

A Brief Review on Article-, Author-, and Journal-Level Scientometric Indices

Abstract

Scientometric indices help rank the impact of an article, an author, and a journal in scientific literature. Additionally, it helps to rank institutions, universities, and countries in the scientific field. There are various author-, article-, and journal-level metrics provided by different service providers. It is important to know the underlying calculation method for an informed comparison between authors, articles, and journals. In this article, we described briefly some of the common author-level metrics (h-index, i10-index, and g-index), article-level metrics (Altmetric, Dimensions, and PlumX), and journal-level metrics (Impact Factor®, CiteScore, SCImago journal ranking, and h5-index).

Keywords: *Altmetric, CiteScore, Dimensions, g-index, h-index, h5-index, i10-index, impact factor, PlumX, SCImago*

Introduction

Scientometrics may be defined as the information science that measures the impact of a scientific article. In a broad sense, when the impact of an article is measured by any index, it automatically drags the author and the journal along with it. Hence, scientometrics is the science that helps to find the impact of an article, an author, and a journal. Also, it helps in identifying institutions, universities, and country rank.^[1]

When an article is cited by another article, the former article is thought to make an impact. Hence, in general, the more the citation of an article, the more it scientifically becomes important in the literature. The authors who publish articles that are cited by scientific literature get more scores.^[2]

Science is now accessible to common people, thanks to the open-access journals. Hence, scientific articles are now picked up by news media, cited in Wikipedia articles, shared in social media, and the scientific communities. These are also important for the dissemination of science among scientists and common people. Hence, now the impact of an article is also weighted according to the reach in various media.^[3]

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When an author wishes to publish an article in a journal, s/he wishes to find the best journal in the research field. Simply speaking, the more the citation of articles in respect to published articles, the more valuable is the journal. Although there is criticism about various journal-level metrics, publishing in a journal with a higher Impact Factor® is desired by the majority of the researchers.^[4]

In this context, we described various popular author-, article-, and journal-level metrics in this article. We assume that this compilation would help novice authors to know and understand various scientometric indices and their calculation methods.

Scientometric Indices

In this article, we divide scientometric indices into three major categories—author-level, article-level, and journal-level indices as shown in Table 1. However, many indices can be interchanged among these three categories. For example, the h-index, primarily used as an author-level index, can also be calculated for a journal, or Altmetric, primarily used as an article-level index, can be used to find journal-level impact.^[5]

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Himel Mondal, Shaikat Mondal¹

Department of Physiology, Saheed Laxman Nayak Medical College and Hospital, Koraput, Odisha, ¹Department of Physiology, Raiganj Government Medical College and Hospital, West Bengal, India

Address for correspondence:
Dr. Himel Mondal,
Department of Physiology,
Saheed Laxman Nayak Medical
College and Hospital, Koraput,
Odisha - 764020, India.
E-mail: himelmkg@gmail.com

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Table 1: Some commonly used scientometric indices

Author-level	Article-level	Journal-level
h-index (https://scholar.google.com/citations)*	Altmetric attention score (https://www.altmetric.com)	Journal Impact Factor® (https://mjl.clarivate.com/journal-profile) [†]
g-index	Field citation ratio and Relative citation ratio (https://www.dimensions.ai)	CiteScore (https://www.scopus.com/sources)
i10-index (https://scholar.google.com/citations)	PlumX (https://plumanalytics.com)	SCImago Journal Ranking (https://www.scimagojr.com/journalrank.php) h5 index (https://scholar.google.com/citations?view_op=top_venues)

*h-index of an author can be obtained from various sources like Google Scholar, Scopus (<https://www.scopus.com/free/lookup/form/author.uri>), Publons (<https://publons.com>) and other sources and the h-index may vary across databases^[6]. [†]It is a proprietary product and a user needs a subscription to access the Impact Factor® of the journals from the Journal Citation Report®. However, many journals show it on their websites.

Author-level metrics

h-index

The h-index or “index h” is one of the popular author-level metrics introduced by Jorge E. Hirsch in 2005. According to the name of the author, it is also known as the Hirsch factor.^[6,7] The “index h” is “the number of papers with citation number $\geq h$.” It can be further elaborated that an author “has index h if h of her/his papers have at least h citations each and the other papers have $\leq h$ citations each”.^[8] Google Scholar profile of a researcher with an h-index is shown in Figure 1. The author had an h-index of eight. It means that the author had a minimum of eight articles with at least eight citations of each article. In addition, other papers of the author had ≤ 8 citations each. The h-index of this author would reach nine and 10 if the conditions are met as shown in Figure 2.

The h-index ignores the highly cited article as well articles without citation or with only a few citations. To overcome this, the g-index is another index introduced after 1 year of the introduction of the h-index.

g-index

The g-index was introduced in 2006 by Leo Egghe.^[9] The g-index of an author is g “if g is the highest rank such that the top g papers have, together, at least g^2 citations.” This definition indirectly includes that $(g + 1)^2$ is $>$ cumulative citations of the top (g + 1) papers. In the example shown in Figure 3a and b, the author’s articles were ranked according to the citation count with the highest to lowest from above

downward. The citations were cumulatively added in the third column and the rank of each article was squared in the fourth column. Now, the g-index is the top g papers where the $g^2 \leq$ cumulative citations and $(g + 1)^2$ is $>$ cumulative citations of top (g + 1) papers. In Figure 3a, in the colored row, the top g papers shows that the g^2 (=196) is $<$ cumulative citation (=211), and $(g + 1)^2$ (=225) is $>$ cumulative citations of top (g + 1) papers (= 217); hence, g-index is 14. If in time, the cumulative citation increases to equal or more than the square of the next rank of the paper, the g-index will increase to the next. In Figure 3b, in the colored row, it is seen that the g^2 (= 225) = cumulative citations (= 225) and $(g + 1)^2$ (= 256) is $>$ cumulative citations of top (g + 1) papers (= 230); hence, g-index is 15.

Interestingly, to increase the g-index from 14 to 15 in Figure 3a and 3b, the author just needs to increase the cumulative citation to 225 with increasing citation of any of the articles that rank within 15.

i10-index

The i10-index is a simple index started by Google in 2011.^[10] The calculation is straightforward. It is the number of articles by an author that received at least 10 citations. This index also ignores the highly cited, as well articles without citations or with only a few citations. The i10-index of the first author is 5 as shown in Figure 1 and the idea becomes clear from the article rank and their citation presented in Figure 2.

Article-level metrics

Altmetric attention score

Research articles are now shared, covered, and promoted in various mediums such as Facebook, Twitter, news channels, Wikipedia, and Blogs posts. The attention received by a particular article is summarized and expressed as the Altmetric Attention Score. This real-time, web-sourced metric was started by Euan Adie in 2011. Many of the journals are now showing the Altmetric score with the online version of the journal article. The score is both influenced by the quantity and quality of the source. The weight for the source of mention is available on the Altmetric website.^[11] However, as the score is a whole number, it may not be increased with all the increment of hits. For example, an article with a single YouTube share got 0.25 and the score is shown as 1 and it remains 1 for additional three shares. Figure 4a shows the Altmetric of an article and the number of shares in various mediums. The details about the share can also be obtained from the links of the medium.^[12]

Field citation ratio and relative citation ratio

Dimensions provide article-level metrics of total citation, citation in the last two years, field citation ratio (FCR), and relative citation ratio (RCR). The FCR is “the relative

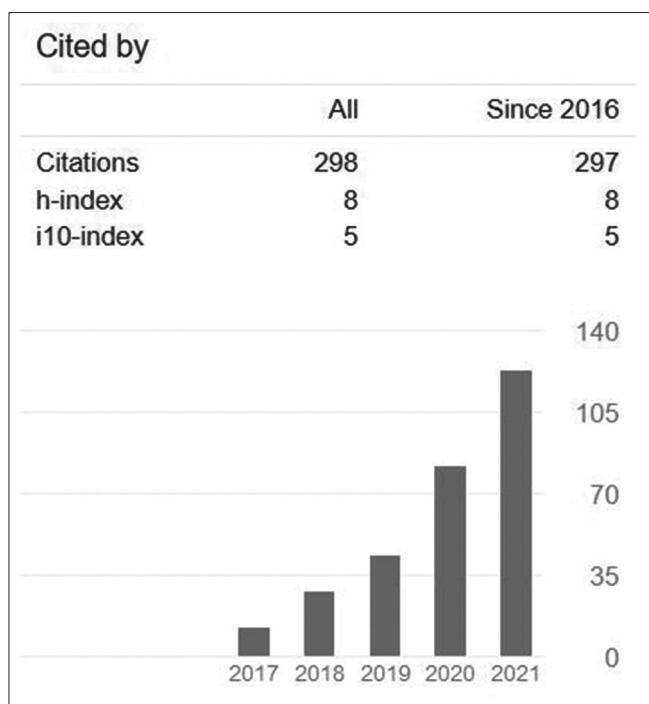


Figure 1: Screenshot of Google Scholar profile of the first author captured on November 24, 2021, at 8:30 pm (Indian standard time)

citation performance of an article when compared to similarly-aged articles in its fields of research subject area.”^[13] An FCR above 1 indicates that the article has citations more than the average number of citations. However, articles with <2 years of age would not show an FCR, and shown as not applicable (n/a).^[14]

The RCR is “the relative citation performance of an article when compared to other articles in its area of research.” An RCR >1 indicates that the article has received an above-average citation rate for its group.^[15]

An article with a total of eight citations had six recent citations is shown in Figure 4b. The FRC of the article was 1.9 and RCR was 0.53. Hence, compared to other similarly-aged publications in the same field, it has received approximately 1.9 times more citations than average. However, it has received below-average citations (0.53 is <1) when compared to all other articles in its area of research. The detailed method of calculation of FCR and RCR is not discussed here and can be found in the article by Janassens *et al.* and Hutchins *et al.*^[14,15]

PlumX

The PlumX metric provides a research impact in an online environment. It provides data regarding the citation (citation by a journal article, patents, and clinical documents), usage (clicks on the article, views, and download count), captures (favorites and bookmarks), mentions (blog posts, Wikipedia references, comments, and news media), and social media hits (shares, likes, and comments). The metric is straightforward and shows the actual number of

Article rank	Citations	Citations	Citations
1	84	84	84
2	20	20	20
3	19	19	19
4	12	12	12
5	11	11	11
6	9	9	10
7	9	9	10
8	8	9	10
9	8	9	10
10	7	7	10
11	6	6	6
12	6	6	6
13	6	6	6
14	6	6	6

h-index 8
h-index 9
h-index 10

Figure 2: Author-level metric - example of how the h-index is increased in respect of article number and citation number. The h-index 8 is from the raw data of the first author's profile (articles are ranked with higher to lower citation count in the column titled “Article rank”) and h-index 9 and 10 are shown with the minimum citations required to reach the index to 9 and 10

impressions in the five categories. The PlumX metric of an article is shown in Figure 4c. The number of citations in Scopus, captures in Mendeley, mentions in Wikipedia, and Social media posts in Twitter and Facebook is shown.^[16]

Journal-level metrics

Journal Impact Factor

The Journal Impact Factor® (JIF) or the Impact Factor® (IF) of a journal is a scientometric index that helps in “ranking, evaluating, categorizing, and comparing journals.”^[17] Eugene Garfield, the founder of the Institute for Scientific Information (ISI), first developed the idea of the IF in 1955. Later in 1961, the Science Citation Index (SCI) was published.^[18] And then, from 1975 the Journal Citation Report® (JCR) was published by compiling the SCI and Social Science Citation Index (SSCI). In 1992, Thomson Scientific and Healthcare acquired the ISI. Since 2018, the business is being handled by Clarivate Analytics. Any journal indexed by Web of Science (viz. Science Citation Index Expanded, SSCI, Arts & Humanities Citation Index, and Emerging Sources Citation Index) gets the IF®.

The calculation of impact factors requires publication in the previous 2 years. The calculation of the impact factor is shown in Figure 5a. For example, if a journal gets 100 citations in 2002 to the published 50 (say, 30 in 2001 and 20 in 2000) articles in the previous 2 years, the journal's IF® (published in 2003 JCR®) in 2002 is = 100/50 = 2. Hence, on average, each article was cited two times in 2002. From the calculation, it is clear that a journal at least requires 3 years (2000 to 2002 in the example in Figure 5a) for getting the IF®.^[19] The citation count (numerator) includes all the citations to the journal as a whole without

Article rank (g)	Citations	Cumulative citations	Article rank squared (g ²)	Article rank (g)	Citations	Cumulative citations	Article rank squared (g ²)
1	84	84	1	1	84	84	1
2	20	104	4	2	20	104	4
3	19	123	9	3	19	123	9
4	12	135	16	4	12	135	16
5	11	146	25	5	11	146	25
6	9	155	36	6	9	155	36
7	9	164	49	7	9	164	49
8	8	172	64	8	9	173	64
9	8	180	81	9	9	182	81
10	7	187	100	10	8	190	100
11	6	193	121	11	8	198	121
12	6	199	144	12	7	205	144
13	6	205	169	13	7	212	169
14	6	211	196 *	14	7	219	196
15	6	217	225	15	6	225	225 *
16	5	222	256	16	5	230	256
17	5	227	289	17	5	235	289

*** g² < cumulative citations and (g+1)² > cumulative citations**
g-index 14

*** g² = cumulative citations and (g+1)² > cumulative citations**
g-index 15

Figure 3: Author level metric – (a) an example of g-index of 14 and (b) an example of g-index of 15 with an increment of cumulative citations. The g-index 14 is from the raw data of the first author's profile and g-index 15 are shown with a fabricated increase.

discriminating among the types of articles. The number of items (denominator) includes only reviews, articles, and proceedings papers. The denominator does not include “editorials, minor editorial correspondence, general news items, small opinion essays, biographical items, interviews, letters, reprints, or minor non-scholarly works”.^[20]

There are other variations of IF[®]. The five-year IF[®] is calculated with the citation in a year to the previous five years' articles. Hence, a journal requires indexing in the web of science for at least 6 years to get a 5-year IF[®].^[17]

CiteScore

The CiteScore was introduced in 2016 by Elsevier. The company claims the metric to “provide comprehensive, transparent, and current insight” of a journal's impact. The metric is available for the journals that are indexed in Scopus. The calculation is different from the IF. The CiteScore is the ratio of 3 years' citations to the same 3 years' publications as shown in Figure 5b (marked with asterisk *).^[21] Although details about this method of

calculation are still available on the Elsevier website (posted on December 7, 2016), the new calculation method (posted on June 03, 2021) is shown in Figure 5b below the old method. In this new method, a 4-year time is considered for the calculation of the CiteScore.^[22,23] An example is shown in the lowest part of Figure 5b. In this example, the CiteScore of 2020 is shown and it was published on May 5, 2021.

Along with the CiteScore, Elsevier shows various other metrics that include the CiteScore Tracker that takes the total number of documents and the total number of citations to date to calculate the ratio and it is updated monthly.

SCImago journal ranking

A research group—SCImago introduced the SCImago Journal Rank (SJR).^[24] The rank of a journal is determined by a complex calculation method available on their website. For the ranking, the group uses the data available in the Scopus database. Hence, the journals indexed in Scopus would get the rank. The higher the rank, the higher



Figure 4: Article-level metrics (a) Altmetric score of an article, (b) Dimensions citation count with Field Citation Ratio and Relative Citation Ratio, (c) PlumX metrics details of an article

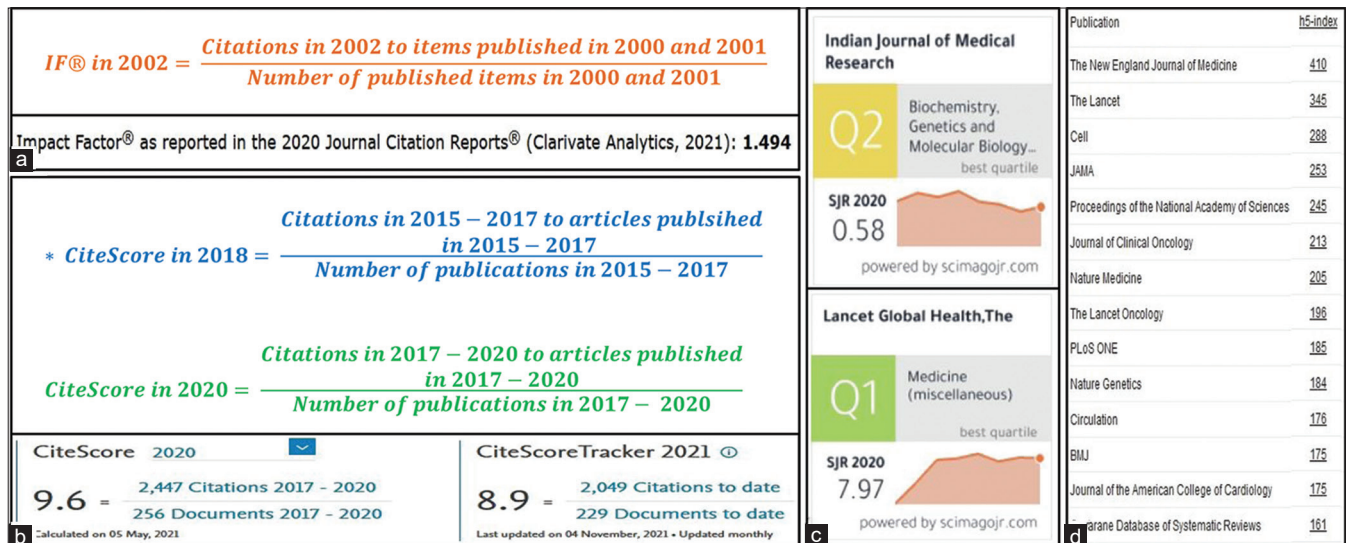


Figure 5: Journal-level metrics (a) Calculation of impact factor and an example of journal reporting their IF in 2020, (b) calculation of CiteScore by old method* (with 3-year data) and new method (with 4-year data including the year of the score) and an example of CiteScore in 2020, (c) example of SCImago Journal Rank of two journals, (d) h-5 index of some journals in "Health & Medical Sciences" category captured on 26 Nov 2021

is the quality of the journal. The SJR of two journals—the Indian Journal of Medical Research and The Lancet Global Health is shown in Figure 5c. This widget is shown on various journal websites to give the readers a glimpse

of the SJR. This contains the quartile in which the journal falls in its category, the SJR, and a trend line of the SJR. The full details are available on the website and it is open to all.^[25]

h5 index

The h-5 index is provided by Google Scholar and its calculation is similar to the h-index calculation [see Figure 2 for author-level calculation]. However, it is calculated for a journal and with citations of five completed years. It is the “largest number h such that h articles published in the last five completed years have at least h citations each.” Figure 5d shows the h-5 index of top journals in the “Health & Medical Sciences” categories (https://scholar.google.com/citations?view_op=top_venues&hl=en&vq=med). The data are available for subcategories also. In Figure 5d, the New England Journal of medicine shows an h-5 index of 410. This indicates that the journal published at least 410 articles in the previous 5 years that have 410 or more citations each. The major limitation of this index is the availability of the metrics for only the top 20 journals in each category or subcategory.^[26]

Discussion

In this article, we discussed the h-index, g-index, and i10-index as author-level metrics. Although other author-level metrics such as authors’ impact factor, e-index, and n-index can be calculated, the majority of the author’s profile includes h-index to express the impact of the author.^[27] However, there may be a difference in the value of the h-index of an author shown in different authors’ profiles. For example, the h-index of the first author in Google Scholar (<https://scholar.google.com/>) is 8, in Publons (<http://publons.com/>) is 3, and in Scopus (<https://www.scopus.com/freelookup/form/author.uri>) is 4. The difference is due to the difference in the indexing of the journals where the papers were published and cited. Google Scholar provides the highest h-index of an author as it includes a higher number of journals in comparison to Scopus or Web of Science.^[6] For any inadvertent high h-index in Google Scholar, authors should always check the list of publications and remove any erroneous addition to the list.^[28]

Among the journal-level metrics, the most preferred one is the IF. If the journal does not declare the IF, a subscription of the JCR is needed to access the IFs of journals. However, journal lists that are indexed in any services of Web of Sciences and entitled to get an IF can be downloaded (<https://mjl.clarivate.com/collection-list-downloads>). Along with providing journal an IF, Clarivate also provides an “Immediacy Index” that measures “how frequently the average article from a journal is cited within the same year of its publication.”^[29] This index helps in identifying the journals publishing researches that are cited immediately after publication. The calculation is simple and the numerator is the citation count in a year to the items published in that year and the denominator is the number of items published in that year. If articles published in 2020 is 200 and the citations

to those 200 articles are 800, then the immediacy index is $800/200 = 4$. The numerator or citation count includes citation to all types of articles and the denominator includes only articles and reviews.

Clarivate also divides the journals into quartiles and reports them in JCR®. In a particular JCR® category, the journals are arranged in higher to lower rank according to IF® to find the quartile of a journal. A journal in the first quartile (Q1) indicates the journal’s position in the top 25% of the journals according to IF. Furthermore, the journals can be divided into percentile according to the IF®. A journal with a 91% percentile indicates that the IF® of the journal performs better than 91% of the journal in the JCR®category.^[29]

If the number of publications of a journal and citation counts to those published articles is available, the impact of the journal can be calculated manually from the formula as shown in Figure 5a. However, the IF® is a proprietary product specifically provided by Clarivate. Several other impact index providers use a prefix with the term “impact factor” and the values are strikingly high. Scientific Journal Impact Factor (SJIF), Universal Impact Factor (UIF), Global Impact Factor (GIF), Research Journal Impact Factor (RJIF) are some of such impact indices. Many of the questionable journals use this number to prove their authenticity and popularity.^[30] Authors receiving email promotion of a journal with impact indices other than that provided by Clarivate may be ignored as those impact indices are of no value in the academic career.

SCImago journal ranking is sometimes shown on the journal websites to show the indexing in Scopus even after cessation of indexing. Hijacked journals (e.g., journal website is hacked, the website is cloned) also show the metrics for proof of indexing.^[31] Novice authors should be very careful before submission to those journals and suggested always checking the journal indexing.^[32]

The metrics discussed in this article are limited to some commonly used scientometric indices. There may be the existence of many other indices for identifying impact at the author, article, or journal level. All indices have their individual advantages and disadvantages. The IF, considered as the indicator of journal quality, can be increased in unethical ways.^[33] The article citations can also be increased in various ways to increase the impact of a paper or an author.^[34,35]

Conclusion

In this article, we provided a brief description and method of calculation of commonly used author-, article-, and journal-level metrics. Although this is not a comprehensive list of all scientometric indices, it includes the most commonly used metrics. The majority of the metrics are provided by private organizations or companies. Tussle and criticism among them would continue and the eventual

emergence of more robust indices would help in effective comparison among authors, articles, and journals' impact in the scientific world.

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Conflicts of interest

There are no conflicts of interest.

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