# Is it time to use the h2-index for scientific evaluation?

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**Abstract**

This article discusses current scientific evaluation, and proposes that it is time to use the h2-index ["Hirsch-Hu" (H-H)-index], a corrected version of the h-index adding the number of first and exclusive or single author papers as a comprehensive indicator for scientific evaluation, so as to promote more innovative scientific outputs.

Mini Review

**Is it time to use the $h^2$-index for scientific evaluation?**

Running title: "Hirsch-Hu (H-H)"-index or $H^2$-index

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**Abstract**

This article discusses current scientific evaluation, and proposes that it is time to use the $h^2$-index ["Hirsch-Hu" (H-H)-index], a corrected version of the h-index adding the number of first and exclusive or single author papers as a comprehensive indicator for scientific evaluation, so as to promote more innovative scientific outputs.

*Keywords:* first author, h-index, innovation, publishing, scientific evaluation

**Highlights**

- Current scientific evaluation mainly uses the h-index.

- As a comprehensive scientific evaluation, the number of first author (FA) and exclusive or single (E/S) author (E/SA) should be covered.
- The $h^2$-index (H-H index) based on the surnames of two scholars "Hirsch-Hu" is a corrected version of the h-index (also known as the Hc-index).
- It's time to use the $h^2$-index which covers the number of first and exclusive or single author (FA & E/SA) papers for scientific evaluation.
- As a comprehensive indicator of scientific evaluation, the $h^2$-index may promote more innovative scientific outputs.

**Abbreviations**

E/SA: exclusive or single (E/S) author; FA: first author; $h^2$-index: "Hirsch-Hu" (H-H) index; S&R: scholars & researchers.

Citation as a tool for scientific evaluation was first proposed by Eugene Garfield in 1950s.[1] Currently, citation-based data are still used for scientific evaluation, and scientific contributions to research are mainly measured by a variety of indicators.[2] For example, some quantitative parameters such as the number of publications, the impact factor of journals, the total number of citations, and/or the h-index,[3] are used as metrics for the evaluation of the scientific performance of scholars and researchers (S&R) and institutions, and the h-index have the widespread application since it was proposed in 2005.

However, journalistic papers published in high impact scientific journals (Nature, Science, PNAS, Cell, BMJ, Lancet, JAMA or New England Journal of Medicine) can be very influential, especially in hot fields,[4] even if those are both non-research papers and related authors. Herein, scientific platforms are important factors for high impact of S&R. Due to the fact that the results of large-scale clinical trials published in high impact journals can provide important reference and basis for relevant clinical practices, in fact, both the first author and corresponding author can receive a significant increase in scientific influence after the paper is published. For example, a series of studies on global life expectancy and risk factors.[5-7] Therefore, not only innovations but also scientific platforms are important to the professional development of S&R.

According to recognized standards in the academic community, the h-index should be greater than their years of work experience for excellent S&R. Usually, the h-index is required to be above 25 in biomedical fields, while professors need to be above 18. However, this measure is not always objective or realistic in this field. In order to more accurately evaluate the scientific level and influence of S&R, an additional indicator should be considered, that is the number of first author (FA) and exclusive or single (E/S) author (E/SA) papers of any types,[8] represented by the HFA-index. For example, if S&R's h-index is 10 and they have published more than 50 FA (including E/SA) papers, their HFA-index score would be at least 60.

Currently, the h-index of S&R is widely used for scientific evaluation in scientific circles internationally. Actually, if the S&R supervise more students, the number of corresponding author papers will definitely increase. Since whoever wants to complete the studies and obtain master's and/or doctoral degrees, they must publish at least two or three papers, it is important for their supervisors to be included as the corresponding authors. This will result in higher the h-index scores for the S&R-sponsored graduates, postgraduates, and fellows. Obviously, although the h-index is frequently used to measure the performance of S&R, there are indeed some limitations.

In fact, innovation should be the crucial contribution of a published work to the development of new knowledge and advancement of science,[9] and S&R should be encouraged to make a great steps at innovations.[10] Obviously, scientific publications focused on innovations by the FA (including E/SA) are a vital indicator, since innovations may forecast and embody the levels and abilities of S&R.[11] Herein, instead of the h-index, novel indicators should be encouraged.[12] As an innovative indicator for the real impact of S&R, the HFA-index covering the number of publications of any types from the FA (including E/SA), should be a new, vital, and better indicator for scientific evaluation of S&R.

Therefore, the HFA-index covering the number of FA (including E/SA) papers presents a more compre-

hensive scientific evaluation. These papers not only demonstrate the S&R's writing abilities and scientific contributions, but also their independent and crucial innovations. In fact, the HFA-index is a more vital indicator for scientific evaluation. While the number of FA (including E/SA) papers may not always be large, the academic influence of S&R increases with each additional paper published. This is because the teams of corresponding authors are continuously outputting new research, thus increasing their influence over time.

**Table 1. Several expressions of the $h^2$-index.**

| No. | $H^2$-index or $h^2$-index |
|---|---|
| 1 2 3 | H-index + the number of FA (including E/SA) papers = H(FA)-index = $H^2$-index or $h^2$-index "Hirsch-Hu"-index = |

Notes: FA, first author; E/SA, exclusive or single (E/S) author.

It is important to note that the high output of FA (including E/SA) papers is a reflection of the true scientific level of S&R. However, currently non-academic physicians or medical doctors had a poor capacity to publish and a low productivity due to limited time or little interest in undertaking research.[13] Therefore, future scientific evaluations should not only focus on the quality of papers, but also on the number of FA (including E/SA) papers, in order to encourage S&R to actively output more scientific achievements. In this regard, the HFA-index is a better and more comprehensive indicator for scientific evaluation of S&R.

Generally, according to the surnames of two scholars (Hirsch & Hu), the HFA-index, can be used as a reference for the h-index, which can also be referred to as the "Hirsch-Hu"-index (H-H-index) or $h^2$-index (Table 1), or corrected h-index (the Hc-index). It is important to note that while the h-index may benefit the corresponding authors, the $h^2$-index is definitely beneficial for the FA (including E/SA). It is an emerging, encouraging, and excellent indicator for more accurate scientific evaluation, as it encourages all S&R to output more scientific works and innovations. In conclusion, it is time to use the $h^2$-index, which includes the number of FA (including E/SA) papers, as a crucial indicator for scientific evaluation of S&R, in order to encourage more active scientific outputs and innovations.

In fact, the first author is usually a vital inventor of biotechnology (e.g., single-particle profiler)[14] in the biomedical research. Of course, a crucial hallmark of innovation in the biopharmaceutical industry (e.g., drug candidates discovered and approvals)[15] may indicate the performance and the magnitude of impact of S&R. And a comprehensive citation map of biomedical patents is a good indicator[16] for evaluating productivity, diversity and translational impact of S&R. All in all, the more innovative medical products there are, the more demands there are in regulatory sciences, particularly in precision health,[17] thus, the scientific community must help public policy-makers to support both innovation and regulations.[18]

As we know, innovative studies on polygenic risk scores (PRSs)[19,20] benefit precision cardiovascular health in global populations. Moreover, innovations in genomic medicine,[21] such as genetic screening, rare disease diagnosis and molecular therapy, may open new applications for genomics in clinical practice, for example, the genetic architecture of coronary artery calcification[22] and specific therapeutics and preventions of spontaneous coronary artery dissection.[23] In fact, innovative strategies are also vital for neuroscience research. For example, noninvasive stimulation of deep brain structures may enhance learning skills,[24]and a combining stimulation of Climbing fiber and Purkinje cells provides essential instructive signals for associative cerebellar learning.[25]

All in all, these innovative studies mainly from the first authors will improve global health. It's time to use the $h^2$-index, which covering the number of FA (including E/SA) papers for scientific evaluation, so as to promote and incentivize more innovative scientific achievements.

**Author Contributors**

CH designed the study, collected and analyzed all data, wrote the draft of this article and revised the final manuscript. The author critically reviewed and approved the manuscript.

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