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RESEARCH ARTICLE

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Academic productivity of faculty associated with microsurgery fellowships

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Background: The Hirsch index (h-index) is widely recognized as a reliable measure of academic productivity. While previous studies have applied the h-index to surgical disciplines, none have analyzed microsurgery faculty. This manuscript aims to examine the h-index of microsurgery fellowship faculty to categorize its applicability to microsurgeons as a determinant of academic output.

Methods: Faculty demographics and institution characteristics were obtained from the American Society of Reconstructive Microsurgery (ASRM) and official program websites. Faculty h-indices were calculated using the Scopus database (Elsevier, USA). Data was assessed using bivariate analysis and multiple linear regression models to determine the relationship between independent variables and total publications, career h-index and 5-year h-index (h5-index) of each faculty.

Results: A total of 139 faculties from 22 programs met inclusion criteria. The median faculty age was 44 (IQR 13) and 84.9% of faculty were male. Faculty size, number of years of fellowship existence, number of fellows, FACS memberships, number of free flaps annually, and academic appointment title were significantly associated with the total publications, h-index, and h5-index. Multivariable analysis based on the significant independent variables demonstrated that geographical region and faculty ranks were significantly associated with the h5-index.

Conclusions: Variables associated with seniority (age, years of practice after fellowship, and academic appointment) were positively correlated with the h-index. Given the increased use of bibliometrics in academic medicine, these results show that h-index is a viable tool that can be used to assess research productivity among academic microsurgeons.

1 | INTRODUCTION

The academic strength of academic institutions and faculty is often measured by the number of publications and total research output. Scholarly activity is a major determinant of program prestige and serves as the basis for faculty promotion in many programs (Carpenter, Cone, & Sarli, 2014; Therattil, Hoppe, Granick, & Lee, 2014). Other factors which may be considered include: procured grants, conference presentations, and teaching evaluations (Gast, Kuzon, Adelman, & Waljee, 2014). Quantitative measures of performance are often used to determine academic promotion.

Over the last decade, the Hirsch index (h-index) has gained popularity as a comprehensive numerical representation of scientific output. As defined by Hirsch, the h-index is an "easily computable index, which gives an estimate of the importance, significance and broad impact of a scientist's cumulative research contributions" (Hirsch, 2005, 2007). To date there have been only preliminary studies done on the academic productivity of plastic surgeons with this tool (Gast et al., 2014). However, there has been no prior attempt to explore the applicability of the h-index among microsurgery faculty in the United States or explore the variables which may affect the h-index scores (Lopez et al., 2015; Susarla et al., 2015; Therattil et al., 2014). Using the h-index as a measure of academic output, we seek to identify the factors associated with scholastic achievement among microsurgeons.

2 | MATERIALS AND MEHTODS

2.1 | Data collection

This is a cross-sectional study of all active microsurgery faculty affiliated with fellowship training programs in the United States. Fellowships were identified via the American Society for Reconstructive

TABLE 1 Summary of program demographics, bivariate analysis

Program demographics	*n*	(%)	Median h-index	IQR	*P* values
Geographical region					0.029
Northeast	59	42.4	11	12.5	
Southwest	29	20.9	10	10	
Midwest	25	18.0	13	19	
West	26	18.7	9.5	8.25	
No. of years in existence					<0.0001
1–5	63	45.3	7	8	
>5	76	54.7	13	13	
No. of faculty					0.004
1-5	45	32.4	8	11	
>5	94	67.6	11	14.25	
No. of fellows					<0.0001
0-1	78	56.1	8	9	
2-3	34	24.5	16.5	14.75	
>3	27	19.4	15	17	
No. annual free flaps					0.0027
0–200	71	51.1	8	10	
>200	68	48.9	12	14	
No. annual complex non-microscopic reconstructions					0.061
0–100	80	57.6	10	10.75	
>100	59	42.4	11	15	
Research requirement					0.9
Yes	73	52.5	11	15.5	
No	66	47.5	10.5	9.25	
Basic science research					0.7
Yes	119	85.6	11	14	
No	20	14.4	10	10	
Affiliation with academic institution					0.07
Yes	134	96.4	11	13.25	
No	5	3.6	4	7.5	
Affiliation with top 20 medical schools					0.26
Yes	68	48.9	11	12	
No	71	51.1	9	13	
Affiliation with honor hospitals					0.24
Yes	60	43.2	11	11.75	
No	79	56.8	9	15	

Microsurgery (ASRM) website, with additional information supplemented from San Francisco Match and official program websites (ASRM, 2015; Match, 2015).

The collection of data was threefold- to capture information regarding: (1) microsurgery fellowship program, (2) microsurgery faculty affiliated with these program, and (3) h-index specific variables. The reasoning behind this methodology is not only to elucidate the h-indices of microsurgery faculty but also to determine characteristics that can contribute to a higher h-index.

Microsurgical program data extracted was from the ASRM website including: geographic location of the program, academic institutional affiliation, the number of years the fellowship has existed, whether the program had a mandatory research requirement, whether the program had an option for basic science research, the number of fellows per year, the number of free flaps performed per year and faculty names.

Faculty data were obtained from microsurgery fellowship websites and supplemented from third party websites such as the American College of Surgeons website for missing values and congruency (FACS, 2015). Demographics of each faculty member collected included age, additional degrees (besides MD), and status as a Fellow of the American College of Surgeons (FACS). Academic rank of their affiliated hospital was also collected as reported by the 2015 *US News and World Report* rankings (News U, 2015).

H-index specific data for each faculty member was obtained using the Scopus database (Elsevier, 2014). The total number of publications and citations attributed to each author, and the journals in which each article was published were extracted from the database. The h5-index was calculated from research papers and citations published over the last 5 years (2010–2014). This methodology was consistent with previously published reports (Lopez et al., 2015; Schoenfeld, Bhalla, George, Bono, 2015; Therattil et al., 2014).

2.2 | Statistical analysis

The three primary outcomes of interest were total number of publications, career h-index and h5-index for each author. We defined our independent variables to be age, gender, academic affiliation, number of faculty in the program, number of fellows, number of free flaps per year, years of fellowship existence, research requirement, basic sciences research provision, affiliation with top 20 research medical schools and honor roll hospitals (2015), degrees in addition to MD, academic rank, and FACS membership. Geographical location was gathered (Northeastern, Southwestern, Midwestern or Western regions). Data distribution of total publications, h-index, and h5-index do not conform to the Gaussian curve, and thus all subsequent computations were conducted with non-parametric studies and presented through median values bound by interquartile ranges (IQR).

Descriptive statistics were used to establish the background for our study variables. Kruskal-Wallis and Mann-Whitney tests were run to investigate differences in medians of total publications, h-index and h5-index for all faculty members. As multiple comparisons can result in significant *P*-values being falsely generated, Dunn's Multiple Comparisons Test was carried out to minimize the probability of obtaining significant p-values purely by chance. Multiple linear regressions were then performed to identify the predictors of high total publications, h-index, and h5-index respectively. Independent variables included in the final regression model had to first achieve significance in univariate linear regression ($P<0.25$). Collectively for total publications, h-index, and h5-index, variables selected were age, gender, academic affiliation, years of fellowship existence, research requirement, basic sciences research provision, degrees in addition to MD, academic rank, FACS membership, and number of faculty in the program, fellows in the program, and specialty cases per year. Multicollinearity was assessed by computation of the variance inflation factor (VIF), with a VIF <10.0 considered negative for the presence of multicollinearity. A significant

TABLE 2 Summary of faculty demographics, bivariate analysis

Faculty Demographics	*n*	(%)	Median h-index	IQR	*P* values
Age					<0.0001
30-39	29	20.9	7	8	
40-49	68	48.9	10.5	8.75	
50-59	27	19.4	12	20	
60-69	14	10.1	22	13	
70-79	1	0.7	1	-	
Gender					0.029
Male	118	84.9	11	14.25	
Female	21	15.1	8	10	
Highest degree attained					0.41
MD only	125	89.9	11	13.5	
MD + Masters	8	5.8	16	12.75	
MD+ Doctorate	6	4.3	10.5	17.25	
FACS					0.03
Yes	89	64.0	11	15	
No	50	36.0	9.5	9.25	
Rank					<0.0001
Instructor	3	5.3	2	22	
Assistant	62	44.6	7	6.25	
Associate	42	30.2	11.5	9.25	
Professor	27	19.4	22	16	
Endowed	5	3.6	31	20	

P values was defined as $<$0.05. All computations were performed using GraphPad Prism ™ (GraphPad Software, Inc., San Diego, CA).

3 | RESULTS

3.1 | Demographics

A total of 22 microsurgery fellowships, with 139 faculty members, met inclusion criteria. Of these programs, 20 were affiliated with academic institutions and 96.4% (135/139) of the faculty came from these programs. Programs in the Northeastern region comprised the majority of faculty (42.4%), while the Midwest region had the least (18%) number of faculty. Each program had a median number of 5 (IQR 4) faculty members and 1 (IQR 1) fellow. The median age of faculty examined was 44 (IQR 13) and female surgeons represented 15.1% (21/139) of the group. Assessed by academic appointment there were three instructors (5.3%), 62 assistant professors (44.6%), 42 associate professors (30.2%), 27 full professors (19.4%), and five endowed professors (3.6%). 64% of the faculty (89/139) had FACS membership. The total

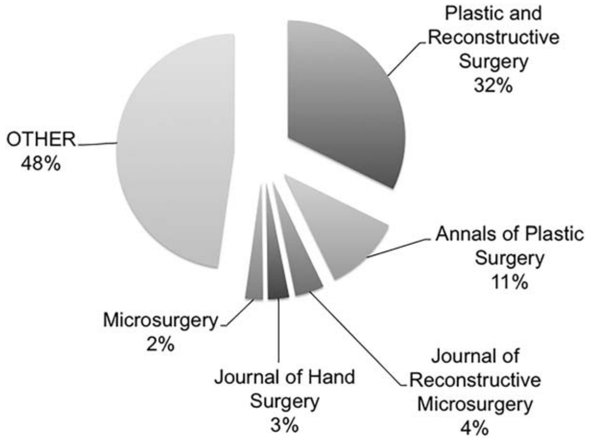

FIGURE 1 Summary of publications by microsurgical faculty from 2010–2014 by journal

publications per faculty ranged from 0 to 246, (median 28, IQR 57), and for the past five years (2010–2014) that figure ranged from 0 to 105 (median 4, IQR 6). Program and faculty demographics were shown in detail in Tables 1 and 2. The median h-index and h5-index achieved were 11 (IQR 13) and 4 (IQR 6) respectively and found in Table 3.

From 2010 to 2014, the median number of publications per program was 246 (IQR 386.8). Fellowships with an academic affiliation produced a greater number of publications (271, IQR 495 vs. 23, IQR 16, $P = 0.007$). Of all published research papers, 32% were published in Plastic and Reconstructive Surgery. Publication in one of the top five most popular journals for microsurgeons took up over half (52%) of all articles reviewed in our study (Figure 1). Median h-index and h5-index achieved per program were 12.65 (IQR 8.425) and 4.35 (IQR 3.7) respectively. The top five institutions by total number of publications, h-index and the h5-index, blinded by geographical region, are presented in Table 4.

3.2 | Multivariable analysis

Bivariate analyses (Kruskal-Wallis and Mann-Whitney tests) revealed significant differences in h-index medians in faculty demographics of age ($P<0.0001$), gender ($P=0.029$), FACS membership status ($P=0.031$) and academic rank of associated hospital ($P<0.0001$). Variables of program demographics including number of faculty members ($P=0.004$) and number of fellows ($P<0.0001$) were also deemed to have a positive relationship with h-index. Interestingly, mandatory research and basic science research provisions did not demonstrate significant differences in h-index computation of their respective medians. (Table 1)

TABLE 3 Summative medians and ranges of program and faculty academic variables

	Program		Faculty			
	Total publications	5-Yr publications	Career publications	5-Yr publications	H-index	H5-index
Median	246	72.5	28	13	11	4
Range	15-1126	3-688	0-246	0-131	0-43	0-19
IQR	300.5	134.75	57	25.5	13	6

TABLE 4 Top 5 programs achieving highest median values for primary outcomes variables (total publications, h-index and h5-index)

Rank	Total publications per intuition	Median 5 year faculty publication	Median h-index per faculty	Median h5-index per faculty
1	SW (1126)	NE (58)	NE (22)	NE (12)
2	NE (770)	NE (50)	MW (19.5)	NE (12)
3	NE (721)	W (36.5)	NE (17.5)	NE (9.5)
4	W (696)	NE (32)	W (14.5)	SW (8.5)
5	NE (667)	SW (29)	NE (14)	W (7.5)

Programs are blinded and coded only by region: NE, Northeast; SW, Southwest; MW, Midwest; and W, West.

Multiple linear regressions revealed that geographical region and academic rank were significantly associated with the h5-index. Additionally, full professorship and endowed professorship positively associated with the h-index (RC 10.75, $p = 0.00033$; RC 21.97, $p = 0.00001$ respectively), and h5-index with reference to assistant professorship (RC 2.01, $p = 0.042$; RC 5.49, $p = 0.031$ respectively, Table 5). Test for multicollinearity revealed no variance inflation with VIF well below our preset threshold of 10 across all identified independent variables.

4 | DISCUSSION

Current metrics to determine a faculty member's suitability for promotion rely heavily on the quantitative number of research publications. New emerging metrics, such as the h-index, have been introduced to capture the impact of the research and the quantitative aspects. Previously examined in other areas of medicine, the h-index has not been applied to the field of reconstructive microsurgery. This study was able to demonstrate that microsurgery fellowship faculty are not only productive investigators, possessing a median h-index of 11 (IQR 13), and a h5-index of 4 (IQR 6), but also produce on a level comparable to other academic surgeons in similar fields. Among all plastic surgeons, an h-index of 7 (range 0–62) has been reported, while a study of hand surgeons revealed a comparable mean h-index of 10.2 (Gast et al., 2014; Lopez et al., 2015). Studies of other surgical fields have also yielded similar results: orthopedic surgeons, h-index 11 (IQR 15); hepatic surgeons, h-index 6 (IQR 10); and general surgeons, h-index 11 (IQR 15) (Cucchetti et al., 2013; Culley et al., 2014; Stavrakis et al., 2015).

Previous h-index studies have revealed positive correlations between measures of academic productivity and seniority. Intuitively, longer academic careers lead to more publications and thus time for citations. Accordingly, in our study, the predictors associated with seniority (age, FACS membership, academic rank) were uniformly demonstrated to positively associate with publications and h-indices (Table 2) on bivariate analysis. Additionally, larger programs, with more faculty and fellows, may seem to derive a benefit from human capital and increased resources for publishing. Specifically, fellow number positively correlated with total publications while faculty size contributed to the standards of research through intellectual interaction and collaboration, directly increasing h-index and h5-index. Studies looking at the correlation of faculty size with h-index among neurosurgical departments in the United States and Canada found similar outcomes (2010; Lozano, Tam, Tam, Lozano, 2015; Ponce, Lozano; Schoenfeld et al.,

TABLE 5 Significant independent variables in multiple linear regression model

Variable	β	SE	95% CI	*P* values
			–	–
Significant association w/total publications			–	–
Complex non-micro reconstructions per year	0.024	0.011	0.0013, 0.047	0.038
Associate professorship	26.55	9.17	8.4, 44.69	0.0045
Full professorship	58.69	15.0	29.0, 88.38	0.00015
Endowed professorship	164.43	27.47	110.05, 218.81	$2.25*10^{-8}$
Significant association w/h index			–	–
Associate professorship	4.6	1.76	1.12, 8.08	0.01
Full professorship	10.75	2.91	4.99, 16.5	0.00033
Endowed professorship	21.97	5.45	11.18, 32.76	0.00001
Significant association w/h5 index				
Midwestern region	−2.57	1.00	−4.55, −0.58	0.012
Masters	3.25	1.53	0.22, 6.29	0.036
Associate professorship	1.7	0.78	0.16, 3.23	0.031
Full professorship	2.01	0.98	0.07, 3.96	0.042
Endowed professorship	5.49	2.51	0.52, 10.45	0.031

2015). Academic appointment, being a proxy of seniority, produced an informative trend on Kruskal-Wallis and multiple linear regression analyses (Bland et al., 2005). A rising rank reflected a corresponding increase in values of the median h-index (Table 2). This trend once again highlighted the increased opportunities for citations of published work as one's career matured.

Interestingly several predictors thought to positively associate with h-indices were found to be insignificant in association. It had been proposed by some authors, that mandatory research requirements could be built into low academic output programs as a way to encourage publications, however, this was not borne out in our study (Schoenfeld et al., 2015). The reversal of cause and effect eroded away what was generally considered to be a positive predictor of academic output. Similarly, provisions for optional basic science research also did not demonstrate any correlation with h-index. This could be due to the fact that much of the research attributed to clinically active physicians within these institutions were clinical research which did not require the presence of large scale basic laboratories for effective output (Sackett, 2000). Importantly, clinical productivity was positively associated with academic productivity as seen in higher case volumes (free flaps per year) correlating with higher h-indices. High volume centers naturally have more opportunities for recruitment into trials and establishment of patient databases as resources for potential research projects (Bland et al., 2005; Sackett, 2000).

There are several limitations to this study. Firstly, we focused only on faculty with fellowship programs listed in ASRM or the SF Match, although there are other fellowship programs (not in the match) that were not captured via this method. Furthermore, only American programs were investigated even though other countries are represented in the listing. Given the similarities between US and international training programs, there might be some applicability of these results to international surgeons. However, to elucidate this more clearly, a focused study evaluating high volume international training programs and centers would likely be needed. Additionally, the inherent formula governing the h-index is not without flaws and therefore this is not a measure to be used in isolation. Given that the frequency of citation is used in the h-index calculation, bias is introduced as it is vulnerable to manipulation through self-citation. Variability can be introduced with article obtainability which would result in it not being captured. Finally, limitations include inherent criticisms of the h-index in that it does not account for information contained in author placement in the author list. Overall, the strength of this study is it is the first investigation utilizing the h-index as a metric for microsurgeons. Despite its limitations, the h-index is intended to measure both the quality and quantity of scientific research simultaneously and provides a standardized number that can be compared across faculty and institutions.

5 | CONCLUSIONS

The h-index is a powerful tool in determining academic throughput and research strength. The results of this study demonstrate it to share vital predictors with conventional measures represented here by total career publications. In addition, the h-indices calculated for the microsurgeons in this study also correlated well to those reported by surgeons from other disciplines. The h-index is easily computable, reproducible, widely transparent, and is an excellent resource for candidate assessment and personal evaluation. As our study population is young, the indices we observe in this study is bound to alter in significant magnitudes over the years.

DISCLOSURES

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