

The effect of online status on the impact factors of general internal medicine journals

P.S. Mueller^{1*}, N.S. Murali¹, S.S. Cha², P.J. Erwin³, A.K. Ghosh¹

Divisions of ¹General Internal Medicine and ²Biostatistics, ³Medical Library, Mayo Clinic, Rochester, Minnesota 55905, USA, *corresponding author

ABSTRACT

Background: We sought to determine the effects of becoming available online on impact factors of general medicine journals.

Methods: Through MEDLINE with an institutional subscription, the 2004 online status of "Medicine, General and Internal" journals listed in the Institute for Scientific Information (ISI) Journal Citation Reports (JCR) was classified as full text on the Net (FUTON), abstract only, or no abstract available (NAA)/unavailable in MEDLINE. Similarly, through use of a home computer without an institutional subscription, the 2004 online status of the same journals was determined. For each journal, impact factors for 1992 to 2003 were obtained.

Results: Of the 102 "Medicine, General and Internal" journals listed in the ISI JCR, 71 (70%) existed in both pre-Internet (1992) and Internet (2003) eras. Of these 71 journals, those available as FUTON in 2004 had higher median impact factors than non-FUTON journals in 1992 ($p < 0.0001$) and 2003 ($p < 0.0001$). Journals that became available online, at least partially, had significant increases in median impact factors from 1992 to 2003 ($p < 0.0001$ for journals that became available as FUTON and for journals that provided an abstract only). However, journals that became available as FUTON had a greater increase in median impact factor from 1992 to 2003 than other journals ($p = 0.002$). Similar results were obtained using impact factor data according to journal online status through use of a home computer without an institutional subscription and for English-language journals only.

Conclusion: Becoming available online as FUTON is associated with a significant increase in journal impact factor.

KEYWORDS

Bias, impact factor, Internet, journals

INTRODUCTION

When caring for patients, teaching trainees, or conducting research, healthcare professionals can readily locate and access up-to-date literature in online journals, textbooks, and other resources. A free and easy-to-use tool for searching the scientific literature is MEDLINE, the primary subset of PubMed, produced by the United States National Library of Medicine. From any computer with Internet access, researchers can use MEDLINE to identify references from more than 4600 journals.^{1,2} Journals must meet strict criteria to be included in the MEDLINE database. Indeed, those included in MEDLINE represent a small fraction of more than 126,000 science journals published worldwide.³

More than 75% of the references included in MEDLINE since 1975 include an English-language abstract. Some full-text articles are available for free through PubMed Central, a full-text archive. However, most full-text articles are available only for a fee or with a paid individual or institutional (e.g. medical school) subscription (e.g. publisher website or commercial entity such as Ovid or Science Direct).

With institutional access to MEDLINE, journal article information is available online as a full-text article (full text on the Net; FUTON), an abstract only, or citation information only (no abstract available; NAA). Notably, some journals are unavailable through MEDLINE. Journal article information accessed with a home computer without an institutional subscription is available online as free FUTON or as free abstract only, or no reference information may be available (i.e. the journal's website does not provide full-text articles, abstracts, or citation information).³

One measure of a journal's visibility and accessibility is the impact factor. The impact factor is a means of ranking journals by citation analysis; i.e. the more frequently a given journal's articles are cited, the higher the journal's impact factor.^{4,5} For a given year (e.g. 2003), a journal's impact factor is calculated by dividing the total number

of published citations to articles in the journal during the previous two years (e.g. 2001-2002) by the number of source items (original research articles, review articles, etc) published by the journal during the same two years.^{3,4,6,7} Every year, the Institute for Scientific Information publishes impact factors for 5000 science and technology journals.^{4,8} Notably, fewer than 2000 of these journals are biomedical journals and not all of them are searchable through MEDLINE.

In this study, we sought to determine whether an association existed between becoming available online as FUTON or free FUTON and a change in impact factor (i.e. we hypothesised that becoming available online increases a journal's visibility and, hence, its impact factor).

MATERIALS AND METHODS

A retrospective longitudinal design was used. During December 2004, the Institute for Scientific Information listed 102 "Medicine, General and Internal" journals in its Journal Citation Reports. This group of journals comprised the dataset for this study. For each journal, impact factors for the years 1992 to 2003 (if available) and language (i.e. English, multiple languages (including English), or non-English) were determined. Because of the method of calculating the impact factor, the 2003 impact factors were the latest available during December 2004. The 2004 online status of these journals was determined through use of MEDLINE with an institutional subscription (FUTON, abstract only, or NAA/unavailable in MEDLINE) and through use of a home computer without an institutional subscription (free FUTON, free abstract only, or no reference information available). Finally, the year a journal became available as FUTON was determined from the cataloguing records of our institution's libraries, which include when database licenses were signed with journals and publishers. Notably, none of the journals in our study were available online before 1993. The full list of journals that we analysed is available from us on request or through the Institute for Scientific Information database.

Statistical analysis

Of the 102 "Medicine, General and Internal" journals the Institute for Scientific Information listed in its Journal Citation Reports during December 2004, 71 (70%) existed in both the pre-Internet era (1992) and the Internet era (2003). These 71 journals were classified according to their 2004 online status through MEDLINE with an institutional subscription (see above). The Kruskal-Wallis test along with the Wilcoxon rank-sum test was performed, comparing the median impact factors among these groups in both the pre-Internet and the Internet era. The changes in median impact factors among these groups from the

pre-Internet era to the Internet era were also determined. The Kruskal-Wallis test along with the Wilcoxon rank-sum test was performed, comparing the median changes in impact factors from the pre-Internet era with the Internet era among these groups. The same analyses were carried out for English-language journals only. The Bonferroni correction for multiple comparisons was done as appropriate. The same analyses were also carried out for the 71 journals according to their 2004 online status without an institutional subscription (see above).

RESULTS

Of the 71 journals that existed in both the pre-Internet era (1992) and the Internet era (2003), 31 (44%) were available as FUTON in 2004 through MEDLINE with an institutional subscription, whereas 35 (49%) were available as abstract only and five (7%) were NAA/unavailable in MEDLINE. The median 1992 impact factor of the journals available as FUTON in 2004 was greater than that of journals available as abstract only or NAA/unavailable in MEDLINE (Kruskal-Wallis, $p < 0.0001$). Likewise, the median 2003 impact factor of journals available as FUTON in 2004 was greater than that of the other journals (Kruskal-Wallis, $p < 0.0001$). These highly statistically significant differences persisted when impact factor data were analysed for English-language journals only (*table 1*). Next, the changes in median impact factors from the pre-Internet era (1992) to the Internet era (2003) were determined. Journals available as FUTON or abstract only in 2004 had significant increases in their median impact factors between 1992 and 2003 (*figure 1A*). Similar statistically significant results were found when impact factor data were analysed for English-language journals only (*figure 1B*). Compared with the other journals, those available as FUTON in 2004 had a greater increase in their median impact factor from 1992 to 2003 (Kruskal-Wallis, $p = 0.002$). Similar statistically significant results were found when impact factor data were analysed for English-language journals only (*table 1*).

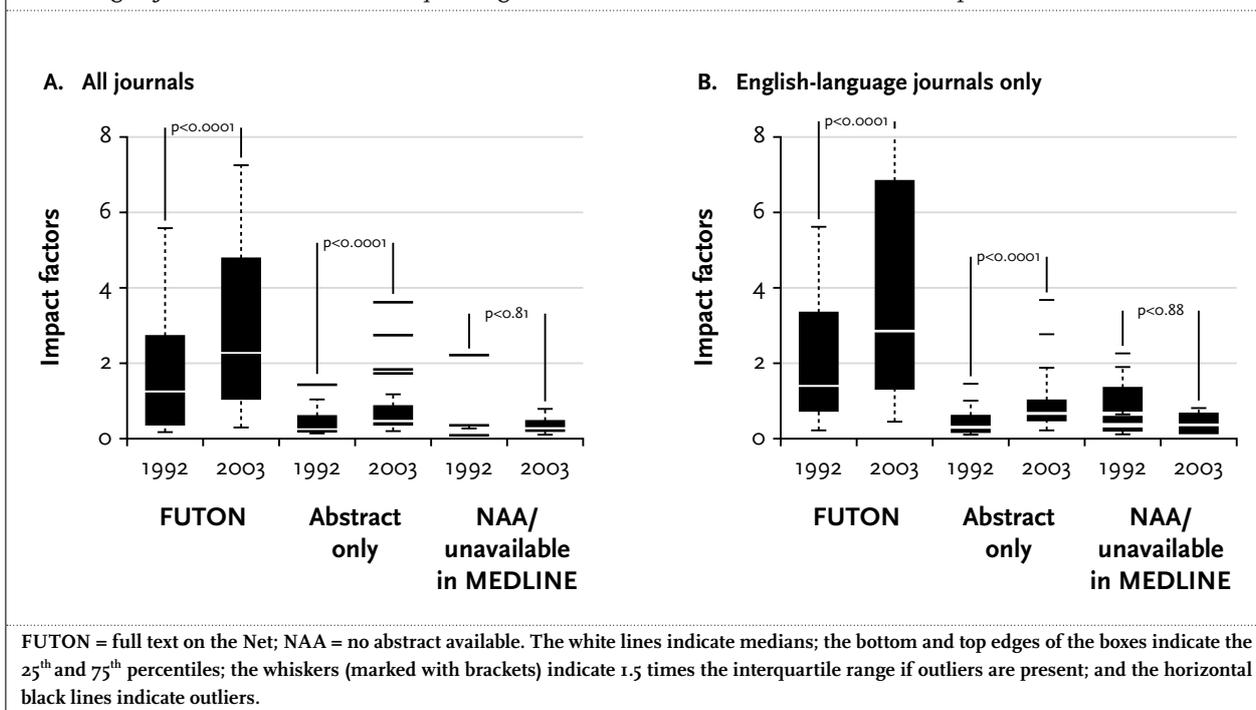
The same analyses were done using impact factor data according to online status without an institutional subscription. Of the 71 journals, 24 (34%) were available as free FUTON in 2004, 43 (60%) as free abstract only, and four (6%) had no reference information available. The median 1992 impact factor of journals available as free FUTON in 2004 was not different from that of journals available as free abstract only or those with no reference information available (Kruskal-Wallis, $p = 0.67$). However, the median 2003 impact factor of journals available as free FUTON in 2004 was greater than the median impact factors of the other journals (Kruskal-Wallis, $p = 0.026$). Similar statistically significant results were obtained when

Table 1. Pre-Internet era (1992) and Internet era (2003) median impact factors of general medicine journals, according to journal online availability through MEDLINE with an institutional subscription

Journals	No. of journals	Impact factor, median (range)		Change in impact factor from 1992 to 2003, median (range)
		Pre-Internet era (1992)	Internet era (2003)	
<i>All journals</i>	71			
FUTON	31	1.24 (0.16-24.46)*	2.25 (0.27-34.83)*	0.68 (-0.89-15.90) [†]
Abstract only	35	0.23 (0.04-1.41)	0.45 (0.19-3.61)	0.23 (-0.20-2.61)
NAA/unavailable	5	0.30 (0.07-2.21)	0.29 (0.07-0.75)	0.06 (-2.14-0.38)
Kruskal-Wallis test		p<0.0001	p<0.0001	p=0.002
<i>English-language journals only</i>	53			
FUTON	27	1.36 (0.17-24.46)*	2.81 (0.41-34.83)*	0.93 (-0.89-15.90) [‡]
Abstract only	22	0.28 (0.05-1.40)	0.62 (0.20-3.61)	0.32 (-0.13-2.61)
NAA/unavailable	4	0.31 (0.07-2.21)	0.30 (0.07-0.75)	0.14 (-2.14-0.38)
Kruskal-Wallis test		p<0.0001	p<0.0001	p=0.006

FUTON = full text on the Net (i.e. online); NAA = no abstract available. *Wilcoxon rank-sum test: FUTON vs abstract only, p<0.0001 (Bonferroni: significant). [†]Wilcoxon rank-sum test: FUTON vs abstract only, p=0.0023 (Bonferroni: not significant). [‡]Wilcoxon rank-sum test: FUTON vs abstract only, p=0.0098 (Bonferroni: not significant).

Figure 1. Pre-Internet era (1992) and Internet era (2003) median impact factors of general medicine journals, according to journal online availability through MEDLINE with an institutional subscription



impact factor data were analysed for English-language journals only (table 2).

Journals available as free FUTON and free abstract only in 2004 had significant increases in their median impact factors between 1992 and 2003 (figure 2A). Similar statistically significant results were found for English-language journals only (figure 2B). Compared with the other journals, those available as free FUTON in 2004 had a greater increase in their median impact factor from 1992 to 2003 (Kruskal-Wallis, p=0.007). Similar statistically

significant differences were found when impact factor data were analysed for English-language journals only (table 2).

DISCUSSION

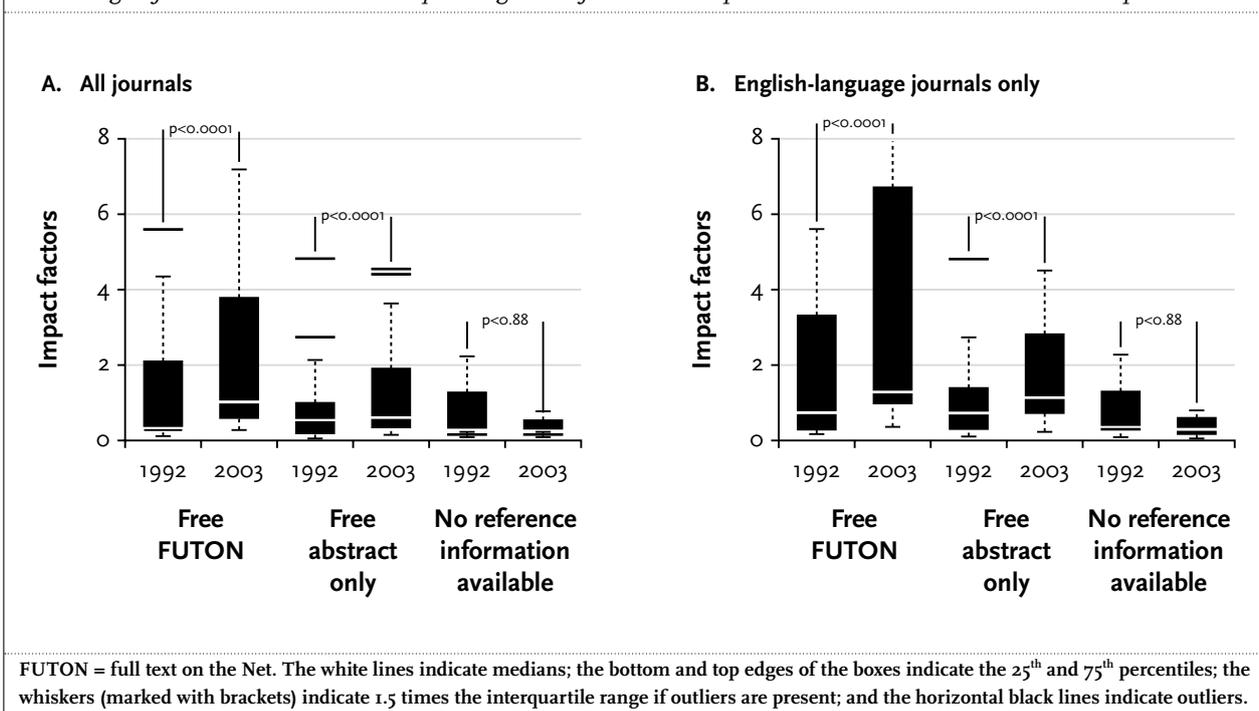
The impact factor is a means of ranking journals by citation analysis; i.e. the more frequently a given journal's articles are cited, the higher the journal's impact factor.⁴⁵

Table 2. Pre-Internet era (1992) and Internet era (2003) median impact factors of general medicine journals, according to journal online availability through use of a home computer without an institutional subscription

Journals	No. of journals	Impact factor, median (range)		Change in impact factor from 1992 to 2003, median (range)
		Pre-Internet era (1992)	Internet era (2003)	
<i>All journals</i>	71			
Free FUTON	24	0.32 (0.05-24.46)*	1.02 (0.27-34.83)†	0.63 (0.04-15.90)‡
Free abstract only	43	0.56 (0.04-15.94)	0.62 (0.19-18.32)	0.22 (-0.89-9.24)
No reference information available	4	0.27 (0.07-2.21)	0.27 (0.07-0.75)	0.16 (-2.14-0.38)
Kruskal-Wallis test		p=0.67	p=0.026	p=0.007
<i>English-language journals</i>	53			
Free FUTON	19	0.72 (0.15-24.46)§	1.26 (0.31-34.83)	0.70 (0.14-15.90)¶
Free abstract only	30	0.73 (0.05-15.94)	1.12 (0.20-18.32)	0.39 (-0.89-9.24)
No reference information available	4	0.27 (0.07-2.21)	0.27 (0.07-0.75)	0.16 (-2.14-0.38)
Kruskal-Wallis test		p=0.44	p=0.013	p=0.014

FUTON = full text on the Net. *Wilcoxon rank-sum test: free FUTON vs free abstract only, p=0.53 (Bonferroni: not significant). †Wilcoxon rank-sum test: free FUTON vs free abstract only, p=0.73 (Bonferroni: not significant). ‡Wilcoxon rank-sum test: free FUTON vs free abstract only, p=0.005 (Bonferroni: not significant). §Wilcoxon rank-sum test: free FUTON vs free abstract only, p=0.47 (Bonferroni: not significant). ||Wilcoxon rank-sum test: free FUTON vs free abstract only, p=0.14 (Bonferroni: not significant). ¶Wilcoxon rank-sum test: free FUTON vs free abstract only, p=0.02 (Bonferroni: not significant).

Figure 2. Pre-Internet era (1992) and Internet era (2003) median impact factors of general medicine journals, according to journal online availability through use of a home computer without an institutional subscription



The size of a journal's impact factor depends on the journal's visibility and accessibility, which, in turn, may be enhanced by becoming available online. In fact, Murali *et al.* found that cardiology, nephrology, and rheumatology journals available as FUTON through MEDLINE with an institutional subscription had higher impact factors than journals available as abstract only or NAA/unavailable in MEDLINE.³ We found similar results for 71 "Medicine,

General and Internal" journals the Institute for Scientific Information listed in its Journal Citation Reports not only through use of MEDLINE with an institutional subscription but also through use of a home computer without an institutional subscription. More importantly, however, our results suggest that a causal association exists between becoming available online as FUTON or free FUTON and an increase in journal

impact factor. Journals available as FUTON or free FUTON in 2004 had greater increases in their median impact factors between the pre-Internet (1992) and Internet (2003) eras than non-FUTON and non-free-FUTON journals. Similar results were obtained when impact factor data were analysed for English-language journals only. These results suggest that providing content online increases the visibility of a journal and, as a result, its impact factor.

Evidence for causality is most convincing when it is derived from an experimental study. However, data from observational studies such as ours (which had a retrospective longitudinal design) may be used to assess for causality by using criteria formulated by Hill.⁹ When these criteria are applied to our study, our results suggest a causal association between becoming available online and an increase in journal impact factor as follows:

- becoming available online (e.g. FUTON or free FUTON) preceded the increase in journal impact factors;
- the association is plausible (easier access to—hence, greater likelihood to cite—journal articles available online than to articles available only in print);
- our results are consistent with those of similar studies;^{3,7,10}
- the association is statistically significant;
- journals that became available online as FUTON or free FUTON had greater increases in impact factors than journals available as abstract only or free abstract only, respectively, whereas journals that did not provide content online had no increase in impact factor (suggesting a dose-response effect, where ‘dose’ is the amount of content made available online and ‘response’ is the impact factor).

Regarding the dose-response effect, we cannot determine from our study results whether a levelling of impact factors over time will occur as more journals become available as FUTON or free FUTON. In addition, we could not determine whether becoming unavailable online was associated with a decrease in impact factor.

Several confounding factors may have affected our results. For example, our data suggest that a difference exists between journals available as FUTON with an institutional subscription and journals available as free FUTON without an institutional subscription. FUTON journals had a higher median impact factor than the non-FUTON journals in both the pre-Internet and the Internet eras, whereas the free-FUTON journals had a higher median impact factor than non-free-FUTON journals in the Internet era only. The reasons for this difference are unclear. It may be due, in part, to FUTON journals enjoying greater wealth, prestige, and wider circulation in the pre-Internet era (when journals were circulated in print only) and recognising the importance of, having

the capacity to commit the resources to, and supporting and marketing online access. In other words, although impact factor is associated with online availability, online availability may be a surrogate marker of journal financial wherewithal. However, our results also suggest that less resource-rich journals recognised the benefits of becoming available online. We found that the 1992 median impact factor of journals available as free FUTON in 2004 was no different from that of the non-free-FUTON journals. By 2003, however, free FUTON journals had a significant increase in their median impact factor, which, in turn, was a greater increase than for the non-free-FUTON journals. Furthermore, making some content available online (e.g. an abstract) was associated with a significant increase in impact factor between the pre-Internet and Internet eras. Journals that were NAA/unavailable in 2004 through MEDLINE with an institutional subscription or that provided no reference information through use of a home computer without a subscription had no change in their median impact factors between the pre-Internet and Internet eras. Finally, a recent study of the relationship between online hit counts on a journal website and subsequent citations found that hit counts for an article during the week after online publication predicted the number of citations of that article in subsequent years.¹⁰ The results of this study complement ours and add to a growing body of evidence that visibility and accessibility of a journal may be enhanced by becoming available online. Other confounding factors may have affected our results. For example, journals included in the Institute for Scientific Information Journal Citation Reports (i.e. those with impact factors) represent a select group of journals of substantial quality. Hence, the journal impact factor data that we examined may not accurately reflect the association between online status and impact factors of all “Medicine, General and Internal” journals. Indeed, in recent decades, there has been a linear growth (approximately 3.5% per year) in the number of new journal titles, and the number of articles and pages published has increased substantially.^{11,12} Furthermore, 30% of the “Medicine, General and Internal” journals the Institute for Scientific Information listed in its 2004 Journal Citation Reports either did not exist or did not have impact factors from the pre-Internet era. If anything, however, these developments would likely dilute the impact factors of journals that are currently highly visible (i.e. by providing many more easily accessible references to cite). Another confounding factor may be changes in journal publication policy. Journals may inflate their impact factors by publishing more articles that are likely to generate citations (e.g. review articles) and nonsource items (e.g. editorials and letters) that are later cited.¹³⁻¹⁵ However, it is unlikely that such policies are practiced only by journals available as FUTON or free FUTON.

The results of our study also suggest that FUTON bias exists (i.e. scholars may be more inclined to read and therefore cite easily accessible articles in journals available as FUTON and ignore relevant references that are not available as FUTON).¹⁶ Ignoring relevant articles simply because the full-text article or its abstract is unavailable online is akin to other forms of bias such as publication bias.^{16,17} Researchers and others should be aware of FUTON bias because it may affect the results and conclusions of their scholarship.

Becoming available as FUTON (or free FUTON), however, may be prohibitively costly for some journals. Many journals rely on income from journal subscriptions and advertising and may avoid becoming available as FUTON because of lost income. Some journals, previously available as free FUTON, are now available as FUTON only through subscription.¹⁸ Success in selling online subscriptions (and advertisements on journal websites) is important for maintaining not only journal visibility but also viability. Notably, many scholars and institutions, especially in Third World countries, cannot afford subscriptions for paper journals or online access to journals (although some journals make their online content available free of charge to scholars in Third World countries).^{19,20} Indeed, our institution's libraries pay nearly US \$1 million annually for access to approximately 2800 journals available as FUTON. This situation has prompted some to suggest new means of publishing the results of research and other forms of scholarship without relying on traditional journals²¹ or to create free access to online journals by researchers and scholars in Third World countries.¹⁹ In fact, government agencies, publishers, and other organisations are discussing how to develop more open access to research literature.^{22,23}

CONCLUSION

Journals that are available as FUTON or free FUTON are more visible and therefore have higher impact factors. Furthermore, becoming available online as FUTON or free FUTON may be causally associated with a significant increase in journal impact factor. These findings also suggest that FUTON bias exists (i.e. ignoring a relevant article simply because it is unavailable online). Researchers and others should be aware that these forms of bias might affect the results and conclusions of their scholarship.

REFERENCES

1. United States National Library of Medicine, National Institutes of Health [homepage on the Internet]. Bethesda (MD): National Institutes of Health; c2001-2005 [updated 2005 Feb 19; cited 2005 Feb 22]. Available from: <http://www.nlm.nih.gov/pubs/factsheets/medline.html>.
2. Van der Meer JW, Stalenhoef AF, Smits P, Thien T. Abstract! *Neth J Med* 2002;60:418.
3. Murali NS, Murali HR, Auethavekiat P, et al. Impact of FUTON and NAA bias on visibility of research. *Mayo Clin Proc* 2004;79:1001-6.
4. Kurmis AP. Understanding the limitations of the journal impact factor. *J Bone Joint Surg Am* 2003;85:2449-54.
5. Gowrishankar J, Divakar P. Sprucing up one's impact factor. *Nature* 1999;401:321-2.
6. Garfield E. Journal impact factor: a brief review. *CMAJ* 1999;161:979-80.
7. Curti M, Pistotti V, Gabutti G, Klersy C. Impact factor and electronic versions of biomedical scientific journals. *Haematologica* 2001;86:1015-20.
8. Neuberger J, Counsell C. Impact factors: uses and abuses. *Eur J Gastroenterol Hepatol* 2002;14:209-11.
9. Hill AB. The environment and disease: association or causation? *Proc R Soc Med.* 1965;58:295-300.
10. Perneger TV. Relation between online "hit counts" and subsequent citations: prospective study of research papers in the BMJ. *BMJ* 2004;329:546-7.
11. Tenopir C, King DW. Towards electronic journals: realities for scientists, librarians, and publishers. Washington (DC): Special Libraries Association, 2000. p. 59-67.
12. Tenopir C, King DW. Lessons for the future of journals. *Nature* 2001;413:672-4.
13. Bloch S, Walter G. The impact factor: time for change. *Aust N Z J Psychiatry* 2001;35:563-8.
14. Seglen PO. Why the impact factor of journals should not be used for evaluating research. *BMJ* 1997;314:498-502.
15. Van Diest PJ, Holzel H, Burnett D, Crocker J. Impactitis: new cures for an old disease. *J Clin Pathol* 2001;54:817-9.
16. Wentz R. Visibility of research: FUTON bias. *Lancet* 2002;360:1256.
17. Montori VM, Smieja M, Guyatt GH. Publication bias: a brief review for clinicians. *Mayo Clin Proc* 2000;75:1284-8.
18. Hawley JB. The JCI's commitment to excellence—and free access [editorial]. *J Clin Invest* 2003;112:968-9.
19. Aronson B. Improving online access to medical information for low-income countries. *N Engl J Med* 2004;350:966-8.
20. Khan FA. The Net is many people's only chance of access. *Nature* 2001;411:522.
21. Abbasi K, Butterfield M, Connor J, et al. Four futures for scientific and medical publishing. *BMJ* 2002;325:1472-5.
22. Butler D. Access to the literature: the debate continues. *Nature* [serial on the Internet]. 2004 Mar [cited 2005 Jan 13]; [about 1 p.] Available from: <http://www.nature.com/nature/focus/accessdebate/index.html>.
23. Harnad S, Brody T. Comparing the impact of open access (OA) vs non-OA articles in the same journals. *D-Lib Magazine* [serial on the Internet]. 2004 Jun [cited 2005 Jan 13];10(6): [about 6 p.]. Available from: <http://www.dlib.org/dlib/june04/harnad/o6harnad.html>.