obituaries, book and television reviews, and much more. It is not clear what should be included in the denominator, and many editors have discovered that the best way to increase the impact factor of your journal is to persuade the Institute for Scientific Information, which compiles the impact factors, to exclude as much as possible from the denominator. By doing this editors can more than double the impact factors of their journals.

Malcolm Chiswick, at one time editor of Archives of Disease in Childhood, described how an obsession with impact factors can lead to what he termed an 'impacted journal.' Everything readable and entertaining is cut in favour of material that will be cited. This means that a journal is designed for citing rather than reading and for authors (who can cite articles) rather than readers (who cannot). In the case of medical journals this means that the needs of researchers are put before the needs of ordinary doctors, even though for many general medical journals ordinary doctors far outnumber researchers as readers. A journal's impact factor might rise but its readership declines.

So, has the impact factor conceived by Garfield all those years ago been a force for good or harm? Perhaps this is a meaningless question. Perhaps like many technologies—nuclear energy, the telephone, and the internet, for example—it has the potential for both good and harm. It is not the technology itself, it is how we use it. Accepting that, I still believe that we might have been better off if the impact factor had not been invented. Other, more intelligent and meaningful ways would have had to be used to assess research and journals. The story could, however, have been different if citation analyses had been used in the way Garfield imagined in that *Science* article—to avoid the citing of unreliable studies and to deepen historical understanding. Things went wrong, I believe, when the impact factor became a number. People, including scientists, credit numbers with an importance that they deny to words.

Garfield presciently ended his 1955 article with these two sentences: 'The new bibliographic tool, like others that already exist, is just a starting point in literature research. It will help in many ways, but one should not expect it to solve all our problems'. Mistakenly, we asked the number to do too much.

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Commentary: The 'bibliographic impact factor' and the still uncharted sociology of epidemiology

Miquel Porta,[1,2,3]* Esteve Fernandez[4,5] and Francisco Bolúmar[6]

It is 1955, a time of 'mechanical devices' and 'punched cards',[1] before microcomputers, of course, before the 'impact factor'. 1955: Bill Gates and Steve Jobs are born (Box 1). It is only 50 years ago: Eugene Garfield first proposes a bibliographic 'indexing' or 'citation' system for scientific literature.[1] His paper advocates a *new citation* index—as opposed to *traditional subject* indexing—based on a clever and innovative concept—today not much *en vogue*—: the association-of-ideas. An association-of-ideas index. Of course, 'nothing could substitute for extensive reading, but . . .' (page 3[1]).

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Box 1 The 'calendar year' of 1955, some events

Pentagon announces plan to develop intercontinental ballistic missiles armed with nuclear weapons
United States President Dwight D. Eisenhower sends the first advisors to South Vietnam
Winston Churchill resigns as Prime Minister of the United Kingdom
The Salk polio vaccine is introduced
McDonald's first franchised fast food restaurant opens
Imre Nagy, Premier of Hungary, is forced to resign and expelled from the Communist Party by hardline comrades
West Germany becomes a sovereign state and joins NATO
The Warsaw Pact is formed by the communist states of Eastern Europe and the USSR
Disneyland opens
The first atomic-generated electrical power is sold commercially
In Algeria the National Liberation Front (FLN) continues the guerrilla war of independence against the French armed forces
Vladimir Nabokov's *Lolita* is published in Paris by Olympia Press
President of Argentina Juan Peron is ousted in a military coup
In the US racial segregation is forbidden on trains and buses in interstate commerce. Rosa Parks (a Montgomery, Alabama seamstress), refuses to give up her bus seat to a white man and is arrested. Martin Luther King, Jr and other ministers coordinate a Black boycott of city buses
General Motors becomes the first American corporation to make over $1 billion in a year
1955 is the year of birth of: Bill Gates (cofounder of Microsoft) and Steve Jobs (CEO of Apple Computer), Isabelle Adjani, Whoopi Goldberg, Kevin Costner and Bruce Willis (actors), Simon Rattle (conductor), Greg Norman (golfer), Alain Prost (race car driver), Yo-Yo Ma (cellist) . . .
1955 is also the year of death of: Albert Einstein and Alexander Fleming (scientists), Charlie Parker (saxophonist), Alfred Radcliffe-Brown (anthropologist), Thomas Mann (writer), Carlos Gardel (tango singer), James Dean (actor) . . .
Source: Wikipedia. http://en.wikipedia.org/wiki/1955
In epidemiology, the tobacco - lung cancer controversy is raging. Berkson has one more critical paper in the Mayo Clinic Proceedings; Wynder edits a book trying to build a consensus with contributions from many epidemiologists; Doll publishes his groundbreaking work on the relation of asbestos to lung cancer (Br J Ind Med); the previous year, Doll and Hill have published a new article on mortality of doctors in relation to smoking (BMJ), and Armitage and Doll theirs on the multi-stage theory of carcinogenesis (Br J Cancer). Times these 4 papers have been cited: 121 (Berkson), 466 (Doll), 212* (Doll & Hill), and 621 (Armitage & Doll). Do we care much?
*The 212 citations in the ISI-Thomson database exist in spite of a typical mistake by ISI-Thomson: the database contains an error in the primary reference of the article (BMJ 1954; 1 (4877): 1451-1455): in the database the first page is wrong. The article may hence have "lost" (in the database) some of the citations it actually received. Furthermore, the "Times cited" figure for the article in ISI's "Web of science" "Full record" of the "General search" is said to be zero (i.e., never cited). Several other papers by Doll & Hill on the same study have each been cited over 400 times, even more than one thousand times. So much for rankings of highly cited articles: meaningless without knowledge on context.

Box 2 Main reasons why the 'bibliographic impact factor' is often not the scientometric indicator of choice *or*

Why the 'bibliographic impact factor' is usually a much poorer indicator than the total number of citations *or*

Why is it sort of unbelievable that we care about the 'impact factor'

- **Reason/problem 1:** The 'bibliographic impact factor' (BIF) is extremely influenced by the number of 'source items' or 'citeable articles' chosen as the denominator of the BIF, i.e. by the number of articles that according to ISI were published in the journal in the previous 2 years (say, 2003 and 2004 for the 2005 BIF)[22,34] (Table 1 and Figure 1)
  - Subproblem 1.1.: Nobody ever knows what those 'citeable' articles are
  - Subproblem 1.2.: Nobody ever knows the criteria used by ISI to decide which articles are counted (included and excluded) in the denominator of the BIF
  - Subproblem 1.3.: Citations to articles *excluded from the denominator* of the BIF are nevertheless *counted in the numerator*. Yes, the BIF includes or counts in the numerator citations to articles deemed as 'non-citable'.[2] Unbelievable . . . ?
  - Related anecdote: in June 2006, days before the release of the 2005 BIFs, the editors of *PLoS Medicine* published an unusually frank editorial.[31] They complained about the opacity in ISI's choice of 'source items'. They did not complain about citations received by articles excluded from the denominator being counted in the numerator of BIF. Fragments follow[31]:

We would be lying if we said that our journal's impending first impact factor is not of interest to us. For a number that is so widely used and abused, it is surprising how few people understand how a journal's impact factor is calculated, and just how limited it is a means of assessing the true impact of an individual publication in that journal. A journal's impact factor cannot tell us anything about the quality of any specific research article in that journal, nor of the quality of the work of any specific author. It is well known that editors at many journals plan and implement strategies to massage their impact factors. Editors may decrease the denominator [of the BIF] by attempting to have whole article types removed from it. The rules of the game are unclear—editors can, for example, try to persuade Thomson Scientific to reduce the denominator, but the company refuses to make public its process for choosing 'citable' article types.

During discussions with Thomson Scientific over which article types in *PLoS Medicine* the company deems as 'citable,' it became clear that the

process of determining a journal's impact factor is unscientific and arbitrary. After one in-person meeting, a telephone conversation, and a flurry of e-mail exchanges, we came to realize that Thomson Scientific has no explicit process for deciding which articles other than original research articles it deems as citable. We conclude that science is currently rated by a process that is itself unscientific, subjective, and secretive

During the course of our discussions with Thompson Scientific, *PLoS Medicine*'s potential impact factor—based on the same articles published in the same year—seesawed between as much as 11 (when only research articles are entered into the denominator) to less than 3 (when almost all article types in the magazine section are included, as Thomson Scientific had initially done—wrongly, we argued). At the time of writing this editorial, we do not know exactly where our 2005 impact factor has settled. But whatever it turns out to be, we feel the time has come for the process of 'deciding' a journal's impact factor to be debated openly.[31]

Finally, *PLoS Medicine*'s BIF was 8.389.

- **Reason/problem 2:** The BIF is the poor average or mean (actually, the mean of an incoherent ratio, especially as per 1.3 above) of a highly skewed distribution. The BIF would not be a good indicator even if problem 1 was solved
- **Problem 1+2:** How did the so-called 'scientific community' ever come to care so much about an average of a ratio that does not apply to any article published (for basic statistical reasons), nor to the journal itself (for validity and simple conceptual reasons)? To us, this is the most relevant question. Until we find scientific methods to answer it, much of the debate on scientometrics is superfluous. We have no solution other than to suggest that professional historians and sociologists of science intervene more energetically in the debate.[24–30] We only have four solutions for the minor, domestic problems:
- **Possible solution A:** If you wish to know the bibliographic 'impact' of a journal—if the journal is your focus or unit of analysis—then you should first look at the *total number of citations received* by the articles published by such journal.[18–21] With over 300 000 citations each year, there is little doubt that the *Journal of Biological Chemistry*, *Nature*, *Proceedings of the National Academy of Sciences of the USA* and *Science* have a wide academic, bibliographic impact. Among general medical journals, only the *New England Journal of Medicine* and *The Lancet* now 'have' over 100 000 citations per year. In epidemiology and public health, only a handful of journal receive over 5000 citations per year (Table 1)

– *Note A.1.:* The total number of citations received by articles published by the journal is not influenced by the number of 'citeable articles' chosen as the denominator of the BIF. Of course, the total number of citations is influenced by the total number of articles published by the journal[2]

– *Note A.2.:* You do not need to limit your analyses to citations received over the previous 2 years, you may choose the period that is more coherent with your purpose

– *Note A.3.:* There may be quite a dissonance between the number of citations received and the BIF (Figure 1)

- **Possible solution B:** If you wish to know the bibliographic 'impact' of an article, just look at the *total number of citations received by the article*. It is simply wrong to apply to any given article the mean of an incoherent ratio of a highly skewed distribution
- **Possible solution C:** If you wish to know the bibliographic 'impact' of an individual or an institution, look at the *total number of citations received* by the articles published by that individual or by people working at that institution. And, as Garfield has long emphasised,[2,3] do consider adjusting by relevant factors (field or specialty, citation density, half-life, number of journals and researchers in the field, number of coauthors, working periods, partners, funding . . .)
- **Possible solution D:** To remember that 'nothing could substitute for extensive reading . . . ' (page 3)[1]

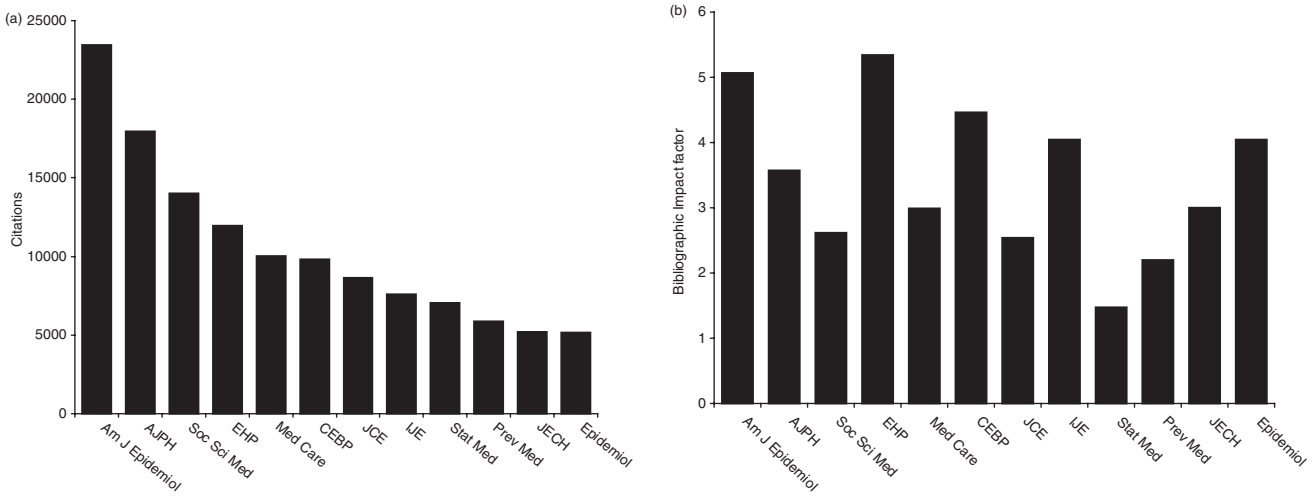

Figure 1 Total number of citations received by (a) and bibliographic impact factor of (b) selected journals of epidemiology and public health. (*Source*: Science Citation Index, Thomson Scientific, 2005)

Table 1 The enormous impact of the number of 'source items' or 'citable articles' selected by ISI: wide differences in the bibliographic impact factor and the total number of citations in selected journals*

	2005			2000			1995		
Journal	Citations	BIF	SI	Citations	BIF	SI	Citations	BIF	SI
Journal of Biological Chemistry	404 397	5.854	5050	3 44 256	7.368	5549	2 78 026	7.385	4635
Nature	372 784	29.273	1065	3 06 184	25.814	1315	2 57 287	27.074	945
Proceedings of National Academy of Sciences USA	357 239	10.231	3200	3 02 228	10.789	2505	2 68 077	10.520	2526
Science	345 991	30.927	827	2 74 443	23.872	920	2 03 375	21.911	1037
New England Journal of Medicine	167 894	44.016	308	1 35 613	29.521	379	1 03 033	22.412	413
The Lancet	131 616	23.407	423	1 13 804	10.232	821	89 957	17.490	490
JAMA	95 715	23.332	380	69 197	15.402	377	44 822	7.686	550
BMJ	59 516	9.052	440	51 530	5.331	512	38 600	4.549	770
Annals of Internal Medicine	38 396	13.254	175	35 912	9.833	210	32 492	9.920	221
American Journal of Epidemiology	23 459	5.068	253	18 191	3.870	263	13 315	3.712	259
American Journal of Public Health	17 954	3.566	297	14 167	3.269	265	9349	2.775	248
Water Resources Research	16 806	1.939	309	12 051	1.640	314	7888	1.536	271
Social Science & Medicine	13 990	2.619	460	8721	1.691	277	5075	1.117	322
Environmental Health Perspectives	11 968	5.342	310	9671	3.033	328	4417	1.194	244
American Journal of Tropical Medicine & Hygiene	10 159	2.482	359	7 172	1.765	82	5077	1.822	231
Medical Care	10 034	2.994	172	7404	2.535	138	4400	2.418	155
Cancer Epidemiology, Biomarkers & Prevention	9832	4.460	435	4149	4.354	198	810	2.705	130
Journal of Clinical Epidemiology	8657	2.538	178	5127	2.075	158	2364	1.280	165
International Journal of Epidemiology	7599	4.045	139	5216	1.892	149	3051	1.000	178
Statistics in Medicine	7066	1.477	254	4088	1.717	231	2043	1.804	191
Preventive Medicine	5856	2.195	234	3316	1.557	163	1836	1.043	89
Transactions of the Royal Society of Tropical Medicine & Hygiene	5581	1.665	128	4869	1.485	177	4212	1.149	215
Bulletin of the World Health Organization	5506	3.961	102	3733	1.937	139	3012	1.535	71
Journal of Epidemiology & Community Health	5197	3.003	162	3040	1.827	147	1762	1.357	135
Epidemiology	5164	4.043	104	3232	3.632	114	954	2.167	109

Source: *Journal Citation Reports*, Science edition and Social Sciences edition, Institute for Scientific Information (ISI), The Thomson Corporation.

Citations: Total number of citations received from articles published in ISI—selected journals in the year shown; e.g. total number of citations received in 2005 to all and any papers—'citeable' and 'non-citeable'—published by each journal at any time.

BIF: Bibliographic impact factor: Number of citations received in a given year to papers published the previous 2 years, divided by the 'source items' in the previous 2 years. Thus, the BIF of 2005 is the result of dividing: a) the number of citations received by journal J in 2005 (i.e. from articles published in 2005 by all 'citing' journals) to papers published by J in 2003 and 2004, by b) the number of 'source items' published by J in 2003 and 2004.

SI: Source items or citeable articles: The denominator of the BIF. The number of 'items' (articles) published by the journal that are deemed 'citeable' by ISI; each year and for each of the thousands of journals that its databases include, ISI chooses which are the 'source items' among the scientific articles and all sorts of other items published.

The core of his starting point is not *that* new (centuries old, actually): the ideas expressed by authors in articles ('the micro unit of thought', page 1[1]) can be found and followed-up in the citations to those articles. Every time an author cites a previous article (i.e. the ideas within the article), he or she is *indexing* it from his/her experience. This emphasis on the *ideas*, uhm...

Among the fascinating projects that Eugene Garfield has been able to make real, to us this is the one that nowadays remains most valuable—immensely useful and influential in this era of information contamination: the ease with which we can conduct orderly, structured, thoughtful, insightful (and computerized) retrievals of papers, that is, associations of ideas, relationships among findings, among hypotheses...just by clicking at 'Cited References', 'Times Cited'... and thinking.

Useful and influential to the point that the *impacts* of Garfield's Science Citation Index are immeasurable and invaluable. At least the most important impacts: upon 'thought processes' and the generation of new ideas, upon 'critical appraisal and interpretation' (page 3),[1] to 'eliminate the uncritical citation of fraudulent, incomplete or obsolete data' (opening sentence, page 1).[1] The genuine, true impact upon hundreds of thousands of scientists who have used Garfield's tools 'to evaluate the significance of a particular work and its impact on the literature and thinking of the period' (page 3)[1].

In his article[1] Garfield shows an amazing vision, imagination, creativity, and ambition. And he anticipates that the new system 'would provide a complete listing, for the publications

covered, of all the original articles that had referred to the article in question'. Moreover, this article contains the first seed—if not formulation—of the idea of an 'impacfot factor' (page 2),[1] as acknowledged in the opening sentence of a recent article in *JAMA*: 'I first mentioned the idea of an impact factor in *Science* in 1955.'[2] Today there can be no doubt about the influence not exactly of the paper itself but of the work that put the paper ideas in motion: influence on the ways researchers search, retrieve, and use the scientific literature, certainly, but also on how and where scientists publish the results of investigations, on how—and how much—research is funded, academic positions assigned...

'Citation Indexes for Science'[1] is just one of the early papers by Eugene Garfield. His vast production spans some 1524 articles. Although most of them are available from his own website,[3] let us cite some favourites,[4–16] since someone is surely counting citations to his papers. Surely, as we all know only too well, citations are often redundant, superfluous, vehement, self-serving. Eugene Garfield knows that we have long acknowledged our intellectual respect and debt to him[17–23]—but we know for sure that someone is counting our citations too. More than incidentally, today the same technologies that make it possible for us to enjoy the results of Garfield's dreams are also providing new tools for scientists (this is a reality). Information technologies are also promising new ways to assess the influence of scientific work (this being yet rather imperfect). And new tools for the sociology of science,[24–26] including a still uncharted sociology of epidemiology.[13–15,17,27–30]

We could indeed follow the path walked by the idea of the 'citation index' using the *Science Citation Index* itself: the article[1] has been cited in—or 'by'—248 articles, mostly in the field of information science and library sciences; e.g. in 28 articles published in *Current Contents* and in 12 articles published in—or 'by'—*Scientometrics*. The article has seldom been cited (just 2 cites) in journals of epidemiology and public health. Remarkably, some 200 different researchers have cited it. Almost a quarter of the citations to the paper come from the author himself. Also, the paper is presently cited more than ever before: it was cited in 96 articles (38.7% of the total) in the period 2000–2006 and in 50 papers (20.2%) in 1990–1999. Is it that the article has been rediscovered in recent times? Does the citation trend reflect an increase in the interest on the 'impact factor'? Why would that be? (Box 2).

Presumably to acknowledge that an article may have a wide spectrum of impacts,[20–23,31] the revered 'impact factor' [32–34] has recently begun to be referred to more precisely as 'journal impact factor (JIF)' by Garfield himself,[2] while it has been named as 'bibliographic impact factor (BIF)' by others for rather long. For reasons that few of us would pretend to comprehend,[22] the JIF/BIF has become not only the more widely used and misused scientometric indicator but, surprisingly—given the alternatives—, the most popular indicator of the ISI—Thomson galaxy (http://www.isiwebofknowledge.com and http://scientific.thomson.com/knowledgelink/). Surprisingly?

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