (B) as a function of career duration interval for male and female academic pediatric ophthalmology providers.

Table 1.

Gender comparison of pediatric ophthalmology faculty based on academic rank

Academic category	Women	Men	*P* value
Assistant Professor			
Percentage (n)[a]	64.4% (125/194)	46.2% (90/195)	0.738
Median career duration, years (IQR)[b]	9.0 (11.0)	16.5 (20.0)	<0.001
Associate Professor			
Percentage (n)[a]	21.7% (42/194)	19.0% (37/195)	0.357
Median career duration, years (IQR)[b]	16.0 (12.0)	22.0 (19.0)	0.004
Full Professor			
Percentage (n)[a]	13.9% (27/194)	34.9% (68/195)	0.119
Median career duration, years (IQR)[b]	29.0 (11.0)	32.0 (11.0)	0.132
Overall			< 0.001
Percentage (n)[a]	49.9% (194)	51.1% (195)	
Median career duration, years (IQR)[b]	12.0 (16.0)	25.0 (19.0)	

IQR, interquartile range.

[a] *P* value from binomial logistic regression model adjusted for career duration.

[b] *P* value from Wilcoxon rank-sum test.

Table 2.

Gender comparison of scholarly achievement of pediatric ophthalmologists divided by career length intervals and academic rank[a]

Category	Measure	Women (IQR)	Men (IQR)	*P* value
Median overall				
	h-index[a]	5.0 (7.0)	8.0 (17.0)	0.008
	m-quotient[b]	0.5 (0.4)	0.5 (0.6)	0.525
Career length				
0-15 years	h-index[a]	3.0 (5.0)	4.0 (7.0)	0.271
	m-quotient[b]	0.5 (0.3)	0.5 (0.5)	0.972
16-28 years	h-index[a]	6.5 (8.0)	11.5 (18.0)	0.014
	m-quotient[b]	0.4 (0.4)	0.6 (0.7)	0.017
≥29 years	h-index[a]	14.0 (25.0)	13.0 (24.0)	0.530
	m-quotient[b]	0.5 (0.6)	0.4 (0.6)	0.151
Academic rank				
Assistant professor	h-index[a]	3.0 (5.0)	3.0 (7.0)	0.294
	m-quotient[b]	0.4 (0.4)	0.3 (0.6)	0.411
Associate professor	h-index[a]	7.0 (7.0)	10.0 (11.0)	0.055
	m-quotient[b]	0.5 (0.3)	0.5 (0.3)	0.567
Full professor	h-index[a]	19.0 (27.0)	22.5 (21.0)	0.866
	m-quotient[b]	0.7 (0.7)	0.7 (0.7)	0.334

IQR, interquartile range.

All comparisons are made with Wilcoxon rank-sum tests.

[a]The h-index was defined as the highest number of an author's publications that received at least *h* number of citations.

[b]The m-quotient was calculated by dividing the h-index by the number of years between residency graduation to 2019.