

Bibliometric Indicators for Evaluating the Quality of Scientific Publications

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ABSTRACT

Evaluation of quality and quantity of publications can be done using a set of statistical and mathematical indices called bibliometric indicators. Two major categories of indicators are (1) quantitative indicators that measure the research productivity of a researcher and (2) performance indicators that evaluate the quality of publications. Bibliometric indicators are important for both the individual researcher and organizations. They are widely used to compare the performance of the individual researchers, journals and universities. Many of the appointments, promotions and allocation of research funds are based on these indicators. This review article describes some of the currently used bibliometric indicators such as journal impact factor, crown indicator, h-index and its variants. It is suggested that for comparison of scientific impact and scientific output of researchers due consideration should be given to various factors affecting these indicators.

Keywords: Bibliometric indicators, Journal impact factor, Crown indicator, Citation half-life, h-index.

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INTRODUCTION

Scientific publications have become mandatory for health professional educators to be eligible for promotion to higher position (MCI and DCI) Evaluation of the quality of publication is a difficult task. Ideally peer evaluation by true experts in the field of study using established rules would be the best way to decide on the quality of the scientific work. But when the manuscripts are sent for publication the review is done by a reviewers who have general competencies in the subject but may not be specialists in that particular field of work.

The impact of a scientific publication is commonly measured by the number of times the article gets cited in other scientific publications. Analysis of the data obtained

from these citations can be used to indicate the relative importance of the article or the journal in which the article is published.¹ Bibliometrics is the term used to indicate the quality and quantity of an article and is derived by application of statistical and mathematical methods to books, articles, and other media of communication.² Bibliometrics which are generally expressed as various indicators have been used extensively in the scientific community as well as by organizations for diverse purposes. Researchers utilize them to objectively quantify the impact of their work on the scientific community. Organizations utilize them to evaluate the researcher for appointment, promotion decisions, fund distributions as well as to measure the quality of the research published by a particular researcher or the research group.³

Bibliometric Indicators can be classified into Three Types

1. *Quantitative indicators:* Used to measure the productivity of a researcher
2. *Performance indicators:* Measure the quality of the journal or the researcher.
3. *Structural indicators:* These help to establish a link between publication, authors and research fields.

Only the first two indicators will be discussed in this paper as they are better developed and more relevant to health profession education.

Quantitative Indicators

Number of Publications

The simplest way is to count the number of publications of a particular author in a defined time period. This indicator should be used cautiously while comparing the productivity of faculty members as the number indicates only the quantity without indicating the quality of the publications. This can be overcome to certain extent by analyzing the publications based on the type of article (whether it is a case report, a case control study, a randomized clinical trial or a review article) as each is given a different weightage in Evidence-Based Practice.⁴

Number of Publications in Top-ranked Journals

To improve upon the simple count, only the number of articles published in highest quality journals, for example

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according to their impact factor, is considered. Though this might look like a performance indicator described below, the reference to impact factor is brought in to overcome the short comings of the number count of publications.

Performance Indicators

Performance indicators can be subdivided into (i) indicators that measure the quality of the journals (Journal performance indicators) and (ii) indicators that help to quantify the quality of the article published by the researcher as well as its impact on the scientific community (Researcher performance indicators).

JOURNAL PERFORMANCE INDICATORS

A Journal Impact Factor (IF)

Or simply called as impact factor was first proposed by E. Garfield in 1955 and later on developed by Garfield and Sher in early 1960s (Schoenbach and Garfield 1956; Garfield 1999),⁶ is defined as the number of times articles from a journal are cited within 2 years divided by the total number of articles published in the same journal during that 2-year period.⁶ As an illustration: if there are 450 citable articles in a journal in 2 years (2010-11), and these have been cited 5645 times during the same period, then the IF for that journal for the year 2012 will be $5645/450 = 12.544$. Impact factor indicates the importance of the journal in its area of specialization and is probably the most extensively used quality indicator. The IF measures how frequently, on an average, authors cite fairly recent articles from that particular journal. IFS are available in the Science Citation Index (SCI), Journal Citation Reports (JCR) and on the Web of Knowledge (WoK) for more than 10,800 scientific journals.^{7,8}

Though widely used, IF has a number of limitations that need to be kept in mind while using it as a comparator for either comparing the research productivity of a researcher or for promotions, or fund distributions or any other administrative purposes. Though a high IF indicates a greater impact of the journal it does not necessarily indicate the quality of a particular article published in that journal. The IF may be high due to higher citations of a small percentage of articles. The IF of Nature in 2007 was 28.751, wherein 89% of citations came from only 25% of articles. That means majority of articles had less than 20 citations.¹⁰ The factors that affect the IF are the subject specialty area of the journal, the publication type of journal, number of authors, time taken for publication, etc.

Subject Specialty of the Journal

The IF is higher for journals from fundamental and pure sciences and lower in specialized or applied fields. Hence

if comparison has to be done, then the subject specialty of the journals should be same.⁹ Also multidisciplinary journals have higher IF than single specialty journal. This may be because of the wider readership from different disciplines and hence wider citations. One study (Chew et al. 2007)¹¹ has shown that the editors of general medical journals had taken conscious steps such as active conscription of 'high impact' articles, media promotion, better services to authors, that would increase the IF. Authors might contribute to increase the IF of a journal further by choosing a multidisciplinary journal because of its higher IF to a journal of their specialty with a lower IF even though these journals may be more appropriate to reach wider readership in their specialty.¹²

Number of Authors

Generally the number of authors contributing to an article is closely related to the subject specialization. Percentage of papers having multiple authors is more in fundamental sciences as compared to social sciences. It is frequently observed that the authors tend to cite their own work there by increasing the impact factor of the journal.

Publication Type

Within the same subject area there is a large variation in IF due to the type of journal and the type of articles published in these journals. A review article or technical report carries a lot many citations and a journal that has a shorter time lag between the time of submission and time of publication and publishes higher number of review articles is likely to have higher IF than a journal that primarily publishes original research papers.¹³ For example, the Physiology Reviews has an IF of 30.174 for year 2012 whereas it is 6.750 for Physiology, a journal that mainly publishes original research articles.

Journal Size

The number of articles published per year is called the journal size. It has been shown that if the mean variation in the impact factor is plotted against the journal size, a clear relationship emerges, suggesting the journal size should be taken into consideration while IF are to be compared.

Correct Usage of Words in Abstract and Title

The keywords used, the way title is worded and the abstract is written affects the number of times the article gets a hit during search in electronic database, thereby influencing the impact factor.

Effect of Numerator/denominator Articles

Only the normal articles, notes and reviews are taken as citable items by SCI database for denominator value but

numerator contains all types of articles including editorials, letters and meeting abstracts. Inclusion of all types of articles in numerator increases the IF considerably. Since there is no restriction for self-citation or on number of letters to editors published in the correspondence section, researchers may play a significant role in increasing the IF by self-citation. Editors may influence the IF by encouraging authors to cite articles published in the journal, accepting less number of manuscripts or by publishing higher proportion of review articles.¹⁴⁻¹⁶ To factor for such self-citations, SCI Journal Citation Reports now provides the journal self-cites indicator which compute the contribution of such self-citations to its IF.¹⁷

Title of the Journal and the Language

Some journals change the title after successfully publishing under one name for a number of years and this change is shown to adversely affect the IF.¹⁸ Similarly, most of the journals are published in English language and SCI does not include other language publications for IF citations, hence high impact work gets reported in English.

In Spite of Many Shortcomings

It is observed that the best journals in a field of specialization are those where getting a manuscript accepted for publication is very difficult and that these journals have high IF, too.⁶ It is recommended in the literature that the quality and the impact of the research should be measured using a variety of indicators rather than using just IF.^{17,19,20}

Five-Year Journal IF

This is one of the three additional journal performance indicators published by SCI Journal Citation Reports. Other than using a 5-year citation window period for calculation this indicator is very much similar to the traditional IF. This is considered to be giving better information on the journals that belong to more theoretical fields with a more 'durable' literature.¹² This indicator is of more recent origin and is available from 2007 onwards.

The Immediacy Index

Measures the current importance of the article published by a journal. It is calculated by counting on an average, number of times articles published by that journal during a particular year are cited over the duration of that same year.²¹ In other words Immediacy Index tells us how quickly the article from that journal is able to impact the scientific community. It is calculated by dividing the number of times the articles published in a particular journal is cited by other researchers by the number of articles published in that journal in the same year.

Cited Half-Life

Is defined as the number of years calculated backwards from the current year that account for 50% of total citations received by a journal in that current year (Thomson Reuters, Glossary of Scientific).²² It is the median age of the articles that were cited in the JCR year. For example, the cited half-life of British Journal of Clinical Pharmacology for 2013 is 8.70, which mean 50% of the citations received by the journal in 2013 were in reference to the articles published in last 8.70 years. In other words, cited half-life indicates the number of years between the publication of the cited study and the publication of the articles citing that study.²³

Researcher Performance Indicators

The performance of an individual researcher or a research group can be evaluated using the following indicators.

The frequency with which an article is cited by others is taken to gauge the performance of the author, higher number of citations pointing toward a better performance. Average citations per year can be compounded by number of citations divided by the number of years within a period of time. Average citations per item can be calculated by dividing the number of citations by number of articles.

CROWN INDICATOR

It is also known as field normalized citation score. This indicator proposed by Centre for Science and Technology Studies at Leiden University, corresponds to the number of citations to publications by a researcher or a group during an analyzed time span, compared to the world average of citations to publications of the same document types, ages and subject areas, seen as a group.²⁴ The indicator is stated as decimal number that shows the relation of the indicator to the world average which is taken as 1. As an example, 0.9 means that the publications are cited 10% below average and 1.2 that they are cited 20% above average. (Oncon-Albuquerque Júnior and Leite-Moreira 2000) (Rehn and Kronman 2008).²⁵ Crown indicator overcomes many of the disadvantages of IF such as types of articles, research field characteristics etc. by controlling for citation rates for the research field, publication year, and document type.

However, since the assignment of articles to particular research field is based on the Thomson Reuters⁸ Subject categories of the published journals, it fails to take into account the fact that many a times publications from a particular field are published in journals from other field category.²⁶ For calculation of crown indicator, the citation rates are not normalized on the level of individual publications, but on a higher aggregation level where the average citation rate of a researcher, group or department is compared to the average

citation rate of the fields in which the researcher or group has published. This way of calculating gives more weight to older publications (particularly reviews), published in fields with high citation dynamics.²⁵ For example a clinical pharmacology article published in a multidisciplinary journal such as *New England Journal of Medicine* is not included in clinical pharmacology field and hence does not figure in the number of articles when calculating the crown indicator in the field of clinical pharmacology. This disadvantage could be easily overcome by categorizing articles based on the field of specialization rather than that of publishing journal.³ As the group size matters while comparing the published articles by the researchers, it is advisable to compare crown indicator of research groups with same number of researchers in each group.²⁷

THE H-INDEX

This is an index that was proposed by JE Hirsch in 2005²⁸ to evaluate the scientific output of individual researcher from the field of Physics but can be applied to all research fields. The h-index is the number of publications with citation number $\geq h$ (Hirsch 2005).²⁸ To calculate the h-index, the researcher's published articles in a citation index are sorted in descending order by number of citations. The articles are counted from the top of the list downwards, and when the number of an article rises above the citation count for that very article, the number of the preceding article is to be counted as the h-index. For example, according to the Web of Science (WoS), a researcher has published 148 articles during the analyzed time span. The articles are sorted in descending citation count order in WoS and it is found that article number 29 has 31 citations and article number 30 has 28 citations, which is lower than the article number. The h-index for this researcher will therefore be 29, since the researcher thus has 29 articles with at least 29 citations. This index is very easy to calculate in the ISI Web of Sciences.

h-index measures overall impact of a researcher's work and avoids the disadvantages of other criteria of comparisons such as the total number of papers, total number of citations, citations per paper and number of 'significant papers'. Hirsch argues that two researchers with a similar h-index are comparable in terms of overall scientific impact even if the total number of their publications or total number of citations is different. h-index is not swayed by very rarely or very frequently cited articles.²⁹ Threshold values for interpreting the h-indexes has been proposed thus are 20 years of scientific activities, h-indexes at 20, 40 and 60 are labeled as 'successful', outstanding or as 'truly unique individual' respectively.²⁸

Limitations of h-index: The field of work, the average number of references required to be cited per paper, average

number of papers produced by scientists in that field, are some of the factors that influence the h-index. Although self-citations are likely to influence a researcher's h-index, the effect is much smaller than the total citation count. It includes only the journal articles and does not include books, book chapters, working papers, reports conference papers.³⁰ When using WoS for calculation of h-index, the researcher having a similar name may alter the index. Even after the researcher stops publishing articles after an active publication career of 15 to 20 years, his or her h-index remains high and does not decline in spite of not publishing in later part of their career.^{31,32}

M QUOTIENT

To overcome the last mentioned limitation of h-index, Hirsch proposed m-quotient that takes into account length of academic career. It is calculated dividing the h-index by the number of years the researcher has been active (as measured by the number of years since the first published paper). m-quotient is useful for comparing the researchers with different lengths of academic careers. This parameter loses its utility if a researcher does not maintain his or her level of productivity as compared to h-index which may continue to increase over time even after the researcher has stopped publishing.³⁰

OTHER INDEXES

A number of other indexes including variants of h-index such as g-index (Egghe 2006),³³ modified h-index called h(2)-index (Kosmulski 2006),³⁴ contemporary h-index (Khan et al. 2013),³⁵ Zhang's e-index³⁶ have been proposed to overcome the shortcomings of h-index, but these have not been used extensively nor have received empirical substantiation. These additional indexes may be used as complementary to h-index while assessing the scientific productivity of a researcher.

Recently Saxena et al³⁰ have proposed a index that gives weight to the originality, productivity and visibility of the publications. Called as Original Research Publication Index, it is claimed to negate the influence of self-citation, and gift authorship. This index needs to be validated and accepted as a bibliometric indicator by the scientific society.³⁰

CONCLUSION

From the above discussion, one can see that there is not a single parameter that is perfect for evaluating the scientific output and its impact on the scientific community. Each parameter has its own set of advantages and limitations. Impact factor is not an ideal parameter to measure the quality of the scientific publication, but is still accepted

as one of the valid indicators as we do not have anything better, IF has been in existence for a number of years and it is seen that the best journals in a field of specialization have high impact factor.^{6,37} To evaluate the scientific impact and scientific output of an individual researcher h-index is the most useful index as it is easy to calculate and can be used to compare the productivity of researchers from the same field of specialization.

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