A Correlation Between National Institutes of Health Funding and Bibliometrics in Neurosurgery

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■ OBJECTIVE: **The relationship between metrics, such as the h-index, and the ability of researchers to generate funding has not been previously investigated in neurosurgery. This study was performed to determine whether a correlation exists between bibliometrics and National Institutes of Health (NIH) funding data among academic neurosurgeons.**

■ METHODS: **The h-index, m-quotient, g-index, and contemporary h-index were determined for 1225 academic neurosurgeons from 99 (of 101) departments. Two databases were used to create the citation profiles, Google Scholar and Scopus. The NIH Research Portfolio Online Reporting Tools Expenditures and Reports tool was accessed to obtain career grant funding amount, grant number, year of first grant award, and calendar year of grant funding.**

■ RESULTS: **Of the 1225 academic neurosurgeons, 182 (15%) had at least 1 grant with a fully reported NIH award profile. Bibliometric indices were all significantly higher for those with NIH funding compared to those without NIH funding (P < .001). The contemporary h-index was found to be significantly predictive of NIH funding (P < .001). All bibliometric indices were significantly associated with the total number of grants, total award amount, year of first grant, and duration of grants in calendar years (bivariate correlation, P < .001) except for the association of m-quotient with year of first grant (P = .184).**

■ CONCLUSIONS: **Bibliometric indices are higher for those with NIH funding compared to those without, but only the contemporary h-index was shown to be predictive of NIH funding. Among neurosurgeons with NIH funding, higher bibliometric scores were associated with greater total amount of funding, number of grants, duration of grants, and earlier acquisition of their first grant.**

An academic physician's publication productivity and impact on his or her scientific community can by determined by quantitatively analyzing the number of publications and citations that appear in peer-reviewed journals, a process termed evaluative bibliometrics (25). Bibliometrics (or more broadly, infometrics or scientometrics) is rooted in citation analysis, or data on references cited in the footnotes and bibliographies of research publications (22). Although not perfect, it is generally believed that there is a correlation between the citation count of a publication and the impact or interest created within the academic community by the article. Some view citations as networks of trust (5): when researcher A cites researcher B, then A assumes B's claims are supported and true, and that publications cited by B (i.e., research done by other researchers C, D, E, etc.) were evaluated and influenced B's thinking and direction of research. Therefore, a successful publication record would consist of a number of publications (i.e., quantity), some of which are published in higher-impact journals or receive high citation counts (i.e., quality) (3).

Bibliometrics, such as the Hirsch index (16) and the impact factor of the publishing journal, allow one to portray the publication record of a researcher in quantitative detail. A bibliometric profile can be used to compare the research output of individual researchers, groups of individuals (e.g., male vs. female, young vs.

Key words
- Bibliometrics
- Citations
- Contemporary h-index
- Funding
- g-Index
- h-Index
- Neurosurgery
- NIH
- m-Quotient

Abbreviations and Acronyms
CIHR: Canadian Institutes of Health Research
GS: Google Scholar
NIH: National Institutes of Health
PoP: Publish or Perish
RePORTER: Research Portfolio Online Reporting Tools Expenditures and Reports

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old), and academic departments (18, 19). The use of bibliometrics in neurosurgery has been growing since the initial analysis by Lee et al. in 2009 (2, 8, 17-19, 21, 24, 28). Prior studies have investigated the relationship of bibliometrics to National Institutes of Health (NIH) funding within the fields of otolaryngology (29), radiology (25), and urology (10). Here we evaluate nearly all of academic neurosurgery—1225 neurosurgeons from 99 departments—to determine whether bibliometric indices, such as the h-index, m-quotient, g-index, and contemporary h-index (h_c)-index, are correlated to the number of research grants, total amount of funding, and duration and timing of funding.

METHODS

Study Population

A listing of the 2012 Accreditation Council for Graduate Medical Education neurosurgery residency training programs was obtained (https://www.acgme.org/ads/Public/Reports/ReportRun?ReportId=1&CurrentYear=2012&SpecialtyId=35). Departmental websites were consulted for names, academic ranks (i.e., assistant, associate, professor, and chairman), and subspecialties (i.e., spine, pediatrics, neurooncology/skull base, vascular, general, functional/epilepsy, peripheral nerve, and radiosurgery). Nonneurosurgical faculty (e.g., neurologists and basic science researchers) were excluded from this study. If there was insufficient information provided on a departmental website, we contacted the department via e-mail or telephone.

Definition of Bibliometrics

The h-index has a number of limitations that have prompted the development of innumerable other indices (1, 6). Here, we supplement the h-index with the m-quotient, h_c-index, and g-index.

h-Index. The h-index is defined as an individual having h papers with at least h citations. In other words, it corresponds to the point where the number of citations crosses the publications listed in decreasing order of citations.

m-Quotient. The m-quotient, also proposed by Hirsch (16), is the h-index divided by the number of years since the author's first publication. It allows a more accurate comparison of veteran to junior researchers, a bias inherent with the h-index.

h_c-Index. The contemporary h-index was developed by Sidiropoulos et al. (27). It corrects the original h-index by placing greater weight on newer publications than older ones. It is derived by multiplying the citation count of the article by 4, then dividing by the number of years since publication. Thus, the number of citations an article published in this year (2013) would be multiplied by 4; a paper from 4 years ago would have its citation count multiplied by 1; and a paper from 6 years ago would have its citation count multiple by 4/6.

g-Index. With articles ranked in decreasing order of the number of citations that they received, the g-index is the largest number such that the top g articles received (together) at least g^2 citations (12, 13). This gives credit to highly cited articles that would not have been recognized by the h-index.

Calculation of Bibliometrics

The h-index was calculated for individuals and departments using Elsevier's Scopus and Google Scholar (GS). The automated h-index from Scopus (http://www.scopus.com) was obtained using the Author Search function. Each individual then also had a manually calculated h-index determined by looking at each of the author's manuscripts (accounting for articles prior to 1996 in Scopus). The m-quotient was calculated by dividing Scopus's manually calculated h-index by the years since the first publication. Harzing's Publish or Perish (PoP; http://www.harzing.com/pop.htm) application was used to access GS for the g-index and contemporary h-index (h_c). PoP uses the Advanced Scholar Search capabilities of GS (14).

Authors' first and last names were used within search strings. Careful examination of the results from each search determined whether the author had a preference on how their initials were used for authorship. Further analysis was performed on each search result to determine whether it indeed represented the individual being searched for. This included looking at article titles, journals, and locations, as well as in some instances reading articles in their entirety for consistency.

NIH Funding Data

The funding status of each academic neurosurgeon was queried using the NIH's Research Portfolio Online Reporting Tools Expenditures and Reports (RePORTER) website (http://projectreporter.nih.gov/reporter.cfm), which provides data from 1989 to the present. The total amount of funding, total number of grants (including subprojects), total calendar years, and year of first grant awarded were recorded.

Statistical Analysis

We compared the median h-index, m-quotient, h_c-index, and g-index of academic neurosurgeons with and without NIH funding. A logistic regression model was used to determine whether any of the bibliometric indices under study were predictive in acquiring NIH funding. Among funded neurosurgeons, bivariate correlation was performed to determine whether the h-index, g-index, m-quotient, and h_c-index correlated with the total number of grants, total award amount, year of first grant, or duration of grants in calendar years. Correlation coefficients were calculated. Significance was determined as $P < .05$. Mean values $\pm$ standard deviations are presented. All statistics were calculated using SPSS version 21 (IBM, Aramonk, New York).

RESULTS

Study Population

A total of 233 (19%) academic neurosurgeons out of 1225 at 99 academic centers had obtained at least 1 NIH grant throughout their career. There were a total of 2369 NIH funding grants given to these 233 neurosurgeons (2 instructors, 38 assistants, 54 associates, 84 professors, and 54 chairmen). The total number of grants ranged from 1 to 87, with an average of 10 ± 13 and a median of 6 grants. The year of first grant ranged from 1989 to 2013, with an average of 1999 $\pm$ 7.5 years. The total calendar years of funding ranged from 1 to 25, with a mean of 5 ± 7 and a median of 5 years. Of the 233 academic neurosurgeons with at least 1 NIH grant, 182 had complete data—including total amount of funding (U.S. dollars)—and were