Part I: The Application of the *h*-Index to Groups of Individuals and Departments in Academic Neurosurgery

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■ OBJECTIVE: **The *h*-index was introduced as a means of quantifying the contribution a researcher makes to the scientific literature. We evaluated the *h*-index for academic neurosurgeons to assess the various methods of calculation and to determine whether the *h*-index can be used to differentiate groups of individuals by various classifications.**

■ METHODS: **The *h*-index was calculated for all neurosurgeons from 10 institutions ranked highly by *2012 U.S. News & World Report* plus the authors' institution via Scopus. The *h*-index also was calculated manually to evaluate its accuracy. The average *h*-index was calculated for groups on the basis of sex, academic rank, years in practice, institution, and subspecialty. Cumulative and mean *h*-indices were calculated for each department.**

■ RESULTS: **The median *h*-index for the 188 neurosurgeons was 16 (mean, 19.71; range, 0–61). There was a positive association between the *h*-index, academic rank, and years posttraining. There was a significant difference between the "manually calculated" and automated h-indices, particularly for more senior physicians. The difference in *h*-index between men and women was not statistically significant. Among subspecialties, vascular surgeons had the greatest average *h*-index and general neurosurgeons had the lowest. There were significant shifts in departmental rankings when the cumulative or mean departmental indices were compared with the *U.S. News & World Report* rankings.**

■ CONCLUSION: **Application of the *h*-index as a bibliometric in neurosurgery can distinguish academic productivity on the basis of academic rank, years posttraining, and neurosurgical subspecialties. The application of the *h*-index to compare departments is problematic and, at this time, not reliable.**

INTRODUCTION

The *h*-index is a method to objectively quantify academic output that has been widely studied since its first description in 2005 by Hirsch (10). The *h*-index is defined as the number of papers *h* from a researcher with citation counts of *h* or greater for each paper. Historically, the number of publications and the citation count have been used to characterize the academic productivity of a researcher. The *h*-index attempts to combine both of these metrics into a robust and simple method for measuring the quantity and scientific impact of a researcher's work. A researcher's *h*-index can be easily calculated by the use of existing online databases such as Google Scholar, Scopus (Elsevier), and ISI Web of Knowledge/Web of Science (Thomson Reuters). The *h*-index has been found to be useful in determining employment offers, promotions, tenure, fellowship, and allocation of research funds primarily in the natural sciences (3, 21). Recently, the application of the *h*-index has been evaluated in medicine, including urology (4), anesthesiology (5, 16), otolaryngology (23), radiation oncology (7, 19), radiology (20), and neurosurgery (1, 6, 15, 18, 22).

In 2009, Lee et al. (15) first described the use of the *h*-index in neurosurgery. They found that the *h*-index correlated well with academic rank and time from American Board of Neurological Surgery certification. Others have corroborated this linear relationship between increasing *h*-index and academic rank in neurosurgery (6, 22). Spearman et al. (22) used Google Scholar to

Key words
- Academic neurosurgery
- Bibliometrics
- Citations
- Department
- *h*-index
- Impact
- Individual
- Subspecialty

Abbreviations and Acronyms
ANOVA: Analysis of variance

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calculate the *h*-index for all 1120 academic neurosurgeons in the United States and found the median *h*-index was 9. Ponce and Lozano (18) calculated three versions of the *h*-index for neurosurgery departments in the United States and Canada with residency programs. The various *h*-indices correlated well with funding from the National Institutes of Health, number of faculty, total papers, and total citations, but there were large fluctuations in rankings depending on which *h*-index was used.

The *h*-index can be applied to departments, individuals, and groups of individuals on the basis of certain criteria such as academic rank, but which is most appropriate? What is the most accurate method of calculating the *h*-index? Which of the many variations of the *h*-index is most appropriate? Although the *h*-index has garnered much interest, to our knowledge it has not been widely adopted by the academic neurosurgery community to compare the scholarly productivity within or among departments. We calculated the *h*-indices for departments and individuals and compare our calculations with those from previous publications and to evaluate whether the use of the *h*-index for departments is robust. We also describe for the first time the *h*-index among various neurosurgical subspecialties.

METHODS

Selection of Programs

A list of programs was obtained from the 2012 rankings of Neurology and Neurosurgery programs published by *U.S. News & World Report* (http://health.usnews.com/best-hospitals/rankings/neurology-and-neurosurgery). We selected the top 10 programs that were academic- or university-based, comprised neurosurgeons, and had easily accessible websites typically listing the faculty members, their academic ranks, and subspecialties. The programs that were excluded either did not have well-defined academic affiliation (e.g. Hospital for Special Surgery) or did not have easily accessible departmental websites with academic ranks and subspecialties (e.g., Cleveland Clinic). Those individuals deemed not part of the clinical neurosurgical faculty (i.e., neurologists, clinical researchers, non-MD/PhDs) were excluded from this study. Academic rank was determined from departmental websites. The number of years posttraining was determined by accessing the American Board of Neurological Surgeon's website or by e-mailing the department. A total of 11 institutions, including our own, were chosen.

h-Index Calculation for Individuals and Departments

For the individual neurosurgeon, the *h*-index was calculated in two ways. The automated *h*-index was the output calculated by Scopus; however, Scopus numbers are based on post-1995 publications only. Therefore, to correct for this, we manually calculated the *h*-index for each of the clinical neurosurgical faculty at these 11 institutions to include publications before 1995. Both values were obtained during October–December 2012. The average *h*-index was calculated for groups of individuals on the basis of sex, academic rank (instructor, assistant, associate, professor, chairman), number of years in practice post-training (0–10 years, 10–20 years, >20 years), and subspecialty (spine, pediatrics, neurooncology/skull base, vascular, general, functional/epilepsy, peripheral nerve, radiosurgery). To evaluate a potential confounder, a comparison was made between subspecialty and years after training to determine whether a difference in the average *h*-index was attributable to an older or younger population within one of the subspecialties rather than a true difference in academic productivity.

For a neurosurgery department, two *h*-index numbers were computed: a cumulative and a mean, both based on the individual, manually calculated *h*-index as described previoulsy. The cumulative departmental *h*-indices also were hand-calculated. To be sure that we counted only papers that were produced by a single department (to eliminate papers that members of the department authored when they were at a previous institution) and that papers were not counted multiple times (because it is common for several authors on a paper to be from the same department), a search string using a Boolean formula was created for each department (Appendix I, available online). This search string was then applied by using the "advanced search" option within Scopus. The search string provided us a list of the papers published only by that department or its affiliated institutions. This string effectively pooled all members of a department so that the group now could functionally be considered as an individual. The cumulative *h*-index was then calculated and included publications before 1995. The second departmental *h*-index was the average of the manually calculated *h*-indices of all current members within a particular department.

Statistical Analysis

The following a priori statistical comparisons were performed:

- *h*-index (manual and automated) versus academic rank;
- difference between manual versus automated *h*-index with academic rank;
- *h*-index (manual and automated) versus length of practice;
- difference between manual versus automated *h*-index with length of practice;
- *h*-index (manual) for male versus female neurosurgeons; and
- *h*-index (manual) for neurosurgical subspecialties.

All statistical analysis was performed using Stata/SE 11.2 (College Station, Texas, USA). Significance was determined as $P < 0.05$. Mean values are presented with ±SD.

RESULTS

Individual and Group *h*-Indices

The *h*-index was calculated for 188 academic neurosurgeons from 11 institutions. The distribution of the manual *h*-index values exhibited a slight positive skew (median = 16, mean = 19.7) with a range of 0–61. The mean *h*-index for men (n = 177) was 20.1 (range, 0–61) compared with 14.3 (range, 7–32) for women (n = 11), but this difference was not statistically significant (two-tailed t-test, $P = 0.336$).

Both the automated and manual *h*-indices significantly differed across academic rank (one-way analysis of variance [ANOVA], $P < 0.0001$) (**Table 1**, **Figure 1**). The mean manual *h*-index was 41 (±14.7) for a chairman, 28.1 for a professor (±12.7), 14.9 for an associate (±7.7), 10.3 for an assistant (±5.8), and 4.6 for instructor (±4.1). The average number of years posttraining was 26.4 (±5.9) for a chairman, 24.9 (±10.8) for a professor, 15.8 (±8.7) for an associate professor, 9.3 (±11.3) for an assistant professor, and 2 (±2) for an instructor.

Table 1. Mean *h*-Index Based on Academic Rank

Academic Rank	Our Study (n)*	Spearman et al. (22)†	Lee et al. (15)‡	Campbell et al. (6)‡
Chairman	41.0 (13)	22	14.8	N/A
Professor	28.1 (66)	19	10.1	16.0
Associate	14.9 (48)	10	8.3	9.7
Assistant	10.3 (56)	5	4.9	5.6
Instructor	4.6 (5)	2	N/A	N/A

N/A, not available.
*Manual Scopus.
†Google Scholar.
‡Automated Scopus.

A statistically significant difference was observed between the manually and automated calculated *h*-indices when all ranks were considered together (Kruskal-Wallis test, $P < 0.0001$). When the ranks were analyzed individually, all but Instructor were significantly different (sign test, $P < 0.001$). The differences between manually calculated and automated *h*-index values for neurosurgeons designated as either Professor (28.1 vs. 22.9) or Chairman (41.0 vs. 31.5) were larger than those for lower-ranking neurosurgeons (Figure 2).

A positive association (one-way ANOVA, $P < 0.0001$) was demonstrated between both automated and manual *h*-index and length of practice (Figure 3). The manually calculated *h*-index was 11 (±6.1) for the 67 (36%) neurosurgeons who had been in practice between 0 and 10 years; 21 (±12.6) for the 53 (28%) neurosurgeons in practice between 11 and 20 years; and 27 (±15.5) for the 68 (36%) physicians with more than 20 years of practice. Similar to academic rank, differences between the automated and manually calculated *h*-indices are most evident among neurosurgeons with longer careers. For neurosurgeons with more than 20 years of practice, the average manually calculated *h*-index was 26.9, whereas the mean automated value was 19.7 (sign test, $P < 0.0001$).

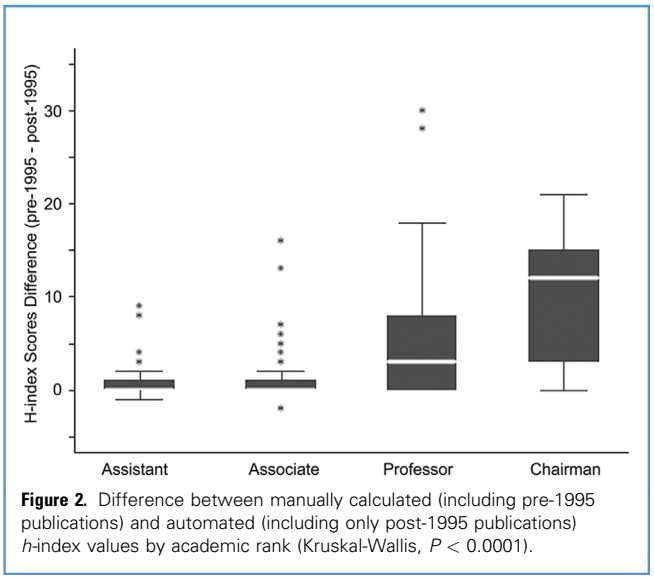

Figure 2. Difference between manually calculated (including pre-1995 publications) and automated (including only post-1995 publications) *h*-index values by academic rank (Kruskal-Wallis, $P < 0.0001$).

Table 2 shows the average manually calculated *h*-index calculated across eight separate neurosurgical subspecialties. Vascular neurosurgeons have the greatest *h*-index values and general neurosurgeons the lowest (Figure 4). There was a statistically significant difference in *h*-indices among the various neurosurgical subspecialties (one-way ANOVA, $P < 0.0001$), but no difference between the number of years in practice and subspecialty (one-way ANOVA, $P = 0.7527$).

Departmental *h*-Indices

The ranking of each department based on the *U.S. News & World Report* ranking was compared with the cumulative and mean *h*-indices (Table 3). The ranking by *h*-index did not correlate well with the published ranking. The change in position of

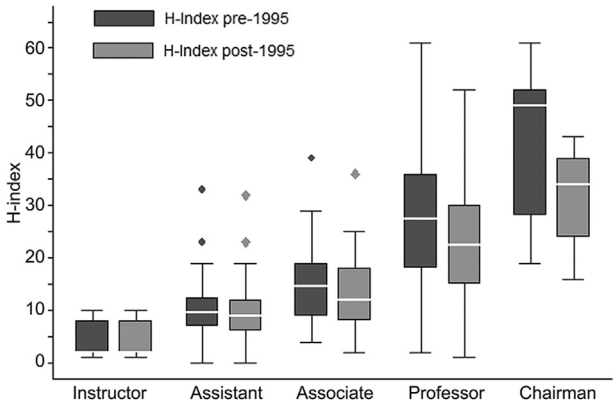

Figure 1. Box-and-whisker diagram depicting the *h*-index values (manually calculated to include publications pre-1995 and automated post-1995) as a function of academic rank (one-way analysis of variance, $P < 0.0001$ for each index, respectively, across all academic ranks). The *box* represents the 25th to 75th percentile, the *line* within the box the median (50th percentile), and the *bars* all values except the outliers.

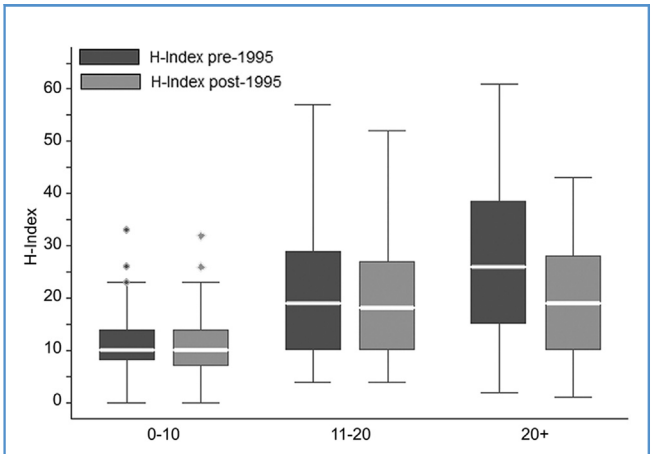

Figure 3. *h*-index values (manually calculated to include pre-1995 publications and automated post-1995) as a function of years in practice (one-way analysis of variance, $P < 0.0001$ for each index, respectively, across years in practice).

Table 2. Mean *h*-Index Based on Subspecialty

Subspecialty (n)	Mean Number of Years in Practice	Mean *h*-Index (±SD)
Vascular (24)	18.8	30 (±17.2)
Functional/epilepsy (15)	15.1	25 (±14.0)
Radiosurgery (8)	23.6	25 (±14.3)
Skull base (40)	17.5	21 (±13.4)
Pediatrics (33)	17.5	19 (±11.0)
Peripheral nerve (4)	12.5	17 (± 6.1)
Spine (53)	16.3	14 (±11.9)
General (11)	20.2	13 (±9.4)

departments ranged from −5 to +11 for the cumulative *h*-index and −4 to +9 for the mean *h*-index. The University of California, Los Angeles program is ranked 12th in *U.S. News and World Report*, but it is ranked first if we use the cumulative *h*-index (gain of 11 spots) and third if we use the mean *h*-index (gain of 9 spots). Barrow Neurological Institute also gained 11 spots for the cumulative *h*-index ranking and 8 for the mean *h*-index ranking. Mayo Clinic and Cornell each dropped 5 positions with respect to the cumulative index, whereas Mayo's mean departmental *h*-index remained at the same rank and Cornell's dropped 4 spots. The change in rankings compared with the 2012 *U.S. News & World Report* rankings for the rest of the programs were within 3 positions of their original rank.

DISCUSSION

The *h*-index has quickly gained popularity as a simple, powerful bibliometric to quantify the academic output and its impact during a specified time period of an individual, a group of individuals that share a similar characteristic, or a department (13). Hirsch (9) also found that the *h*-index was superior in predicting future scientific achievement to other bibliometrics such as total citation count, citations per paper, and total paper count. We report results that support previously published work as well as new findings and controversies.

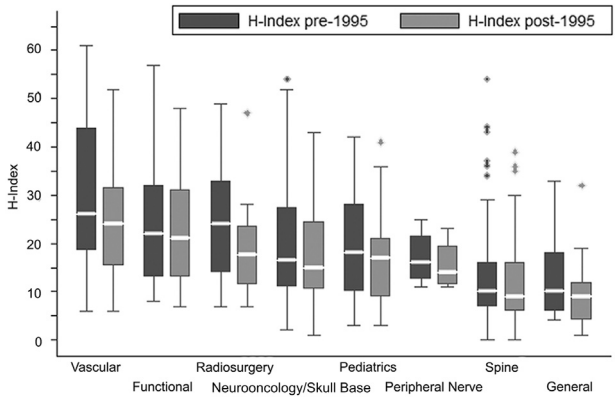

Figure 4. Manually calculated (including pre-1995 publications) *h*-index values and automated (including post-1995 publications) *h*-index values as a function of subspecialty (one-way analysis of variance, $P \leq 0.0001$ for each index, respectively, across subspecialty).

As demonstrated by others (6, 22, 25), the *h*-index can reliably distinguish between various neurosurgical academic ranks, which is a surrogate variable for the number of years in practice; however, our mean *h*-scores for the different academic ranks were significantly greater than those previous reports (**Table 1**). There are two reasons for this. Our group of academic neurosurgeons was selected from top-tier neurosurgery programs as ranked by the *U.S. News and World Report*, which means theoretically we selectively sampled more scholarly accomplished neurosurgeons. This technique is supported by the fact that our overall mean and median *h*-indices are much greater than those found by Spearman et al. (22), who measured the *h*-index of all academic neurosurgeons. Second, we manually calculated the *h*-index, which reduced the shortcoming of the automated Scopus *h*-index. Although the automated *h*-indices, whether from Google Scholar, Web of Science, or Scopus may be precise, we believe that our manual calculations are the most accurate. We have demonstrated that when using Scopus, the difference between the automated and manually calculated *h*-indices becomes quite significant ($P < 0.0001$) for more senior neurosurgeons (assistant on upwards). Lee et al. (15) found no significant difference in the calculated *h*-indices between Google Scholar and Scopus.

With our work, we assume that our corrected Scopus numbers for more senior neurosurgeons would differ from those that would have been obtained if Google Scholar had been used. Manually calculated Scopus *h*-indices may still underestimate the theoretical true *h*-index because the Scopus database from which the manually calculated *h*-indices were created includes only citations dating from 1995. That is, the manual calculation includes contribution of articles published before 1995 only if there were 'h' citations since 1995 regardless of how many citations occurred before 1995. This drawback of Scopus will diminish with time as senior neurosurgeons retire, leaving neurosurgeons who began publishing after 1995. Nonetheless, the numbers provided in **Table 1**, in conjunction with other variables of academic achievement, could serve as a useful guide for chairmen and university officials when determining whether an individual should be promoted from one rank to the next. In his landmark publication, Hirsch (10) himself suggested that a physicist's *h*-index could be used to determine promotion, tenure, and membership into major academic or professional societies.

Within the limits of our selection bias, vascular neurosurgeons as a group seem to be the most academically productive group of neurosurgeons and general neurosurgeons were the lowest. This contrast could be the result of different number of neurosurgeons with academic interests within each of these fields. Nonetheless, the difference in *h*-indices among subspecialties was not confounded by the number of years posttraining. In other words, there was no significant difference between the various subspecialties in the average number of years posttraining of its members. Although male neurosurgeons had a greater mean *h*-index than female neurosurgeons, this difference was not statistically significant. Some believe that the *h*-index is biased against female researchers (11, 12). Symonds

Table 3. Cumulative and Average *h*-Index by Department

Institution	2012 *U.S. News & World Report* Ranking	Cumulative *h*-Index (Rank Among These Programs, Change*)	Ponce and Lozano (18) h(c)	Mean *h*-Index (Rank, Change)
Johns Hopkins University	1	85 (4, −3)	83	23.0 (4, −3)
Mayo Clinic	2	75 (7, −5)	116	26.4 (2, NC)
Massachusetts General Hospital	3	84 (5, −2)	129	19.3 (6, −3)
Columbia	4†	92 (3, +1)	75	26.9 (1, +3)
Cornell	4†	58 (9, −5)	51	16.2 (8, −4)
New York University (NYU)	8	52 (11, −3)	79	13.9 (10, −2)
Washington University	9	76 (6, +3)	139	17.9 (7, +2)
Northwestern	11	59 (8, +3)	55	14.5 (9, +2)
UCLA	12	106 (1, +11)	90	23.4 (3, +9)
Barrow Neurological Institute (BNI)	13	94 (2, +11)	67	20.5 (5, +8)
UT-Memphis	NR	51 (11, NA)	57	10 (11, NA)

NA, not available; NC, no change; NR, not reported.

*Compared with the *U.S. News & World Report* ranking. A negative number indicates a decrease in rank; a positive number indicates an increase in rank.

†These two institutions are combined in the *U.S. News & World Report* ranking.

et al. (24) found that within the field of evolutionary biology and ecology, female scientists produce greater-quality research than their male counterparts, who tend to produce a greater quantity of research output. Within radiation oncology, Choi et al. (7) found that overall women had lower *h*-indices than men did (6.4 vs. 9.4), but this difference was nullified when stratified by academic ranking. Further investigation is needed within our field to establish whether a gender difference truly exists with respect to publishing output. This will be aided by the growing number of female neurosurgeons entering practice.

Our calculations for neurosurgical departments yielded some interesting results. Depending on which index was used (cumulative or mean), the ranking of some programs changed considerably. This was also demonstrated by Ponce and Lozano (18), who ranked American and Canadian neurosurgical programs by three different *h*-indices. The different methodologies in calculating the three unique *h*-indices resulted in large shifts in rankings, ranging from an increase of 45 positions to a fall of 70 out of 99. When comparing our cumulative *h*-indices to the h(c) by Ponce and Lozano (**Table 3**), we found there were some notable differences. Our manually calculated cumulative *h*-index was greater in 6 of the programs and lower in 5. In 7 of the programs, our calculations were within 20 points of theirs (range, −2 to +17); the other 4 had differences that ranged from −45 to +27. These variations between our results and theirs are unlikely to be caused simply by the different time point at which the numbers were calculated (end of 2012 for our study, 2010 for theirs). It is almost certainly attributable to the different sources and definitions of the cumulative *h*-index. Their calculations were derived from Thomson's ISI Web of Science, and the h(c) was defined as the cumulative impact of all work in the Web of Science database attributed to that department with no limits on time span or career path (i.e., academic productivity of nonneurosurgeons such as neurologists and basic science researchers was included if they were part of the department).

Our calculations were derived from Scopus with no time limit but were limited to neurosurgeons only. Given these differences, we would have expected their numbers to be, in general, much greater than ours. In fact, the h(c) given for their own program (Barrow Neurological Institute) was 67; our manual calculation was 27 points greater (94). Therefore, we can only assume that the automated numbers provided by Web of Science were less accurate for some programs. Not surprisingly, Ponce and Lozano found very little to no correlation between their h(c) index and the 2009 *U.S. News & World Report* rankings and modest correlation with National Institutes of Health funding (18).

With regard to determining the departmental academic output and impact, we believe that the mean *h*-index is the more representative bibliometric, rather than the cumulative *h*-index, but both should probably be presented. The latter is too susceptible to the top-heavy historical picture of faculty productivity. For instance, many junior faculty members' *h*-indices have no bearing on the cumulative *h*-index for the department with a chairman or senior professors who possesses a very high *h*-index value. Conversely, the mean *h*-index is more easily influenced by the academic productivity of all members of the department.

Each of the databases that provide an *h*-index calculation (Google Scholar, Web of Science, Scopus) appears to have advantages and disadvantages, meaning there is no "gold standard." Google Scholar is free, but it is unknown whether there is a time interval constraint and its citation information is inconsistent, inadequate, and less frequently updated (8). Web of Science and Scopus offer fee-based access; Scopus only includes citations after 1995, although the database contains articles from before that

date, whereas Web of Science contains citation data from 1900 to the present. Campbell et al. (6) found Scopus had better predictive value in discriminating between assistant, associate, and full professors in neurosurgery. Patel et al. (17) found that the *h*-index was the most consistently calculated bibliometric across the three databases for Nobel laureates in Physiology or Medicine; however, there was no concordance among the databases when considering the number of publications and citations count per laureate. Bould et al. (5) found poor agreement between the *h*-indices calculated from Scopus and Web of Science for anesthesiologists of different academic ranks. Kulkarni et al. (14) demonstrated that the three databases produced quantitatively and qualitatively different citation counts for articles published in *JAMA*, *The Lancet*, and the *New England Journal of Medicine*. Bakkalbasi et al. (2) also did not find that one database satisfied all citation tracking needs, but suggested that the choice of database may depend on the subject and publication year of a given article.

The strength of our study is the effort that we have put forth to calculate what we believe are the most accurate *h*-indices for this select group of highly achieved academic neurosurgeons and their respective departments and how they compare with prior studies (1, 6, 15, 18, 22). Our study also provides the first evaluation of *h*-index values across subspecialties and gender in neurosurgery. Furthermore, we have the first comparison of pre-1995 Scopus "manually calculated" *h*-indices with the automated post-1995 Scopus *h*-indices. The weaknesses are our small study group, compared with the more than 1000 neurosurgeons analyzed by Spearman et al. (22), which limits the generalizability of our findings, and the difficulty in applying our labor-intensive methods on a large scale. The comparison with *U.S. News & World Report* rankings has its own inherent weaknesses. The *U.S. News & World Report* rankings are combined for both neurology and neurosurgery and may be weighted more toward the neurology side of an academic center. The rankings are generated by several factors that may not be directly linked to the academic output of a center (i.e., the reputation of an academic center). Finally, some departments are more aligned with clinical productivity than academic productivity, and one single index is insufficient to capture the complete picture of departmental productivity.

In this work, we have not challenged the merits of the *h*-index. Despite its popularity, it has a number of drawbacks and may need to be modified to be best applied to neurosurgeons. This will be addressed in Part II.

CONCLUSION

The *h*-index continues to be an intriguing measure of scholarly output and impact of an individual. Cumulative and average *h*-indices can be calculated for groups of individuals and departments. We have again demonstrated that the *h*-index can satisfactorily distinguish neurosurgeons of different academic rank and/or years out of training, and our calculations were significantly greater than what has been previously reported. Our results are attributable to the way in which we calculated the *h*-index and the purported high quality of the academic programs from which we sampled academic neurosurgeons (programs ranked highly in the 2012 *U.S. News & World Report*). We have suggested that there are significant differences in the *h*-indices among subspecialties, but the evidence is inconclusive with regards to gender. Until organized neurosurgery adopts a standardized definition and method of calculating the *h*-index as a means to compare programs, we believe that at this time, the *h*-index is best used at the individual level within a department to complement, but not replace, other measures of academic productivity.

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http://dx.doi.org/10.1016/j.wneu.2013.07.010
*Journal homepage: **www.WORLDNEUROSURGERY.org***
*Available online: **www.sciencedirect.com***

***The Ballroom at Arles*, 1888, Arles, Bouches-du-Rhône, France, Vincent van Gogh (1853–1890).** See Apuzzo p. 675 and Salcman pp. 676-679.

APPENDIX I: SEARCH STRINGS USED IN SCOPUS TO CALCULATE CUMULATIVE DEPARTMENTAL H-INDEX.

1. Barrow Neurological Institute:

((((((((((((((((((((((((AF-ID("Barrow Neurological Institute" 60001362))) AND (AU-ID("Spetzler, Robert F." 7201704294) OR AU-ID("Spetzler, Robert F." 55172026100))) OR (AU-ID("Sonntag, Volker K H" 7102047679) OR AU-ID("Sonntag, Volker H." 7102047685) OR AU-ID("Sonntag, Volker K H" 55348295200))) OR (AU-ID ("Nakaji, Peter" 6602707159) OR AU-ID("Nakaji, Peter" 55347890300))) OR (AU-ID("Theodore, Nicholas" 7006310221) OR AU-ID("Theodore, Nicholas" 7006310225) OR AU-ID("Theodore Lange, Nicholas" 6504491710))) OR (AU-ID("Zabramski, Joseph M." 7005918946))) OR (AU-ID ("Dickman, Curtis A." 7102521106) OR AU-ID("Dickman, Curtis A." 35980023600))) OR (AU-ID("McDougall, Cameron G." 35411389300))) OR (AU-ID("Smith, Kris Alan" 7410183754))) OR (AU-ID("Porter, Randall W." 7401897126))) OR (AU-ID("White, William L." 7402245825))) OR (AU-ID("Shetter, Andrew G." 7003390886) OR AU-ID("Shetter, Andrew G." 55517640000))) OR (AU-ID("Albuquerque, Felipe C." 26435054300))) OR (AU-ID("Papadopoulos, Stephen M." 35463442500))) OR (AU-ID("Fitzpatrick, Brian C." 7005080696))) OR (AU-ID("Bristol, Ruth E." 7003694262) OR AU-ID("Bristol, Ruth E." 55283143400))) OR (AU-ID("Kaibara, Taro" 6602863285))) OR (AU-ID("Sanai, Nader" 6508067049))) OR (AU-ID("Kakarla, Udaya Kumar" 14066110000))) OR (AU-ID("Wanebo, John E." 6602325096) OR AU-ID("Wanebo, John S." 35779633000))) OR (AU-ID("Tumialán, Luis M." 10040025300) OR AU-ID("Tumialán, Luis" 35781299700))) OR (AU-ID("Chang, Steve" 12808253500))) OR (AU-ID("Ponce, Francisco A." 7005404086)))

2. University of California, Los Angeles:

((((((((((((((((((((((AF-ID("University of California, Los Angeles" 60027550) OR AF-ID("David Geffen School of Medicine at UCLA" 60005247) OR AF-ID("Los Angeles County Harbor-UCLA Med Center" 60016081) OR AF-ID("UCLA Medical Center" 60032023) OR AF-ID("UCLA School of Public Health" 60029270) OR AF-ID("UCLA Health Sciences" 60032655))) AND (AU-ID("Ausman, James I M D" 35454217400))) OR (AU-ID("Batzdorf, Ulrich" 7005716892))) OR (AU-ID("Becker, Donald P." 7401884439))) OR (AU-ID("Bergsneider, Marvin" 70044 60634))) OR (AU-ID("Cheatham, Mel Lee" 19337207800))) OR (AU-ID("De Salles, Antonio A F" 7006012889))) OR (AU-ID("Frazee, John G." 7004379027) OR AU-ID("Frazee, John G." 36787485900) OR AU-ID("Frazee, M. D John G" 65045 50670))) OR (AU-ID("Fried, Itzhak" 7006553962) OR AU-ID("Fried, Itzhak" 55165561300) OR AU-ID("Fried, Itzhak" 55235576900))) OR (AU-ID("González, Nestor R." 7101714844) OR AU-ID ("González-Cadavid, Néstor F." 700700 7286))) OR (AU-ID("Holly, Langston Tyler" 6603944469))) OR (AU-ID("Lazareff, Jorge Antonio" 7004079421))) OR (AU-ID("Liau, Linda" 26642869100) OR AU-ID("Liau, Linda M." 26661406600))) OR (AU-ID("Lu, Daniel" 24587130300))) OR (AU-ID("Malkasian, Dennis R." 136105 51300))) OR (AU-ID("Martin, Neil A." 7401810133))) OR (AU-ID("Mathern, Gary W." 7005309077) OR AU-ID("Mathern, Gary W." 35830757000))) OR (AU-ID("McBride, Duncan Q." 7102290724))) OR (AU-ID("Pouratian, Nader" 660301 3239))) OR (AU-ID("Shafa, Bob" 37052830000))) OR (AU-ID("Yang, Isaac" 7101797924))

3. Northwestern:

((((((((((((((((((((AF-ID("Northwestern University" 60007363) OR AF-ID("Northwestern University Feinberg School of Medicine" 60013227) OR AF-ID("McGaw Medical Center of Northwestern University" 60006203))) AND (AU-ID("Ondra, Stephen L." 6701363702))) OR (AU-ID ("Bendok, Bernard R." 35427674600) OR AU-ID("Bendok, Bernard B." 55503092100) OR AU-ID("Bendok, Bernard B." 55503092200))) OR (AU-ID("Chandler, James G." 7201941447))) OR (AU-ID("Cybulski, George R." 7003 284562))) OR (AU-ID("Fessler, Richard G." 7005640859))) OR (AU-ID("Ganju, Aruna" 6701582670) OR AU-ID("Ganju, Aruna" 55553741536) OR AU-ID("Ganju, Aruna" 55553741537))) OR (AU-ID("Koski, Tyler R." 12769305300))) OR (AU-ID("Rosenow, Joshua M." 6602919539) OR AU-ID("Rosenow, Joshua M." 55553 738255))) OR (AU-ID("Smith, Zachary A." 35269786700))) OR (AU-ID("Brown, Justin Thomas" 7409453945))) OR (AU-ID("Gutierrez, Francisco A." 71023431 79))) OR (AU-ID("Onibokun, Adebukoa" 8253604600) OR AU-ID("Onibokun, Adebukola" 55392592500))) OR (AU-ID ("Yapor, Wesley Y." 6506401732))) OR (AU-ID("Tomita, Tadanori" 35479560 300))) OR (AU-ID("Alden, Tord D." 35517 341900))) OR (AU-ID("Bowman, Robin M." 7201764898))) OR (AU-ID("DiPatri, Arthur J." 8937231900))) OR (AU-ID ("McLone, David G." 7101983302) OR AU-ID("McLone, David G." 55553736920))

4. Washington University:

((((((((((((((((((AF-ID("Washington University in St. Louis School of Medicine" 60022756) OR AF-ID("Washington University in St. Louis" 60010261) OR AF-ID("Edward Mallinckrodt Institute of Radiology" 60006 263))) AND (AU-ID("Chicoine, Michael R." 6701572210) OR AU-ID("Chicoine, Michael M." 12773084200))) OR (AU-ID("COXE, William S." 6602198610))) OR (AU-ID("Dacey, Ralph G." 7005346897) OR AU-ID("Dacey, Ralph G." 55229290700))) OR (AU-ID("Dowling, Joshua L." 7202 654847) OR AU-ID("Dowling, Joshua L." 55368496100))) OR (AU-ID("Grubb, Robert L C S" 35451100600))) OR (AU-ID("Kim, Albert" 13610020500))) OR (AU-ID("Leonard, Jeffrey Russell" 7402283447))) OR (AU-ID("Leuthardt, Eric C." 6506900711))) OR (AU-ID("Limbrick, David D." 6507947818))) OR (AU-ID("Park, TaeSung" 24576874800))) OR (AU-ID("Ray, Wilson Z." 7202982100)) OR (AU-ID("Rich, Keith M." 7102063277)) OR (AU-ID("Santiago, Paul" 7004326221))) OR (AU-ID("Smyth, Matthew D." 7202702203))) OR (AU-ID("Stewart, Todd J." 7202178747))) OR (AU-ID("Wright, Neill M." 7201532034))) OR (AU-ID("Zipfel, Gregory J." 55320 147400) OR AU-ID("Zipfel, Gregory Joseph" 6603051199))

5. New York University:

((((((((((((((((AF-ID("New York University" 60021784) OR AF-ID("New York University School of Medicine" 60024541) OR AF-ID("New York University Langone Medical Center" 60032105))) AND (AU-ID("Golfinos, John G." 6701697432))) OR (AU-ID("Riina, Howard A." 6603746999))) OR (AU-ID("Jafar, Jafar Jafar" 7003833630))) OR (AU-ID("Babu, Ramesh P." 700496 0677))) OR (AU-ID("Doyle, Werner K." 7103092878) OR AU-ID("Doyle, Werner

K." 55239153600))) OR (AU-ID("Frempong-Boadu, Anthony K." 6508059386) OR AU-ID("Frempong-Boadu, J." 6503880788))) OR (AU-ID("Perin, Noel I." 6603894602))) OR (AU-ID("Wisoff, Jeffrey H." 7003778641) OR AU-ID("Wisoff, Jeffrey H." 55335006000))) OR (AU-ID("Harter, David H." 35464257700))) OR (AU-ID("Huang, Paul" 7403659159))) OR (AU-ID("Parker, Erik C." 7201840861) OR AU-ID("Parker, Erik" 36957415800))) OR (AU-ID("Placantonakis, Dimitris G." 650769 0305) OR AU-ID("Placantonakis, Dimitris G." 46261581800) OR AU-ID("Placantonakis, Dimitris G." 55062760000))) OR (AU-ID("Russell, Stephen M." 7401537704))) OR (AU-ID("Samadani, Uzma" 66025 57097))

6. Cornell University:

((((((((((AF-ID("Cornell University" 60007776) OR AF-ID("Weill Cornell Medical College" 60007997) OR AF-ID("Weill Cornell Medical Center" 60019868))) AND (AU-ID("Stíeg, Philip Edwin" 7004343297))) OR (AU-ID("Boockvar, John A." 6603038002))) OR (AU-ID("Elowitz, Eric H." 6602581952) OR AU-ID("Elowitz, Eric" 36821032800) OR AU-ID("Elowitz, Eric H." 36856836200) OR AU-ID("Elowitz, Eric H." 55061376200))) OR (AU-ID("Fu, Kai Ming G" 24066751400) OR AU-ID("Fu, Kai Ming G" 7202283442) OR AU-ID("Fu, KaiMing" 23088112600) OR AU-ID("Fu, Kai Ming" 23088182200))) OR (AU-ID("Greenfield, Jeffrey P." 7102090700))) OR (AU-ID("Härtl, Roger" 25653534700))) OR (AU-ID("Kaplitt, Michael G." 7004424290))) OR (AU-ID("Knopman, Jared" 25653969100))) OR (AU-ID("Pannullo, Susan C." 6603283424))) OR (AU-ID("Schwartz, Theodore H." 7203077980))) OR (AU-ID("Souweidane, Mark M." 7003660107) OR AU-ID("Souweidane, Violet" 55091094700) OR AU-ID("Souweidane, Violet" 8916231500))

7. Mayo Clinic:

((((((((((AF-ID("Mayo Clinic" 60005558) OR AF-ID("Mayo Medical School" 60026829) OR AF-ID("Mayo Clinic in Rochester, Minnesota" 60032610) OR AF-ID("Mayo Graduate School" 60018859) OR AF-ID("Mayo Clinic Cancer Center" 60010480) OR AF-ID("Mayo Clinic Hospital" 60021705) OR AF-ID("Mayo Clinic Education and Research" 600 09553) OR AF-ID("Mayo Health System" 60019849) OR AF-ID("University of Minnesota Rochester" 60000149) OR AF-ID("Mayo School of Health Sciences" 60011540))) AND (AU-ID("Atkinson, John L D" 7402665150))) OR (AU-ID("Fogelson, Jeremy L." 8606233000) OR AU-ID("Fogelson, Jeremy L." 36942352800))) OR (AU-ID("Krauss, William E." 2475 3397300))) OR (AU-ID("Lee, Kendall" 8076565200))) OR (AU-ID("Link, Michael J." 14018005900))) OR (AU-ID("Marsh, W. Richard" 7102633630))) OR (AU-ID("Meyer, Fredric Bruce" 35415113 900))) OR (AU-ID("Piegras, David G." 26428926100))) OR (AU-ID("Pollock, Bruce E." 7103208372))) OR (AU-ID("Spinner, Robert J." 7006125040) OR AU-ID("Spinner, Robert" 36793150300) OR AU-ID("Spinner, Robert M." 7006 125038))) OR (AU-ID("Wetjen, Nicholas M." 7801575988) OR AU-ID("Wetjen, Nicholas M." 55452663300) OR AU-ID("Wetjen, Nicholas W." 15743361200))

8. Columbia University:

((((((((((((((((AF-ID("Columbia University in the City of New York" 60030162) OR AF-ID("Columbia University, College of Physicians and Surgeons" 60011605) OR AF-ID("Columbia University Medical Center" 60027565))) AND (AU-ID("Solomon, Robert A." 7202756069))) OR (AU-ID("Anderson, Richard Ce E" 24392215300))) OR (AU-ID("Angevine, Peter D." 6701843669))) OR (AU-ID("Bruce, Jeffrey N." 7201835650))) OR (AU-ID("Connolly, Jr Sander" 7102030678))) OR (AU-ID("Feldstein, Neil A." 7003703024) OR AU-ID("Feldstein, Neil" 54883033900))) OR (AU-ID("Kaiser, Michael G." 7201713045))) OR (AU-ID("Lavine, Sean D." 7004063861) OR AU-ID("LaVine, Sean" 35942845300) OR AU-ID("Lavine, Sean D." 55369717800))) OR (AU-ID("McCormick, Paul C." 72016 03492))) OR (AU-ID("McKhann, Guy M." 7006642858))) OR (AU-ID("Meyers, Philip M." 7102316370))) OR (AU-ID("Ogden, Alfred T." 7005381150) OR AU-ID("Ogden, Alfred T." 36961657400))) OR (AU-ID("Quest, Donald O." 7003992679) OR AU-ID("Quest, Donald O." 35851121800) OR AU-ID("Quest, Donald O." 368933 72800))) OR (AU-ID("Sisti, Michael B J" 7006404314))) OR (AU-ID("Winfree, Christopher J." 6701454597))

9. Massachusetts General Hospital:

((((((((((((((((((AF-ID("Massachusetts General Hospital" 60029929) OR AF-ID("Massachusetts General Hospital and Harvard Medical School" 60020999) OR AF-ID("Massachusetts General Hospital Cancer Center" 60008130))) AND (AU-ID("Martuza, Robert L." 7006342404))) OR (AU-ID("Barker, Fred G." 354026 96600))) OR (AU-ID("Borges, Lawrence F." 26663964000))) OR (AU-ID("Butler, William E." 7201698674))) OR (AU-ID("Chapman, Paul H." 7402618512))) OR (AU-ID("Coumans, Jean Valéry C E" 6602744824))) OR (AU-ID("Curry, William Thomas" 8241991500))) OR (AU-ID("Duhaime, Ann Christine" 7003644713))) OR (AU-ID("Eskandar, Emad N." 6603632302) OR AU-ID("Eskandar, Emad" 54408 293100) OR AU-ID("Eskandar, Emad H." 35324416500))) OR (AU-ID("Mathews, Ernest S." 7007041599))) OR (AU-ID("Medlock, Michael D." 6701767960))) OR (AU-ID("Nahed, Brian Vala" 36027109300))) OR (AU-ID("Ogilvy, Christopher S." 7004678532))) OR (AU-ID("Sheth, Sameer A." 7102603372))) OR (AU-ID("Shin, John H." 36452495700))) OR (AU-ID("Swearingen, Brooke" 700460 2630))) OR (AU-ID("Wilkinson, Harold A." 7103040737) OR AU-ID("Wilkinson, Harold A." 36867235100) OR AU-ID("Wilkinson, Harold A." 55317031000) OR AU-ID("Wilkinson, Harold L." 245208 35700))) OR (AU-ID("Williams, Ziv M." 6701736906) OR AU-ID("Williams, Ziv" 36849446100))) OR (AU-ID("Zervas, Nicholas T." 7006745395))

10. University of Tennessee, Memphis:

((((((((((((((((AF-ID("Semmes-Murphy Neurologic and Spine Institute" 60076241))) OR (AF-ID("University of Tennessee Health Science Center" 60002194) OR AF-ID("The University of Tennessee System" 60016429) OR AF-ID("University of Tennessee College of Medicine Memphis" 60012655) OR AF-ID("University of Tennessee Medical Center" 60102405))) AND (AU-ID("Boop, Frederick A." 35518734600) OR AU-ID("Boop, Fredrick A." 36811524400) OR AU-ID("Boop, A. Frederick" 16938448500) OR AU-ID("Boop, Frederick A." 55544890 600))) OR (AU-ID("Arnautović, Kenan I."

6602879932))) OR (AU-ID("Einhaus, Stephanie L." 6506254756))) OR (AU-ID("Fernández, Julius" 8131938200))) OR (AU-ID("Foley, Kevin T." 7102856392))) OR (AU-ID("Fountain, Todd" 193341 03500) OR AU-ID("Fountain, Todd" 36853185100))) OR (AU-ID("Hoit, Daniel A." 10141573800))) OR (AU-ID("Michael, Madison" 35181755300))) OR (AU-ID("Mühlbauer, Michael S." 7005171 329))) OR (AU-ID("Robertson, Jon H." 7404531611))) OR (AU-ID("Sanford, Robert Alex" 7102623251))) OR (AU-ID("Smith, Maurice M." 15037619200))) OR (AU-ID("Sorenson, Jeffrey M." 8690246600))) OR (AU-ID("Watridge, Clarence B." 6603268014) OR AU-ID ("Watridge, Clarence B." 36948153200))

11. Johns Hopkins University:

(((((((((((((((((((((((AF-ID("Johns Hopkins University" 60005248) OR AF-ID("The Johns Hopkins School of Medicine" 60001117) OR AF-ID("Johns Hopkins Bloomberg School of Public Health" 60006183) OR AF-ID("Johns Hopkins Hospital" 60001555) OR AF-ID("Johns Hopkins Medical Institutions" 60003443) OR AF-ID("Johns Hopkins Bayview Medical Center" 60030952) OR AF-ID("Johns Hopkins Medicine" 600064 33))) AND (AU-ID("Ahn, Edward" 26642991700))) OR (AU-ID("Anderson, William Stanley" 13805238100))) OR (AU-ID("Belzberg, Allan J." 7004056966))) OR (AU-ID("Bettegowda, Chetan" 65058 49268))) OR (AU-ID("Brem, Henry" 35391358800))) OR (AU-ID("Bydon, Ali" 17134454800))) OR (AU-ID("Carson, Benjamin C." 7005404464) OR AU-ID("Carson, Benjamin S." 7005404475) OR AU-ID("Carson, Benjamin" 35069 044100) OR AU-ID("Carson, Benjamin" 35959569800) OR AU-ID("Carson, Benjamin M." 36441065900) OR AU-ID("Carson, Benjamin Solomon" 35961151100))) OR (AU-ID("Gallia, Gary L." 35229021500))) OR (AU-ID("Germanwala, Anand V." 6507599831))) OR (AU-ID("Gokaslan, Ziya Levent" 354078 03800))) OR (AU-ID("Huang, Judy" 7407188797))) OR (AU-ID("Jallo, George I." 7004021212) OR AU-ID("Jallo, George I." 36784030000) OR AU-ID("Jallo, George I." 55314283400))) OR (AU-ID("Lenz, Frederick A." 35402292000))) OR (AU-ID("Lim, Michael" 8623337000))) OR (AU-ID("Lin, David C." 36785674 400))) OR (AU-ID("Olivi, AlessORro" 7003325947))) OR (AU-ID("Quiñones-Hinojosa, Alfredo Redo" 7004875939) OR AU-ID("Quiñones-Hinojosa Alfredo, A." 37861893200))) OR (AU-ID("Rigamonti, Daniele R." 7005542698))) OR (AU-ID("Sciubba, Daniel M." 85899858 00))) OR (AU-ID("Tamargo, Rafael J." 7006674944))) OR (AU-ID("Weingart, Jon D." 7005840787) OR AU-ID("Weingart, Jon" 7005840791))) OR (AU-ID("Witham, Timothy F." 660283 6796))) OR (AU-ID("Wolinsky, Jean Paul" 8918413500))