Impacted Science: Impact Is Not Importance

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ABSTRACT **The journal impact factor (IF) exerts a tremendous influence on the conduct of scientists. The obsession with IF has been compared to a medical condition, sometimes referred to as "IF mania" or "impactitis." Here, we analyze the difference between impact and importance, using examples from the history of science to show that these are not equivalent. If impact does not necessarily equal importance, but scientists are focused on high-impact work, there is a danger that misuse of the IF may adversely affect scientific progress. We suggest five measures to fight this malady: (i) diversify journal club selections, (ii) do not judge science on the publication venue, (iii) reduce the reliance on journal citation metrics for employment and advancement, (iv) discuss the misuse of the IF in ethics courses, and (v) cite the most appropriate sources. If IF mania is indeed a medical condition, the most appropriate course of action may be disimpaction.**

> **The use of journal impacts in evaluating individuals has its inherent dangers. In an ideal world, evaluators would read each article and make personal judgments.**
> —Eugene Garfield, inventor of the impact factor (1)

We suspect that when future historians and sociologists look back on our time, they will be bewildered by the preoccupation of many scientists with the journal impact factor (IF). The IF is a measure of the frequency with which the articles in a journal have been cited during the previous 2 years, divided by the number of published articles. Eugene Garfield originally developed the IF to select journals for inclusion in the *Science Citation Index* (1). However, over time the IF has become regarded as a surrogate measure of journal prestige and, by extension, desirability. We and others have portrayed the problem as a medical disease, referring to "IF mania," "IF obsession," or "impactitis" (2–4), in the hope of focusing negative attention on the practice of judging a paper on the basis of where it is published rather than the value of its content. Although IF mania seems irrational, the behavior is actually rational for an individual scientist because it confers disproportionate benefits to those who succeed in placing their work in high-IF journals. The behaviors associated with IF mania constitute a "tragedy of the commons," with scientists pursuing self-interest to the detriment of the community (2, 5). Volumes have been written on the misuse of the impact factor in judging publications, scientists, and scientific work, and we will not revisit those arguments here (see, for example, references 6 to 9). However, there has been relatively little discussion of the effect of IF mania on scientific progress. As part of our exploration of the state of current science, which has included essays on descriptive (10), mechanistic (11), important (12), specialized (13), diseased (14), competitive (15), (a)historical (16), and field (17) science, we now examine the consequences of the focus on scientific impact rather than importance. There are many problems with IF mania, but perhaps its most pernicious effect is its influence on how scientists work and what they choose to study.

Today there is a widely held notion that investigators must publish in high-IF journals to obtain grants, jobs, or promotions. In this economic framework, a journal's IF correlates with quality, and the mean IF of papers in a particular journal is taken to imply that all papers published by that journal are of similar quality. Publication in the highest-IF journals has been likened to admission to a "golden club" (18), whose members are more likely to succeed in science. Since IF is proportional to the frequency of citations and inversely proportional to the number of papers published, journals are rewarded for being highly selective, excluding articles that are not anticipated to be highly cited in the near future. This exclusivity creates an artificial scarcity that is conflated with quality. In turn, there is tremendous pressure on researchers of all ranks to publish in high-IF journals, as acceptance by such journals is considered to be indicative of high-quality work (in many cases, by other scientists who have not even read the paper), which brings disproportionately high rewards to the author. This reward system can create incentives for behaviors that are not conducive to good science, including secrecy, haste, misconduct, and error (19–21). Consistent with this notion, there is a positive correlation between the proportion of papers retracted from a journal and its impact factor, which we have measured by a formula called the retraction index (22), and the majority of retractions result from misconduct (19). Even when there is no obvious misconduct, there is a concern that many studies in highly cited journals are not reproducible (23). Although lack of reproducibility can have various causes, ranging from inadequate controls to misconduct, the demand by high-IF journals for clean stories with a clear message may tempt some investigators to selectively report their data, thereby reducing the likelihood that the work can be reproduced.

The use of journal IF to measure the quality and impact of individual papers is invalid from a statistical standpoint. The high IF of selective journals results from their ability to attract a few papers that are very highly cited (6, 9, 24). However, publication venue is a poor predictor of the number of times that an individual article will be cited. Thus, for most authors, the benefits of publishing in high-IF journals result more from their association with other papers in the same journal that happen to be highly cited

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than from their own extraordinary content. In other words, publishing in a high-IF journal may be easier than producing highly cited work (25).

Impact and importance are not the same. One dictionary defines "impact" as "a powerful effect that something, especially something new, has on a situation" while "important" is defined as "necessary or of great value" (26). These definitions distinguish impact as something occurring recently, whereas importance has the potential to become timeless. The related term "impacted" means "blocked" (27), and we note that the current obsession with impact may be blocking scientific progress. Apart from these very different definitions, impact and importance differ in our ability to measure them. Impact is measurable by its effect on the present. For example, impact may be measured by media attention or a large number of citations occurring soon after publication. However, the fact that impact is measurable does not mean that high-impact papers are necessarily important in a more fundamental sense. For example, papers describing common experimental methods or review articles that compile information tend to be more highly cited than those describing fundamental conceptual advances (28). A recent survey of biomedical scientists found that highly cited papers were more likely to describe evolutionary advances than surprising and revolutionary findings (29). Hence, citation rates tend to capture only one type of importance. Attention in the popular press signifies short-term recognition, but this impact is transient and fleeting unless the work is truly important. In contrast, importance may not be initially appreciated, and science lacks precise quantitative tools with which to measure importance (12). While some scientific findings have both high impact and importance, such as the description of the structure of DNA by Watson and Crick (30), Mendel's seminal studies that were foundational for the field of genetics (31) were neglected for the next 35 years and cited fewer than half a dozen times during that period before rediscovery by de Vries and Correns (32). Focusing on impact belies the fact that scientists are more interested in importance. There are also examples of high-impact papers that are not important, such as the widely publicized paper describing a bacterium purporting to incorporate arsenic instead of phosphorus into its DNA (33). Although this work has been cited over 100 times, the central finding is now known to be erroneous (34, 35), providing an example of high impact but low importance. Sadly, many papers in the literature are seldom if ever cited (36, 37) and thus lack both impact and importance.

If impact is not equivalent to importance, then there is a danger that IF mania could distort the course of science by diverting scientists to research that seems most likely to be cited rather than allowing them to pursue their natural intellectual interests and curiosity, which might lead to unsuspected and important findings. This concern is compounded by the difficulty in assessing the importance of a scientific discovery when it is first made (12, 29, 38). Papers are more likely to be cited in high-impact journals if they are in large, established fields (6). Thus, an excessive emphasis on bibliometrics may perversely steer scientists away from understudied areas of research. The history of science is replete with anecdotes of individual scientists doing fundamentally important work that was not appreciated at the time, and there are no features that can reliably distinguish breakthrough papers at the time of their publication (38). One can imagine that in today's highly competitive environment, such investigators might not survive, especially if their work is out step with trendy, high-impact science (39). Unfortunately, there is no way to measure the consequences of work that is not done. Nevertheless, historical trends in research expenditures and measurable outputs in the biomedical sciences suggest that the frequency of revolutionary breakthroughs may be declining (40).

Today the gateway to publishing in the highest-IF journals is determined by a small cadre of professional editors and the reviewers whom they select. Although these individuals generally do a superb job in selecting papers that will be highly cited, there can be little confidence that they are selecting the most important science. In fact, the high retraction indices associated with high-IF journals suggest that not all of their decisions are wise. Since the choices made by editors and reviewers have a tremendous impact on the careers of authors whose papers are selected or not selected, and the papers published by these journals can have an enormous influence on the work of other scientists, a handful of elite journals are exerting a disproportionate effect on who does science, what work they do, and how it is valued. This in turn encourages researchers to work in areas favored by the high-IF journals and their editors.

The many criticisms of the IF seem to have no effect on its inappropriate use, creating a sense of resignation to the flawed value system that pervades science today. Most scientists feel helpless to fight the system and simply play the game of trying to get their work into a journal with the highest IF. Others express concern that their fields, which have historically published their advances in respected but low-IF society-supported journals, may go extinct if forced to compete on the basis of IF in academic settings (5). Another cost is that IF mania leads scientists to cascade their articles through multiple submissions as they shop for the highest IF journal that will publish their work. Since the time for each submission can take months, this delays the communication of scientific findings and slows the progress of science. Young scientists feel caught in a situation that is no fault of their own and that they are powerless to do anything about. However, there are encouraging signs that the IF headwinds may have begun to abate. A group of scientists and organizations have signed on to the DORA (Declaration on Research Assessment) initiative in the hope of discouraging the use of IF in hiring and promotion decisions (41). A change in the format of the curriculum vitae (CV) to emphasize accomplishment and de-emphasize papers has been advocated; such an approach is reflected in the new requirements for the biosketches used in grant applications to the National Institutes of Health. Some eminent scientists have called upon researchers to place less emphasis on IF and more emphasis on quality and service when selecting an appropriate venue for their work (42, 43). An analysis of citation trends in the 20th century shows that the relationship between journal IF and citations increased until 1990 but has been declining since. Furthermore, the proportion of highly cited papers outside the top journals is increasing (44, 45). If these trends continue, we will see more diversity in highly cited sources, which would be good for science. However, even if the importance of the IF is in decline, any adverse impact on the course of science from decades of IF mania will continue for many years to come.

Individuals can make a difference. Here are some practical steps that an individual scientist can take to combat this malady.

(i) Diversify journal club selections. Journal clubs are popular in research institutions and are generally considered essential for the training of young scientists. A typical journal club format in-

volves the review, discussion, and critique of selected scientific papers in an effort to inform participants about new developments in science. Journal clubs are often dominated by papers from a small number of high-IF journals, based on the assumption that such papers are more likely to represent cutting-edge science. Although there is no question that many papers published in high-IF journals are outstanding, the persistent selection of such papers for journal clubs perpetuates the misperception that impact equals quality. Discussing interesting articles from more specialized society journals in a journal club can counteract this impression and might help to improve journal club discussions, which too often degenerate into discussions of why a particular paper was published by such a high-impact journal.

(ii) Do not judge science on the basis of publication venue. In scientific conversations, one often hears scientists justifying findings by saying that the work was published in a high-IF journal. This lazy and all-too-common practice contributes to IF mania by replacing critical assessment with prestige by association. Justifying scientific quality on the basis of publication venue makes little sense given the wide range of citation impact of individual papers published by high-IF journals. Science should be judged by the quality and interest of the data and their reproducibility.

(iii) Reduce the reliance on journal citation metrics for employment and advancement. The listing of journal IF in CVs is a new phenomenon that presumably reflects a desire by the individual to elevate the importance of a published work by demonstrating that it was published in a frequently cited journal. This rationale is flawed, since the journal IF is an average of article citation frequency, which it provides no indication of how frequently the specific article will be cited in the future. This practice should be discouraged, and such information should be disregarded.

(iv) Discuss the misuse of the IF in ethics courses. All scientists should be aware of the pervasiveness of IF mania, how the IF is calculated, how the IF influences scientist behavior, and the ways in which some journals attempt to game the system and elevate their IF (46). These issues can be incorporated into the graduate curriculum and discussed in seminars on publication ethics for established scientists, postdoctoral fellows, and research staff. This information would allow scientists to understand the limitations of this parameter for any use other than comparing journal citation averages.

(v) Take care to cite the most appropriate sources in scientific papers. By definition, papers in high-IF journals are cited, on average, more frequently. Authors may preferentially cite papers from high-IF journals due to their greater visibility. Some evidence to support this notion has been obtained from a study in which investigators independently reviewed research submitted to a single meeting and rated it according to quality and newsworthiness (47). The subsequent citation performance of the work showed only a very weak correlation with the independent scientific assessment, whereas the IF of the journal was the strongest predictor of subsequent citation by other papers (48). If this is a general phenomenon, the positive feedback loop between IF and citation may represent another example of the Matthew effect in science (49), in which papers in high-IF journals are more frequently cited than comparable papers in low-IF journals for reasons unrelated to their importance (50). Authors may also preferentially cite papers from high-IF journals to give the appearance of virtue by association. Such problems can be avoided if authors take care to cite the most appropriate original source of a statement irrespective of the journal in which it is published. With today's emphasis on citation productivity, it is more important than ever for authors to be as complete and accurate as possible in referencing the scientific literature.

IF mania continues despite broad condemnation because it is useful to certain elite investigators, journals and funding organizations (2). As long as resources and positions remain scarce, the perverse competitive cycle driven by IF mania will continue despite the overall damage that it causes to the scientific enterprise. The possibility that a focus on impact over importance is distorting the course of science should be of tremendous concern to all scientists, even those who benefit from the status quo. A renewed effort is needed to return science to an emphasis on rigor, reproducibility, and responsibility while encouraging scientific curiosity in all its forms. Together we can disimpact science. (In clinical medicine, the procedure of disimpaction involves the manual removal of feces from the rectum of an impacted individual to relieve constipation. The patient feels much better afterwards.)

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