

## SPECIAL ARTICLE

# Web of Science's Citation Median Metrics Overcome the Major Constraints of the Journal Impact Factor

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**ABSTRACT:** There are many metrics to evaluate the performance and status of journals. Among these, the journal impact factor (JIF) has become the dominant metric. The influence of JIF is illustrated by its widespread use to evaluate academic status, compensation, and funding decisions. However, as noted by Clarivate Analytics, the parent company of the Web of Science (WoS), the JIF should not be used without careful attention to the many phenomena that influence citation rates. To facilitate transparency, Clarivate Analytics provides all data used to determine the JIF. In addition, WoS provides other metrics for journal evaluation, including the article citation median and the review citation median. These metrics are represented as medians to minimize the confounding influence of a small number of highly cited articles that may occur when data are represented as means. Another feature of these WoS metrics is that data are separated according to different publication types of article (original research and review). To systematically compare these selected metrics, we used the data provided on the WoS web site to analyze 25 top ranked cardiovascular journals in the same mode as represented in the WoS citation distribution window. The results indicate that the article citation median and review citation median overcome several concerns that have been raised about the JIF and seem to provide enhanced objectivity as an indicator of journal impact in publishing original research and reviews. Therefore, we advocate that these additional WoS metrics might be preferentially considered as indicators of journal performance.

**Key Words:** benchmarking ■ bibliometrics ■ cardiovascular research ■ journal impact factor ■ periodicals as topic ■ publishing

## OVERVIEW OF THE HISTORY OF QUANTIFYING JOURNAL PERFORMANCE

The history of quantifying journal performance prominently features Eugene Garfield during his long tenure as President of the Institute for Scientific Information. Dr Garfield's career focused on innovations in indexing scientific literature, perhaps most clearly demonstrated by his conception and development of the science citation index.<sup>1</sup> In 1976, Institute for Scientific Information introduced Journal Citation Reports which included the journal impact factor (JIF).<sup>2</sup> Many metrics were developed subsequently for evaluating journal influence and prestige. Institute for Scientific Information launched the Web of Science (WoS) in 1997 to combine many journal metrics into a single source. Institute for Scientific Information was acquired in 1992 by the organization now known as Thomson Reuters. Clarivate Analytics acquired

ownership of the WoS in 2016 and has been continuously updating information on its web site, making it more transparent, and transforming it into a rich source of many useful journal metrics with both current and historic data displayed in the numerous different fields. This transparency includes their web site permitting the export of all data on citable items to enable analysis of the contribution of each individual article towards a journal's JIF. Therefore, the WoS is now a source of primary information that facilitates assessment of the pros and cons of specific journal metrics.

## THE PREMISE AND CONSEQUENCES OF ASSESSING JOURNAL METRICS

Research is a process of determining modes of quantitation and analyses of acquired data, as well as

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## Nonstandard Abbreviations and Acronyms

<b>WoS</b>	Web of Science
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representation of results to provide the most objective and rigorous conclusion. As noted in guidelines for the American Heart Association journals, data should be presented in a way that emphasizes completeness, informativeness, and truthfulness. When articles are bundled together into a journal, a range of metrics have been devised to gauge overall journal quality. Despite numerous available metrics for this purpose, there is an almost ubiquitous focus on the JIF. The JIF has evolved to have a major influence over many facets of research, beyond the impact of the journal itself. For example, the JIF is now commonly used in academia to contribute to determination of faculty appointment, promotion, tenure, grant funding, institutional funding to a laboratory, salary, and stipends.<sup>3</sup> Hence, in many countries, JIF is now routinely embedded within bibliographies and curriculum vitae for each journal article cited and is given weight within the evaluation of the author's perceived academic achievement. It is commonly assumed that the journal's reputation as a source of original scientific observations is reliably captured by the JIF and that this, in turn, can be extrapolated as an objective index of the value of the faculty member's contributions or impact to the global research community. However, it is noteworthy that even the Clarivate Analytics web site cautions that the JIF should be used wisely and states, "Web of Science does not depend on the JIF alone in assessing the usefulness of a journal, and neither should anyone else."

## CALCULATION AND CONSTRAINTS OF JIF

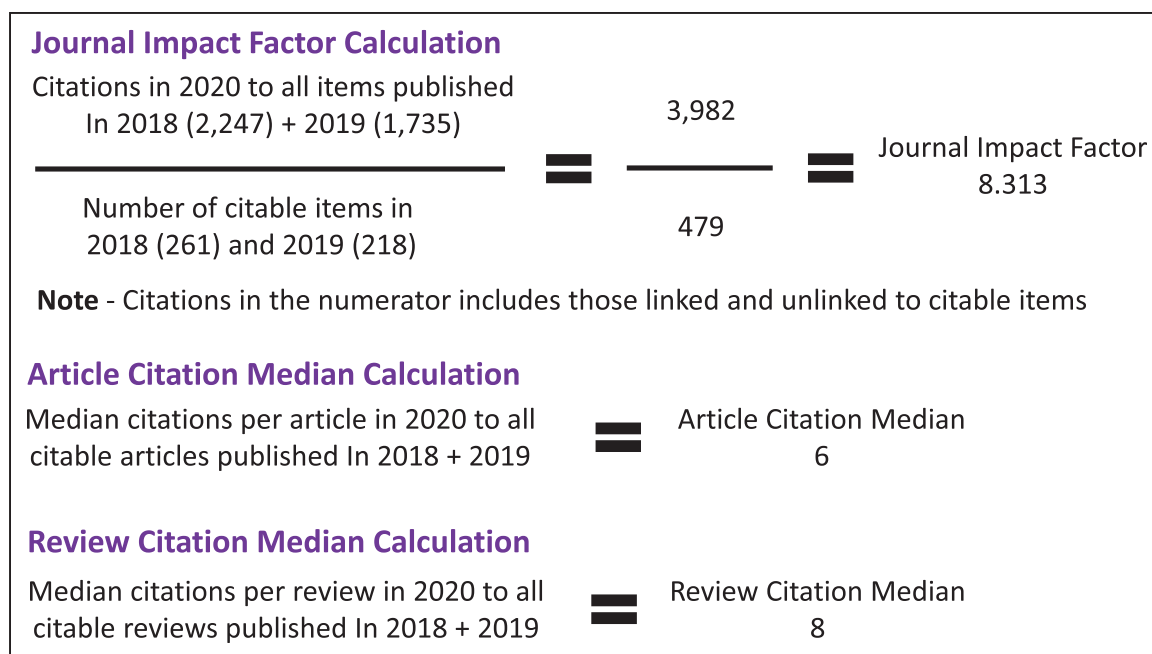
The JIF was created as a means to quantitate the influence of a journal that was not dependent on the number of articles published but instead to determine the influence of a specific journal when normalized to the number of published articles. The dominance of the JIF can be partially attributed to its ease of calculation. It is calculated by the total number of citations in a year for all articles published in the prior 2 years, dividing by the number of citable items. The term citable item is defined by WoS as encompassing manuscripts of original research, reviews, statements, and guidelines but not short publication formats such as editorials, letters, and news articles. The cites to these short publication formats are considered as unlinked citations on the WoS. In the JIF calculation, the numerator is the total citations associated with both citable items and unlinked citations, whereas the denominator only

includes the number of citable items. This calculation is illustrated in Figure 1 using the most recent JIF for *Arteriosclerosis, Thrombosis, and Vascular Biology* as an example. With the growth of the influence of JIF on the prestige attributed to journals, there have been several descriptions of how journals have reacted with practices adapted to optimize the JIF.<sup>4-6</sup> These articles have pointed out multiple factors that influence JIF but are unrelated to scientific merit and impact, including self-citation, optimizing publication dates, inclusion of citations that are not linked to a citable item, and the disproportionate influence of specific publishing formats, such as reviews, guidelines, and statements.

One of the most commonly noted constraints of the JIF is its calculation as a mean.<sup>7-10</sup> This mode of data representation has the potential limitation of a small number of highly cited manuscripts disproportionately influencing the JIF. Therefore, if the number of citations per article is a skewed distribution, a metric based on a calculation of a mean could render an evaluation that is not representative of the majority of the articles included in the calculation. For example, reviews, guidelines, and statements can garner far larger numbers of citations than the vast majority of original research articles. This can frequently lead to a situation in which <1% of the publications can contribute to >50% of citations contributing to the JIF.<sup>7</sup> Since the data on citations per article frequently do not display a normal distribution, presenting a summary metric using the median instead of the mean provides a more accurate representation of the citation for the totality of the manuscripts that are being assessed.

The other most commonly described constraint of the JIF is an aggregate index encompassing many different types of publications that include not only original research articles but also reviews, guidelines, and statements, which have higher citation metrics.<sup>11</sup> While JIF is an aggregate index, it is usually assumed that an article reporting original research findings which is published in a journal with a higher JIF contains original research of greater value or importance than if it had been published in a journal with a lower JIF. Obviously, this would be an erroneous conclusion if the metric was subject to major influence from manuscripts that did not report original research. Conversely, the aggregate index might not provide an accurate representation of the comparison for other forms of publications. Given that reviews, guidelines, and statements are extremely important to the research enterprise, it would be optimal to use metrics for their appraisal that compare the same types of publications. Indeed, separate assessment for different publication formats was a major recommendation of the San Francisco Declaration of Research Assessment (DORA- [sf-dora.org](http://sf-dora.org)).

The JIF has a long history as an index journal metric since it was devised in 1976. Given the potential



**Figure 1. Calculation of the journal impact factor (JIF), article citation median, and review citation median for *Arteriosclerosis, Thrombosis, and Vascular Biology* for 2020.**

Citable items are defined by Web of Science (WoS) as encompassing articles of original research, reviews, statements, and guidelines but not short publication formats, such as editorials and letters. The short publication formats are considered as unlinked items. In the JIF calculation, the numerator is the total citations associated with both citable items and unlinked items, but the denominator only includes the number of citable items.

real-world consequences of using journal metrics to appraise personal academic achievement and advancement, it would be appropriate to evaluate other WoS metrics and illustrate how their applications would influence the perception of journal performance.

## WOS CALCULATION OF CITATION MEDIAN METRICS

It is revealing that Clarivate Analytics has provided additional metrics that overcome the most frequently expressed concerns as noted above and in previous publications.<sup>12</sup> Since 2018, Clarivate Analytics has published journal citation distributions on the WoS. This data representation provides a histogram of citation per article with metrics of article citation median, review citation median, and unlinked citations. The term article on the WoS refers to publications of original research, while review includes a variety of other types of publications, such as reviews, guidelines, and statements. The WoS Citation Distribution also provide the number of unlinked citations that, as noted above, can cover a range of other types of publications, often nonpeer reviewed, such as editorials, letters, and news articles. These data are presented on WoS in an interactive graphical mode that displays these variables with the number of times cited in the years related to the JIF calculation. This calculation is illustrated in Figure 1 as an example using the most recent article

citation median and review citation median for *Arteriosclerosis, Thrombosis, and Vascular Biology*.

## METRICS OF CARDIOVASCULAR JOURNALS REPRESENTED AS CITATION MEDIANS

To illustrate how different metrics can convey different impressions, we analyzed journals in 3 cardiovascular related categories, namely peripheral vascular disease, hematology, and cardiac and cardiovascular systems, using WoS metrics, including the JIF. Our analysis included the top 10 ranked journals from the peripheral vascular disease and hematology categories that have 84 and 76 listings, respectively, for 2020; and the top 15 ranked journals for the broader category of cardiac and cardiovascular system that have 194 journals in this category for 2020. Some journals have listings in multiple categories, and consequently an analysis of a total of 25 journals was performed.

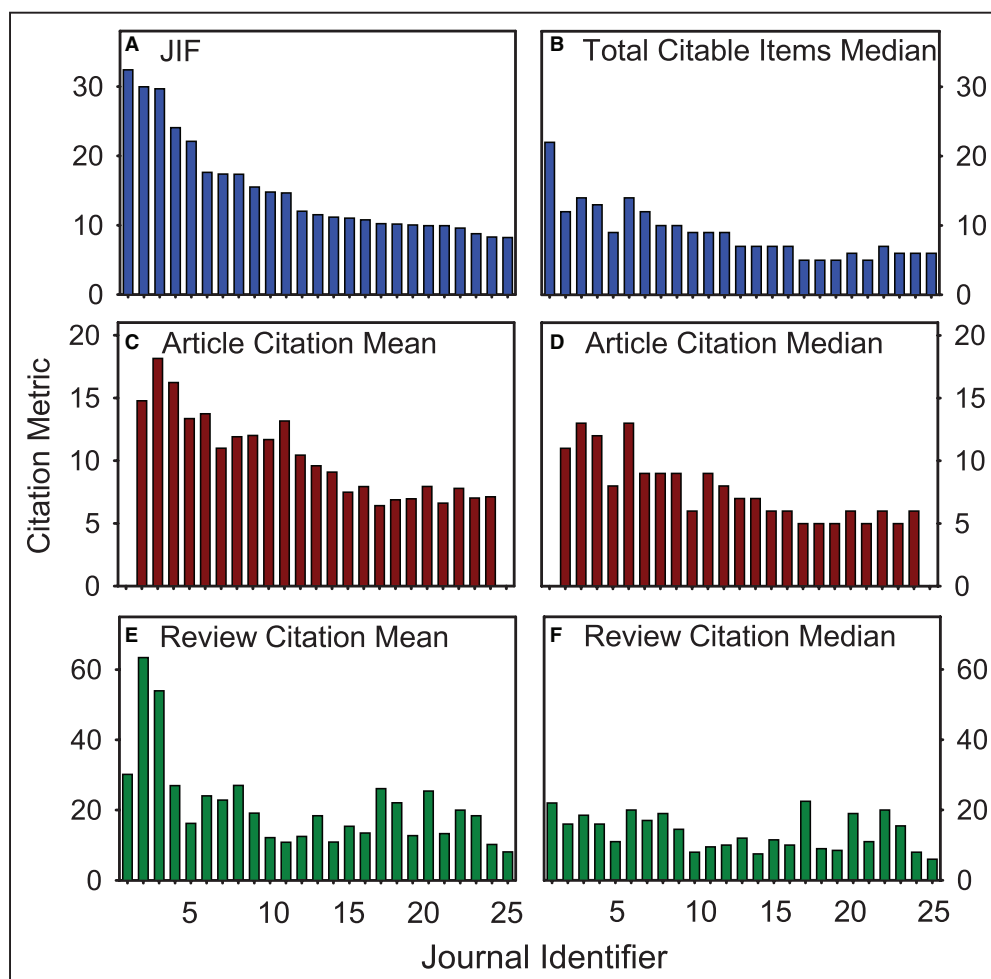
This analysis is facilitated by the transparency of the data on the WoS. The WoS mode of calculating citation medians removes unlinked citations. However, unlinked citations only contributed a median of 2.0% of citations (range 0.7%–10.1%) to the JIF in the journals included in this analysis, and their exclusion had a minor effect on data representations. The transparency on the WoS extended to the ability to download all the data used to calculate metrics. In the downloaded data,

it was noted that reviews were frequently misclassified as articles. Therefore, for our analysis, assignments were changed to the classification in PubMed with the assumption that this approach would provide a more uniform and objective assignment of the actual article types. Specifically, a publication was designated as a review when it was labeled in PubMed under one of the following categories: reviews, statements, practice guidelines, or guidelines. Therefore, our representation of Citation Medians is based on the data following this re-assignment process.

The comparisons are presented in Figure 2. Figure 2A is the 25 journals presented in the rank of their JIF which is calculated as a mean of all citations for citable items and unlinked citations. All other figures represent the journals in the same rank as the JIF. Figure 2B represents the median of citable articles.

Therefore, unlinked citations are also excluded from the calculation, although as noted above, this has a minor effect for the vast majority of journals. It is notable that there are marked changes in some values and positions in the ranking when the median of the citable articles is used rather than the mean. As would be expected, some JIFs seem to be potentially sensitive to outlier effects of a small number of articles that received a very large number of citations. While the boundary of the data distribution being represented as median versus the mean cannot be clearly defined, representing data as a median attenuated the outside influence of outlier data points that disproportionately affected mean values.

To further illustrate the effect of the mode of presentation on visualization and interpretation of results, Figure 2C through 2F represent data on citable items



**Figure 2. Metrics of journal performance.**

Data for 25 top rated journals in the categories of cardiac and cardiovascular system, peripheral vascular disease, and hematology. Journal names are not shown. All journals are represented in the same order in each panel. **A**, 2020 journal impact factor (JIF) listings from the Web of Science (WoS). **B**, The impact factor for total citable items expressed as a median. This and all other subsequent panels exclude unlinked citations in the calculations. **C** and **D**, The metric for citable items of articles of original research expressed as a mean (**C**) or median (**D**). **E** and **F**, The metric for citable items designated as review expressed as a mean (**E**) or median (**F**). Some highly rated cardiovascular journals do not publish articles of original research and hence the absence of some data in **C** and **D**. Note the change in scale of the y axis for these data to accommodate the data.

that have been defined as either original research articles or reviews (including reviews, guidelines, practice guidelines, and statements) represented as either means or medians. The representations in Figure 2D and 2F are the equivalent of WoS's Citation Medians. Note that the *y* axis scaling was adjusted to accommodate the large differences in these metrics. Figure 2C through 2F only represent data from citable items and hence, as in Figure 2B, excluded unlinked citations.

After these analyses, we have the following observations of the data shown in Figure 2:

1. Representation of citation performance for all forms of publication as a median value reduces this metric, particularly journals that have high JIFs.
2. The overall JIF and relative rank of the journal have a variable relationship when the data are segmented into articles versus reviews.
3. Reviews have a greater influence on the JIF compared with original research articles. Also reviews show the largest disparities when comparing mean versus median values.
4. Articles have less influence on the JIF relative to reviews and also show less disparity when citations are represented as mean versus median values.

## CONCLUSIONS

It is important to have valid metrics that permit comparisons among journals regarding performance and impact. However, appropriate metrics need to be applied in the correct context, avoid major outlier effects, and use apples to apples comparisons. The JIF involves multiple forms of publications including those not involving original research, and also is calculated as a mean, both of which have the potential to distort its utility as an evaluation tool. Fortunately, the WoS provides alternative metrics including median rather than mean citations and granular data that can allow for direct comparisons among articles that report original research or those for which the broad description of reviews is more appropriate.

Our analysis of top tier cardiovascular journals using the WoS's Citation Median mode illustrates that this representation obviates some major constraints intrinsic to the JIF. The article citation median metric in particular is more representative of the impact and citations for journals focused on publication of original research and is less prone to being swayed by a small number of outliers. This metric permits direct comparison of similar publication types and formats to enable manuscripts that report original research to be compared with other publications reporting original research. Furthermore, the review citation median permits direct comparison of journals with regard to their

citations of reviews, guidelines, and statements. Using the WoS mode of calculating Citation Medians also removes the influence of unlinked citations, which are included in the traditional JIF. On the basis of this analysis, we advocate that the Citation Medians published on the WoS should be afforded increased prominence as a journal performance metric.

## ARTICLE INFORMATION

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