The diverse roles of citation indexes in scientific research

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I want to thank Dr. Alarcon-Segovia for inviting me to help to celebrate the 100th birthday of Dr. Salvador Zubiran. Perhaps Dr. Zubiran left you his formula for long life. It would be nice to return here to celebrate my own 100th birthday. Dr. Alarcon-Segovia and I had many telephone and email exchanges. Eventually, we decided it would be best to speak about "Los roles diversos de índices de citación en la investigación científica".

When the *Science Citation Index* was first introduced in 1964, there was little doubt that its primary function was information retrieval. For about ten years there were controversial discussions amongst librarians about its usefulness for searching the literature. Being conservative and trained to use *Index Medicus*, as well as *Chemical* and *Biological Abstracts*, they were at first reluctant to acquire the SCI. Today, its role in libraries is well established. Acquiring SCI is determined primarily on the grounds of cost, and not on the basis of utility. Since it is multi-disciplinary and includes abstracts, many libraries give it a higher priority than traditional abstracting services. After my talk, I will give you a live demonstration of the latest technological development of *SCI* now called the *Web of Science*. However, the transformation of *SCI* from print to CD-ROM a decade ago already accentuated its use as a bibliometric tool for quantitative scientometric analyses. Indeed *SCI* was the first computer-generated index and one of the first to be made available on-line in 1972. Unfortunately, time does not permit me to discuss all of the varied types of retrieval problems that can be solved uniquely with SCI. But there is one fundamental use that every scientist should learn which complements the use of primary journals and Medline. No matter where you have encountered or learned about a paper, book, or patent, you should check the *SCI* to learn whether and where that paper has been cited. As editors and authors, this will provide the assurance that relevant material will not be overlooked when publishing new work.

Later in my talk, I will discuss the status of Mexican research in a few areas and provide a brief scientometric analysis showing the relative impact of research in the dozen most-active Mexican biomedical specialties. I also will report on the number of papers covered in the SCI and the percentage in Spanish or English.

In the forty years since we started Current Contents the literature has been transformed enormously. While science was fundamentally always international in character, globalization has increased the dominance of English as the language of science. But this does not mean there is no longer a need for journals published in vernacular languages. However, the role of these local journals is, I believe, fundamentally changed. Whereas one might argue in 1957 that hundreds of foreign-language journals contributed significantly to international research, today that is an illusion. While there may be political or other rationales for publishing research of local interest in this or that revista, your best scientists are motivated to publish in the highest impact international journals. Of course, any country can aspire to publish journals with international scope and the Internet may facilitate that possibility. But, in my opinion, local journals, especially in medicine and other applied fields, have the primary job of reviewing international research in Spanish, or reporting research of local interest. Undoubtedly, there are problems in each country which are unique, but it is unreasonable to expect researchers in high-impact research fields to follow all these local journals. I say this even though CC and SCI cover quite a few such local journals. In some respects, ISI's policy is counterproductive because resentment is created among the hundreds of other local journals that are not yet covered by ISI. And those journals

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that are covered suffer from the stigma of low impact factors. Impact data may not tell us much about the value of these journals, e.g. in reporting local clinical studies. Indeed, there is now a large literature about journal impact factors written by authors expressing their frustration about this dilemma. A recent example of this appeared in the German literature. Several Springer Verlag journals including *Der Unfallchirurg, Der Anaethesist, Der Ophthalmologie, HNO,* and *Gynäkolosich-geburtshilfliche Rundschau* published editorials criticizing the impact factor.[1,2] But let me paraphrase my recently published response:[3]

"I would like to comment on the statement by Profs H-J. Oestern and J. Probst of the German Trauma Society which appeared in the October 1997 issues of your journal *Der Unfallchirurg.* The authors assert that the work of German specialits in these fields is published "primarily" in German language journals. Without supporting data they assert that the impact factor is not appropriate for judging scientific achievements in trauma surgery and that "its use leads to an unjustified disadvantage in comparison with other fields."

In 1997, German scientists published over 77,000 papers in SCI covered journals -7.8% of the ISI database. Only 12,000 of those articles were published in German. To determine how well any country performs in surgery research, it is necessary to calculate the percentage of papers from each country and their relative performance. An agreed upon list of cohort source journals is essential in this case. Authors talk about self-citations, but there is no evidence that this changes impact factor. In fact, for the smaller journals, self-citations may be the major source of citations, especially when they are new. Authors allege that there is discrimination against other unspecified journals. Are they aware that all references, regardless of the journals in which they were published, are included in the SCI data? Unfallchirurg and other clinical journals are included in SCI. Which journals are missing whose citations might improve their impact?

The idea that non-English language journals do not have a chance to be cited is untrue. The SCI processes all references regardless of the journal cited, with the exception of those in exotic alphabets such as Chinese and Japanese. German scientists who publish in English-language journals are never forbidden to cite relevant work in German. One might argue that English-speaking readers may not read the original German-language journals, but today the use of English titles and abstracts means that few important articles are missed. But even that in itself does not guarantee citation. Authors cite one another because they become familiar with their work through many channels including international meetings and educational exchanges. And hopefully good refereeing keeps most references relevant. It is absurd to make invidious comparisons between specialist journals and multi-disciplinary general journals like *Nature* and *NEJM.* To compare journals you should stick to a particular category as is explained very carefully in the Guide to *Journal Citation Reports.*

The source of much anxiety about Journal Impact Factors (JIF) comes from their misuse in evaluating individuals, e.g. during the habilitation process, that is granting post-graduate degrees. In many countries in Europe, in order to shortcut the work of looking up actual (real) citation counts for candidate investigators, the JIF is used as a surrogate to estimate the citation count. I have always warned against this practice. There is wide variation from article to article within a single journal as has been widely documented by Seglen[4] of Norway and others. Nevertheless, Koren et al of Montreal use JIF to rate clinical studies.[5] Citation data and analysis should always be used in combination with other indicators when evaluating departments or individuals. For nation by nation comparisons, there is very little controversy about the use of citation indicators. Further, these measures have been used in the USA for an NRC evaluation of 5,000 university departments. Similar research assessment exercises were performed in the UK.

To test the validity of the ISI data you should identify a cohort of experts in trauma surgery and see how their citation records compare. This would augment an article-by-article citation audit of articles published in your journal. This can be done by contacting David Pendlebury at ISI or by use of the various online vendors of citation indexes or the *Web of Science.* I believe the source of much resentment about citation data is due to the fact that throughout the world there has been a gradual acceptance of journal and citation impact as a *metaphor* for research excellence.

Consider the recent news report "France sets high targets for impact factors and patents" in Nature by Butler[6] which reports that the French have declared that they want to increase their citation impact over the next five to ten years. How will they do this?

I don't think it means they will try to artificially increase the number of references to their papers by publishing more review articles. They might even try to invent new methods, assuming they will be highly cited. But this widely accepted myth will be pointless since there are many methods journals with ordinary impact factors. What the French mean, of course, is that they will give better financial support to centers of excellence, to those researchers who demonstrate the ability to conduct world class science. By publishing innovative research, they will increase their impact on world science and thereby their impact factors. Given enough time, I could demonstrate the high correlation between high impact and Nobel class research. I refer you to my recent paper at AAAS, available on my web page.[7] As you may recall, I reported on similar studies in *Current Contents* over a 30-year period.[8]

Referring again to the question of the role of languages. Recently, Mexican researchers in Durango[9] have published a paper which alleges that the original language of publication makes little difference. They studied the journals of the Institute Pasteur in Paris over a long period and concluded from citation data that the impact of the research in this journal did not change during its transformation from French to English. They did not report whether or not the work was published and or cited by Frenchman or not. However, if you publish inconsequential, low impact work in French or Spanish, does it matter if it is translated into English? What would these authors have found if they investigated the fate of French research published in English in the international journals rather than in the local Pasteur journals which happened to have an historical tradition of greatness. I long ago demonstrated that the articles published by French scientists in the international journals achieve much higher impact than those published in French journals.[10] This is a problem that defies any serious quantitative study. One has to accept on faith the assertion that it is wise to publish in English for an international audience, or at least to publish in Spanish with good English summaries -a practice that is far from universal in the Spanish-language journals. Even the above-quoted article from Durango does not have a complete summary in English. The author Rodolfo Bracho provided me a translation. In the near future, I would hope that Spanish and other journals would publish full English translations on their web sites. It is unreasonable to expect these journals to publish print versions in two or more languages. Unfortunately, we are still quite far from reliable Spanish-to-English computer translations. Even the effort in scanning a scientific paper by computer is not trivial. Quite frequently, I write to a foreign author asking for an English translation since I can no longer read fluently (if I ever did) German, French, Spanish, Russian, Japanese, or Chinese.

Latin American journal editors have long had ambiguous desires. They want to be recognized internationally, but they also want to be recognized locally. Any editor or publisher must decide who his primary audience is. If you are writing for the Mexican physician, is it reasonable to ask him or her to read in English? Assuming it is not, then it is unreasonable to expect that same journal to publish research of interest to a completely international audience. I qualify this statement because in the Spanish-speaking world there are journals which may be considered international. But even that sub-set published in 1997 is less than 1% of the articles covered in SCI. Like any other group of physicians in the English-speaking world, Mexican physicians also need good reviews. Translations of biomedical reviews would be relevant if combined with local expert interpretations. The incidence of many diseases varies from country to country, but medical reviews described originally in English should be valuable to local physicians.

English has become the lingua franca of science. This trend began after World War II and has accelerated over the past twenty years. For 1997, 95% of the articles indexed in the *SCI* were published in English. Of the 925,000 articles in the 1997 *SCI* on the Web of Science, half are from the English-speaking countries like the USA, UK, and Australia. The remaining half are from other countries where English is not the native language. Only 5% of the *SCI*-indexed articles are published in Chinese, French, German, Italian, Japanese, Spanish, and Russian. Today European and other non-US scientists publish more in English than in any of these languages. A further confirmation of this trend is a recent report on Medline coverage. It was over 87% English in 1994. But it is now 89%. The non-English European language representation in the *SCI* has changed over the past 20 years for seven languages (Table 1). For example, German language has dropped from about 6% to 1.5%. French has dropped from 4.5% to 1%. Spanish has changed from 0.7 to 0.3 percent which is a drop above 50%. However, lacking a reliable

Table 1. Percentage of papers by language in Science Citation Index in the past 20 years.

Year	Chinese	Italian	Japanese	Spanish	Russian	French	German	English
1977	0.0	0.5	0.6	0.7	4.3	4.5	5.7	82.8
1978	0.0	0.5	0.7	0.8	3.9	3.7	5.9	83.5
1979	0.0	0.4	0.6	0.8	3.7	3.6	5.4	84.6
1980	0.1	0.3	0.7	0.7	3.9	3.8	5.1	84.5
1981	0.1	0.4	0.7	0.6	4.1	3.2	5.0	85.1
1982	0.1	0.4	0.5	0.6	4.0	3.1	4.9	85.4
1983	0.1	0.2	0.5	0.6	4.0	2.9	4.3	86.6
1984	0.1	0.2	0.5	0.6	3.9	2.7	3.9	87.3
1985	0.1	0.3	0.9	0.5	3.8	2.6	3.6	87.4
1986	0.1	0.1	0.8	0.6	3.7	2.6	3.6	87.8
1987	0.1	0.1	0.6	0.6	3.5	2.4	3.4	88.6
1988	0.1	0.1	0.5	0.4	4.0	2.3	3.1	88.9
1989	0.1	0.1	0.5	0.4	4.1	2.1	2.8	89.3
1990	0.0	0.1	0.5	0.4	3.5	1.9	2.5	90.5
1991	0.1	0.1	0.4	0.4	3.0	1.7	2.3	91.5
1992	0.0	0.0	0.4	0.4	2.6	1.5	2.0	92.4
1993	0.0	0.0	0.4	0.3	1.8	1.4	1.7	94.1
1994	0.0	0.1	0.3	0.3	1.8	1.3	1.6	94.3
1995	0.1	0.1	0.4	0.3	1.4	1.3	1.5	94.6
1996	0.1	0.1	0.4	0.2	1.3	1.2	1.3	95.1
1997	0.1	0.1	0.3	0.3	1.1	1.1	1.4	95.2

census of Spanish-language article output, these can only be estimates. These drops have occurred while total output has increased as shown in Table 2.

In Table 2 we also see the number of articles published from 1981 to 1997 for Latin America, Mexico, Spain, and Brazil. All are about 25% lower due to difference in definitions for the *Web of Science®* and *National Science Indicators*. Editorials, letters, abstracts, and other items have been omitted.

Journal Impacts as Surrogates

As I stated earlier, the use of journal impact factors, especially in Europe, has created much anxiety. Until a few years ago, it was difficult to get anyone to pay attention to citation data. But then the dam broke and a week did not go by when one or more papers used citation analysis and impact factors. Many of these papers, however, attacked any quantitative studies as though they were synonymous with the use of journal impact factors as surrogates. So from

Table 2. Changes in the output by country (number of papers in thousands) for Europe and Latin America.

	Europe ISI Web of Science				Latin America ISI National Science		
	1977	1997	Ratio		1981	1997	Ratio*
Germany	35	70	2.0	Latin America	5.8	17.7	3.1
France	25	50	2.0	Spain	3.5	18.5	5.3
Russia	24	27	1.1	Brazil	1.9	6.7	3.5
Japan	22½	73½	3.3	Mexico	0.9	3.6	4.0
Italy	8½	34	4.0	Mexico†	1.2	4.1	3.4
Spain	3	21	7.0				
China	0.1	17	170				

* Ratio 1997/1977 in Europe and 1997/1981 in Latin America.
† Source: SciSearch

the outset, let me state what might seem obvious. It is dangerous to use any kind of statistical data out of context. The use of journal impact factors as surrogates for actual individual citation performance is to be avoided, if at all possible. However, let me give you a few examples when it was justifiable.

Several years ago, the Sores Foundation wanted to help Russian scientists in desperate need of funds. How could they, within a three-month period, decide which of 20,000 applicants should receive grants? An arbitrary decision was made – if the applicant had published a paper in a journal with an impact above a given threshold for each field, he or she would receive an immediate short-term stipend. As you can imagine, those Russian scientists who regularly published in international journals had an advantage over those who exclusively published in Russian language journals or other low impact journals. Few Russian language journals, except in physics, achieve better than average impact. Of the many that are translated cover to cover only a few, again in physics, do somewhat better. Many of my friends, e.g. in the small field of marine biology, were initially hurt by this Soros policy. Even English language journals in that field do not achieve impacts comparable to fields like physics, biochemistry, etc. But as time passed and normal peer review procedures could be implemented, scientists even in small or low-impact fields were better accommodated.

It is reasonable to expect that higher impact work is generally reported in English and not in vernacular languages. But surely the Soros Foundation could not say that it would not fund Russian scientists who had exclusively published in Russian. Some Soviet physicists and chemists benefited because cover-to-cover translation journals not only promoted their work, but in some cases increased their impact artificially. The translated versions systematically cited the original Russian version, thereby giving each original Russian article an extra citation, depending on the dating system used. However, it is widely believed that if your work is available in English, this alone may increase its citation. That basic assumption is not proven. Indeed, the study by Bracho in Durango mentioned earlier involving the Pasteur Institute journals[9] argues against this conclusion. However, it is often assumed, because the translated version is cited, that the Russian version would not have been cited. But in the days before cover-to-cover translations, we relied on abstracts and individual translations. Leading physicists often read Russian physics in original. Today, even Russian physicists may cite translated versions because they believe more readers will have access to them than the Russian version.

Let me cite another example of justified use of impact factors. Over 20 years ago, the then new director of the Italian National Research Council adopted a policy similar to that of Soros. However, he established a very low threshold of journal impact. He too did not even inquire whether the individual's work had ever been cited. He was not surprised to learn how many Italian clinical researchers had never published a paper at all. And many who did publish, chose vernacular, low-impact journals mainly supported by the pharmaceutical industry. It is well known how politics has affected Italian research funding policies in the past, but today the situation has improved. The interest in journal impact in that country may have started with Professor Luigi Rossi-Bernardi but has accelerated. The recent publication of a book in Italian covering this phenomenon is significant.[11] It was discussed at a G7 Conference in Capri about two years ago. The authors clearly understand how to use citation data appropriately.

So the use of journal impact factors as surrogates can be justified in certain situations. The use in these cases is simply another way of determining whether a scientist had published in a journal of minimal prestige. The mere acceptance of a paper in such a journal makes a statement. Even if that paper is never cited, the fact that a respected peer-reviewed international journal accepted it, means that the scientist met some minimum international standard. Now we know that this generalization is not always true. I regularly see papers that I think should never have been published. But we hope that the peer review process minimizes the publication of trivial, me-too salami-slice science.

Another criticism of journal impact factors comes from journals in slow-moving fields. We all know that molecular biology and other areas are considered hot fields. However, you can use ISI journal data to calculate long-term journal impacts. I reported such a study recently in *The Scientist*.[12,13] The cumulative impact factor of the 200 leading life sciences journals showed that there may be significant differences between 2-, 7-, and 15-year impacts, as e.g., in the field of physiology. Table 3 shows the 7-year and 15-year IF of the 25 leading journals. However, our

Table 3. The 7-year (1989-90 papers cited 1989-95) and 15-year impact factor (1981-82 papers cited 1981-95) of the 25 journals with the highest ranking. The original ranking (2-year IF) is given.

Journal	7yIF	Ranking 7y	Ranking 2y	Journal	15yIF	Ranking 15y	Ranking 2y
Cell	161	1	1	Cell	137	1	2
New Engl J Med	111	2	2	New Engl J Med	118	2	1
Science	106	3	3	J Exp Med	92	3	4
Nature	99	4	4	J Cell Biol	88	4	7
J Exp Med	68	5	10	Proc Nat Acad Sci	87	5	8
EMBO J	67	6	9	Arch Gen Psychiatry	84	6	18
Fed Proceed	65	7	5	J Clin Invest	80	7	11
J Cell Biol	62	8	11	Nature	79	8	6
Proc Nat Acad Sci	60	9	12	J Mol Biol	72	9	19
Arch Gen Psychiatry	51	10	18	Science	71	10	9
J Clin Invest	49	11	16	Mol Cell Biol	68	11	24
Lancet	48	12	6	J Neurosci	65	12	5
Ann Intern Med	45	13	13	Brain	65	13	215
Mol Cell Biol	2	14	21	EMBO J	64	14	25
J Neurosci	40	15	31	Circ Res	62	15	30
Blood	38	16	19	Neuroscience	60	16	23
J Immunol	37	17	24	Ann Intern Med	59	17	10
J Biol Chem	37	18	25	J Histochem Cytochem	57	18	52
Circulation	37	19	14	Nucleic Acid Res	57	19	16
J Natl Cancer Inst	36	20	23	J Gen Physiol	57	20	110
Physical Rev Lett	36	21	22	J Comp Neurol	56	21	35
Am J Hum Genet	36	22	20	J Immunol	55	22	15
J Mol Biol	33	23	38	J Biol Chem	55	23	19
Am J Pathol	32	24	44	Astrophys J	55	24	48
J Virol	32	25	29	Blood	54	25	17

study also showed that the ranking of journals within discipline will not change much.

Let's return now to a significant point about statistical indicators in science. Table 4 shows you citation frequency data for a huge *SCI* database. A large percentage of papers are only cited one or two times. Uncitedness is a very complex issue which has been discussed by David Pendlebury of ISI. The extent of uncitedness has been greatly exaggerated. There is a pattern in human activities known as the

Table 4. Distribution of the frecuency of citation of individual papers in the SCI (1945-88).

Number of citations	Distribution N	Distribution %	Number of citations	Distribution N	Distribution %
> 10,000	20	< 0.01	300 - 399	7736	0.02
5000 - 9999	47	< 0.01	200 - 299	21952	0.07
4000 - 4999	23	< 0.01	100 - 199	112299	0.34
3000 - 3999	54	< 0.01	50 - 99	348537	1.06
2000 - 2999	181	< 0.01	25 - 49	842950	2.58
1000 - 1999	1051	< 0.01	15 - 24	1.089731	3.33
0900 - 999	325	< 0.01	10 - 14	1.207577	3.69
0800 - 899	438	< 0.01	5 - 9	2.955984	9.03
0700 - 799	727	< 0.01	2 - 4	7.877213	24.07
0600 - 699	1073	< 0.01	1	18.255577	55.78
0500 - 599	1828	< 0.01			
0400 - 499	3406	0.01	Total	32.728729	100%

Table 5. Mexico. Five-year IF (1993-97) and relative impact by field of research. Source: ISI National Science Indicators.

Field of research	Papers N	Citations N	Relative impact	Impact factor
Cell & Developmental Biology	97	603	0.41	6.2
Immunology	143	749	0.61	5.2
Space Science	511	2034	0.73	4.0
Neurosciences & Behavior	539	2054	0.58	3.8
Rheumatology	100	377	0.91	3.8
Molecular Biology & Genetics	261	982	0.37	3.8
Microbiology	492	1638	0.57	3.3
Endocrinology & Nutrition	127	403	0.57	3.2
Earth Sciences	383	1165	0.90	3.0
Biochemistry & Biophysics	348	1030	0.34	3.0
Animal & Plant Sciences	200	585	0.58	2.9
Organs & Systems, Medical	277	809	0.71	2.9
Pharmacology & Toxicology	438	877	0.53	2.0
Environment & Ecology	561	1067	0.75	1.9
Cardiovascular & Respiratory	93	166	0.42	1.8
General Topics, Medical	409	723	0.23	1.8
Agriculture & Agronomy	250	426	1.65	1.7
Agricultural Chemistry	151	248	0.66	1.6
Treatment & Diagnostic, Medical	117	190	0.41	1.6
Plant Sciences	611	983	0.50	1.6
Biology	355	568	0.44	1.6
Biotechnology & Applied Microbiol	199	312	1.57	1.6
Food Science & Nutrition	251	388	0.83	1.6
Mechanical Engineering	80	112	1.23	1.4

80/20 rule.[14] Citation analysis tells us a lot about the upper 20%. It may or may not tell us anything about the lower 80%. So let me remind you what Irving Sher and I learned about the top 20% over 30 years ago. We presented a paper at a conference in 1965 which reported that Nobel Prize winners publish 5 or 6 times as many papers as average scientists. Further, their work is cited 30 to 40 times the average.[15] This does not mean that if you publish 5 times as much as the next fellow, you will be cited 30 times as much or that you will win a Nobel Prize. But it increases the probability. The ultimate source of high impact is creativity, innovation, and other factors such as publicity in the lay and scientific press. If you create the right conditions for genius to flourish, then the high impact papers will follow. If you promote international contacts in person communication, you will make it possible for Mexican ideas to permeate the English-dominated word of research. If we knew exactly which makes a paper "hot" then we would write them!

Finally, let me review some of the data I have prepared from the ISI database called *National Science Indicators*. This permits us to identify the fields in which Mexico does best in terms of publications (Table 5). You can see that rheumatology and immunology are the fields in which Mexico does best in terms of *relative impact*. Relative impact takes into account worldwide performance for each specialty.

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