Impact of impact factor in quantifying the quality of scientific research

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The first science journal was published in 1662 by the Royal Society of London in the name *Philosophical Transactions of the Royal Society*. Since then, there has been a dramatic increase in the number of scientific journals, particularly after Second World War, which reinstated the necessity of some scale to measure the standard of these journals. In 1927, the method of counting citations of the published articles to rank journals was introduced[1], which was later on improved as *Science Citation Index* (*SCI*) by the Institute of Scientific Information (ISI)[2]. Funded by the National Institutes of Health and National Science Foundation, ISI undertook the citation indexing project for Genetics Study Section in 1961. The *Genetic Citation Index* covered 613 journals and indexed them based on three metrics namely, number of citations in 1 year, number of citations in 5 years and number of citations in 14 years[3]. In 1963, the *SCI* included a new metric termed 'Impact Factor', which is still being used as a standard bibliometric indicator for identifying quality journals. Later on, *SCI* was renamed as *Journal Citation Reports* (*JCR*) and since 1975, it is being published annually, offering a systematic and objective means to evaluate the journals. The ISI was acquired by Thomson Corporation in 1992, which then took over Reuters in 2008 to form Thomson Reuters, and publishes *JCR* in two editions, viz. science and social science. The *JCR* Science Edition contains data from over 8,000 journals in 171 subject categories whereas the Social Sciences Edition covers more than 2,900 journals in 55 subject categories[4].

The key metrics of *JCR* includes impact factor (IF), five-year IF, Immediacy Index, cited half-life, *Eigenfactor* score and *Article Influence* score. IF is a ratio between the citations to a journal and the size of that journal and calculated using the formula; IF in 2013 = (citations in 2013 to items in 2012 + citations in 2013 to items in 2011)/(scholarly citable items in 2012 + 2011). IF was intended to evaluate the weightage of a given journal and compare its relative importance with other journals. Further, IF also enables the researchers to analyse the frequency of article citation for choosing the best journal for publication. The five-year IF is the average number of times the articles from a journal published in the last five years have been cited in the *JCR* year[4]. This metric is a better device to measure the impact of journals in fields where the influence of published research evolves over a longer period of time. The Immediacy Index measures how frequently the average article from a journal is cited within the same year of publication[4]. This is beneficial in evaluating journals that publish innovative research. The cited half-life scales the age of cited articles by showing the number of years back from the current year that account for 50% of the total number of citations to a journal in the current year[4]. This metric is helpful in managing literature collections and making decisions on archiving the papers. The *Eigenfactor* score is measured using the current JCR year citations to citable items from the past five years. While the IF weighs each citation to a journal equally, the *Eigenfactor* score assigns a greater weight to those citations coming from influential journals, allowing these journals to exert greater influence in the determination of the rank of any journal which they refer[4]. Of note, *Eigenfactor* score excludes journal self-citations. The sum of *Eigenfactor* scores for all journals is 100, where *Eigenfactor* score of each journal is a percentage of this total[4]. *Article Influence* score is the journal's *Eigenfactor* score divided by the fraction of articles published by the journal. That fraction is normalized so that the sum total of articles from all journals is 1. As the mean *Article Influence* score is 1.00, a score greater than 1.00 indicates that each article in the journal has above-average influence whereas score less than 1.00 shows that each article in the journal has below-average influence[4].

Of these metrics, IF is invariably debated in the context of its use and abuse in science. Since times, it has been used as a tool to compare the articles published in the journals and to judge the credential of authors. Though these practices urged the inventor of IF, Eugene Garfield (Founder Director of ISI) to provide a warning note in 1996 (ref. 5), IF is still being used as a device to evaluate individuals and individual articles throughout the world. As a rule, the journals with high IFs are considered to be prestigious and whoever publish in those journals are recognized by the research community. Further, laws and regulations for inducting researchers/scientists use IF as a prime tool for assessing the potential of those individuals. Adding to this saddle, evaluation of scientists for promotion, extension of tenure, granting research funding is also based on cumulative IF score of the respective scientists. Spanish law rewards the researchers for publishing in journals that are deemed 'prestigious' by ISI (upper third of IF listings), whereas in China, scientists get cash bonuses for publishing in high-impact journals[6]. In some Chinese schools, physics students should publish at least 2 articles with a combined IF of 4 to get their doctoral degree. Similarly, in Sweden, a Ph D student must publish two papers in journals with IF 4 (ref. 6).

In India, recruitment, awards, fellowships and promotions are determined by IF. Although there are no criteria of IF for the award of Ph D degree in India, the career after Ph D strongly demands IF. The 'Senior Research Associateship' and 'CSIR-Nehru Science Postdoctoral Research Fellowship' awarded by the Council of Scientific and Industrial Research consider the publications in high impact SCI journals as a selection criteria[7,8]. The 'INSPIRE Faculty Scheme' awarded by the Department of Science and Technology requires publications with aggregate IF of 10 or at least 3 (one for mathematics) research publications in *SCI* journals of high IF as a desired eligibility criteria[9]. The Post-Doctoral Fellowship awarded by the Indian Institute of Technology Delhi requires a minimum qualification of at least 2 referred conference/journal papers (of which at least 1 should be in 'reputed' journals)[10]. The Indian Council of Medical Research (ICMR) primarily screens the applicants for 'ICMR Centenary Postdoctoral Research Fellows' based on their publications, citation and IF[11]. The guidelines of the University Grants Commission for the appointment of Associate Professor

and Professor have a complex Academic Performance Indicator (API) for evaluating candidates based on IF of the journals in which they published. The API score for publications is calculated as: (i) 5 points for publications in indexed journals, (ii) 10 points for papers with IF between 1 and 2, (iii) 15 points for papers with IF between 2 and 5, and (iv) 25 points for papers with IF 5–10 (ref. 12).

Hence, it is well evidenced that the IF is being misused from its original intention in India and abroad. The system of calculating IF itself has major flaws, including: (i) limited coverage of journals with predominant journals in English language, (ii) a narrow window of only 2-year citation is taken into account, and (iii) obscurity regarding the types of article which are taken into consideration for IF calculation. Further, the reliability of the IF data is also debatable as it is computed by a private organization (Thomson Reuters). The recent Editorial in *Science* by Bruce Alberts underlines the drawbacks of IF as it encourages repetitive research, increases mediocrity, favouring only a few subject domains and more importantly, it discourages the researchers from undertaking risky long-term projects[13]. This simultaneously hinders the advancement of subject and innovation in research. The Editorial is a wake-up call for young researchers to explore the less studied areas in science rather than working on the richly populated research areas and to pay no heed to the automated numerical evaluations wrongly meant for judging their performance.

In addition to being used as an inappropriate gauge to measure the productivity of individuals and their articles, in Indian context, the IF-based evaluation system strongly discourages the researchers from publishing in Indian journals. It is worth mentioning that none of the Indian journals have an IF above 3 and the main reason for this retarded IF is the compulsion for Indian researchers to publish their outcomes in International journals of high repute. Ghosh *et al.*[14] report that the number of research articles published by Indian authors has considerably increased since 2010, and the number of publications from India is higher than China, Brazil and the United Kingdom. A survey by Elsevier shows that the annual growth rate of Indian publications was 14.4% between 2008 and 2012 (ref. 15). Unfortunately, the rise in the number of publications from India could not be correlated with the IF of Indian journals as the 'home' journals are ignored by the 'native' authors. Lakhotia[16] showed this tragic fact and has made an open call for the Indian experts to take an initiative to publish their works in Indian journals so that the upcoming youngsters would follow the suit. But, the prevalence of IF-based evaluation system in India severely obstructs the authors from publishing in Indian journals. Therefore, it is high time for the Governing bodies to (i) amend the evaluation criteria to eradicate the so called 'impact factor slavery', (ii) stop distinguishing the publications of an individual as 'national' and 'international', and (iii) promote publication in Indian journals.

For measuring the impact of individual researchers/scientists, few other metrics have been developed such as h-index[17], i10-index[18], honest h-index[19], g-index[20], AR-index[21], m-quotient[17], Percentile Rank Index (PRI) and Author Superiority Index (ASI)[22]. h-index is defined as the largest number h such that h publications have at least h citations and i10-index is the number of publications with at least 10 citations. The h-index excluding self-citation is termed honest h-index, whereas g-index is the highest number g of papers that together received g^2 or more citations. AR-index is age-dependent, which takes into account the age of publications and thus complementing the h- and g-indices, whereas m-quotient is h-index divided by the number of years since the first paper was published by the author. PRI denotes the citation rank of the author's individual papers among the papers published in the same year and source[22]. ASI is calculated using PRI by establishing a threshold (n) for PRI and counting the number of papers at the n percentile or higher[23]. Irrespective of the availability of several methods for evaluating the author and author's article, no single metric is versatile enough to measure the author impact and productivity. Ultimately, the only feasible way to accomplish this is to choose a set of articles published by the researcher, read to understand the quality of research and judge the researcher based on it instead of relying on numerical metric systems. This would be perpetually useful in identifying the potential candidates for pioneering research towards nation building.

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