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Worshiping False Idols: The Impact Factor Dilemma

Roger A. Brumback, MD

It always begins innocently enough! In the middle of the 19th century, mining and earthmoving were increasingly important enterprises of the industrial revolution. To remove rock and to open mine shafts, an explosive was needed, but nitroglycerine was too unstable for practical use. The Swedish scientist/inventor Alfred Nobel discovered that mixing nitroglycerine with the diatomaceous earth kieselguhr produced a stable explosive product he patented as dynamite, which was quickly adopted by the mining and construction industries. In the early 20th century, the Italian physicist Enrico Fermi, while attempting to understand the structure of atomic nuclei, discovered that nuclei bombarded by neutrons would split and release large amounts of energy. As others have employed these discoveries, both dynamite and nuclear fission have had destructive effects on society that were initially unimaginable by their discoverers. It was only a quarter century after the first nuclear fission bombs that Eugene Garfield, a library scientist and structural linguist from the University of Pennsylvania, discovered a metric that could be used to select journals for inclusion in his new publication *Genetics Citation Index* (the forerunner of *Science Citation Index*, which was subsequently commercialized by Garfield's company Institute for Scientific Information). This metric for journals was named "impact factor" and was to be calculated "based on 2 elements: the numerator, which is the number of citations in the current year to any items published in a journal in the previous 2 years, and the denominator, which is the number of substantive articles (source items) published in the same 2 years."[1,2] Thus, although the journal impact factor was born innocently enough, just like the examples involving Nobel and Fermi, Garfield's impact factor is now being used by others in ways that threaten to destroy scientific inquiry as we know it.[3,4]

For much of human history (about 200,000 generations), scientists were few in number, often worked in relative isolation, and only communicated findings to close friends or family. Thus, the accumulation of knowledge was slow, knowledge was rediscovered many times, and many discoverers were never known (for example, who invented the wheel? discovered fire? domesticated cattle? introduced the "zero" in arithmetic?). Some now famous discoverers were only acknowledged posthumously (one of the most notable examples being Leonardo da Vinci). Modern scientific communication was born in 1665 with the first widely circulated scientific journal—*Philosophical Transactions of the Royal Society of London*—which was championed by Robert Boyle (famous for Boyle's Law of gases, which states that for an ideal gas in a closed system, the volume times pressure is a constant). Boyle was concerned that without a publication to show priority, others might steal credit for his alchemical discoveries.[5]

Since the 17th century, there has been an almost exponential growth in the number of scientific and engineering publications worldwide.[6-8] Estimates vary, but it has been suggested that there are currently about 40 000 such journals, although only about 15 000 are academic publications in which the submitted articles undergo some form of peer-review.[7,8] The major scientific indexing services choose even fewer journals to include in their databases: the Thomson *Web of Science* source items include about 7500 journals, the Elsevier EMBASE includes more than 5000 journals, and the United States National Center for Biotechnology Information/National Library of Medicine PubMed includes nearly 5000 journals. Of these databases, the most prestigious is that of the National Library of Medicine, which was actually begun in the 19th century by John Shaw Billings, who was a United States Army surgeon assigned to oversee the Surgeon General's library. Billings expanded the library to what by 1876 was called the "National Medical Library," and he produced 2 catalogs—the *Index Catalogue of the Library of the Surgeon General's Office* for books and a parallel index of medical journals termed *Index Medicus*. To sort the library catalogs, Billings developed, in conjunction with the engineer Herman Hollerith, a punch card system, which was subsequently patented as Hollerith cards and sorting machine by Tabulating Machine Company (later merged into Computing Tabulating Recording Corporation and then renamed International Business Machines). Inclusion in the National Library of Medicine database has required a journal to undergo review of its quality by a panel

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of peer scientists. Thus, Garfield's idea of a metric, such as the journal impact factor, to sort journals and determine which should be included in indexes (or in library collections) could serve a useful function in the peer-review process.[9]

Unfortunately, over the past decade, the journal impact factor has been transformed into a singular rating to determine not just the value of journals but also the quality of scientists, institutions, and even scientific research.[3,4,10-13] This is partly due to aggressive commercial marketing of the impact factor by Thomson Corporation, after purchasing the Institute for Scientific Information for its Thomson Scientific division (which now generates $600 million in annual revenues). The journal impact factor is now being used extensively by committees and government in Europe and to a lesser extent in North America to make decisions concerning the awarding of grant funding and about the promotion and tenure of individual scientists.[14,15] Apparently, busy committee members prefer to rank candidates and institutions on the basis of simple numbers available from Thomson Scientific, rather than undertaking the more onerous task of reading and evaluating the quality of published scientific articles.

Journals have also been beguiled by impact factor values, often highlighting the number in flyers aimed at attracting subscribers and advertisers. Even the editor of the *Journal of Child Neurology* has courted the impact factor on 4 separate occasions[16-19] (this brazen effort at self-citation in this editorial by the editor of the *Journal of Child Neurology* should aid the journal's 2008 impact factor since one of the citations is to a 2006 publication [even though that 2006 publication will not appear in the denominator of the calculation, it should add to the numerator]).

More troubling are concerns often raised about the validity of the calculation of journal impact factors, but these alarms have generally been regarded as "sour grapes" comments by editors unhappy with low values for their journals. However, in December 2007, the executive director of the prestigious Rockefeller University Press, along with the editors of the *Journal of Experimental Medicine* (2006 impact factor of 14.484; ranked number 3 in category of medicine research and experimental) and the *Journal of Cell Biology* (2006 impact factor of 10.152; ranked number 15 in category of cell biology) took the bold move of simultaneously publishing an editorial in the 3 Rockefeller University Press journals questioning the integrity of the Thomson Scientific data.[20] Rossner and colleagues point out that Thomson Scientific will not provide (even for sale) the data used to calculate the impact factor, raising serious concerns about the methodology for determining the denominator in the journal impact factor equation.[20]

A brief look at the published journal impact factor values for 2 journals (*Journal of Child Neurology* and *Lancet*) is instructive for readers regarding this problem. According to *Journal Citation Reports*, the 2006 impact factor for the *Journal of Child Neurology* was calculated on the basis of 218 citations to 199 items published in the year 2005 and 268 citations to 161 items published in the year 2004. Thus, the numerator (citations) of 486 (218 + 268) divided by the denominator (published "source" items) of 360 (199 +161) resulted in the journal impact factor of 1.350. How did the *Journal Citation Reports* arrive at those numbers? Another Thomson Scientific product—the Internet-based *Web of Science*—can be used to identify published items. For just the year 2005 in the *Journal of Child Neurology*, the *Web of Science* lists a total of 213 published items that are further categorized as 193 articles, 7 editorial materials, 6 reviews, 4 letters, and 3 biographical items. Obviously the *Journal Citation Reports* considered only the 193 articles and 6 reviews to obtain the figure of 199 "source" items to be used in the denominator of the impact factor calculation. Interestingly, the National Center for Biotechnology Information *PubMed* database lists for the *Journal of Child Neurology* in the year 2005 a total of 207 published items (categorizing 33 of those items as reviews). Surely both indexes (*Web of Science* and *PubMed*) used the same journal issues, so why the disparity in counting items? Comparison of *PubMed* and *Web of Science* reveals some odd categorizations in the *Web of Science* (for example, 2 sets of meeting abstracts published in the *Journal of Child Neurology* were considered as articles by the *Web of Science*).

For the prestigious high-impact journal *Lancet*, the problem is slightly different. The *Journal Citation Reports* listed the 2006 impact factor for *Lancet* as 25.800, based on a calculation of 20 021 citations to 776 "source" items (360 items in the year 2005 and 416 items in year 2004). Meanwhile, the *Web of Science* lists for *Lancet* in the year 2005 a total of 1772 published items categorized into editorial material (723), letter (474), article (348), review (86), biographical item (77), correction (43), news item (20), and software review (1). [The *PubMed* database lists 1581 published items, of which 92 are considered reviews.] Interestingly, the *Journal Citation Reports* only considered 360 or just 20% of these total 1772 published items as "source" items for the denominator (what are those 360 items?). Adjusting the denominator for the other 80% of the published material (much of which received citations and counted in the numerator) would reduce the impact factor of *Lancet* from the lofty 25 to a more lowly 5. Interestingly, over the past 5 years of journal impact factor calculations for *Lancet*, the denominator has gotten progressively smaller (by nearly 40%) causing the impact factor to rise by more than 65%.

It is obvious that the easiest way to increase the journal impact factor is to publish articles that are cited (for the numerator) but not counted by Thomson Scientific for the denominator of the impact factor calculations[21] (in fact, reducing the denominator to 0 would be ideal since the impact factor from even just 1 citation would be ∞ [infinity]). Journal editors have recognized the potential for manipulating journal impact factor calculations[3,4,22,23] (even to the point of parody[24]), but only recently have some editors gone so far as to change the designation of published items (to reduce the likelihood that Thomson Scientific will count them in the denominator for the calculations) and to require authors to add extra citations to recent articles in their journals before accepting papers.[3,4,22,25-28] Unfortunately, the opacity in Thomson Scientific's refusal to reveal the details of their calculations only serves to increase suspicion about possible data manipulations. At a time when both the scientific community and the general public are lamenting the lack of transparency in science (particularly in relation to industry-supported research), it is unconscionable for academicians to deliver their careers into the hands of a for-profit company like Thomson Scientific that secretively derives a number to pigeonhole their research efforts.

In the past few years, some publicly available alternatives to the journal impact factor have been suggested.[29-32] Three years ago, the Google internet search engine introduced the freely available Google Scholar, which indexes scientific publications and can be used to identify the number of times an article has been cited. A free software tool published online by Anne-Wil Harzing (http://www.harzing.com/pop.htm) permits a rapid evaluation of the Google Scholar data. Many publishers also collect their own citation data (for example, all the journals using the HighWire Press online service [http://highwire.stanford.edu/], including *Journal of Child Neurology*, have a listing of citations). Mike Rossner, Executive Director of Rockefeller University Press, has suggested that the National Center for Biotechnology Information "mandate that publishers have to send them citation data" (Rossner, personal communication, December 2007). Such citation data would then be publicly available and could be readily used to develop a variety of verifiable journal metrics. Now would seem to be the appropriate time for the academic community to demand valid metrics to assess published scientific material and to ponder the quotation (often attributed to Albert Einstein): "Not everything that can be counted counts, and not everything that counts can be counted."

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