Editorial

Brace for Impact

> Look beneath the surface; let not the several quality of a thing nor its worth escape thee.
>
> —Marcus Aurelius, *Meditations*, VI.3

Eugene Garfield, intellectual and entrepreneur, was born in the Bronx, New York, in 1925. His eclectic education included a bachelor's degree in chemistry from Columbia University and a doctorate in structural linguistics from the University of Pennsylvania.[3] Garfield's passionate interest in the interrelatedness of scientific concepts led to the 1955 publication of a treatise in the journal *Science* titled "Citation Indexes for Science: A New Dimension in Documentation Through Association of Ideas."[15] He proposed creating a compendium of scientific research publications that was organized in a revolutionary manner. Previous approaches to such an "index" had arranged the studies either simply alphabetically or grouped under predetermined subject headings. Garfield thought that the latter method was intellectually stultifying, forcing innovative research into tight pigeonholes that disguised the interdisciplinary reach of scientific innovation. In contrast, he proposed organizing such a compilation by the association of ideas: each new article would be its own subject heading, under which all subsequent publications that cited it would be listed. Garfield's proposal led to the publication of the Science Citation Index (SCI) by his company, the Institute for Scientific Information (ISI), in the early 1960s.

Even in that pre-Internet age, the number of scientific publications was formidable. Garfield was confronted with the problem of identifying the most important ones for inclusion in his index. He started with the contents of the most prominent journals, the automatic consensus choices in each field. However, he recognized that important papers might appear in smaller, high-quality periodicals as well. How could these additional worthy journals be identified? His solution to this conundrum gave birth to the most revered and most reviled statistic in scholarly publishing: the journal impact factor.

The concept and function of the impact factor evolved over time.[16] When Garfield first introduced the term, it referred to the importance of an individual study as reflected in the list of publications that cited it. As a vehicle for selecting journals to include in his citation index, the impact factor became an attribute of the journals themselves. Garfield rejected the idea of simply choosing the journals with the greatest number of total citations, as this would unfairly favor those that merely published a large number of articles. He therefore arrived at the concept of dividing the number of citations to a given journal by a figure representing the number of articles that it had published in a defined period of time.

The meaning of the impact factor was eventually codified in the ISI publication, *Journal Citation Reports* (*JCR*), which first appeared in 1975.[3] Recognizing that citation practices differed among fields of research, in 1978 *JCR* began to group the listed journals into subject categories. In 1979, the journals in each category were arranged in the order of their impact factors. For better or worse, this decision effectively enshrined the impact factor as the primary measure of journal rank.[3] Since then, a number of rival metrics have been proposed or introduced by *JCR* and others.[10,13,28,30] For example, *JCR* also reports the Eigenfactor score, which removes journal self-citations and weighs the quality of the sources of the citations as well. However, none of these alternative measures has yet succeeded in supplanting the impact factor in the minds of many academics.

Before I became editor of *The American Journal of Sports Medicine*, I frankly had never heard of the impact factor. When we contracted with SAGE to produce the journal in 2004, the publisher alerted me that such a metric existed and that, in fact, *AJSM* had a pretty good one. It took a few more years until I really understood how the impact factor was calculated, which has changed very little since Garfield devised and refined the formula. The impact factor is not as well known among orthopaedic surgeons as it is among researchers and practitioners in other fields of science, so I suspect that many *AJSM* readers may also not understand it completely.

Among medical and other scientific journals, only those selected for inclusion in the Science Citation Index Expanded (SCIE), the descendent of the original SCI, receive an impact factor. Calculated annually, the impact factor is essentially a decimal quotient. The most widely cited version is the 2-year impact factor. For the 2016 impact factor, reported in June 2017, the numerator is the total number of citations that occurred in 2016 to papers published in a journal in 2014 and 2015. Not all citations count, however—only those that appeared in journals listed in the Web of Science Core Collection, which includes the SCIE and several other indexes in science, social science, and humanities produced by Clarivate, the current owner of *JCR*.[19] In order to normalize the impact factor to account for the size of each journal, the citation numerator is divided by a denominator consisting of the number of citable items published by the same journal during the 2-year collection period. Citable items are limited to original studies and review articles. Other items described by Garfield as "ephemera," such as editorials, letters, commentaries, perspectives, news stories, interviews, tributes,

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and obituaries, are not counted in the denominator.[16] However, if these items are cited, the citations are added to the numerator of the impact factor. In addition, any citation in such ephemera is included in the numerator of the cited journal's impact factor. Garfield's rationale for this formula was that ephemera, by their nature, would rarely be cited and therefore should not reduce the impact factor, which was designed to reflect the scientific resonance of the more substantive items.

A 2009 study in *The Journal of the American Medical Association* showed that this generalization is usually, but not universally, accurate.[24] When the authors tracked all citations to journals indexed in 2000 or 2006 in the SCIE or its social science counterpart, they found that, whether a 2- or 7-year time frame was considered, a surprisingly stable 97.2% to 97.6% of them were to "citable items," with only 2.4% to 2.8% referencing "ephemera." Interestingly, when they specifically examined 4 of the most respected general medicine journals, a substantially larger proportion of the citations, ranging from 9.2% to 22.9%, referenced these ephemeral items. This is hardly surprising, considering that noncitable items constituted 75.6% to 82.9% of the content of these 4 journals, compared with the 27.2% to 28.1% average of all indexed journals.

Garfield selected the 2-year time window for the impact factor because he felt that it was the most current, pertinent, and intense period of article citation.[3,16] In recognition of the fact that article citation in some fields may proceed at a different pace, a 5-year impact factor, calculated by a similar formula, has also been released since 2007. The attention garnered by the impact factor, and the associated ranking of journals, continues to generate intense controversy.[7,9,14,26,27] Garfield himself recognized the potential for misuse of his creation: "Like nuclear energy, the impact factor has become a mixed blessing. I expected that it would be used constructively, while recognizing that in the wrong hands it might be abused."[17] The main lines of criticism have focused on the tendency of many to regard the impact factor as the primary measure of journal quality, its misconstruction as representing the importance of every article appearing in a journal, ambiguity in defining the citable items in the denominator, and its vulnerability to manipulation.

The various ways in which editorial policy can influence a journal's impact factor were neatly summarized in the provocatively titled 2008 article, "The Top-Ten in Journal Impact Factor Manipulation."[12] Some of the behaviors enumerated in that article would seem inappropriate in almost any circumstance, while others might be criticized only if done in excess, and still others appear to be legitimate editorial choices. Awareness of the existence of these practices will empower readers to make their own conclusions as to whether a particular journal is attempting to manipulate its impact factor unreasonably.

The most egregious of these behaviors has been described as "coercive citation"[1,12,29,31]: the practice of sending a manuscript back for revision with the specific request to add more references from the journal that is considering the article for publication. Other criticized behaviors are a matter of degree, such as disproportionately citing a journal's own articles in editorials, commentaries, and summaries. An editor might also insidiously try to boost his journal's impact factor by rejecting high-quality papers merely because they report negative results, confirm the findings of prior landmark studies, deal with obscure topics, or come from relatively unknown authors, although such an editorial policy seems unwise and unpredictable.

As a rule, review articles tend to be cited more often than individual research studies, and pure review journals frequently rank near the top of subject categories. This phenomenon reflects the intentions of Eugene Garfield, who placed high value on efforts to organize and highlight interrelationships in research.[3] Thus, increasing the number of review articles in a journal might increase its impact factor, although this would seem to be a choice that an editor might make for sincere educational reasons. In a similar vein, an editor might decide to reduce or eliminate the publication of case reports, which tend to be rarely cited. Again, as the scientific contribution of most case reports is small compared with original research studies, such a decision appears to be a justifiable one.

The impact factor is calculated according to a journal's total citations and should not be construed to represent the citations of each and every article that appears in its pages. Garfield himself described article citation as following the "80/20 rule": 20% of a journal's articles generate 80% of its citations.[16] In fact, the journal *Nature* reported in 2005 that 25% of its papers generated 89% of the citations represented in its 32.2 impact factor.[25] Occasionally, one blockbuster paper can single-handedly launch a journal's impact factor into the stratosphere. An article published in 2008 in *Acta Crystallographica Section A* was cited 2391 times in 2009, resulting in a 20-fold increase over the journal's previous impact factor.[23] Although this is an extreme example, the usually skewed distribution of article citations within journals has thus led to criticism of Garfield's decision to calculate the factor as a simple mean.[5,9]

A recent publication by Bozzo and colleagues[6] documented that orthopaedic journals adhere to this typically skewed citation distribution. They noted that 85% of the articles published in orthopaedic journals in 2013 and 2014 were cited fewer times than their journal's impact factor would indicate and that 64.5% were not cited at all. Their analysis also provides a possible insight into Garfield's decision to use the mean rather than the median number of citations to calculate the impact factor. Bozzo et al[6] calculated that the median number of citations for 7 orthopaedic journals was 1, while it was 0 for the other 67. Clearly, if the goal is to produce a journal ranking order, utilizing the median number of citations would not allow for much of a spread. A comment by Garfield suggests that similar reasoning may have been behind the decision to calculate the impact factor to 3 decimal places: "The precision of impact factors is questionable, but reporting to 3 decimal places reduces the number of journals with identical impact rank."[16]

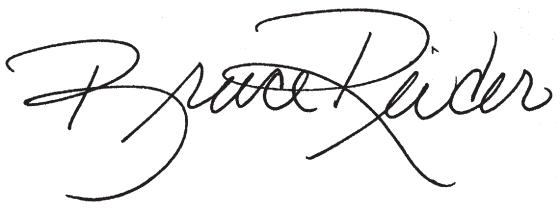
The impact factor is a journal-based metric, derived from the citation pattern of the articles that it contains. Within each journal, individual articles will inevitably vary in scientific quality and the generation of future citations. Various studies have shown that the publication of

an article in a highly ranked journal tends to produce more citations[8,21,22]; that the quality rating of clinical trials is related to the impact factor of the journal in which they appear[2,20]; and that, in orthopaedics, randomized trials, meta-analyses, and basic science studies tend to be cited more frequently than other article types.[4] However, in all of these relationships, other factors are also at work. A 2008 McMaster University study of higher quality articles from over 130 journals set out to detect factors that predicted 2-year citation counts for the individual studies.[21] The authors identified 9 article-specific variables and 2 journal-specific attributes that together produced an R^2 of 0.56 in a validation sample. Their model could predict the top half of cited articles with a sensitivity of 83.3% and specificity of 71.5% and the top third with a sensitivity of 66.1% and specificity of 82.2%.[21]

We humans seem to revel in assigning a numerical value to people or things so that we can rank them. Perhaps we have an inborn love of hierarchy. We rank billionaires by their net worth, motion pictures by their box office gross, and television programs by their viewership. Magazines and their online counterparts assign numerical ranks to everything from universities to dishwashers. As sports medicine specialists, we should understand this trait. Faster, higher, or stronger, athletic competition is focused on measuring performance quantitatively and ranking the contenders. In sports that cannot be quantified in seconds, meters, or kilograms, such as gymnastics or figure skating, we invent a scoring system so that performances can be ranked and a winner declared. Although the quality of a scientific journal is a complex attribute that cannot be adequately expressed in a simple number, if the impact factor did not exist, it is likely that another formula, with its own set of flaws, would take over the ranking duties.

A key step to preventing misuse and recognizing abuse of the impact factor is to understand what it is and what it is not.[11,18] A recent editorial in *BMC Medicine* suggested that renaming it the Citation Average Per Citable Item, or CAPCI factor for short, would help immeasurably in that regard.[11] While it seems improbable that a name as established as the impact factor is likely to be replaced, it would be beneficial for stakeholders, including academic promotion committees, to keep this description in mind. Citations of individual studies and other article-specific metrics are now available to supplement journal-wide measures and help assess the "impact" of each article; I will discuss this interesting development in a future editorial.

AJSM is proud that authors frequently choose to cite the articles that appear in its pages, as reflected in its current 2-year impact factor (5.673), 5-year impact factor (6.255), and Eigenfactor score (0.04301). We are also proud of the breadth of citation that contributes to these metrics: the 2016 2-year impact factor was supported by 116 articles with 10 or more citations and 319 with 5 or more; Bozzo et al[6] reported that *AJSM* had the lowest percentage of articles with zero citations among orthopaedic journals for 2015. We are grateful to the respected authors who generate these citations by entrusting their best work to our journal. Nevertheless, we urge readers to look beyond the impact factor, and we remind them that every scientific article, whether published in *AJSM* or elsewhere, should be read critically and evaluated individually.



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2017 American Journal of Sports Medicine Award Papers

Congratulations to the winners of the Hughston Award and the Systematic Review Award, presented during the annual meeting of the AOSSM in Toronto, Ontario, Canada, in July.

Hughston Award: "Changes in Knee Osteoarthritis, Symptoms, and Function After Anterior Cruciate Ligament Reconstruction" by May Arna Risberg, PT, PhD, Britt Elin Oiestad, PT, PhD, Ragnhild Gunderson, MD, Arne Kristian Aune, MD, PhD, Lars Engebretsen, MD, PhD, Adam Culvenor, PT, PhD, and Inger Holm, PT, PhD; published in the May 2016 issue.

Systematic Review Award: "Surgical Versus Nonsurgical Treatment for Midshaft Clavicle Fractures in Patients Aged 16 Years and Older: A Systematic Review, Meta-analysis, and Comparison of Randomized Controlled Trials and Observational Studies" by Diederik P.J. Smeeing, MD, Denise J.C. van der Ven, MD, Falco Hietbrink, MD, PhD, Tim K. Timmers, MD, PhD, Mark van Heijl, MD, PhD, Moyo C. Kruyt, MD, PhD, Rolf H.H. Groenwold, MD, PhD, Olivier A.J. van der Meijden, MD, PhD, and Roderick M. Houwert, MD, PhD; published in the July 2017 issue.