

The impact factor of leading cardiovascular journals: where is your paper best cited?

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The impact factor is based on the number of times papers published by a scientific journal are cited by all journals. More specifically, this number of citations is limited to the citation of papers published during the two preceding years. Thus, a journal's impact factor for 2000 is calculated by summation of all citations during the year 2000 to all papers published in 1998 and 1999 by a specific journal divided by the total number of papers published by that same journal during those same two years. Table 1 shows the impact factors for the year 2000 of the ten top journals within the category 'Cardiac and Cardiovascular Systems' published by the Journal Citation Reports™, which calculates the impact factors of scientific journals for the Institute for Scientific Information in Philadelphia (USA). In 2000 *Circulation*, the clinical journal of the American Heart Association, held the top position in the category. It was cited 10,511 and 8454 times for 1998 and 1999 items, respectively. This total of 18,965 citations divided by 1741 items (820 in 1998 plus 921 in 1999) yielded an impact factor of 10.893. Similarly, the impact factors of the other journals were calculated (table 1).

Figure 1 shows the impact factors of the five leading cardiovascular journals in 2000 over the last ten years. It is the first time in history that a cardiovascular speciality journal has scored an impact factor above 10.00. *Circulation* has been leading over the last ten years with an impact factor around 9.00, but it has increased further during the last two years. The *Eur Heart J* and *Cardiovasc Res* have substantially improved their positions during the last years both in terms of impact factors and in ranking (increasing from positions around 30 in 1991 towards 4 and 5 in 2000)

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within the cardiovascular category of the Journal Citation Reports. For these two journals, the estimated impact factors for 2001, both closer to 5.00 than to 4.00, have also been included in the graph (figure 1).

Impact factor only reflects short-term citation

It has been noted that there may be huge differences between the citation profiles of papers. Some papers have been cited at about the same frequency for the last 20 or 30 years. Others are cited with a dominant peak, but that peak can either occur at three to four years or as long as 15 years after publication.¹ Indeed, the order of journals ranked on the basis of the impact factor would be different if longer periods for citation were to be used.² Also, it has been suggested that some parameter for the longevity of citation after the period used for the calculation of the impact factor might change the ranking of scientific journals. The editorial team of *Circ Res* has suggested that this would reverse the ranking of *Circulation* and *Circ Res*.³ We will see in the next sections that this is not the case.

Cited half-life

Figure 2 shows the cumulative citations obtained in the year 2000 to papers published in the year 2000 itself and to papers published during the preceding years for the top five journals in the category 'Cardiac and Cardiovascular Systems' (see also table 1 and figure 1). For *Circulation*, *J Am Coll Cardiol*, *Eur Heart J* and *Cardiovasc Res* the contents of 1996-2000 yielded about 50% of all citations obtained during 2000. Therefore, the cited half-life of these journals is said to be about 5.0 years. This means that the other half of the citations obtained during 2000 were acquired by the papers published in 1995 and earlier. This directly indicates that new journals always have a short cited half-life compared with journals with a long history. This would seem to be an unattractive bibliometric parameter for new journals. Indeed for *Circ Res* the cited half-life is about 7.0 years: the contents of 1994-2000 yielded 50% of all citations during 2000. The other half came from papers published in 1993 and earlier. Besides the obvious drawback of new journals with respect to 'cited half-life', changes in the number

Table 1. Impact factor of the top ten journals in the cardiovascular category of the Journal Citation Reports of the Institute for Scientific Information in the year 2000.

Journal	Impact factor
1. Circulation	10.893
2. Circ Res	9.193
3. J Am Coll Cardiol	7.082
4. Eur Heart J	3.840
5. Cardiovasc Res	3.783
6. J Mol Cell Cardiol	3.383
7. Am J Physiol (H)	3.243
8. J Thorac Cardio Sur	3.057
9. Trends Cardiovasc Med	2.879
10. J Cardiovasc Electr	2.789

of papers published per year by a journal would also influence this parameter. Moreover, a substantial change in the impact factor will affect the cited half-life in the opposite direction. If there were a tenfold increase in the impact factor of a journal within a year, there would be a dramatic fall in cited half-life and, in contrast, a decrease of the impact factor to 0, would increase the cited half-life. Simply multiplying the cited half-life with the impact factor as suggested by the editorial team of *Circ Res*⁵ is not the best method to answer an author who simply wants to know where his paper has the best chance of being cited as often as possible.

Which journal obtains the largest number of citations per paper?

The answer to the question raised in this article is very simple. Rather than fixing the year of citation and

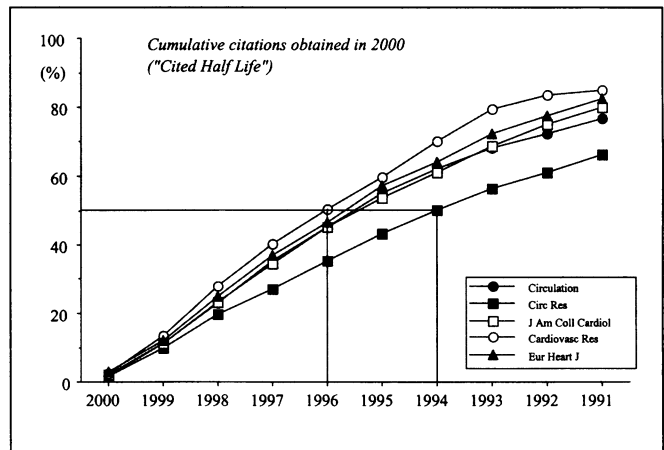


Figure 2. Cited half-life for the top five journals in the cardiovascular category. The contents of *Circulation*, *J Am Coll Cardiol*, *Eur Heart J* and *Cardiovasc Res* between 1996 and 2000 generate about 50% of all citations obtained during 2000. Therefore the cited half-life is about 5.0 for those four journals. The other half of the citations was generated by the contents of 1995 and all previous years. For *Circ Res* the cited half-life is about 7.0 years with 50% of citations obtained during 2000 generated by the contents between 1994 and 2000.

looking back to previous years of publication as is the case in calculating the cited half-life (figure 2), one may reverse this procedure. Fixing the year of publication and accumulating citations over the next years provides the cumulative number of citations since publication. Thus, figure 3 shows the cumulative number of citations that a journal would have accumulated for an average paper published in 1994 over the years 1994-2000 if published in one of the top five journals

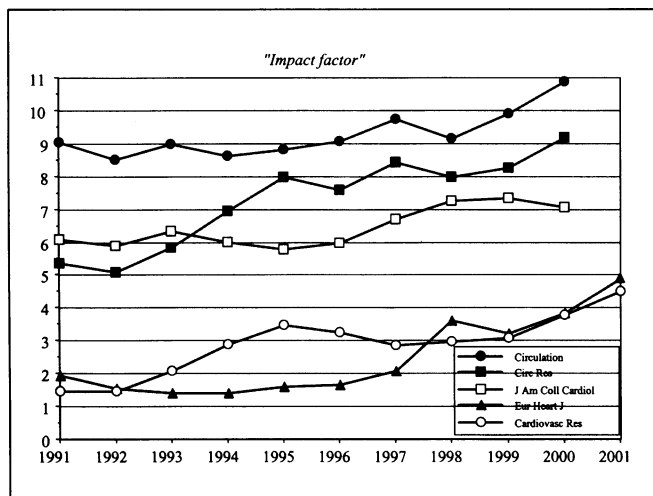


Figure 1. Impact factors of *Circulation*, *Circ Res*, *J Am Coll Cardiol*, *Eur Heart J* and *Cardiovasc Res* between 1991 and 2001. Impact factors for 2001 for *Eur Heart J* and *Cardiovasc Res* have been estimated by the authors.

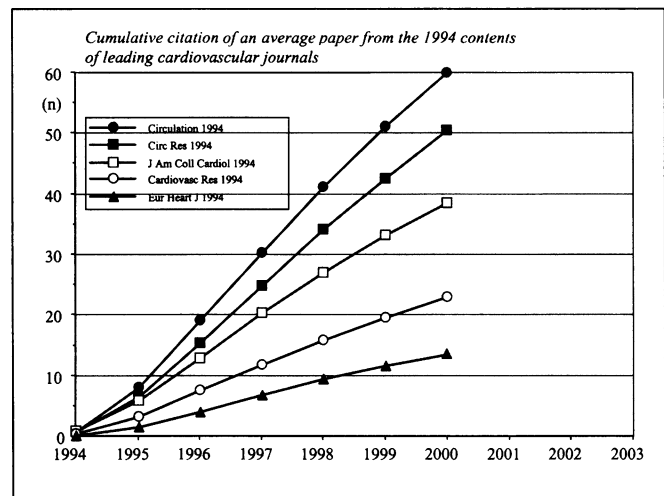


Figure 3. The cumulative citation of an average paper from the 1994 contents of the top five journals in the cardiovascular category during the years 1994-2000.

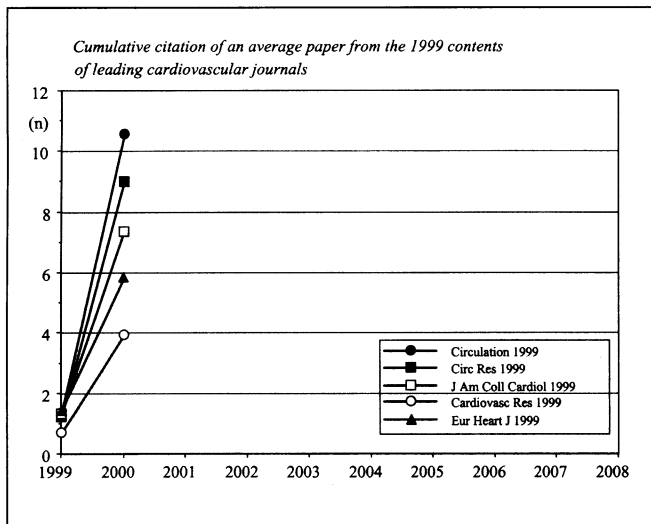


Figure 4. The cumulative citation of an average paper from the 1999 contents of the top five journals in the cardiovascular category during the years 1999-2000.

in the cardiovascular category (table 1). This number would have been 60 for the average paper in *Circulation*, just over 50 for a paper in *Circ Res*, 38 for the *J Am Coll Cardiol*, 23 for *Cardiovasc Res* and 13 for an average paper in the *Eur Heart J*. Figure 4 shows more recent data for an average paper from the 1999 contents of the same five journals. The order is almost unchanged, although the two European journals have changed position and the gap between the American and European journals has narrowed. For clinical cardiologists it may be of interest to have a closer look at the differences between *Circulation* and the *Eur Heart J*. Figure 5 shows the number of accumulated citations during the years after publication for the average paper from the 1994, 1998 and 1999 contents of both journals (solid lines for *Circulation*; dotted lines for the *Eur Heart J*). There are increases for *Circulation* when 1998 and 1999 are compared with 1994, but not when 1999 is compared with 1998 (data for 1999 are superimposed over the data for 1998). For the *Eur Heart J* there is a continuous increase for any comparison between years, and the journal has become far more competitive since 1998 than during the previous years. The same trend is obvious when are compared the basic science journals *Circ Res* and *Cardiovasc Res* (data not shown).

What does a high impact factor mean?

The higher the impact factor of a journal, the higher the scientific esteem of the journal. Figure 6 shows the relationship between the number of journals within 69 scientific categories in the biomedical and medical sciences and the impact factor of the top journal within each category (filled circles) and of the journal at the 10th percentile (open circles). Thus, the last-

mentioned would be the impact factor of the journal ranked at position 5 (ranked from top to bottom) if there were 50 journals in a given category (data taken from Journal Citation Reports, version 1999). There is a strong correlation between the magnitude of a speciality expressed as the number of journals in that speciality and the impact factor of the top journal ($r=0.595$, $p<0.0005$, $n=69$), although this correlation is already lost at the 10th percentile of quality ranking. The direct consequence is that one cannot compare scientific output of pharmacologists with that of molecular biologists and so on. There are scientific categories in which the impact factor of the top journal is not higher than about 2.00. It goes without saying that it would be extremely unfair, not to say unwise, to consider a top journal in one field of less value than a lower ranked journal in another category, simply because the impact factor of the former is lower than that of the latter. An example might be the impact factor of *Hum Reprod* in the category Obstetrics (see 'A' in figure 6; ranked at number 1 in its category with an impact factor of 3.003 in 1999) compared with a journal ranked at position 80 (*Prog Biophys Mol Biol* with 3.182, marked with an asterisk) in the category Biochemistry & Molecular Biology. The bottom line is that comparisons between journals are only valid if made within the same field of research.

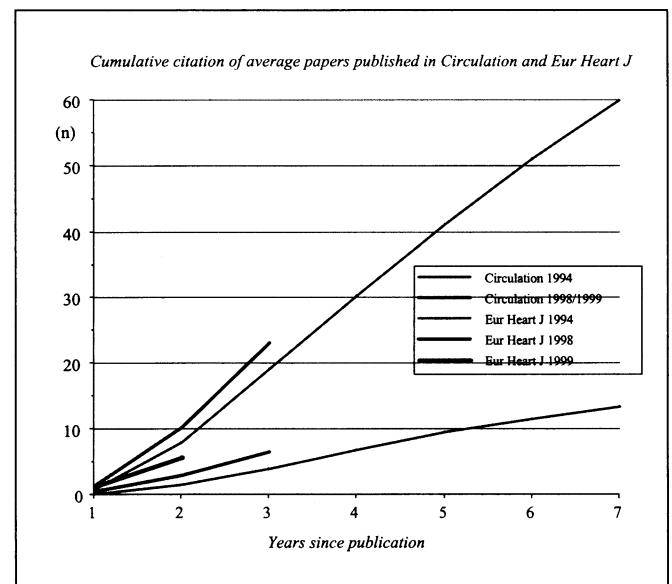


Figure 5. The cumulative citation of the average paper from the contents of 1994, 1998 and 1999 during the years after publication for *Circulation* and the *Eur Heart J*. Note the strong improvement of citation of the *Eur Heart J* during recent years. For *Circulation* the citation of the papers published in 1999 during 1999 (year 1) and during 2000 (year 2) was completely superimposed over the data for 1998. For this reason the legend reads as 'Circulation 1998/1999'. The data between year 2 and year 3 only reflect citation of the papers published in 1998 and cited during 2000, because these data are not yet available for papers published in 1999 for obvious reasons.

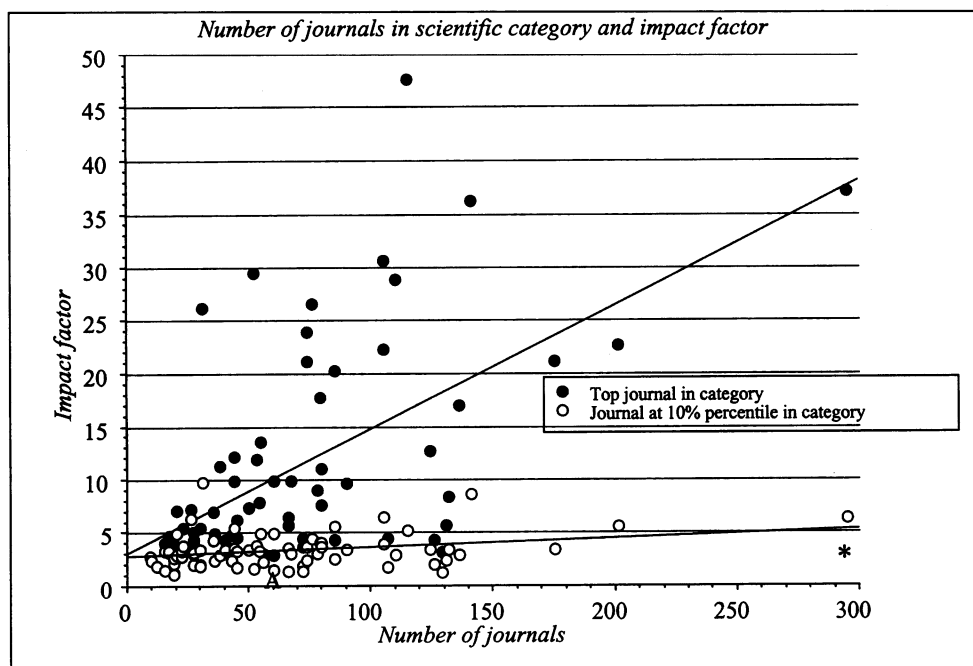


Figure 6. Impact factors (ordinate) of the top journals in 69 categories (filled circles) in the Journal Citation Reports (1999) of the Institute for Scientific Information vs. the number of journals (abscissa) in those categories (medical and biomedical science). Open symbols depict the impact factors of journals at the 10th percentile, i.e. the impact factor of the journal ranked at position 5 in a category with 50 journals). See text of section 5 for explanation of 'A' and the asterisk.

What does a journal's high impact factor mean for individual papers?

Despite the fact that the impact factor was originally meant for comparison of journals, it is also used for the assessment of the quality of individual papers and (groups of) scientists. For the latter, a scientific basis is lacking as we and others have demonstrated.^{4,5} Apart from differences between research fields within medicine and life sciences (see previous section), it is also important to underscore that a scientific paper is not a *pars pro toto*, where 'toto' is the journal. Figure 7 shows a ranking of the contents of *Cardiovasc Res* and *Circ Res* along the abscissa in the order from most frequent to zero citations in 1994. The cumulative citations for the journals are given along the ordinate. If each paper were to be cited with the same frequency one would expect the dashed line of identity. The citation of the individual papers is very skewed. In fact 50% of all citations were obtained by only 12% and 16% of the contents of both journals. Also, 50% of the contents scored around 90% of all citations leaving only 10% for the other half. This implies that the large majority of papers are substantially less frequently cited than the impact factor of the journal suggests and that a citation analysis is a more suitable instrument. Thus, if an individual paper is published in a journal with a high impact factor, it is possible that it is actually less frequently cited than a paper published in a journal with a lower impact factor. Publication of a paper in a top specialty journal or even in general journals like the *New England Journal of Medicine*, the *Lancet*, *Science* or *Nature* does not imply that the paper is frequently cited. Assessment of the citation of individual papers is a better approach. This requires time to elapse after publication of a paper, but there is no reasonable

alternative for this. There is no scientific basis for assessment of citation data of individual papers during the first two calendar years after publication, simply because the fact whether these papers are published in January or December produces too much bias for obvious reasons (unpublished data). The differences

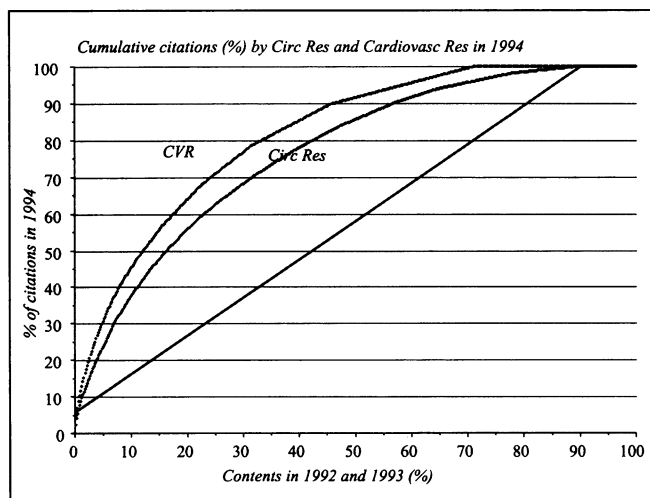


Figure 7. Contents of *Cardiovasc Res* and *Circ Res* during 1992 +1993 ranked according to the citation frequency from highest to lowest (=zero) vs. the cumulated number of citations on a percentage scale. Half of the citations are accumulated by 12% and 16%, respectively, of the contents of both journals (dotted lines). The line of identity shows the relationship if all papers of the journals were to have been cited equally. This figure shows that an individual paper is not cited with the same frequency as indicated by the impact factor of the journal. Therefore a single paper is not a *pars pro toto* for the publishing journal.

between citation of individual papers are so large that they even cause disparity in 'impact factors' of individual issues of the same journal.^{6,7}

Of course, there can be no discussion about the fact that when a research group or an individual scientist within the field of cardiology publishes in *Circulation* or *Circ Res* on a regular basis, this reflects scientific quality.

In summary, within clinical cardiology most citations over years can be expected when the work is published in *Circulation*. For experimental cardiology most citations can be expected to result from publication in *Circ Res*. Whether you also have the best buy is a different question, because *Circulation* is the only journal with page charges.

Conclusions

- The impact factor is a valid tool for the quality assessment of scientific journals, but not for the assessment of the quality of individual papers.
- *Circulation* is not only the cardiovascular journal with the highest impact factor in the cardiovascular category, but also provides the largest numbers of citations over longer periods for an average paper.

- The European cardiovascular journals are starting to bridge the gap with the American cardiovascular journals. ■

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