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Education

A gender-based comparison of academic rank and scholarly productivity in academic neurological surgery

Krystal L. Tomei [a], Meghan M. Nahass [c], Qasim Husain [a], Nitin Agarwal [a], Smruti K. Patel [a], Peter F. Svider [a], Jean Anderson Eloy [a,b], James K. Liu [a,b,*]

[a] Departments of Neurological Surgery and Otolaryngology – Head & Neck Surgery, Rutgers University – New Jersey Medical School, Newark, NJ, USA
[b] Center for Skull Base and Pituitary Surgery, Neurological Institute of New Jersey, Rutgers University – New Jersey Medical School, 90 Bergen Street, Suite 8100, Newark, NJ 07103, USA
[c] Rutgers University – Robert Wood Johnson Medical School, New Brunswick, NJ, USA

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ABSTRACT

The number of women pursuing training opportunities in neurological surgery has increased, although they are still underrepresented at senior positions relative to junior academic ranks. Research productivity is an important component of the academic advancement process. We sought to use the *h-index*, a bibliometric previously analyzed among neurological surgeons, to evaluate whether there are gender differences in academic rank and research productivity among academic neurological surgeons. The *h-index* was calculated for 1052 academic neurological surgeons from 84 institutions, and organized by gender and academic rank. Overall men had statistically higher research productivity (mean 13.3) than their female colleagues (mean 9.5), as measured by the *h-index,* in the overall sample ($p < 0.0007$). When separating by academic rank, there were no statistical differences ($p > 0.05$) in *h-index* at the assistant professor (mean 7.2 male, 6.3 female), associate professor (11.2 male, 10.8 female), and professor (20.0 male, 18.0 female) levels based on gender. There was insufficient data to determine significance at the chairperson rank, as there was only one female chairperson. Although overall gender differences in scholarly productivity were detected, these differences did not reach statistical significance upon controlling for academic rank. Women were grossly underrepresented at the level of chairpersons in this sample of 1052 academic neurological surgeons, likely a result of the low proportion of females in this specialty. Future studies may be needed to investigate gender-specific research trends for neurosurgical residents, a cohort that in recent years has seen increased representation by women.

1. Introduction

The number of women pursuing training opportunities in neurological surgery has increased substantially in recent years, with women representing approximately 12% of neurosurgery residents in 2003 and about 19.6% in 2011 [1]. However, these numbers still trail behind the percentage of females training in other specialties. For instance, women comprise approximately 30% of residents in general surgery residency programs and well over half of medical student classes [2–4].

In addition to the differences in gender composition of academic departments, there exist observed differences in academic productivity throughout the career of academic physicians. A 2007 intra-institutional longitudinal cohort study from the Mayo Clinic suggested that while men published an overall greater amount of articles throughout their career, research productivity amongst women increased throughout their career, ultimately leading to higher publication rates later in life [5]. The authors concluded that early and middle career assessments of research productivity may not be appropriate for evaluating academic advancement. We attempted to investigate the gender-specific research patterns within neurological surgery to investigate if similar trends exist.

There are several commonly used methods to assess research productivity among academic physicians [6]. As mentioned above, the total number of publications is frequently used [7]. Another regularly used measure is total number of citations of an author's works by other publications [8]. Although both are objective and easily quantified, they have their limitations. Total number of publications indicates little about the quality and type of research. Additionally, total number of citations also has the potential to be skewed and is dependent on several factors. One example is if an individual was just one of many co-authors on a single significantly cited study, total number of times cited

* Corresponding author. Tel.: +1 973 972 2906; fax: +1 973 972 2333.
E-mail address: james.liu.md@rutgers.edu (J.K. Liu).

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would be disproportionately affected by that one project regardless of whether the author was a primary contributor.

One recently described bibliometric that attempts to evaluate the relevance of an individual's research contributions and produce an objective quantification is the *h-index*. Initially described by Dr. J.E. Hirsch in 2005, an author's *h-index* is defined as the number of publications *h* that has been cited by other publications at least *h* times [8]. An author with an *h-index* of 30 has had 30 publications that have been cited at least 30 times in peer-reviewed journals. This measure judges the relevance of a researcher's contributions by evaluating not only the number of publications, but also the frequency that his or her works are cited. This measure can be calculated using one of several online *h-index* calculators, including those available from Google Scholar, Scopus, and ISI Web of Knowledge.

The use of the *h-index* has been examined in a wide variety of medical disciplines [9–20]. One study examined the use of the *h-index* in neurological surgery and demonstrated a direct correlation between the *h-index* score and academic rank, although there was no evaluation of research output by gender [21]. The same paper utilized resources from both Google Scholar and Scopus, finding that results from these two databases had a high correlation.

In addition to clinical performance, educational contributions, and administrative roles, research productivity is an important component of the evaluation process of academic physicians when evaluating applications for promotion. Our objectives were to evaluate whether there are gender-associated differences in academic rank and research productivity among neurological surgeons, as measured by the *h-index*.

2. Methods

A list of academic neurological surgery departments was obtained from the American Medical Association's Fellowship and Residency Electronic Interactive Database Access System (FREIDA). The faculty listings from the websites of these programs were used to compile a list of faculty members and their respective academic ranks. These faculty members were additionally categorized by gender. An *h-index* calculator from the Scopus Database (www.scopus.com) was used to calculate the *h-indices* of each of these faculty members.

Faculty members were organized into the following cohorts: junior faculty (assistant professor) and senior faculty (associate professor, professor, and chairperson). For institutions where neurological surgery was a division of surgery, division chiefs or directors were counted under the chairperson category for the purposes of this analysis. Full-time non-clinical research faculty, adjunct professors, instructors, non-academic, and non-physician faculty were excluded from this analysis. Individuals whose academic ranks were not listed anywhere on the website of the academic department or related clinical website were also excluded from the study. Out of the 102 neurological surgery programs listed on FREIDA, the websites of 18 departments did not list all required data for faculty members, and were thus excluded from this analysis. All data were collected between May and June 2012. Mann–Whitney U tests and Kruskal–Wallis tests were calculated where appropriate using the Statistical Package for the Social Sciences version 20 (SPSS, Chicago, IL, USA). Non-parametric statistical analyses were performed due to the asymmetrical distribution of the data. Statistical significance was set at $p < 0.05$.

3. Results

Out of the 1052 academic neurosurgeons from 84 institutions included in this analysis, 93 (8.8%) were women and 959 (91.1%) were men (Fig. 1). At the rank of full professor, women comprised only 3.7% of faculty. There was one female chairperson out of the 84 departments included in this analysis. When including all academic neurosurgeons, males had higher research productivity, mean 13.3 (95% confidence interval [CI] 12.6–14.0) as measured by the *h-index*, relative to their female counterparts' mean of 9.5 (95% CI 7.7–11.3) in this analysis (Mann–Whitney U test, $p = 0.0007$) (Table 1). This finding persisted when the predominantly male cohort of chairpersons were excluded from the calculation (*h-index* = 12.4 *versus* 9.5, $p = 0.008$). When broken down further by faculty rank, the statistical significance did not persist. Men had a higher mean *h-index* of 7.2 (95% CI 6.7–7.8) than women at 6.3 (95% CI 4.5–8.1) at the junior rank of assistant professor (Mann–Whitney U test, $p = 0.0673$) (Table 1). For associate professors, the average male *h-index* was 11.2 (95% CI 10.2–12.2) compared to 10.8 (95% CI 8.1–13.5) in females (Mann–Whitney U test, $p = 0.6965$). The average *h-index* of male professors was 20.0 (95% CI 18.7–21.3), higher than that of their female counterparts (*h-index* = 18.0, 95% CI 10.2–25.1) (Mann–Whitney U test, $p = 0.6241$). Upon aggregating senior faculty data (i.e. associate professors and professors), men had a statistically higher *h-index* (Table 1). However, upon removing chairpersons from the cohort of senior faculty, this comparison bordered but did not reach statistical significance (*h-index* = 16.1 *versus* 13.2, $p = 0.05$). For chair positions, the average male *h-index* was 22.5. However, given the low sample size of women (n = 1) in this category, adequate statistical analysis could not be calculated.

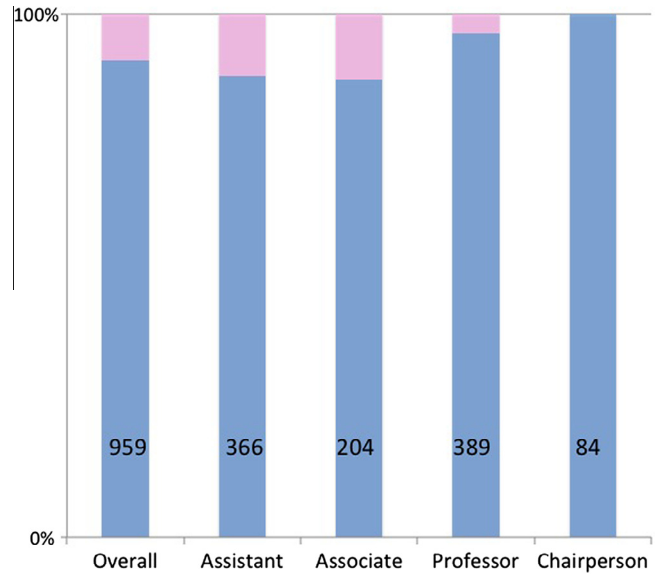

Fig. 1. Gender breakdown of 1052 academic neurological surgeons from 84 institutions included in this analysis. Numbers in bars represent actual sample size. Bottom numbers represent men, top numbers represent women, y-axis represents percentage.

Table 1
h-index organized by academic rank and gender

	Median [Interquartile range], (n)	
	Male	Female
Overall	10 [5–18], (959)	8 [3–12], (93)
Assistant professor	6 [3–10], (366)	4 [2–9], (49)
Associate professor	10 [6–16], (204)	9 [6–15], (29)
Professor (no chairs)	17 [10–27], (389)	15 [12–23], (15)
Chairpersons	20 [12–31], (84)	14, (1)
Senior faculty	15 [8–24], (593)	11 [8–15], (44)
Overall (no chairs)	10 [5–16], (875)	8 [3–12], (92)

Mean *h-index* increased with successive academic rank (Kruskal–Wallis test, $p < 0.0001$) (Table 1). This relationship persisted when broken down by gender (Kruskal–Wallis test, $p < 0.0001$).

4. Discussion

Standard metrics used in assessing research productivity have traditionally focused on how many publications a faculty member has, along with grant history [8,9,13]. While these and other measures have their merits, metrics that address both the relevance and significance of scholarship are valuable in determining academic output in an impartial manner. The *h-index* is an objective accounting of an individual's influence on research discourse within his or her field of expertise.

There are several limitations inherent to using the *h-index* to assess research productivity as well as any associated gender-specific differences. There is the potential for self-citation by authors to inflate their own *h-index* scores, although repeated self-citation would be required to significantly inflate one's *h-index* [22,23]. For example, increasing the *h-index* score by a single digit requires that each publication accounted for in the *h-index* is cited an additional time as well as requiring that an additional paper be cited $h + 1$ times.

A limitation in the calculation of gender differences within this analysis is the possibility of exclusion of any papers authored by female academic physicians under their maiden name. If these women had not made a request for databases, including Scopus, to merge their citation profiles, those papers authored under their maiden name would not be accounted for in their *h-index* calculation. This may result in an underestimation of female academic neurosurgeons' research productivity. Lastly, *h-index* calculations do not account for a career time-course. Those individuals with longer careers have had more opportunity for papers to be cited as well as to increase publication numbers.

As noted, the proportion of women entering neurological surgery has not increased until relatively recently; the first woman did not gain certification in this specialty until 1960. While the number of women entering neurological surgery has since grown, a later date of entry into the field certainly limits career lengths and impacts publication opportunities. Overall, approximately 3% of American Board of Neurological Surgery (ABNS) diplomats are female. Of those diplomats actively practicing, only about 4.7% are women. While the percentage of women active in academic neurological surgery is a little higher, at approximately 6%, this low proportion clearly underscores the potential limitations of any results, which suggests significant differences in scholastic productivity with regards to gender [1].

One reason, beyond the scope of this analysis, that may explain the relative underrepresentation of women in neurological surgery may be that traditionally greater family responsibilities shouldered by women (relative to their male colleagues) may affect early-career scholarly productivity among those in surgical specialties [1,24–32]. This may possibly affect subsequent career trajectory. For instance, 10.9% of full professorships are held by women in academic medicine, whereas within neurosurgery only 6% hold those same high ranking faculty positions. Moreover, until 2005 not a single female neurological surgeon was chair of an American department. These gender differences persist in professional neurosurgical organizations with regards to positions for elected officials.

Our analysis indicated that there was a statistically significant difference in the overall *h-indices* between female and male academic neurological surgeons, with mean *h-index* values of 9.5 and 13.2, respectively ($p = 0.0007$). As men comprised all but one of the chairpersons included in this analysis, this calculation was also performed with chairpersons excluded, and found a lesser but still significant difference in *h-indices* between men and women (*h-index* = 12.4 *versus* 9.5, $p = 0.008$). Of course, as mentioned above, the limitations must be considered when analyzing this result.

Interestingly, when evaluating *h-index* differences categorized by academic rank, the statistical significance disappeared. This may be a function of inadequate power to show a difference, or a consequence of the paucity of women in academic neurological surgery (Fig. 1). The mean *h-index* difference between male and female academic neurological surgeons was ± 2 at the assistant professor, associate professor, and professor levels. Given these data, any observed differences are likely nominal and moreover may diminish as a greater proportion of women are given the opportunity to enter and be active members of the field of neurological surgery. Additionally, this lack of difference found upon breakdown by academic rank may emphasize the rigorous, thorough, and impartial nature of the process used by promotions committees across the country.

5. Conclusion

The *h-index* is a valuable metric that takes into account both the quantity and influence of research contributions to academic discourse within a field. Based upon our study, academic productivity of females and males in similar faculty positions is not statistically significantly different. While differences were noted in the proportion of females incumbent in senior faculty positions, any lack of female representation in senior or chair positions is likely indicative of the low proportion of women in neurosurgery. As the number of females trained in neurological surgery increases, there will likely be an increase in the number of females of higher academic rank. Future studies may be necessary to investigate gender-specific research trends for neurosurgical residents, a cohort that in recent years has seen increased representation by women.

Conflicts of Interest/Disclosures

The authors declare that they have no financial or other conflicts of interest in relation to this research and its publication.

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