Original Investigation

Associations Between NIH Funding and Advanced Bibliometric Indices Among Radiological Investigators

Andrew B. Rosenkrantz, MD, MPA, Anthony Jiang, BS

Rationale and Objectives: Whereas data support the h index (reflecting both publications and citations) as an indicator of academic productivity, other advanced bibliometric indices aiming to address shortcomings of the h index remain poorly studied. Our objective was to compare the associations between bibliometric indices and total National Institutes of Health (NIH) grant funding among investigators within U.S. academic radiology departments.

Materials and Methods: NIH grant funding amounts for 400 NIH-funded investigators within radiology departments were obtained from Blue Ridge Institute for Medical Research. Investigators' publications and associated citations were identified using Scopus. Indices computed for each investigator included: publication count, citation count, h index, i-10 index, h_c index (h index adjusted for recency of publications), m quotient (h index adjusted for career duration), and e index and g index (both account for highly cited articles). Spearman correlations were performed between indices and funding. Multivariable linear regression was performed to identify significant independent predictors of funding.

Results: For MD investigators: the indices exhibited no-to-weak correlations with funding ($r = 0.173–0.387$); m quotient exhibited the largest correlation and was the only significant (albeit weak) independent predictor of funding ($P = 0.011$). For PhD investigators: correlation with funding was weak for m quotient ($r = 0.323$), although moderate for other indices ($r = 0.518–0.568$); publication count exhibited highest correlation; publication count ($P < 0.001$) and h_c index ($P = 0.024$) were significant independent predictors of funding.

Conclusions: Bibliometric indices were more strongly associated with grant funding for PhD than for MD radiology investigators, with publication count exhibiting the strongest association in the latter group. Time-weighted adjustments, as reflected by the m quotient and h_c index, may improve efforts to predict funding using bibliometrics.

Key Words: Bibliometrics; publication; citation; h-index; academic radiology.

INTRODUCTION

An optimal approach for objectively measuring the research productivity of faculty working within an academic medical center is lacking. A straightforward and historically applied method is to simply perform a count of an individual investigator's publications. However, this scheme fails to account for wide variability in quality and impact among publications. In 2005, Hirsch described the h index (1), a measure impacted not only by the number of publications by an investigator, but also by the citations to these articles. According to Hirsch's original description, an investigator "has index h if h of his or her N_p papers have at least h citations each and the other $(N_p - h)$ papers have $\leq h$ citations each" (1). Accordingly, an investigator with an h index of 10 has 10 articles with at least 10 citations, along with any number of additional articles that all have less than (or equal to) 10 citations. Since its initial description, the h index has rapidly gained interest and acceptance in academic medicine, becoming applied as a measure of academic performance (2,3). Substantial associations were identified between the h index and other measures of academic achievement in numerous biomedical disciplines (4–8). Within radiology, the h index was observed to be predictive of academic rank (9) as well as attainment of at least one grant (10). Currently, the h index is used by departments for assessing faculty productivity, academic medical centers for tenure and promotions decisions, and funding agencies in grant considerations (11,12).

Despite the recent enthusiasm for the h index, the measure has also received criticism. The h index favors more senior investigators, increasing as one gains in number of publications and associated citations over the course of a career (11). In this regard, it fails to consider the recency of one's publications or the total time span over which they are published. In addition, all of an investigator's publications with more citations than the h index contribute equally to the index, such that the h index fails to account for highly cited publications that have an even larger number of citations (11). Given these limitations, other advanced bibliometrics indices have been

Acad Radiol 2016; ■:■■–■■

From the Department of Radiology, NYU Langone Medical Center, 660 First Avenue, New York, NY 10016. Received November 13, 2015; revised February 19, 2016; accepted February 19, 2016. **Address correspondence to:** A.B.R. e-mail: andrew.rosenkrantz@nyumc.org

http://dx.doi.org/10.1016/j.acra.2016.02.006

proposed. These include the i-10 index, h_c index, m quotient, e index, and g index, which seek to complement or improve upon the h index through adjustments for the timing of publications or very highly cited articles (12).

The advanced bibliometric indices are hoped to provide better benchmarks for assessing academic productivity than more traditional metrics such as the h index or simple counts of an investigator's publication and citation counts. However, there is currently a paucity of data formally evaluating such metrics or comparing them to standard bibliometric measures. Such insights could be useful in efforts to better predict an investigator's likelihood of receiving external grant funding, which in turn could influence academic departments' decisions regarding allocation of resources for research support. Bibliometric indices have been noted to vary substantially among scientific disciplines due to a combination of factors, including differences in the number of investigators, number of journals, average number of references per articles, and timing of citations following publication (1,11,13). Therefore, studies of the role of the indices are warranted at the level of individual disciplines of interest. In this study, we compare associations between bibliometric indices and the amount of National Institutes of Health (NIH) grant funding among investigators within academic radiology departments in the United States, with a hypothesis that proposed advanced indices, reflecting a wider array of features of an investigator's publication record, may have added value relative to conventional indices such as publication count, citation count, and h index.

METHODS

This retrospective study was approved by our institutional review board with a waiver of written informed consent. Data regarding NIH funding in 2014 were obtained from the Blue Ridge Institute for Medical Research (BRIMR) (14). The BRIMR is a nonprofit biomedical research and education organization that obtains funding information from the NIH's Research Portfolio Online Reporting Tool and provides such information in a publicly available online format, categorized on an annual basis by various factors, including medical school, academic department, scientific discipline, and individual investigator (15). A listing of 546 investigators within a radiology department having NIH funding in 2014 was retrieved, along with the investigator's total amount of funding. Because the NIH combines funding data for diagnostic radiology and therapeutic radiology (i.e., radiation oncology, biology, or physics) departments into a single category (15,16), Internet searches were performed to identify each investigator's faculty Web page. Only those investigators representing faculty with an appointment within a radiology department were included, providing a final included sample of 400 investigators. In addition, faculty Web pages were reviewed to classify investigators in terms of graduate degree as MD ($n = 44$), PhD or comparable doctorate level degree ($n = 317$), or MD/PhD ($n = 39$).

The Scopus database (17) was used to identify a listing of each included investigator's publications and the number of citations to each publication. A distinguishing feature of Scopus in comparison to other databases is its more precise identification of investigators based on institution and coauthors (12), thereby minimizing errors that may result from different authors with the same name. Based on the retrieved listings, the following indices were computed for each investigator: publication count, citation count, h index, i-10 index, h_c index, m quotient, e index, and g index (Table 1) (12).

Total NIH funding and bibliometric indices were computed between MD and PhD radiological investigators using Mann-Whitney *U* tests. Associations between the bibliometric indices and total NIH grant funding were computed using

TABLE 1. Summary of Bibliometric Indices Evaluated in This Study

Index	Definition
Direct indices	
Publication count	Total number of publications by investigator
Citation count	Total number of citations to investigator's publications
Composite indices	
h index	The number of publications by an investigator having at least h citations, whereas all remaining publications have no more than h citations
i-10 index	The number of publications by an investigator that have been cited at least 10 times
Time-adjusted composite indices	
h_c index	A "contemporary" version of the h index in which each publication's citation count is multiplied by four and then divided by the number of years since publication, thereby giving greater weight to more recently published articles
m quotient	H index divided by the number of years since an investigator's first publication*
Composite indices adjusted for highly cited articles	
e index	Average number of citations beyond the h index for those articles included in the h index; provides a measure of measure of excess citations not considered by the h index*
g index	Maximal number of publications that have received an average of g citations; accounts for all citations included in both the h index and the e index

* Has been applied to complement the h index by providing an index for comparing investigators having the same h index.