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The use and misuse of the "impact factor" as a parameter for evaluation of scientific publication quality: a proposal to rationalize its application*

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Abstract

We present a critical analysis of the generalized use of the "impact factor". By means of the Kruskal-Wallis test, it was shown that it is not possible to compare distinct disciplines using the "impact factor" without adjustments. After assigning the median journal the value of one (1.000), the "impact factor" value for each journal was calculated by the rule of three. The adjusted values were homogeneous, thus permitting comparison among distinct disciplines.

Key words
- Impact factor
- Multidisciplinary adjustment
- Citation index
- Bibliometric evaluation

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Introduction

The use of the "impact factor" Journal Citation Reports (JCR) from the Science Citation Index (SCI) published by the Institute of Scientific Information (ISI) (1) as an indicator of scientific journal excellence is becoming increasingly generalized. In Brazil, this index is being used as a parameter in judgments carried out by financing agencies supporting scientific research and evaluating graduate programs and by educational and research institutions when selecting their scientific personnel (2).

Recently, some aspects related to the indiscriminate use of the "impact factor" have been discussed elsewhere, such as its use without the evaluation of its reach, as well as its limitations for comparing scientific production among the various areas of knowledge (3,4). As a practical result of the suggestions presented in the cited papers, a well-known international journal introduced changes in its editorial policy for improving its "impact factor" (5).

As the need for further discussions about essential points of the "impact factor" still exists, issues meriting considerations are ad-

*The calculation of the 2001 "impact factor" for a journal is as follows: number of citations in 2001 to papers published in 1999 plus 2000 divided by the number of papers published by the journal in 1999 plus 2000. Thus, if a journal published 150 and 160 papers in 1999 and 2000, respectively, and these papers were cited 151 times in 2001 the journal's 2001 "impact factor" would be 151/310 or 0.487.

dressed in the present article. A new proposal with the objective of establishing a more practical and rational use for this index is presented in order to prevent distortions in judgments where its use is appropriate.

The source publications

The SCI, as per its own definition, is a calendar-year index to scientific literature published by the ISI. The source publications are only the journals processed for the SCI. The first aspect to be considered is the fact that a private commercial enterprise is the most important organ for assessing the quality of scientific production. Only a small number (57) of Latin-American scientific journals are cited by ISI: Brazil (15), Mexico (14), Chile (9), Argentina (7), Venezuela (4), Colombia, Costa-Rica, Cuba, Ecuador, Jamaica, Uruguay and Trinidad-Tobago (1 each), from a universe of nearly 16,000 journals within 160 areas of knowledge published by 46 countries. The second aspect is that there is a large body of scientists and of scientific institutions that do not participate in the process of establishing criteria for judging scientific production. Our suggestion would be to create an organ with this objective, supported by the United Nations, with the participation of agencies financing scientific research and of scientific societies.

Policy of support and encouragement of Brazilian scientific journals

The present tendency, due to the reasons discussed above, is for Brazilian scientists to publish their papers only in journals with higher "impact factor" values. This tendency could lead Brazilian scientific journals to ostracism within a short period of time. It is common knowledge that, in general, scientists send their papers to different international journals and, only after running out of all the possibilities for publication abroad, will send an article to an indexed Brazilian journal. This fact prevents Brazilian journals from reaching the desired excellence level. It is important to consider publications in our journals indexed by SCI or in our journals with possibilities to attain this indexing status. This would be taken into account in judgments carried out by financing agencies and educational/research institutions, acting as a stimulus to scientists to send first hand their qualified articles or at least a proportion of their papers to these journals. For the areas of Biology, Medicine and Public Health, the "impact factor" of SciELO (Scientific Electronic Library on Line), which includes 106 Brazilian scientific journals (about 21% of all Brazilian journals), could be used together with the SCI. SciELO follows criteria similar to those of SCI and uses a continuous evaluation process. The SciELO program is coordinated by the Biblioteca Regional de Medicina (BIREME) and Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP).

Proposal for a more rational use of the "impact factor" as an instrument for intra- and inter-area comparison of scientific knowledge

At present, until the appearance of adequate court(s) to establish criteria for evaluating scientific production, it is worth quoting the recommendations of caution expressed by the authors of the SCI: "Caution!" Caution is advisable in comparing journals, especially journals from different disciplines. The journal literature varies in its importance as a means of disseminating information in different fields. Wide citation may be necessary practice in one field, but a redundancy in another discipline because of other means of dissemination. Citation practices differ from one field to another. The difference may be complicated by a difference in the cited half-life of journal literature in different fields, as well as the size of the

extant citable literature. Rapid obsolescence may characterize one field but not another. Thus, for example, it would be foolish to conclude merely on the basis of citation counts that the journal of the American Chemical Society is a "better" journal than Annals of Mathematics, or to hypothesize, without a great deal of study, which serves its own field "better". To enable the JCR user to analyze more carefully these data within subject groupings, a breakdown of journals by subject categories with "impact factors" and cited half-life indicators is provided in the "Subject Category Listing" (6).

To overcome these limitations, an adjustment is proposed in order to harmonize discrepancies. The adjustment is not an ideal solution, but may prevent distortions, errors or injustices in judgments in which scientific production - evaluated by the "impact factor" - constitutes the principal element in the decision process.

To illustrate, characteristics of the distribution of the "impact factor" of scientific journals from three areas, Parasitology, Microbiology and Immunology, are presented in Table 1. These areas are considered jointly (Biology 3) during the process of evaluation of Graduate Programs conducted by the Coordenação do Aperfeiçoamento de Pessoal de Nível Superior - CAPES (Brazilian Ministry of Education). The analysis of these distributions (Shapiro-Francia H test for normality) has revealed that, with the exception of Parasitology journals, they are not normal. In these situations, if the data are not transformed, the median should be the measure of central tendency (or location) to be used to characterize or compare distributions. The Kruskal-Wallis test for equality of populations showed a highly significant difference (P = 0.0006) between their medians. In other words, these distributions are not comparable. By transforming the value of the median to 1.000, adjusted "impact factors" can be generated by a simple calculation. For example, in the area of Parasitology/Tropical Medicine, the adjusted value for the Parasitology "impact factor" would be:

$$aif = \frac{if \times 1}{m} = \frac{if}{m} = \frac{2.114}{1.047} = 2.019$$

where aif = adjusted "impact factor"; m = median, and if = "impact factor" (for values, see Table 2).

The original (from JCR) and adjusted "impact factor" values can be seen in Tables 2 to 4. Comparison of the distribution of the adjusted values showed that 1) they are not normal (Shapiro-Francia H test for normality) and 2) their medians do not differ significantly (Kruskal-Wallis test, P = 0.772).

Since review journals do not publish original data, we suggest that these journals be

Table 1. Characteristics of the distribution of original and adjusted "impact fator" (from JCR, SCI, ISI).

Characteristics	Parasitology[2] (N = 22)	Microbiology[1,2] (N = 66)	Immunology[1,2] (N = 77)
Original "impact factor"			
IF higher value	2.814	6.881	18.866
IF 90 percentile	2.182	3.688	4.516
IF 75 percentile	1.693	2.701	2.760
Mean	1.295	2.110	2.693
Median	1.047	1.806	2.094
Standard deviation	0.685	1.339	2.740
IF 25 percentile	0.818	1.154	1.483
IF lower value	0.333	0.405	0.359
Skewness	0.602	1.495	4.095
Kurtosis	2.395	5.618	22.483
Adjusted "impact factor"			
IF higher value	2.688	3.810	9.010
IF 90 percentile	2.084	2.042	2.157
IF 75 percentile	1.617	1.496	1.318
Mean	1.237	2.110	1.286
Median	1	1	1
Standard deviation	0.654	1.339	2.741
IF 25 percentile	0.781	0.639	0.708
IF lower value	0.318	0.224	0.171
Skewness	0.602	1.495	4.095
Kurtosis	2.395	5.618	22.483

[1]Significant skewness/kurtosis test for normality. [2]Significant Bartelet's test for equal variances. IF = "impact factor"; N = number of journals.

Table 2. "Impact factors" in decreasing order of periodics in the areas of Parasitology and Tropical Medicine and respective adjusted values.

Parasitology and Tropical Medicine		"Impact factor"	Adjusted value
*	Parasitology Today	6.134	5.859
*	Advances in Parasitology	4.097	3.913
1	International Journal for Parasitology	2.814	2.688
2	Molecular and Biochemical Parasitology	2.397	2.289
3	Parasite Immunology	2.182	2.086
4	American Journal of Tropical Medicine and Hygiene	2.126	2.031
5	Parasitology	2.114	2.019
6	Transactions of the Royal Society of Tropical Medicine and Hygiene	1.693	1.617
7	Journal of Parasitology	1.521	1.453
8	Tropical Medicine and International Health	1.500	1.433
9	Experimental Parasitology	1.434	1.370
10	Veterinary Parasitology	1.401	1.338
	Median	**1.047**	**1.000**
11	Annals of Tropical Medicine and Parasitology	1.049	1.002
12	Acta Tropica	1.045	0.998
13	Parasitology Research	1.025	0.979
14	Journal of Medical Entomology	0.949	0.906
15	Systematic Parasitology	0.919	0.878
16	Parasite-Journal de la Societé Française de Parasitologie	0.853	0.815
17	Acta Protozoologica	0.818	0.781
18	Journal of Helminthology	0.698	0.667
19	Memórias do Instituto Oswaldo Cruz	0.643	0.614
20	Folia Parasitologica	0.557	0.532
21	Journal of Tropical Pediatrics	0.425	0.406
22	Journal of the Helminthological Society of Washington	0.333	0.318

*Review (not considered for median determination).

Table 3. "Impact factors" in decreasing order of periodics in the area of Microbiology and respective adjusted values.

Microbiology		"Impact factor"	Adjusted value
*	Annual Review of Microbiology	11.447	6.338
*	Clinical Microbiology Reviews	10.652	5.898
*	FEMS Microbiology Reviews	9.000	4.983
*	Current Topics in Microbiology and Immunology	3.554	3.272
*	Advances in Microbial Physiology	5.867	3.249
*	Reviews in Medical Virology	5.050	2.796
*	Advances in Virus Research	4.074	2.241
*	Critical Reviews in Microbiology	2.291	1.611
*	Current Microbiology	1.059	0.586
1	AIDS	6.881	3.180
2	Molecular Microbiology	6.398	3.543
3	Journal of Virology	5.622	3.113
4	Antimicrobial Agents and Chemotherapy	4.562	2.526
5	Journal of Bacteriology	3.984	2.206
6	Journal of Clinical Microbiology	3.965	1.900
7	Applied and Environmental Microbiology	3.688	2.042
8	Journal of Acquired Immune Deficiency Syndromes	3.586	1.986
9	International Journal of Systematic Bacteriology	3.558	1.970
10	Journal of Antimicrobial Chemotherapy	3.490	1.932
11	Virology	3.270	1.811

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Table 3 continued

	Microbiology	"Impact factor"	Adjusted value
12	Journal of General Virology	3.248	1.798
13	Microbial Ecology	2.891	1.601
14	Journal of Medical Virology	2.881	1.595
15	FEMS Microbiology Ecology	2.847	1.576
16	Microbiology-SGM	2.846	1.576
17	Journal of Neurovirology	2.701	1.496
18	Protist	2.574	1.425
19	Yeast	2.540	1.406
20	AIDS Research and Human Retroviruses	2.523	1.397
21	Journal of Viral Hepatitis	2.391	1.324
22	Journal of Interferon and Cytokine Research	2.281	1.263
23	Archives of Microbiology	2.156	1.194
24	Diagnostic Microbiology and Infectious Disease	2.086	1.155
25	Antonie Van Leeuwenhoek International Journal of General and Molecular Microbiology	2.066	1.144
26	Microbial Pathogenesis	2.061	1.141
27	Systematic and Applied Microbiology	2.054	1.137
28	Microbes and Infection	1.960	1.085
29	Antiviral Research	1.934	1.071
30	APMIS	1.924	1.065
31	Intervirology	1.871	1.036
32	Journal of Microbiological Methods	1.810	1.002
33	FEMS Microbiology Letters - **Median**	**1.806**	**1.000**
34	Virus Research	1.806	1.000
35	Journal of Virological Methods	1.768	0.979
36	Journal of Medical Microbiology	1.762	0.976
37	Journal of Eukaryotic Microbiology	1.739	0.963
38	Archives of Virology	1.711	0.947
39	Medical Microbiology and Immunology	1.673	0.926
40	Veterinary Microbiology	1.647	0.912
41	International Journal of Food Microbiology	1.579	0.874
42	Research in Microbiology	1.568	0.868
43	FEMS Immunology and Medical Microbiology	1.561	0.864
44	Clinical and Diagnostic Laboratory Immunology	1.483	0.821
45	Antiviral Chemistry and Chemotherapy	1.414	0.783
46	International Journal of Antimicrobial Agents	1.412	0.782
47	European Journal of Clinical Microbiology and Infectious Diseases	1.386	0.767
48	Journal of Antibiotics	1.264	0.700
49	Viral Immunology	1.190	0.659
50	Microbiology and Immunology	1.154	0.639
51	Letters in Applied Microbiology	1.151	0.637
52	Food Microbiology	1.135	0.628
53	Virus Genes	1.086	0.601
54	Oral Microbiology and Immunology	1.081	0.599
55	Canadian Journal of Microbiology	1.071	0.593
56	European Journal of Protistology	0.919	0.509
57	Comparative Immunology Microbiology and Infectious Diseases	0.830	0.460
58	Acta Protozoologica	0.818	0.453
59	Folia Microbiologica	0.776	0.430
60	International Journal of Leprosy and other Mycobacterial Diseases	0.648	0.359
61	Acta Virologica	0.644	0.357
62	Symbiosis	0.634	0.351
63	Zentralblatt für Bakteriologie - International Journal of Medical Microbiology, Virology, Parasitology and Infectious Diseases	0.538	0.299
64	Journal of General and Applied Microbiology	0.512	0.283
65	Journal of Basic Microbiology	0.421	0.233
66	Microbios	0.405	0.224

*Review (not considered for median determination).

Table 4. "Impact factors" in decreasing order of periodics in the area of Immunology and respective adjusted values.

Immunology		"Impact factor"	Adjusted value
*	Annual Review of Immunology	46.233	22.078
*	Advances in Immunology	23.083	11.023
*	Current Opinion in Immunology	13.724	6.554
*	Immunology Today	12.157	5.806
*	Immunological Reviews	07.000	3.343
1	Immunity	18.866	9.010
2	Journal of Experimental Medicine	15.340	7.326
3	Journal of Immunology	07.065	3.374
4	AIDS	06.881	3.286
5	Critical Reviews in Immunology	06.070	2.899
6	Journal of Allergy and Clinical Immunology	05.506	2.629
7	European Journal of Immunology	04.990	2.383
8	Journal of Leukocyte Biology	04.516	2.157
9	Infection and Immunity	04.212	2.011
10	International Immunology	03.611	1.718
11	Journal of Acquired Immune Deficiency Syndromes	03.586	1.712
12	Current Topics in Microbiology and Immunology	03.554	1.697
13	Clinical Infectious Diseases	03.545	1.693
14	Journal of Clinical Immunology	03.442	1.644
15	Journal of Neuroimmunology	03.342	1.596
16	Vaccine	02.943	1.405
17	Developmental and Comparative Immunology	02.909	1.389
18	Tissue Antigens	02.864	1.368
19	Immunologic Research	02.853	1.362
20	Clinical Immunology	02.760	1.318
21	Journal of Autoimmunity	02.745	1.311
22	Clinical and Experimental Immunology	02.716	1.297
23	Immunology and Cell Biology	02.665	1.273
24	Immunology	02.656	1.268
25	Journal of Immunotherapy	02.604	1.244
26	Cellular Immunology	02.604	1.244
27	Bone Marrow Transplantation	02.554	1.222
28	AIDS Research and Human Retroviruses	02.523	1.205
29	Infectious Disease Clinics of North America	02.460	1.175
30	Cancer Immunology Immunotherapy	02.389	1.141
31	Human Immunology	02.373	1.133
32	Pediatric Infectious Disease Journal	02.289	1.093
33	Journal of Immunological Methods	02.283	1.090
34	Journal of Interferon and Cytokine Research	02.281	1.089
35	Immunogenetics	02.268	1.083
36	Immunopharmacology	02.249	1.074
37	Parasite Immunology	02.182	1.042
38	International Archives of Allergy and Immunology	02.164	1.033
39	Annals of Allergy, Asthma, and Immunology - **Median**	**02.094**	**1.000**
40	Microbial Pathogenesis	02.061	0.984
41	Brain, Behavior, and Immunity	02.023	0.966
42	American Journal of Reproductive Immunology	02.020	0.965
43	Immunology Letters	02.009	0.959
44	Cytokine	01.992	0.951
45	Chemical Immunology	01.977	0.944
46	Molecular Immunology	01.973	0.942
47	Microbes and Infection	01.960	0.936
48	Journal of Reproductive Immunology	01.924	0.919
49	APMIS	01.924	0.919
50	Springer Seminars in Immunopathology	01.883	0.899

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Table 4 continued

Immunology		"Impact factor"	Adjusted value
51	Scandinavian Journal of Immunology	01.739	0.830
52	European Cytokine Network	01.677	0.801
53	Medical Microbiology and Immunology	01.673	0.799
54	Experimental and Clinical Immunogenetics	01.667	0.796
55	Immunobiology	01.648	0.787
56	FEMS Immunology and Medical Microbiology	01.561	0.745
57	European Journal of Immunogenetics	01.547	0.739
58	Clinical and Diagnostic Laboratory Immunology	01.483	0.708
59	Veterinary Immunology and Immunopathology	01.389	0.663
60	Inflammation Research	01.325	0.633
61	Inflammation	01.284	0.613
62	International Journal of Immunopharmacology	01.276	0.609
63	Viral Immunology	01.190	0.568
64	Immunological Investigations	01.190	0.568
65	Mediators of Inflammation	01.156	0.552
66	Microbiology and Immunology	01.154	0.551
67	Immunopharmacology and Immunotoxicology	01.083	0.516
68	Oral Microbiology and Immunology	01.081	0.517
69	Lymphology	00.975	0.466
70	Clinical Reviews in Allergy and Immunology	00.931	0.444
71	Comparative Immunology, Microbiology and Infectious Diseases	00.830	0.396
72	Hybridoma	00.698	0.333
73	International Journal of Immunotherapy	00.520	0.248
74	Transfusion Clinique et Biologique	00.442	0.211
75	Immunology and Allergy Clinics of North America	00.439	0.210
76	Journal of Immunoassay	00.367	0.175
77	Infusionstherapie und Transfusionsmedizin	00.359	0.171

*Review (not considered for median determination).

not included in the calculation of the median. However, because they publish invited articles, they should be considered in the judgments, attesting to the investigator's qualification and prestige.

The procedure to be used for evaluation of the merit of papers belonging to the same area would be straightforward: the proportion of publications above or below the median (original "impact factor"), taken as the reference value. To compare scientific production among different areas of knowledge, the adjusted "impact factor" should be used. Since they are proportionally adjusted, the bias which would be introduced when areas with a smaller number of journals (and consequently a smaller number of citers) are compared is prevented.

A more stringent criterion could be used for classifying Graduate Programs: as a suggestion, to be considered as level 6 and 7 (national and international excellence), a specified proportion of the scientific production of these programs would have to be published in journals with an adjusted "impact factor" above the 75th and the 90th percentiles, respectively (above 1.500 and 2.000, Table 1). The criterion currently adopted by the Biology 3 CAPES Committee, to publish a specified proportion of scientific articles in journals with an original "impact factor" above 4.000, introduces distortions, as pointed out earlier.

One aspect to be considered is that, due to competition, in fields with larger numbers of investigators it would be more difficult for authors to have their papers published in journals with higher "impact factors". However, looking at Table 4 (Immunology), it can be seen that even after adjustment these

journals maintain higher "impact factors" compared to other fields. This would compensate for the apparent handicap that the adjustment might have caused to the median level values. Exceptions to this procedure would be journals included in more than one area with different "impact factors"; in these cases, the higher value would be the choice, acknowledging the journal's capacity of being included in more than one area.

Final considerations

The judgment of scientific production quality is a difficult process and controversies regarding its limitations and applications will always be present. In addition to the "impact factor", other indexes, such as the half-life of scientific papers, can also be used to evaluate publications (3).

Presently, an initiative, under the leadership of Drs. Varmus, Brown and Eisen, aiming at creating a "new system based on-line peer review pre-print publishing" is being implemented. It is named Public Library of Science (PLOS); additional information can be obtained through the Internet (www.publiclibraryofsciencemag.org). The Science Now, a subsidiary journal of Science, published an interview with Dr. Eisen, who announced the publication of "PLOS Biology", discussing the policy of "free-of-charge access for readers". This system is intended to be faster compared to the traditional printed journals. However, the financial dependence of scientific societies on their journals led their Editorial Boards to oppose the idea. Scientists, even those who endorsed this initiative, are still publishing their papers in the traditional scientific journals, probably afraid of losing prestige with the absence of publications in these journals. An additional problem, especially for developing countries, is the publication costs (ca. US$ 1,500/article) (7).

It is expected that this article can contribute to the discussion of the "impact factor", raising questions and motivating different viewpoints to be expressed with the intention of rationalizing its use in the complex process of evaluating scientific production quality.

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