Commentary on:
The Spectrum of Altmetrics in Neurosurgery: The Top 100 "Trending" Articles in Neurosurgical Journals **by Wang et al. World Neurosurg 2017**
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Publication Metrics in Neurosurgery

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Evolutionary changes in health care over the past 2 decades have dramatically altered the landscape of academic medicine. Increasing clinical responsibilities, constant documentation reminders, repeated retraining requirements, complex quality metrics, and relative value unit productivity targets are the parameters by which physicians are measured today. These strictures are ever-present and have a great impact on salary and reimbursement and frequently influence physician comportment. For academic physicians, there is 1 more aspect to address or be cognizant of: scholarly efforts in the form of teaching, lectures, research, and publications. Published works in particular are valued and considered sine qua non for the career of an academic physician. They have a significant impact on promotion and tenure decisions. In fact, the privilege of being involved in resident education in the context of an American Council for Graduate Medical Education—accredited program comes with the requirement for publication, preferably in indexed and peer-reviewed journals. This is reported annually, and programs can be cited if their physician or resident faculty have inadequate records of publications. However, there are tangible benefits; published works elevate the silhouette of a program or department, increase its attractiveness to applicants, and raise the profile of the individual physician among academic peers or physicians from other disciplines.

Time, of course, is of the essence. The pressure on physicians to be clinically busy has eroded the protected time that used to be dedicated to research or scholarly endeavors. On occasion, academic physicians abandon these efforts and settle into a clinical track of patient care and teaching; others modify their practices and carefully parcellate time for patient care while staying active in the research and publishing arena. There are also different levels of published material; articles based on randomized controlled multicenter trials or externally funded basic science research are considered top-drawer, but scholarly production may also be in the form of book chapters, published abstracts, technical or case reports, or cohort studies. Social media posts such as blogs or online topic reviews are additional forms that have entered this arena in the age of the Internet. In some instances, especially to the lay public, the last-mentioned forms may actually be more accessible and hence may influence referral patterns and the clinical practice of a physician. Thus, each form of scholarly output potentially serves an important role. It is imperative that they are properly developed and inform in a way that positively influences the care of patients. It is also imperative that we develop methodologies to measure the impact of these disparate academic outputs so as to appropriately accord credit to physicians for their work.

Traditional bibliometrics used to evaluate academic faculty for promotion and tenure apply analytic tools and statistical methods to examine scholarly publication and citation. These are also used to compare same-specialty departments at different institutions.[1-5] Material indexed in databases such as PubMed are easily accessed and quantified and can provide a rapid estimate of an individual's portfolio.[1,2] Physicians also provide updated curriculum vitae or other documents to substantiate their efforts, but this may be less precise or more difficult to correctly attribute credit to. To address some of these concerns, in 2005, Hirsch[2] introduced a more sophisticated method to assess the impact

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Table 1. Summary of Common Bibliometric Indices

Index	Year Introduced	Definition	Uses	Advantages	Limitations
h-index	2005	Number of articles (h) with at least the same number (h) of citations	Measures individual published scholarly output with scientific impact based on citations; most widely used author metric	Easily calculated, easily understood; available from Web of Science, Scopus, Google Scholar, Harzing's Publish or Perish	Every author gets equal credit, favors older authors and larger specialties
m-index	2005	h-index divided by number of years since author's first publication	Allow comparisons of researchers with different career lengths	Allows younger authors and researchers to receive more credit	Every author gets equal credit
g-index	2006	Articles ranked in decreasing order of number of citations received; g-index is the largest number such that the top g articles received together at least g^2 citations	Gives more weight to highly cited articles	Allows highly cited articles to bolster less cited articles	Saturates when average number of citations for all published articles exceeds total number of published articles
e-index	2009	Square root of surplus of citations in the h-set beyond h^2	Differentiate between scientists with similar h-indices but different citation patterns	Allows for higher impact researchers with high-impact concepts to be differentiated	Cannot calculate e-index independent of h-index
i10- index	2011	Number of publications with at least 10 citations	A simple way for comparing author impact	Simple, straightforward	Used only in Google Scholar

of an individual's work. He termed it the "h-index" and based it on the number of published papers an individual has that have the same number of citations.[2] The h-index may seem simplistic, but it is a remarkably accurate measure of an individual's scientific productivity and the scientific impact of the work. It is also an excellent predictor of the scientific impact of an individual's work and future potential, and it allows comparison of an individual with his or her academic peers.[1] The h-index has gained popularity and is now easily available through online databases such as the Web of Science, Scopus, and Google Scholar, and it complements other citation analysis tools. Most medical and nonmedical scientific disciplines have embraced it; Spearman et al.[1] sampled data pertaining to 1120 academic neurosurgeons and noted an average h-index of 9 and an increasing h-index linked to increasing academic rank.

Measures of academic productivity such as the h-index are not perfect and have limitations. For example, publications may not be universally listed in all databases, and citation analysis tools may not have access to all databases, or the tool may be susceptible to repeated self-citation. Other criticisms are that the h-index credits review articles as much as original research, it gives equal credit to all authors listed on a publication, it has a "ceiling effect" (some articles may not be accorded credit in the h-index if the number of citations overall for that author's work are low), it favors senior researchers who have a longer window of time to accumulate citations, and it favors fields with greater numbers of researchers and publications (the h-index should not be used to compare researchers in different fields).[1,5,6] There are other limitations; younger authors may take years to accumulate citations, seminal work that is ahead of its time may not be recognized for years, and finally there is concern that the h-index values quantity over quality.[5,6] The h-index and other citation analysis or bibliometric tools also vary on the accessibility and fidelity of the database used to determine their value. Google Scholar is free, is frequently updated, and has a wide coverage, but it does not list all its sources and includes citations in non—peer-reviewed publications, such as conference proceedings or books.[5,6] Scopus is considered most appropriate for bibliometric analysis at an individual level, but it does not count citations before 1996.[5,6]

Hirsch[2] suggested modifying the h-index by dividing it by the author's years in the scientific field; the m-index is defined as the h-index divided by the number of years since the individual's first publication.[1,5,6] In 2006, Egghe[3] introduced the g-index; this tool takes into account articles by an author that have a greater impact than other works that may be less cited.[6] However, even these metrics have limitations; an author who has published only a few articles but of a very high quality that are frequently cited may have a low h-index or g-index; in these cases, a traditional qualitative analysis would perhaps be most appropriate.[5,6] There are other metrics as well that are less well known. In 2009, Zhang[4] introduced the e-index; the square root of the difference between the total number of citations in h articles minus h^2.[6] Another alternative is Google's i10 index, which is the number of articles with $\geq$10 citations.[5,6] All these metrics provide the ability to carefully distill the significance of a researcher's work, but in the end, their utility is valid only when viewed in the context of an individual's entire portfolio