



Quantifying research publication efficiency: A comparative analysis of the HY-index and the h-index

Mohammad Salem J. Alzahrani ¹, Hamdy M. Youssef ^{2,3}, Najat A. Alghamdi ^{4,*}

¹Electronic and Communications Department, College of Engineering – Al-Leith, Umm Al-Qura University, Makkah, Saudi Arabia

²Mathematics Department, Faculty of Education, Alexandria, Alexandria University, Egypt

³Mechanical Engineering Department, College of Engineering and Islamic Architecture, Umm Al-Qura University, Makkah, Saudi Arabia

⁴Mathematic Department, College of Applied Science, Umm Al-Qura University, Makkah, Saudi Arabia

ARTICLE INFO

Article history:

Received 28 May 2023

Received in revised form

25 September 2023

Accepted 13 October 2023

Keywords:

Researcher efficiency

HY-index

h-index

Scholarly publications

Citation analysis

ABSTRACT

Efficiently quantifying the scholarly output of researchers, scientists, academic institutions, departments, and universities is of paramount importance within academic circles. This study centers on the application of a novel index known as the HY-Index, designed to evaluate the quality of articles from various sources, with the primary aim of addressing the limitations associated with established indices, notably the widely-used h-index. We deploy the HY-Index alongside the h-index to assess the performance of the top fifty researchers affiliated with Umm Al-Qura University, using data from the Google Scholar database. Comparative analyses are conducted, and rankings based on the HY-Index and h-index are scrutinized to determine which index offers a more suitable approach for quantifying researcher efficiency. Our findings reveal that the linear trend equation of the HY-Index rank closely aligns with the linear trend equation of the citation rank, surpassing the alignment observed with the h-index rank. Additionally, the linear trend equation of the HY-Index rank exhibits greater similarity to the linear trend equation of the publications rank compared to the h-index rank. Consequently, the HY-Index provides a more precise means of assessing author quality based on both citation and publication rankings, offering a fairer measurement of author quality compared to the h-index.

© 2023 The Authors. Published by IASE. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

The Science Citation Index (SCI) was first publicized in science in 1955 and is still up now as a tool to make it easy to share and retrieve scientific publications (Larsen and Von Ins, 2010). The SCI database serves two purposes: first, it lists each scientist's publications; second, it shows where and how their publications are cited. As a result, the SCI has always been split into the source author index and the citation index, two sections depending on the authors (Garfield, 1955). The first author's index, known as the h-index, was developed by Hirsch (2007). Hirsch (2007) designed the h-index to overcome the primary shortcomings of existing metrics, such as the overall quantity of publications

and citations. The overall number of articles does not fairly indicate the quality of the publications. On the other hand, the total number of citations might be a fair sign of how well-written those publications were (Hirsch, 2007, Hirsch and Buela-Casal, 2014). Waltman and Van Eck (2012) concluded that the h-index could not be used as a valid indicator of a scientist's total scientific contribution, and then they discussed other indicator types that can be used as a replacement for the h-index. In contrast, Kulasegarah and Fenton (2010) showed that the h-index is a powerful indicator that beats other indicator metrics in many areas like indicates: authors, topics, departments, faculties, institutes, universities, and countries (Hirsch, 2007; Hirsch and Buela-Casal, 2014; Kulasegarah and Fenton, 2010; Jin et al., 2007; Redner, 2010; Sidiropoulos et al., 2007). Mingers et al. (2012) suggested the h-index as an indicator of the quality and significance of a journal's research than other indicators like the number of citations (CPP) or impact factor (IF). Youssef and El-Bary (2021) suggested a new formula or model that measures the total number of

publications, the total number of citations, and the value of a highly cited publication; it is known as HY-index. It's easy to use HY-index to rank the work of authors, institutions, and departments. It is more sensitive to any change in publications or citations. With the rapid growth of online scientific papers, the ranking has increased in significance. They are ranked based on publications and researchers' work citations. In the publication's ranking, papers that have the most significant need to be placed higher. The top-ranked institutions and researchers in a specific field may be found by comparing both academic and industrial research institutions as well as their academics. The results of the comparison can help researchers and students make better decisions about where they want to work or study, and it can help employers find the best candidates for open positions (Ren and Taylor, 2007; Maier-Leibnitz, 1989). Alzahrani (2013) obtained the optimum solution of an existing real word assignment problem known as the seat assignment problem using the Seat Assignment Method (SAM), which is the driven method from three existing methods, the Hungarian Method, the Northwest Corner Method, and the Least Cost Method (Alzahrani, 2013). Alzahrani (2013) applied the SAM method after receiving whole applications from all candidates, and the department ranked all candidates according to the agreed criteria in ascending order (Alzahrani, 2013). Today, publications and researchers' work citations are essential for academic careers and departmental and institutional reputations (Hudson and Laband, 2013).

The goal of this study is to apply the new index known as the HY-index, which evaluates the quality and quantity of the publications from any of the sources mentioned above. The major goal of this new index is to solve the flaws of other indices, such as

the well-known h-index. Thus, in this work, the HY-index will be used and compared to the h-index for the top fifty authors at Umm Al-Qura University (UQU) according to the Google Scholar database. Comparisons will be made to the data and ranked based on the HY-index and h-index to determine whether the index is better and more accurately relevant to quantifying the efficiency of authors' publications.

2. The h-index

The h-index is an author-level indicator that assesses both the productivity and citation effect of publications and is originally used by an individual scientist or researcher. The h-index corresponds with evident success markers such as Nobel Prizes, research scholarships, and employment at prestigious universities (Bornmann and Daniel, 2007). The scientist's most frequently referenced articles and the number of times their work has been mentioned in other publications form the basis of the index. More recently, the index has been used to measure the output and influence of an academic publication as well as a group of scientists, such as a department, university, or nation (Jones et al., 2011). The index, sometimes known as the Hirsch index or Hirsch number, was proposed in 2005 by theoretical physicist Jorge E. Hirsch of the University of California, San Diego (Hirsch, 2005).

The h-index refers to the highest value of h for which a certain author or journal has produced at least h publications, each of which has received at least h citations (McDonald, 2005). Fig. 1 shows how the h-index can be calculated. In Fig. 1, an author has been assumed to have at least 10 publications, each of which has received at least 10 citations, so the h-index of this author is 10.

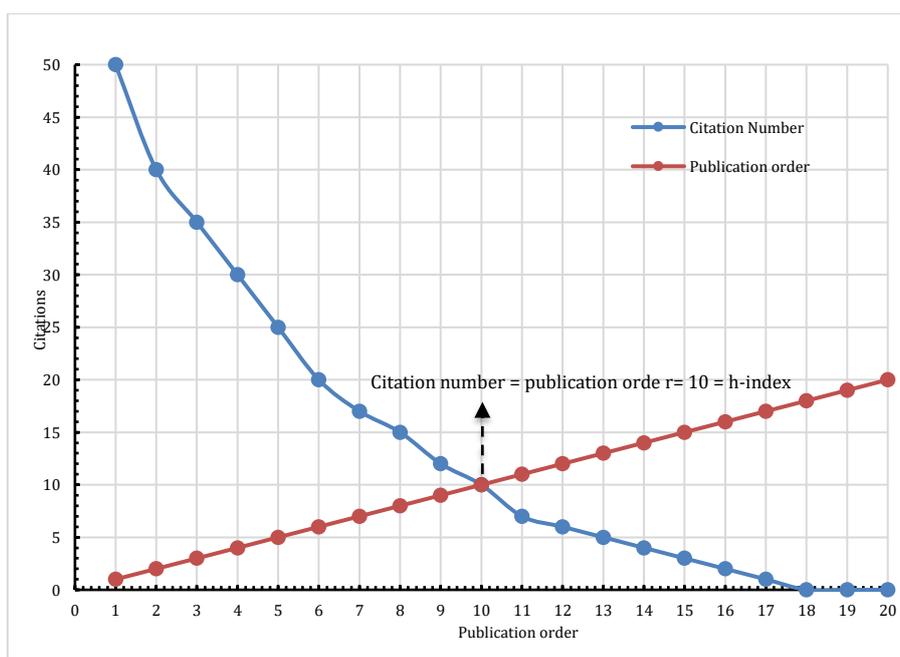


Fig. 1: The h-index definition of an author with h-index=10 as an example

3. Disadvantages of h-index

The disadvantage of the h-index is the independence from the total number of citations, total number of publications, and highest cited publications. On the other hand, the h-index might not affect the increase in the total number of citations or the total number of publications. Therefore, the h-index often fails to compare the publications of authors in terms of quality or the impact of their research (Youssef and El-Bary, 2021).

4. HY-index

Youssef and El-Bary (2021) constructed a different indicator which is called HY-index, and they established the concepts of HY-index based on the following:

1. The quantity of the author's total publications is a crucial criterion for author quality.
2. The quantity of citations is a crucial sign of the author's publication's impact.
3. The publications with a lot of citations must have a significant impact on the author's quality index.
4. A publication with no citations at all must nonetheless have an impact on the author's quality index.
5. The index must become more valuable as the total number of publications or citations rises.

Youssef and El-Bary (2021) assumed an author has a total number of publications "n" (n > 0) and by arranging the publications in descending order according to the number of citations. Then, they defined the number of citations of each publication as "C_i" with the order "i" (1 ≤ i ≤ n). Hence, the total number of citations of the author is:

$$N = \sum_{i=1}^n C_i \tag{1}$$

For each publication, we determine the following parameter to optimize the impact of the citation count and its order:

$$M_i = \frac{C_i}{i}, i = 1, 2, 3, \dots, n \tag{2}$$

Obtain the summation of "M_i" for all the publications as follows:

$$M = \sum_{i=1}^n M_i \tag{3}$$

Finally, the HY-index takes the form (Youssef and El-Bary, 2021):

$$HY - index = \log_2(n \times N \times M) \tag{4}$$

where, (n × N × M) ≥ 1.

Youssef and El-Bary (2021) concluded that the HY-index is a brand-new formula that evaluates the authors' and publications' quality, and authors, institutes, departments, and universities can easily apply for the HY-index. Moreover, the highly cited

publication, total number of publications, and total number of citations affect the HY-index. Finally, the HY-index is extremely sensitive and is impacted by any modifications to the previously mentioned parameters, and it eliminates the drawbacks of the h-index and other indices (Youssef and El-Bary, 2021).

5. Applying the HY-index with comparison to the h-index: Case study Umm Al-Qura University

Now, the HY-index will be applied and compared with the h-index for the top fifty authors at Umm Al-Qura University according to the Google Scholar database on 26 January-2 February 2023, as in Table 1, where Eq. 4 has been applied for the fifty authors as shown in Table 1. According to the data in Table 1, the authors have been ranked according to the number of citations, number of publications, h-index, and HY-index as in Table 2. In Fig. 2, we present the HY-index rank compared with the h-index rank based on the citation rank for the fifty authors as in Table 2. By plotting and getting the linear trends of the three types of studied data, we obtain the linear equations of trends for the citations rank, HY-index rank, and h-index rank, respectively, as follows:

- The linear trend equation of the citations rank
$$y = x + 1 \tag{5}$$

- The linear trend equation of the HY-index rank
$$y = 0.8966x + 2.6376 \tag{6}$$

- The linear trend equation of the h-index rank
$$y = 0.7548x + 5.8922 \tag{7}$$

Now, if we take the coefficient of the x-variable in the above linear equations as the slope (gradient) of the trend lines, we have the following order:

$$Slope(h - indexrank) < Slope(HY - indexrank) < Slope(citationsrank) \tag{8}$$

Therefore, the linear trend equation of the HY-index rank is closer to the linear trend equation of the citation rank than the linear trend equation of the h-index rank. We know that R² it is a statistical measurement that explains what extent to which the variance of one variable explains the variance of the second variable. The values R² for the three types of studied data in Fig. 2 take the following order:

$$R^2(h - indexrank) < R^2(HY - indexrank) < R^2(citationsrank) \tag{9}$$

So, the value R² of the HY-index rank is closer to the value R² of the citation rank than the value R² of the h-index rank. In Fig. 3, we present the HY-index rank compared with the h-index rank based on the publications rank for the fifty authors as in Table 2.

Table 1: Google Scholar database for the top fifty authors at Umm Al-Qura University

Author	Number of citations	Number of publications	h-index	HY-index
Mohamed Fawzy Ramadan Hassani	11100	410	55	32.1164
Saleh Abdel-Mgeed Ahmed	7922	1070	38	32.1869
Adnan Gutub	4967	164	39	29.0405
Mubashir A. Khan	3883	384	27	29.5891
Hamdy M. Youssef	3859	161	35	28.7764
Emad Felemban	3385	118	22	28.9066
Nashwa M. El-Metwaly	3026	243	29	27.6471
Eram Sharmin	2900	93	27	27.4296
Grace Lindsay	2863	111	27	27.1926
Rami Nassir	2707	113	23	27.5770
Abd El Rahman S. Khder	2702	55	20	26.9754
Ahmad Mohammad Ashshi	2626	77	22	27.6213
Ammar Bader	2518	109	30	26.8340
Muhammad Arif	2403	142	25	26.9771
Hatem Alamri	2352	85	23	26.4584
Iqbal A. Khan	2315	110	27	26.4602
Faisal Al-Allaf	2274	98	21	26.8073
A. Abdullah	2244	703	18	28.7565
Thamer Alomayri	2165	106	25	29.6830
Muhammad Rashid	2095	132	27	26.3020
Mahmoud Zaki El-Readi	2083	71	25	25.7511
Mohamed Awad	1996	109	25	26.0452
Mutasim Mohamed Khalafalla	1924	112	24	26.2135
Adel Assiri	1838	68	22	25.4617
Yousef Alotaibi	1807	73	24	25.1787
Mohamed Abdelsabour Fahmy	1749	94	26	24.9097
Mohammed AS Abourehab	1700	200	20	26.8116
Alaa E. Abdel-Hakim M. Aly	1681	62	12	26.3032
Bassem Refaat	1675	94	22	25.5156
Ismail Althagafi	1670	140	20	26.3195
Waleed Alasmari	1565	77	19	25.5643
Agha Zeeshan Mirza	1535	70	18	25.5684
Gamal E. H. Osman	1509	94	20	25.4572
Saad Alghamdi	1477	163	17	26.0239
Anas Basalamah	1431	82	21	24.6560
Radia Fadlilmoula	1427	48	21	24.3128
Adel Madani	1408	67	19	24.9759
Hussein Abulreesh	1404	84	21	24.7087
M. Shaheer Malik	1378	61	23	24.6772
Abdul Haseeb	1325	272	19	25.4260
Turki Ali Alghamdi	1284	60	21	24.1758
Hasan Assaedi	1282	48	16	24.3822
Mohammad Athar	1281	48	12	25.2803
Mohammad S. Alsoufi	1260	116	20	24.9415
Ibrahim Abdel Aziz Ibrahim	1226	79	20	24.5348
Fahad Alzahrani	1195	92	19	24.9026
Mohammad Shahid Iqbal	1168	121	17	25.1999
Mohammed A. S. Abourehab	1144	193	17	24.9346
Atif H. Asghar	1128	74	21	23.8810
Saeed M. Alghamdi	1115	58	10	25.0349

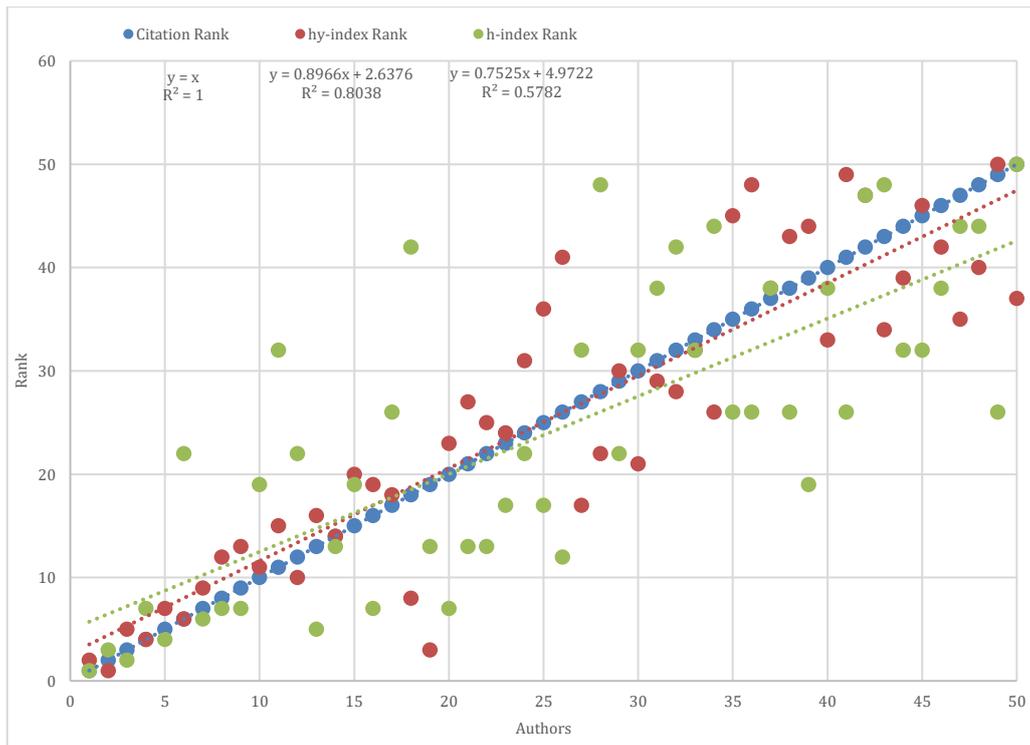


Fig. 2: The HY-index rank compared with the h-index rank based on the citation rank

Table 2: The rank of the top fifty authors at Umm Al-Qura University

Author	Publications rank	Citations rank	h-index rank	HY-index rank
Saleh Abdel-Mgeed Ahmed	1	2	3	1
A. Abdullah	2	18	42	8
Mohamed Fawzy Ramadan Hassanien	3	1	1	2
Mubashir A. Khan	4	4	7	4
Abdul Haseeb	5	40	38	33
Nashwa M. El-Metwaly	6	7	6	9
Mohammed A. S. Abourehab	7	27	32	17
Mohammed A. S. Abourehab	8	48	44	40
Adnan Gutub	9	3	2	5
Saad Alghamdi	10	34	44	26
Hamdy M. Youssef	11	5	4	7
Muhammad Arif	12	14	13	14
Ismail Althagafi	13	30	32	21
Muhammad Rashid	14	20	7	23
Mohammad Shahid Iqbal	15	47	44	35
Emad Felemban	16	6	22	6
Mohammad S. Alsoufi	17	44	32	39
Rami Nassir	18	10	19	11
Mutasim Mohamed Khalafalla	19	23	17	24
Grace Lindsay	20	9	7	13
Iqbal A. Khan	21	16	7	19
Ammar Bader	22	13	5	16
Mohamed Awad	22	22	13	25
Thamer Alomayri	24	19	13	3
Faisal Al-Allaf	25	17	26	18
Mohamed Abdelsabour Fahmy	26	26	12	41
Bassem Refaat	26	29	22	30
Gamal E. H. Osman	26	33	32	32
Eram Sharmin	29	8	7	12
Fahad Alzahrani	30	46	38	42
Hatem Alamri	31	15	19	20
Hussein Abulreesh	32	38	26	43
Anas Basalamah	33	35	26	45
Ibrahim Abdel Aziz Ibrahim	34	45	32	46
Ahmad Mohammad Ashshi	35	12	22	10
Waleed Alasmery	35	31	38	29
Atif H. Asghar	37	49	26	50
Youseef Alotaibi	38	25	17	36
Mahmoud Zaki El-Readi	39	21	13	27
Agha Zeeshan Mirza	40	32	42	28
Adel Assiri	41	24	22	31
Adel Madani	42	37	38	38
Alaa E. Abdel-Hakim M. Aly	43	28	48	22
M. Shaheer Malik	44	39	19	44
Turki Ali Alghamdi	45	41	26	49
Saeed M. Alghamdi	46	50	50	37
Abd El Rahman S. Khder	47	11	32	15
Radia Fadlelmoula	48	36	26	48
Hasan Assaedi	48	42	47	47
Mohammad Athar	48	43	48	34

By plotting and getting the linear trends of the three types of studied data, we obtain the linear equations of trends for the publications rank, HY-index rank, and h-index rank, respectively, as follows:

- The linear trend equation of the publications rank

$$y = 0.0991x + 0.0531 \tag{10}$$

- The linear trend equation of the HY-index rank

$$y = 0.6006x + 10.185 \tag{11}$$

- The linear trend equation of the h-index rank

$$y = 0.3779x + 14.523 \tag{12}$$

The values of slope (gradient) of the above trend lines have the following order:

$$Slope(h - indexrank) < Slope(HY - indexrank) < Slope(publicationsrank) \tag{13}$$

Thus, the linear trend equation of the HY-index rank is closer to the linear trend equation of the

publications rank than the linear trend equation of the h-index rank. So, the HY-index rank gives accurate enhancement to the quality of the authors based on the publication rank.

The values R^2 for the three types of studied data in Fig. 2 take the following order:

$$R^2(h - indexrank) < R^2(HY - indexrank) < R^2(publicationsrank) \tag{14}$$

Hence, the value R^2 of the HY-index rank is closer to the value R^2 of the publications rank than the value R^2 of the h-index rank.

6. Conclusion

This work focused on using the HY-index, a novel index that may evaluate the quality of articles. The top fifty researchers from Umm Al-Qura University according to the Google Scholar database have been sued. The HY-index and h-index are compared with the findings to determine whether the indicator is more useful for assessing the productivity of researchers. According to the results in Figs. 2 and 3, the HY-index rank gives accurate enhancement to

measure the quality of the authors based on the citations rank or publications rank. In other meaning, the HY-index gives a fair enough

measurement of the quality of the authors than the h-index.

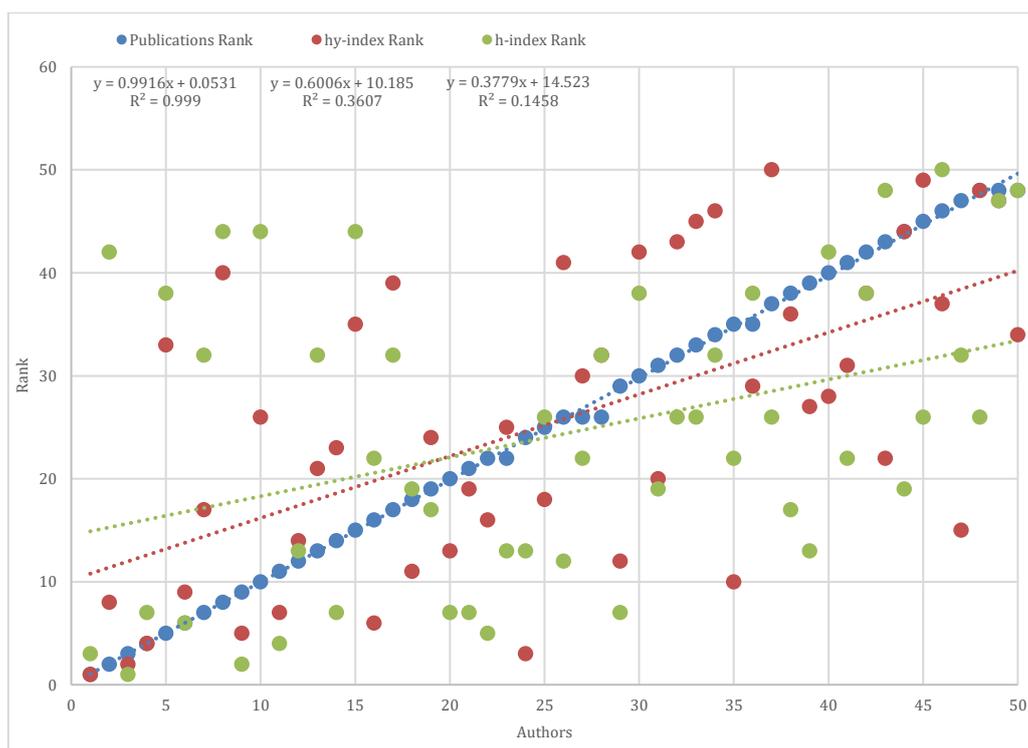


Fig. 3: The HY-index rank compared with the h-index rank based on the publications rank

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

- Alzahrani MS (2013). Seat assignment problem optimization. *International Journal of Computer and Information Engineering*, 7(5): 628-631.
- Bornmann L, Daniel HD (2007). What do we know about the h index? *Journal of the American Society for Information Science and Technology*, 58(9): 1381-1385. <https://doi.org/10.1002/asi.20609>
- Garfield E (1955). Citation indexes for science: A new dimension in documentation through association of ideas. *Science*, 122(3159): 108-111. <https://doi.org/10.1126/science.122.3159.108> **PMid:14385826**
- Hirsch JE (2005). An index to quantify an individual's scientific research output. *Proceedings of the National Academy of Sciences*, 102(46): 16569-16572. <https://doi.org/10.1073/pnas.0507655102> **PMid:16275915 PMCid:PMC1283832**
- Hirsch JE (2007). Does the h index have predictive power? *Proceedings of the National Academy of Sciences*, 104(49): 19193-19198. <https://doi.org/10.1073/pnas.0707962104> **PMid:18040045 PMCid:PMC2148266**
- Hirsch JE and Bucla-Casal G (2014). The meaning of the h index. *International Journal of Clinical and Health Psychology*, 14(2): 161-164. [https://doi.org/10.1016/S1697-2600\(14\)70050-X](https://doi.org/10.1016/S1697-2600(14)70050-X)
- Hudson J, Laband DN (2013). Using and interpreting journal rankings: Introduction. *The Economic Journal*, 123(570): F199-F201. <https://doi.org/10.1111/eoj.12066>
- Jin B, Liang L, Rousseau R, and Egghe L (2007). The R-and AR-indices: Complementing the h-index. *Chinese Science Bulletin*, 52(6): 855-863. <https://doi.org/10.1007/s11434-007-0145-9>
- Jones T, Huggett S, and Kamalski J (2011). Finding a way through the scientific literature: Indexes and measures. *World Neurosurgery*, 76(1-2): 36-38. <https://doi.org/10.1016/j.wneu.2011.01.015> **PMid:21839937**
- Kulasegarah J and Fenton JE (2010). Comparison of the h index with standard bibliometric indicators to rank influential otolaryngologists in Europe and North America. *European Archives of Oto-Rhino-Laryngology*, 267: 455-458. <https://doi.org/10.1007/s00405-009-1009-5> **PMid:19551398**
- Larsen P and Von Ins M (2010). The rate of growth in scientific publication and the decline in coverage provided by Science Citation Index. *Scientometrics*, 84(3): 575-603. <https://doi.org/10.1007/s11192-010-0202-z> **PMid:20700371 PMCid:PMC2909426**
- Maier-Leibnitz H (1989). The measurement of quality and reputation in the world of learning. *Minerva*, 27(4): 483-504. <https://doi.org/10.1007/BF01096541>
- McDonald K (2005). Physicist proposes new way to rank scientific output. *PhysOrg*, London, UK.
- Mingers J, Macri F, and Petrovici D (2012). Using the h-index to measure the quality of journals in the field of business and management. *Information Processing and Management*, 48(2): 234-241. <https://doi.org/10.1016/j.ipm.2011.03.009>
- Redner S (2010). On the meaning of the h-index. *Journal of Statistical Mechanics: Theory and Experiment*, 3: L03005. <https://doi.org/10.1088/1742-5468/2010/03/L03005>

Ren J and Taylor RN (2007). Automatic and versatile publications ranking for research institutions and scholars. *Communications of the ACM*, 50(6): 81-85.
<https://doi.org/10.1145/1247001.1247010>

Sidiropoulos A, Katsaros D, and Manolopoulos Y (2007). Generalized Hirsch h-index for disclosing latent facts in citation networks. *Scientometrics*, 72: 253-280.
<https://doi.org/10.1007/s11192-007-1722-z>

Waltman L and Van Eck NJ (2012). The inconsistency of the h-index. *Journal of the American Society for Information Science and Technology*, 63(2): 406-415.
<https://doi.org/10.1002/asi.21678>

Youssef HM and El-Bary AA (2021). HY-index: A new science-meter index. *International Journal of Advanced and Applied Sciences*, 8: 23-28.
<https://doi.org/10.21833/ijaas.2021.04.004>