Acta Neurochirurgica (2019) 161:1969–1974
https://doi.org/10.1007/s00701-019-04011-2

ORIGINAL ARTICLE - NEUROSURGERY TRAINING

Academic output of German neurosurgical residents in 35 academic neurosurgery residency programs

Fatma Kilinc[1] · Florian Gessler[1] · Daniel Dubinski[1] · Sae-Yeon Won[1] · Johanna Quick-Weller[1] · Volker Seifert[1] · Bedjan Behmanesh[1]

Received: 3 April 2019 / Accepted: 9 July 2019 / Published online: 18 July 2019

Abstract

Background The scientific activity of neurosurgeons and neurosurgery residents as measured by bibliometric parameters is of increased interest. While data about academic output for neurosurgeons in the USA, the UK, and Canada have been published, no similar results for German neurosurgical residents exist. Within this study, we aim to evaluate the academic output of German neurosurgery residents in 35 academic residency programs.

Methods Data for each resident were collected from the departmental websites, Pubmed, and Scopus. Further analyses evaluated the relationship between publication productivity, sex, and academic degree (Dr. med.).

Results Data from 424 neurosurgery residents were analyzed. A total of 1222 publications were considered. A total of 355 (29%) of the 1222 publications were first-author publications. The average number of publications per resident was 2.9; the average h-index and m-quotient was 1.1 and 0.4, respectively. There was a statistically significant difference in academic output and h-index among neurosurgical residents with a doctoral degree compared with residents without such degree (5.3 vs. 1.3, $p < 0.0001$ and 2.0 vs. 0.5, $p < 0.0001$).

Conclusion This is the very first study evaluating the academic output of neurosurgical residents in academic neurosurgical departments in Germany.

Keywords Residents · Neurosurgery · H-index · M-quotient · Gender · Publication

Introduction

Research and publishing are key elements to the preservation of knowledge and the advancement in understanding pathologies, diagnostics, and therapies in medicine. Moreover, it still remains one of the important factors for professional academic advancement. Getting in touch with research and publishing are main steps of an ongoing academic career and are mostly supported by institutional faculty in university hospitals. Previous published studies reported a strong correlation of publication productivity as measured by the h-index later academic rank, position, and even income [6, 11, 18]. Bibliometric parameters are known for the evaluation of academic productivity. One such method is the h-index, which was introduced by Hirsch in 2005 as a method of counting the most highly cited papers by a particular author [8]. The h- index is not only being used as a measure of scientific achievement for individual researcher, but also to measure the scientific output of research groups, scientific facilities and even countries [19]. Nevertheless, the h-index has also some points of criticism such that the h-index can never decrease regardless of whether the author continues to publish, or not. The h-index can also not be used to compare researchers of different scientific areas [3]. Unlike the h- index, the m-quotient avoids a bias toward more senior scientists with longer careers and more publications [4].

Limitation of the h-index, including bias in favor of senior researchers and neglecting the number of years since first publication, leads us to consider the period since first publication and evaluating the m-quotient [12]. The m-quotient: h-index divided by the number of years since first publication is another tool, which helps to consider the period from the first publication.

This article is part of the Topical Collection on *Neurosurgery Training*

✉ Bedjan Behmanesh
bedjan.behmanesh@gmail.com

[1] Department of Neurosurgery, Goethe University Hospital, Frankfurt am Main, Germany

The publication productivity of neurosurgeons in the USA and colleagues from Great Britain has already been published [7, 9, 10, 13–17, 20, 21]. Until now, no similar data for German neurosurgeons and neurosurgical residents have been introduced. Within this study, we aim to evaluate the publication productivity among neurosurgical residency programs in 35 university hospitals in Germany.

Methods

A list of neurosurgical university hospital departments was obtained from the website of the German Society of Neurosurgery (DGNC). An expanded PubMed and Scopus search was performed from July to August 2018 for each resident identifying published articles. The h-index and the number of all published articles were collected.

First-author articles were differentiated from total published articles. Furthermore, all published articles were categorized into neurosurgical subspecialties of vascular, tumor, pediatric, spine, functional, epilepsy, trauma/intensive care medicine, peripheral nerve, and general neurosurgery. The sum and average number of total articles per resident were calculated for each resident.

In Germany, the basic medical degree awarded after graduation from medical school is physician (Arzt, MD). The first academic degree may be awarded for research consisting of a scientific thesis which then has to be successfully defended. Successful candidates earn the title of doctoris medicinae, abbreviated as "Dr. med."

Bibliometric tools selected were the h-index as well as the m-quotient, which is the h-index divided by the number of years since first publication. The relationship between productivity and author, sex, and academic degree was also examined.

Statistical analysis

All statistics were performed using SPSS (version 21, IBM, Armonk, New York). *P* values of < 0.05 were considered to be significant. Comparison of important differences between the study groups was made using Fisher's exact test for categorical variables. Nonparametric tests included the Mann–Whitney *U* and Kruskal–Wallis test to compare groups of data that did not follow the normal distribution. Tests for normality were performed using the Shapiro–Wilk test.

Results

During the study period (July - August 2018), there were 424 current neurosurgery residents identified in 35 university hospital neurosurgery residency programs. Of those, there were 163 (38.4%) female residents, Fig. 1. A total of 1222 publications, of which 355 (29%) were first-author publications were analyzed within the study period. The average number of published articles per resident was 2.9 and the average h-index and m-quotient were 1.1 and 0.4, respectively. On average, a resident published 0.8 first-author papers. Among all residents, 169 (39.9%) hold the academic degree Dr. med., Table 1.

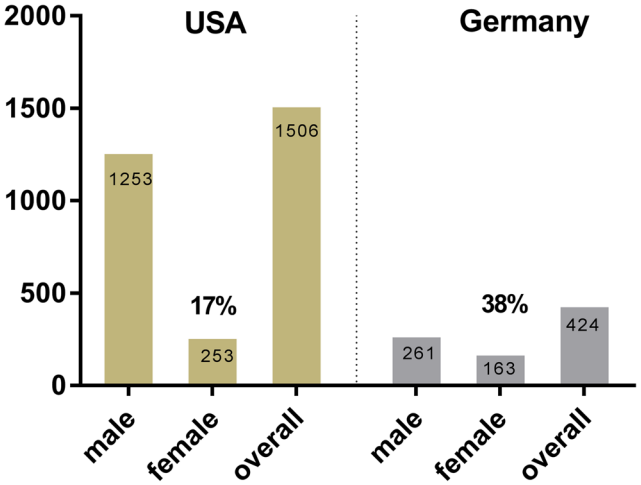

Fig. 1 Proportion of female neurosurgical residents in the USA [10] and Germany

Author sex and publication productivity

Within all programs, there were 163 (38.4%) female residents. Comparing the overall publication activity, h-index and m-quotient, there were significant differences between male and female neurosurgical residents. The average h-index for a male neurosurgical residentwas 1.2 (standard deviation (SD) of 2.3) and for female neurosurgical resident 0.8 (SD 1.4), $p = 0.2$. Comparing average Scopus documents between male and female residents, 3.3 (SD 6.4) vs. 2.2. (SD 3.6), $p = 0.5$ no significant difference was identified, Table 1.

Further, no significant difference was identified for residents' first author publications. Male neurosurgical residents published in average 1.0 (SD 2.3) and female residents 0.6 (SD 1.4) first-author papers, $p = 0.3$, Table 2. From 1222 publications, only 11 were last author publications published by 9 male and 2 female residents. The results of co-author publications revealed a total of 856 co-authorships. Male residents published on average more co-author publications, 2.3 vs. 1.6, $p = 0.6$. The only factor that was associated with higher publication in co-authorship was the possession of a doctoral degree, 3.6 vs 1.0, $p = 0.00001$. Gender did not influence the publication activity focusing on co-authorship. The correlation analyzes as well as the relation first/ non-first authorship revealed a trend to higher co-authorship especially among residents without a doctoral degree, whereas the h-index correlated more higher with first- as well as co-authorship among residents with a doctoral degree, Table 3, Figs. 4 and 5.

Table 1 Overall publication metrics for neurosurgical residents (∑ = sum; μ = average)

Characteristics	No.	∑h-index	∑ doc.	μ h-index	*p* value	μ Doc.	*p* value	μ m-quotient	*p* value
Overall	424	459	1222	1.1		2.9		0.4	
Male overall	261	324	863	1.2		3.3		0.4	
Female overall	163	135	359	0.8	0.2	2.2	0.5	0.3	0.3
Dr. med.	169	335	902	2.0		5.3		0.6	
No Dr. med.	255	124	320	0.5	**< 0.001**	1.3	**< 0.001**	0.2	**< 0.001**
Male Dr.	104	245	673	2.4		6.5		0.6	
Female Dr.	65	90	229	1.4	**0.02**	3.5	**0.04**	0.5	0.2
Male without Dr.	157	79	190	0.5		1.2		0.2	
Female without Dr.	98	45	130	0.5	0.9	1.3	0.5	0.2	0.9

All data in boldface are significant

Author higher academic degree and publication productivity

Almost 40% the current residents hold an academic degree (Dr. med.). The average h-index for residents with and without an academic degree was 2.0 (SD 2.7) and 0.5 (SD 1.0), respectively $p < 0.001$. When comparing residents with an academic degree to residents without an academic degree, both the average number of published articles (5.3 (SD 7.5) vs 1.3 (SD 2.5), $p < 0.001$) and the m-quotient (0.6 (0.6) vs. 0.2 (0.4), $p < 0.001$) were significantly higher. Of all residents with an academic degree, 65 (38.5%) were female residents and 104 (61.5%) were male residents. Further analysis of the residents with an academic degree stratified by sex revealed a significantly higher h-index for male residents with an academic degree, 2.4 (3.0) vs. 1.4 (1.9), $p = 0.02$, as well as a higher average number of publications for male residents with an academic degree 6.5 (8.6) vs. 3.5 (4.5), $p = 0.04$. In contrast, the average m-quotients 0.6 (0.6) vs 0.5 (0.5), $p = 0.2$ revealed no significant differences between both groups.

There were no gender-specific differences in mean h-index, average number of published articles and m-quotient of residents without an academic degree 0.5 (1.1) vs. 0.5 (0.9), $p = 0.9$, 1.2 (2.5) vs. 1.3 (2.4), $p = 0.4$ and 0.2 (0.4) vs. 0.2 (0.4), $p = 0.7$, Table 1.

Residents with an academic degree published significantly more first-author papers than those without an academic degree (1.7 vs. 0.2, $p < 0.001$). Moreover, male residents with an academic degree outperformed their female colleagues concerning first-author publication, 2.2 vs. 1.0, $p = 0.003$, Table 2.

Table 2 First-author publications data for German neurosurgical residents (∑ = sum; μ = average)

	No.	∑ 1st author	μ 1st author	*p* value
Male	261	262	1.0	0.3
Female	163	93	0.6	
Overall	424	355	0.8	
Dr. med.	169	295	1.7	< 0.001
No Dr. med.	255	60	0.2	
Male Dr. med.	104	228	2.2	
Female Dr. med.	65	67	1.0	0.003
Male w/o Dr. med.	157	34	0.2	0.9
Female w/o Dr. med.	98	26	0.3	

First-author publication and subspecialties

The most common subspecialties among all residents first-author publications were oncology and scull base (33.8%), followed by vascular (20.8%), general neurosurgery (11%), spine (7.9%), functional (7.0%), trauma (5.1%), pediatrics (3.7%), hydrocephalus (3.7%), epilepsy (3.4%), nerve (1.4%) ,and miscellaneous (2,2%), Fig. 2. Among all first-author publications there were 333 (93%) original articles, 9 (2.5%) reviews, and 13 (3.7%) case reports.

First-author publication and impact factor

From 355 first-author publications 43 (12.1%) were published in journals with an impact factor 5 and higher and only 10 (2.8%) higher than an impactor factor of 8.

First-author publications stratified by journals

Journals in which more than four first-author papers were published were (in order of descendance) *World Neurosurgery* followed by *Acta Neurochirurgica*, *Journal of Neuro-oncology*, *Neurosurgical Review*, *Journal of Neurosurgery*, *Clinical Neurology*, and *Neurosurgery* as shown in Fig. 3.

Table 3 Co-authorship data for German neurosurgical residents (∑ = sum; μ = average)

	No.	∑ co- author	μ co- author	*1st author/non-1st author	*p* value
Male	261	592	2.3	0.5	0.6
Female	163	264	1.6	0.4	
Overall	424	856	1.8	0.4	
Dr.	169	585	3.6	0.5	< 0.00001
No Dr. med.	255	260	1.0	0.2	
Male Dr. med.	104	436	4.3	0.5	0.1
Female Dr. med.	65	160	2.5	0.4	
Male w/o Dr. med.	157	156	1.0	0.2	0.6
Female w/o Dr. med.	98	104	1.1	0.3	

*Relation first + last authorship / non-first or last authorship

Publication activity and department size

Analyzing the relationship between size of department and research productivity, measured by the existing beds, it is striking that the research productivity is not related to the size of the hospital, number of hired physicians, and number of annually treated patients, $p > 0.05$.

Discussion

Bibliometric research has grown in many medical specialties over the past years. Data about publication productivity among neurosurgeons and residents in neurosurgery, especially in the USA, UK, and Canada have been published, as well as [9, 10, 13–15, 17, 20, 21]. Within this study, we wanted to elucidate the academic output of German neurosurgical residents. Previously published data already underlined the positive correlation between publication productivity, h-index during residency and later academic career after board certification [5, 25].

To the best of our knowledge, this is the first study evaluating whether a higher research degree is associated with publication productivity of neurosurgical residents. The total number of publications authored by these 424 German residents was 1222 (2.9/ resident) and was substantially lower when compared with residents in the USA (9.2/ resident). The same finding was observed for the average h-index (1.1/resident vs. 2.4/ resident) [10].

Gender differences

In recent time, many investigations have been undertaken to evaluate the role of women in medicine and especially in surgical disciplines [1, 2, 6, 22–24]. In contrast to many other surgical disciplines, such as general surgery and urology, female residents in neurosurgery are significantly underrepresented [1]. In addition, current studies show that, on average, women in academic medicine continue to earn at least 10% less than their male counterparts [23, 24]. In contrast to neurosurgical residents in the USA, the proportion of female residents in Germany is significantly higher (17% in USA vs. 39% in Germany), Fig. 1.

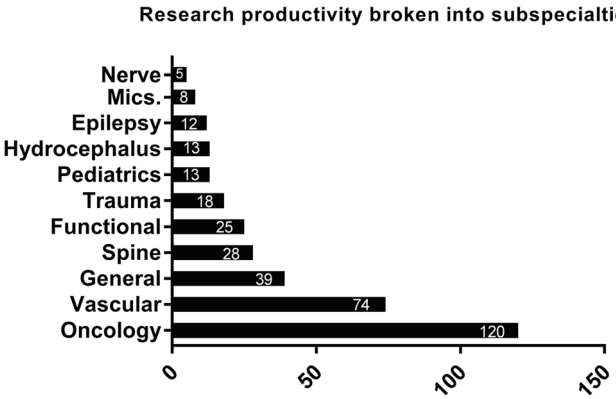

Fig. 2 Resident research productivity and subspecialty

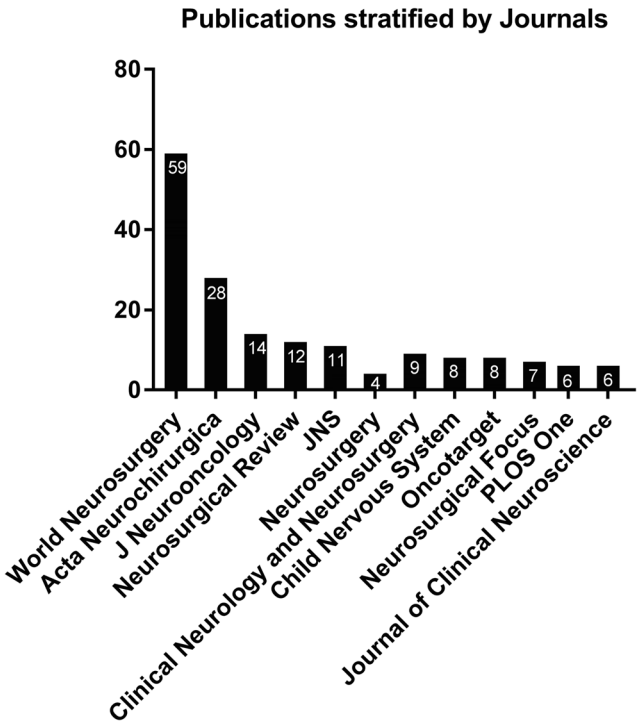

Fig. 3 Resident first-author publications stratified by journals

In Germany, we see a different development toward gender equity. Until now, no other data are published describing such a high proportion of female neurosurgical residents as in Germany. This finding mirrors the increasing number of female medical students in recent years.

In contrast to the published data from the USA, we see no significant difference in publication productivity between male and female neurosurgical residents regarding the overall number of publications. The distinguishing factor for higher research activity and resulting in higher publication activity in Germany is the possession of a doctoral degree (Dr. med.). Male as well female residents with a "Dr. med." are publishing significantly more than their colleagues without a "Dr. med." Here, we identified a gender difference in publication activity, as well. Male neurosurgical residents with an academic degree published more often scientific paper than female neurosurgical resident with an academic degree.

Despite the increasing proportion of female neurosurgical residents, the male counterparts are still outperforming their female colleagues by h-index, number of documents and the m-quotient, when having a doctoral degree. A reason might be that residents with an academic degree already got in touch with research and were successfully awarded an academic degree. They then continue research and produce publications afterwards. Similar data were published by Wilkes et al. reporting about research and academic output of neurosurgeons in Great Britain. They found similar results, the possession of an MD or PhD was in their analysis an important factor of higher publication activity as reflected by a higher h-index and higher number of published papers [21].

Co-authorship and first-authorship

Our analysis revealed a trend to more co-authorship publications as well as higher number of publications in journals with a lower impact factor than 5. Nevertheless, residents with an academic degree either male or female publish more first-author publications compared with residents without an academic degree, Figs. 4 and 5.

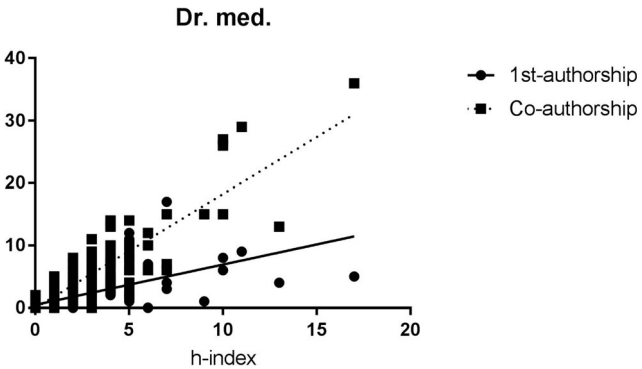

Fig. 4 Correlation between h-index, first-authorship and co-authorship of residents with doctoral degree (Dr. med.)

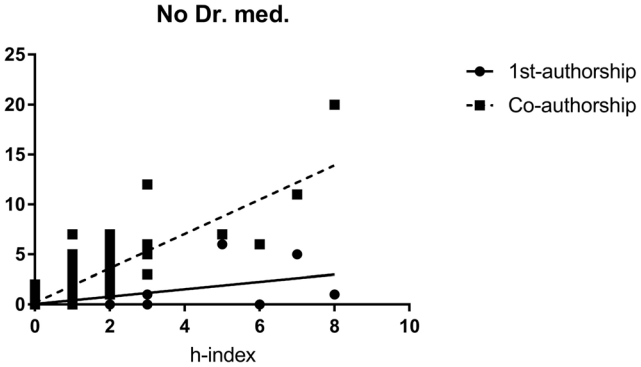

Fig. 5 Correlation between h-index, first-authorship and co-authorship of residents without doctoral degree (Dr. med.)

Study limitation

Despite maximal efforts to provide accurate publication information attributing to each resident, some data, information may have been provided insufficiently or have been missed.

The residents' specific data included in our analysis were obtained from the departmental websites. As such, data accuracy was dependent on having websites that contain accurate and up-to-date information. Research activity and productivity is an ongoing process that can only be depicted as a "snapshot" to a specific timepoint; therefore, the publication indices and even the position of residents, which were investigated within this study, may have changed during the process of production for this paper. It seems to be interesting to know in how far the publication productivity of other department members influence the academic output of the residents. Until now we cannot answer this question because no data exist describing the publication productivity of neurosurgeons in Germany. Further investigations are necessary to consider the publication productivity of board-certified neurosurgeons to elucidate the influence on residents' academic output. Here, the academic status of the specific university could also be investigated as factor for publication productivity of higher academic publication.

Conclusion

This study represents for the very first time a detailed analysis about the academic output of German neurosurgical residents during training. Our results show, when compared with other countries, a significantly higher proportion of female residents, which reflect the increase of female gender in medicine. The most important factor for higher academic output is the possession of a doctoral degree.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was not necessary. All data were used were published on departmental homepages, pubmed ans Sopus.

References

1. Blakemore LC, Hall JM, Biermann JS (2003) Women in surgical residency training programs. J Bone Joint Surg Am 85–A(12): 2477–2480
2. Borman KR (2007) Gender issues in surgical training: from minority to mainstream. Am Surg 73(2):161–165
3. Bornmann L, Daniel H-D (2007) What do we know about the h index? J Am Soc Inf Sci Technol 58(9):1381–1385
4. Bornmann L, Daniel H-D (2009) The state of h index research. Is the h index the ideal way to measure research performance? EMBO Rep 10(1):2–6
5. Daniels M, Garzon-Muvdi T, Maxwell R, Tamargo RJ, Huang J, Witham T, Bettegowda C, Chaichana KL (2017) Preresidency publication number does not predict academic career placement in neurosurgery. World Neurosurgery 101:350–356
6. Fijalkowski N, Zheng LL, Henderson MT, Moshfeghi AA, Maltenfort M, Moshfeghi DM (2013) Academic productivity and its relationship to physician salaries in the University of California Healthcare System. South Med J 106(7):415–421
7. Garner RM, Hirsch JA, Albuquerque FC, Fargen KM (2018) Bibliometric indices: defining academic productivity and citation rates of researchers, departments and journals. J NeuroInterventional Surg 10(2):102–106
8. Hirsch JE (2005) An index to quantify an individual's scientific research output. Proc Natl Acad Sci U S A 102(46):16569–16572
9. Jamjoom AAB, Wiggins AN, Loan JJM, Emelifeoneu J, Fouyas IP, Brennan PM (2016) Academic productivity of neurosurgeons working in the United Kingdom: insights from the h-index and its variants. World neurosurgery 86:287–293
10. Khan NR, Saad H, Oravec CS et al (2018) An analysis of publication productivity during residency for 1506 neurosurgical residents and 117 residency departments in North America. Neurosurgery. https://doi.org/10.1093/neuros/nyy217
11. Khan N, Thompson CJ, Choudhri AF, Boop FA, Klimo P (2013) Part I: the application of the h-index to groups of individuals and departments in academic neurosurgery. World Neurosurgery 80(6): 759–765.e3
12. Khan NR, Thompson CJ, Taylor DR, Gabrick KS, Choudhri AF, Boop FR, Klimo P (2013) Part II: should the h-index be modified? An analysis of the m-quotient, contemporary h-index, authorship value, and impact factor. World Neurosurgery 80(6):766–774
13. Khan NR, Thompson CJ, Taylor DR, Venable GT, Wham RM, Michael LM, Klimo P (2014) An analysis of publication productivity for 1225 academic neurosurgeons and 99 departments in the United States. J Neurosurg 120(3):746–755
14. Lee RP, Xu R, Dave P et al (2018) Taking the next step in publication productivity analysis in pediatric neurosurgery. J Neurosurg Pediatr 21(6):655–665
15. Lozano CS, Tam J, Kulkarni AV, Lozano AM (2015) The academic productivity and impact of the University of Toronto Neurosurgery Program as assessed by manuscripts published and their number of citations. J Neurosurg 123(3):561–570
16. Sarkiss CA, Riley KJ, Hernandez CM, Oermann EK, Ladner TR, Bederson JB, Shrivastava RK (2017) Academic productivity of US neurosurgery residents as measured by h-index: program ranking with correlation to faculty productivity. Neurosurgery 80(6):975–984
17. Schoenfeld AJ, Bhalla A, George J, Harris MB, Bono CM (2015) Academic productivity and contributions to the literature among spine surgery fellowship faculty. Spine J: Off J N Am Spine Soc 15(10):2126–2131
18. Spearman CM, Quigley MJ, Quigley MR, Wilberger JE (2010) Survey of the h index for all of academic neurosurgery: another power-law phenomenon? J Neurosurg 113(5):929–933
19. van Raan AFJ (2006) Comparison of the Hirsch-index with standard bibliometric indicators and with peer judgment for 147 chemistry research groups. Scientometrics 67(3):491–502
20. Wei M, Wang W, Zhuang Y (2016) Worldwide research productivity in the field of spine surgery: a 10-year bibliometric analysis. Eur Spine J: Off Publ Eur Spine Soc, Eur Spinal Deformity Soc Eur Sect Cervical Spine Res Soc 25(4):976–982
21. Wilkes FA, Akram H, Hyam JA, Kitchen ND, Hariz MI, Zrinzo L (2015) Publication productivity of neurosurgeons in Great Britain and Ireland. J Neurosurg 122(4):948–954
22. Woodrow SI, Gilmer-Hill H, Rutka JT (2006) The neurosurgical workforce in North America: a critical review of gender issues. Neurosurgery 59(4):749–755 discussion 755–8
23. Wright AL, Ryan K, St Germain P, Schwindt L, Sager R, Reed KL (2007) Compensation in academic medicine: progress toward gender equity. J Gen Intern Med 22(10):1398–1402
24. Wright AL, Schwindt LA, Bassford TL, Reyna VF, Shisslak CM, St Germain PA, Reed KL (2003) Gender differences in academic advancement: patterns, causes, and potential solutions in one US College of medicine. Acad Med: J Assoc Am Med Coll 78(5): 500–508
25. Yang G, Villalta JD, Weiss DA, Carroll PR, Breyer BN (2012) Gender differences in academic productivity and academic career choice among urology residents. J Urol 188(4):1286–1290

Comments Interesting data for the attention of all EANS members and non-members (ACTA readers) to be aware of and try to copy in their own centers/country.

Jesus Lafuente.

Barcelona, Spain.