

# Scientific metrics

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# Agenda

## 1 Introduction

- Introduction to Research Impact
- Types of Scientific Metrics
- Bibliographic Databases

## 2 Altmetrics

- Altmetric Attention Score

## 3 Bibliometrics

- Impact Factor
- CiteScore
- SNIP
- SJR

## 4 Researcher's metrics

- h-index
- g-index
- c-index
- l-index

**The original purpose of scientific publishing** was to enable the global sharing of scientific results, ideas, and discussions within the academic society for more effective scientific achievements.

**Influence of a publication is used for**

- Allocation of funding resources
- Industrial and economic growth priorities
- Education policies
- The hiring of personnel academics

# Types of Scientific Metrics

**Journal-level metrics** are used to determine the impact a journal has on the scientific community

- Impact Factor

**Article-level metrics** include any measures of the influence of a single publication.

- Citation Counts

**Author-level metrics** assess the impact an author makes on the scientific community or field of the study.

- H-Index

**Alternative metrics** assess other measures of use and influence, such as the number of times a publication is read, downloaded, saved, mentioned, or cited in popular online sources.

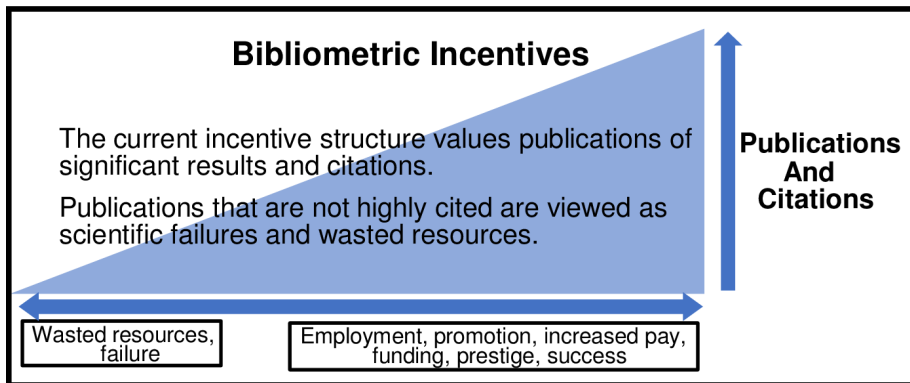


Figure 1: Bibliometric incentives model<sup>1</sup>

<sup>1</sup><https://doi.org/10.1371/journal.pone.0195321.g001>

# Bibliographic Databases

Scopus®



## What is a bibliographic database?

A bibliographic database is a repository of bibliographic or publication records.

Citations in science serve as linkages between similar research items, and lead to related scientific literature

## Frequently used biomedical databases include

- Web of Science
- Scopus
- Google Scholar

# Bibliographic Databases: advantages and disadvantages

## Pros

- ✓ Easy access to publication metadata and citation metrics

## Cons



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- ✗ Most databases only include published articles
- ✗ Bias towards the English language
- ✗ Limited to specific fields

# Altmetric Attention Score

## What is Altmetric Attention Score?

The Altmetric Attention Score is an automatically calculated, weighted count of all of the attention a research output has received

It is calculated using data collected from research articles such as mentions on social media, news outlets, blogs, patents, etc.

### The Colors of the Donut

- |                               |                             |
|-------------------------------|-----------------------------|
| Policy documents              | Google+                     |
| News                          | LinkedIn                    |
| Blogs                         | Reddit                      |
| Twitter                       | Research highlight platform |
| Post-publication peer-reviews | Q&A (Stack Overflow)        |
| Facebook                      | Youtube                     |
| Sina Weibo                    | Pinterest                   |
| Syllabi                       | Patents                     |
| Wikipedia                     |                             |



Figure 3: The colors of different sources of attention

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- ✗ Not an indicator of quality
- ✗ Not everything gets shared

# Bibliography metrics

# IF (Impact Factor)

## What is Impact Factor?

**Impact Factor**[Garfield, 1972] — a per-year metric based on *Web of Science* database which reflect the mean number of citations to the papers published within prior 2 year.

The Impact Factor is calculated by the following formula:

$$IF(y) = \frac{C(y)}{D(y-1) + D(y-2)}$$

where

- $C(y)$  – number of citations to the articles published in  $[y-2, y-1]$  years
- $D(y)$  – number of published articles in year  $y$

# IF: advantages and disadvantages

## Pros

- ✓ Easily calculated and interpreted

## Cons

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✗ Limited availability



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- ✗ Unstable
- ✗ Doesn't allow to compare titles from different fields

## What is CiteScore?

**CiteScore**[Zijlstra and McCullough, 2016] — a per-year metric provided by *Scopus* which measure rate between the received citations to **all peer-reviewed documents** of a title published within 4 years.

The CiteScore is calculated by the following formula:

$$\text{CiteScore}(y) = \frac{CD_{y-3}(y)}{D(y) + D(y-1) + D(y-2) + D(y-3)}$$

where

- $CD_x(y)$  – the number of citations in year range from  $x$  to  $y$  to all documents published within those years.
- $D(y)$  – the number of all **peer-reviewed** documents published in year  $y$

# CiteScore 2016 vs CiteScore 2019

## CiteScore 2019-2021 vs CiteScore 2016-2018

Previously CiteScore has been calculated within 3 year range, and count citation received only in year  $y$ .

$$\text{CiteScore} = \frac{\sum \text{orange}}{\sum \text{blue}}$$

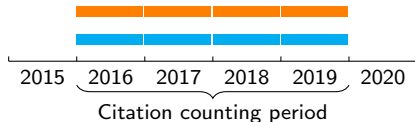


Figure 4: CiteScore 2019

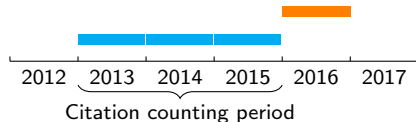


Figure 5: CiteScore 2016

orange – number of citation received by publications published in citation counting period

blue – number of documents (in CiteScore 2019 only peer-reviewed) published in corresponding year



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# SNIP (Source Normalized Impact per Paper)

## What is SNIP?

**SNIP**[Moed, 2010] measures a journal's contextual citation impact, taking into account subject field with use of, so called, citation potential of the field of science. The SNIP score is calculated based on *Scopus* database.

The SNIP is calculated by the following formula:

$$\text{SNIP}(y) = \frac{RIP(y)}{RDCP(y)}$$

where

- $RIP(y)$  – raw impact per paper in year  $y$  (IPP / CiteScore 2016)
- $RDCP(y)$  – relative database citation potential in a journal's subject field in year  $y$

$$RDCP^j(y) = \frac{DCP^j(y)}{\text{med}_i DCP^i(y)}$$

where DCP – database citation potential in a journal's subject field:

$$DCP^j(y) = \frac{\sum_{p \in CP^j(y)} DCP_p^j(y)}{\#CP^j(y)}$$

where

- $CP^j(y)$  – papers citing the journal  $j$  and **published in journals processed for the database** in the range  $[y - 3, y - 1]$  years
- $DCP_p^j(y)$  – number of references to the papers published in those years from paper  $p \in CP^j(y)$

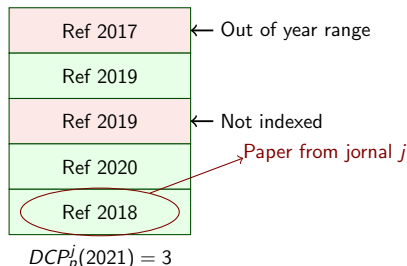


Figure 6: Example of  $DCP_p^j$  calculation

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- ✗ Calculation is more complicated
- ✗ Citation potential tends to be highest for topical journals

## What is SJR?

**SJR**[González-Pereira et al., 2009] is a metric provided by *Scopus* which is based on the number of citations and the prestige of the titles which cite this journal.

### Key points of SJR:

- Based on PageRank[Page et al., 1999] algorithm to calculate the prestige of the journal: citations issued by more important journals will be more valuable than those issued by less important ones
- Self-citation limited to 33% of the total references
- Citation time frame is 3 year

The SJR indicator is computed in two phases:

- 1 Prestige SJR (PSJR) – size- dependent measure that reflects the overall journal prestige
- 2 normalization of this measure to give a size-independent metric

The formula for the SJR metric (2 stage) is the following:

$$SJR_i(y) = c \cdot \frac{PSJR_i(y)}{Art_i(y)}$$

where

- $Art_i(y)$  – number of primary items (articles, reviews, and conference papers) of journal  $i$  published in three previous years  $[y-3, y-1]$ .
- $c$  – common constant to prettify values of SJR

# Prestige SJR

The PSJR calculation is an iterative process which started with **identical amount** of prestige to each journal until the differences between journal prestige in consecutive iterations is under threshold.

$$PSJR_i = \underbrace{\frac{1-d-e}{N}}_{\text{min value}} + \underbrace{e \cdot \frac{Art_i}{\sum_{j=1}^N Art_j}}_{\text{number of papers}} + d \cdot \overbrace{\left[ \sum_{j=1}^N C_{ji} \cdot \frac{PSJR_i}{C_j} \cdot CF + \frac{Art_i}{\sum_{j=1}^N Art_j} \cdot \sum_{k \in DN} PSJR_k \right]}^{\text{number and "importance" of the citations from other journals}}$$

where

- $C_j$  – number of references of journal  $j$
- $C_{ji}$  – references from journal  $j$  to journal  $i$
- $d$  – constant: 0.9
- $N$  – number of journals in the database
- $DN$  – journals that do not cite other journals
- $e$  – constant: 0.0999

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where

- CF(Correction Factor) is introduced that spreads the undistributed prestige over all the journals proportionally to their accumulated prestige

$$CF = \frac{1 - \sum_{k \in DN} PSJR_k}{\sum_{h=1}^N \sum_{l=1}^N C_{lh} \cdot \frac{PSJR_l}{C_l}}$$



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- ✗ Hard to interpret and calculate
- ✗ Still windowed approach

# Author-level metrics

# h-index

## What is the h-index?

The **h-index**[Hirsch, 2005] is a measure used to quantify the cumulative impact and relevance of an individual's scientific research output.

First introduced by Professor Jorge E. Hirsch in 2005.

**h-index** formula:

$$h = \max i \in N : f(i) \geq i$$

where

- $i$  is the published paper
- $f(i)$  is the number of citations for  $i$

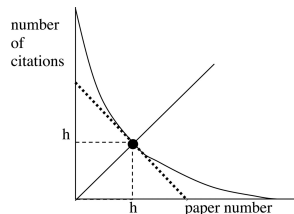


Figure 7: Graphical representation of the h-index

## Example

4 publications: A,B,C,D      citations per paper: 7,5,4,3  
h-index=3

### Pros

- ✓ It avoids previous indexes' problems

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- ✗ Insensitive to highly cited publications
- ✗ Exposed to manipulation
- ✗ Time-dependent

# h-index variations

## m quotient

It allows comparisons between scientists with different career lengths.

**m quotient** formula:

$$m = \frac{h}{n}$$

where

- $n$  the number of years of academic activity

## normalized h-index

It reduces the discipline bias.

**normalized h-index** formula:

$$|h| = \frac{h}{d}$$

where

- $d$  the average number of academics in the field

## individual h-index or hl

It reduces the effects of co-authorship.

**hl** formula:

$$hl = \frac{h}{\sum_{i=1}^n a_i}$$

where

- $h$  – the h-index
- $n$  – the number of papers and
- $a_i$  – average number of authors

## What is the g-index?

The **g-index**[Egghe, 2006] is a modified version of the h-index

First introduced by Leo Egghe in 2006.

## How is it calculated?

Decreasingly order the papers based on the number of citations for each. The index is the largest number s.t. the top  $g$  articles received together at least  $g^2$  citations.

# g-index

**g-index** formula:

$$g^2 = \sum_{i=1}^g c_i$$

where

- $c_i$  – number of citations for each  $i$  paper

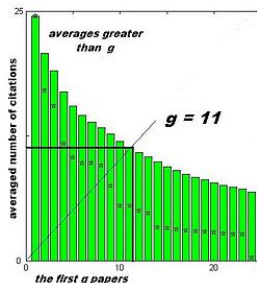


Figure 8: Graphical representation of the g-index

## Example

Top publications: 5  
Citations: 25  
g-index=5

$g$  is always greater or equal to  $h$ .

## Frequently used biomedical databases include

- Web of Science
- Scopus
- Google Scholar



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- ✗ Saturation value
- ✗ It lacks discriminatory power
- ✗ It only favours academics with many publications

## What are c-indexes?

**c-indexes**[Post et al., 2018] are the result of the augmentation of the h-index based on the citation order.

Introduced in 2018 in the magazine Cureus.

**c-indexes** formulas:

$$c_p = h + i_p \quad c_s = h + i_s \quad c_o = h + i_p + i_s$$

The augmentations are given by the following formulas:

$$i_p = n_f + 0.5n_s$$

$$i_s = n_l + 0.5n_s$$

## Pros

- ✓ All the advantages of the h-index

## Cons

## Pros

- ✓ All the advantages of the h-index
- ✓ More accurate

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- ✓ All the advantages of the h-index
- ✓ More accurate
- ✓ Takes citation order into account

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- ✗ Field of research is ignored

## What is the I-index?

The **I-index**[Lando and Bertoli-Barsotti, 2014] is a bibliometric based measure derived from the h-index which enhances highly cited papers.

Introduced in 2014.

**I-index** formula:

$$L(x) = \sum_{i=1}^n \ln \left( 1 + \frac{x_i}{x_i^*} \right) x_i^*$$

After normalization:

$$I(x) = \sqrt{\frac{L(x)}{\ln 2}}$$

where

- $x$  – real citation distribution
- $x^*$  – ideal citation distribution

## Pros

- ✓ All the advantages of the h-index

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## Pros

- ✓ All the advantages of the h-index
- ✓ It rewards papers with many citations

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## Pros

- ✓ All the advantages of the h-index
- ✓ It rewards papers with many citations
- ✓ Regular and robust

## Cons

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- ✗ Complex calculation

# CONCLUSION

- Simple metrics like number of publications, number of citations or impact factor are often inappropriate to quantify the impact of a journal or an academic.
- More complex metrics must be employed.
- Deciding which metric to use depends on its specific properties and on the academic context.

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