# Impact of FUTON and NAA Bias on Visibility of Research

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OBJECTIVE: **To determine whether availability of journals on MEDLINE as FUTON (full text on the Net) affects their impact factor.**

MATERIAL AND METHODS: **A comprehensive search identified 324 cardiology, nephrology, and rheumatology/immunology journals on-line until May 2003. The status of these journals was ascertained in MEDLINE as having FUTON, abstracts only, and NAA (no abstract available). Impact factors for all available journals from the Institute for Scientific Information (ISI) were abstracted.**

RESULTS: **Of the 324 journals, 124 (38.3%) were FUTON, 138 (42.6%) had abstracts only, and 62 (19.1%) had NAA. The mean (±SEM) impact factor was 3.24 (±0.32), 1.64 (±0.30), and 0.14 (±0.45), respectively. Of the 324 current journals, 159 existed in both the pre- and the post-Internet era. An analysis of the change (ie, δ) in impact factor from the pre- to post-Internet era revealed a trend between journals with FUTON and abstracts only (*P*=.17, Wilcoxon rank sum test). Similar analyses of the δ of cardiology journals revealed a statistically significant difference between journals with FUTON and abstracts only (*P*=.04, Wilcoxon rank sum test).**

CONCLUSION: **FUTON bias is the tendency to peruse what is more readily available. This is the first study to show that on-line availability of medical literature may increase the impact factor and that such increase tends to be greater in FUTON journals. Failure to consider this bias may affect a journal's impact factor. Also, it could limit consideration of medical literature by ignoring relevant NAA articles and thereby influence medical education akin to publication or language bias.**

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**ANOVA = analysis of variance; EBM = evidence-based medicine; FUTON = full text on the Net; HSD = honestly significant difference; ISI = Institute for Scientific Information; NAA = no abstract available**

Evidence-based medicine (EBM) and its approach to the practice of medicine have gained considerable acceptance among health care professionals. The Association of American Medical Colleges advocates integration of the principles of EBM into undergraduate training. Promoted as a tool to further learning by inquiry,[1] steer clear from opinion-based medicine,[1] and help students at all levels of training[2-8] to conscientiously assess the best current evidence, EBM has been incorporated into the curriculum of an increasing number of US medical schools. The 2002-2003 Liaison Committee on Medical Education Annual Medical School Questionnaire revealed that 122 of 126 Liaison Committee on Medical Education–accredited schools included EBM as a required course and devoted a mean of 20 hours to it.[9]

The Internet has synergistically facilitated the exponential growth of EBM. The World Wide Web, a part of the Internet, is a cornucopia of databases, guidelines, calculators, tools, and links for the practice of EBM. Nevertheless, most full-text literature, scientific journals, and prefiltered resources in this kingdom of infinite Web space[10] is behind a firewall[11] and controlled by commercial publishers. A free, easy access and familiarity prompt most clinicians to access MEDLINE, the primary subset of PubMed from the US National Library of Medicine,[12] for scientific literature. MEDLINE/PubMed is the world's first and likely largest biomedical literature database, with citations from more than 4600 journals dating back to 1966.[12] However, scientific articles on MEDLINE/PubMed are available as FUTON (full text on the Net), abstracts only, or NAA (no abstract available).[13] For instance, at the time this article was written, a MEDLINE search for the MeSH (medical subject heading) term *myocardial infarction* identified 88,906 articles. Less than 8% of these articles were available as FUTON, 52% had abstracts only, and almost half (40%) had no text except a title or had no citation at all (NAA). Certain journals that are available free to all, even outside an academic institution, with no library subscription were labeled as *free FUTON* or *free abstracts*.

Reading is determined, among other things, by the ease of obtaining the literature. Clearly, few journals have barrier-free access, and a substantial proportion of current bioscience is inaccessible as FUTON to the average physician who can critically appraise it. The innate tendency to

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pick the "low-hanging fruit of convenience" greatly enhances the odds that a FUTON article will be read or cited. This can create a bias, the FUTON or NAA bias, that may impact the visibility of research.[13]

We sought to determine whether availability of journals (cardiology, nephrology, and rheumatology/immunology) as FUTON on MEDLINE or free FUTON on the Web affected their impact factor. The impact factor is a measure of the frequency with which an average article in a journal has been cited in a particular year or period. Impact factors have been published by the Institute for Scientific Information (ISI) since 1975 in its Journal Citation Reports. The Journal Citation Reports calculates an impact factor by dividing the total number of citations by the number of source items (original research, reviews, technical notes, or proceedings) published by a journal during the same 2-year reference period.[14] For instance, Journal Citation Reports 2001 calculates impact factors for journals through 1999 and 2000.

## MATERIAL AND METHODS

A comprehensive search was made to identify all cardiology, nephrology, and rheumatology/immunology journals worldwide using MEDLINE, PubMed, and EMBASE databases; on-line publishers such as HighWire, BioMed Central, and FreeMedJournals; and several search engines including Google, Yahoo, and Ask Jeeves.com. All journals available until May 2003 were compiled. We excluded all non-English journals, journals that were published after 1999, and journals whose publication was discontinued between 1998 and 2000. Journals that underwent title changes were identified and excluded to avoid duplication. The on-line status of these journals was ascertained in MEDLINE as having FUTON, abstracts only, and NAA. Additionally, journals that were available as free FUTON or free abstracts were identified from PubMed LinkOut, freemedicaljournal.com, and aforementioned publishers and search engines through a home computer without institutional access. Impact factors for all available journals from ISI Journal Citation Reports for 1992 and 2001 were abstracted. Also, we identified all US journals from List of Journals Index, Geographic Listing, in *Index Medicus 2003*, which is based on the country of origin of the current publisher. However, titles that indicated *American Journal of*, *Canadian*, or *European Journal of* were so designated regardless of the publisher's location.

We identified 324 journals. We excluded 6 journals to avoid double counting. Four FUTON and 2 on-line journals with abstracts only had changed their title or merged with another journal and were listed as 2 separate journals. For example, *British Heart Journal* became *Heart*, *Catheterization & Cardiovascular Interventions* was *Catheterization & Cardiovascular Diagnosis*, and *British Journal of Urology* was renamed *British Journal of Urology International*. Four journals, although listed in the citation index, did not have an impact factor listed (missing values) and hence were excluded. Of the remaining 324 journals, 159 were available in both the pre- and the post-Internet era (1992 and 2001, respectively).

### Statistical Analyses

**Primary Analysis.** For the 159 journals that were in existence in both the pre- and the post-Internet era (1992 and 2001), the change ($\delta$) in impact factor for each journal from the pre- to post-Internet era was calculated. A Kruskal-Wallis test was performed comparing the change in impact factor between each of the groups classified as FUTON, abstracts only, and NAA. The Wilcoxon rank sum test was used for 2-group comparisons of journals with FUTON and abstracts only. The journals were assigned to the same groups as they existed in 2001. For example, a journal classified as FUTON in 2001 (post-Internet era) remained classified as FUTON before the Internet era (1992), and the change in the impact factor calculated was assigned to the FUTON group. This same analysis was done for the subspecialty journals (cardiology, nephrology, and rheumatology/immunology). Journals that were available free on the Internet were also analyzed analogously.

**Secondary Analysis.** The secondary analysis included all 324 journals. A 1-way analysis of variance (ANOVA) along with the Tukey Kramer honestly significant difference (HSD) was done using the post-Internet impact factor data to compare differences in impact factors among the FUTON, abstracts only, and NAA groups. The same analyses were done for free journals on the Internet and the previously noted subspecialty journals. A similar analysis was done for the 159 journals that were in existence in both the pre- and the post-Internet era.

## RESULTS

Of the 324 journals identified in 2001, 159 existed in the pre-Internet era (Table 1). Most of these 159 journals were FUTON (53.5%) or had abstracts only (43.4%). Only 3.1% of the 159 journals had NAA. Assessment of change in impact factors based on on-line availability of journals before and after the Internet era was accomplished by classifying all available journals as described in the "Statistical Analyses" section. The median (range) of the difference in impact factor ($\delta$) was 0.66 (–1.97 to 13.82) for FUTON journals, 0.38 (–8.12 to 3.10) for abstracts only, and 0.23 (–0.20 to 0.94) for NAA. A Kruskal-Wallis test showed no statistically significant difference in the $\delta$

TABLE 1. **Evaluation for Causal Association of FUTON Journals and Impact Factors***

| | No. of journals | | | Impact factor | | |
|---|---|---|---|---|---|---|
| | FUTON | Abstracts only | NAA | Abstracts only, median δ (range) | FUTON, median δ (range) | *P* value |
| All journals (N=159) | 85 | 69 | 5 | 0.38 (–8.12 to 3.10) | 0.66 (–1.97 to 13.82) | .17† |
| Cardiology (n=53) | 32 | 21 | 0 | 0.32 (–0.33 to 3.09) | 0.66 (–0.30 to 4.11) | .04‡ |
| Nephrology (n=26) | 13 | 11 | 2 | 0.44 (0.09 to 0.80) | 0.76 (–1.09 to 2.32) | .45‡ |
| Rheumatology/ immunology (n=80) | 40 | 37 | 3 | 0.32 (–8.12 to 1.87) | 0.42 (–1.97 to 13.82) | .70‡ |
| Free journals (N=159) | 19 | 132 | 8 | 0.45 (–8.12 to 13.82) | 0.79 (–1.97 to 4.10) | .36‡ |

*FUTON = full text on the Net; NAA = no abstract available.
†For all 3 groups; Kruskal-Wallis test.
‡FUTON vs abstracts only; Wilcoxon rank sum test.

among the 3 groups (*P*=.31). Statistical comparison of the FUTON (n=85) and abstracts only (n=69) journals revealed a *P* value of .17 (Wilcoxon rank sum test). Although we were unable to show a causal relationship for the 159 journals available in both the pre- and the post-Internet era, a trend showed that being available on-line may affect a journal's impact factor. This was especially evident for cardiology journals: FUTON (n=32) vs abstracts only (n=21) revealed a *P* value of .04 (Wilcoxon rank sum test) (Table 1).

Of the 159 journals, 19 were available as free FUTON, 132 had free abstracts only, and 8 had NAA (Table 1). A similar analysis of assessment of change in impact factors by their on-line availability in both the pre- and the post-Internet era revealed no statistically significant difference in the δ among the 3 groups (Kruskal-Wallis test, *P*=.17). The median (range) of the difference in impact factor (δ) was 0.79 (–1.97 to 4.10) for free FUTON journals, 0.45 (–8.12 to 13.82) for free abstracts only, and 0.17 (–0.48 to 0.80) for NAA. As noted previously, with FUTON, the trend appeared to suggest that free full-text access affects a journal's impact factor (Table 1). Of the free FUTON journals, 8 were cardiology, 4 were nephrology, and 7 were rheumatology/immunology specialties.

A secondary analysis of the 324 journals in 2001 revealed that 124 (38.3%) were FUTON, 138 (42.6%) had abstracts only, and 62 (19.1%) had NAA (Table 2). The mean (±SEM) impact factor was 3.24 (±0.32), 1.64 (±0.30), and 0.14 (±0.45), respectively. A 1-way ANOVA and Tukey Kramer HSD revealed a statistically significant difference in the impact factor of these journals (*P*<.001) based on their availability as FUTON, abstracts only, or NAA (Table 2). An analogous subset analysis of individual specialties of cardiology (n=128), nephrology (n=60), and rheumatology/immunology (n=136) revealed similar statistically significant differences (*P*<.001, *P*<.001, *P*=.003, respectively) in the impact factors of journals based on their availability as FUTON, abstracts only, or NAA (Table 2). The highest impact factor was 10.52 among all cardiology journals, 6.34 among all nephrology journals, and 46.23 among all rheumatology/immunology journals.

Of the 324 journals, 177 were of US origin. Of these, 73 (41.2%) were FUTON, 75 (42.4%) had abstracts only, and 29 (16.4%) had NAA (Table 1). The mean (±SEM) impact factor was 4.02 (±0.53) for FUTON, 1.74 (±0.52) for abstracts only, and 0.13 (±0.83) for NAA (*P*<.001). This difference between FUTON and abstract only journals remained even when corrected by Tukey Kramer HSD.

Of the 324 journals, 26 were available as free FUTON, and 236 had free abstracts only that could be accessed from a home computer without institutional access in the post-Internet era (Table 3). Fewer than half of these free

TABLE 2. **On-line Availability of Subspecialty Journals and Their Impact Factors***

| | FUTON | | Abstracts only | | NAA | | |
|---|---|---|---|---|---|---|---|
| Journals | No. | Mean (±SEM) impact factor | No. | Mean (±SEM) impact factor | No. | Mean (±SEM) impact factor | *P* value† |
| All journals (N=324) | 124 | 3.24 (0.32) | 138 | 1.64 (0.30) | 62 | 0.14 (0.45) | <.001 |
| Cardiology (n=128) | 47 | 2.45 (0.25) | 60 | 1.12 (0.22) | 21 | 0 (0.37) | <.001 |
| Nephrology (n=60) | 21 | 2.07 (0.28) | 23 | 1.48 (0.26) | 16 | 0.16 (0.32) | <.001 |
| Rheumatology/ immunology (n=136) | 56 | 4.34 (0.67) | 55 | 2.27 (0.67) | 25 | 0.26 (1.0) | .003 |
| US origin (N=177) | 73 | 4.02 (0.53) | 75 | 1.74 (0.52) | 29 | 0.13 (0.83) | <.001 |

*FUTON = full text on the Net; NAA = no abstract available.
†Calculated for all groups by 1-way analysis of variance and Tukey Kramer honestly significant difference.

TABLE 3. **On-line Availability of Free FUTON Journals and Their Impact Factors***

| | Free FUTON | | Free abstracts only | | NAA | | |
|---|---|---|---|---|---|---|---|
| | No. | Mean (±SEM) impact factor | No. | Mean (±SEM) impact factor | No. | Mean (±SEM) impact factor | *P* value† |
| All journals (N=324) | 26 | 3.97 (0.70) | 235 | 2.22 (0.23) | 63 | 0.17 (0.45) | <.001 |
| Cardiology (n=128) | 9 | 4.69 (0.53) | 98 | 1.43 (0.16) | 21 | 0 (0.34) | <.001 |
| Nephrology (n=60) | 7 | 2.84 (0.48) | 37 | 1.50 (0.21) | 16 | 0.26 (0.32) | <.001 |
| Rheumatology/ immunology (n=136) | 10 | 4.11 (1.61) | 100 | 3.27 (0.51) | 26 | 0.24 (0.99) | .02 |

*FUTON = full text on the Net; NAA = no abstract available.
†Calculated for all groups by 1-way analysis of variance and Tukey Kramer honestly significant difference.

FUTON journals (n=11) were available at publication; more than 90% (n=24) were available at 1 year after publication. The embargo period on free availability varied from 6 months to 2 years. The mean (±SEM) impact factor was 3.97 (±0.70) for *free FUTON*, 2.22 (±0.23) for *free abstracts only*, and 0.17 (±0.45) for NAA ($P<.001$). Only 9 cardiology (7.0%), 7 nephrology (11.7%), and 10 rheumatology/immunology (7.4%) journals were available as free FUTON in 2001. A 1-way ANOVA of the mean (±SEM) impact factor for subspecialty free FUTON, free abstracts only, and NAA was statistically significant ($P<.001$, $P<.001$, and $P=.02$, respectively) (Table 3).

## DISCUSSION

To our knowledge, this is the first study to show that on-line availability of medical literature as FUTON or NAA may possibly determine a journal's impact factor. The impact factor is calculated by dividing the number of citations in the current year by the source items published in that journal during the previous 2 years.[14] This is thought to eliminate bias of large, more frequently published, and older journals vs smaller, less frequently published, and newer journals.[14] Journals with a high impact factor generally have more prestige, and a high impact factor is the top attribute that authors use in determining manuscript submission to a journal.[15] Decreasing impact factors are apparently a source of anguish for editors and publishers.[16,17] Also, some European countries have tended to apportion salaries, research funds, and academic promotions based on impact factors of articles authored by the physician-scientist. Although contentious,[16,17] the impact factor is accepted as a quantitative tool for ranking, evaluating, categorizing, and comparing journals, and when used wisely, it can compare visibility of a journal or its articles. The current study suggests that journals that are available on-line may be perceived to have a higher standing by virtue of being visible.

Our study emphasizes the relevance and importance of FUTON bias—the tendency to peruse what is more readily available and ignore relevant articles with NAA. In its effort to keep abreast of a rapidly evolving body of science, EBM relies on seeking best current evidence from virtual libraries or on-line sources and integrating them with patient values after ascertaining validity of the evidence by critical appraisal. It is perceived that this process helps avoid reliance on obsolete and archaic information from traditional textbooks.[1,18,19] Nevertheless, visibility and easy availability to the user may determine adoption of "available evidence" as "best current evidence" in health care. We informally questioned many physicians and residents at multiple national and international meetings in 2003. They uniformly admitted relying on FUTON articles on the Web to answer a sizable proportion of their questions. A recent study that surveyed computer use of 178 US primary care physician preceptors revealed that, of the 129 responders, 98% used the Internet as a resource for clinical information at least once a week.[20] Interestingly, most used FUTON articles to aid decisions about patient care or patient education and medical student or resident instruction. Also, the senior preceptors (≥60 years) compared with their younger colleagues were twice as likely to use MEDLINE-FUTON articles for decisions about patient care.[20] Therefore, there is undoubtedly a universal tendency to pick the low-hanging fruit of convenience, especially when little time is available to keep abreast of a constantly evolving science. We suspect that this strategy will likely make visible literature more prominent and therefore have a greater impact on everyday care. *Invisible research*, defined as not readily accessible on-line, may possibly be ignored or overlooked and therefore disregarded. Ignoring relevant NAA articles may limit consideration of medical literature akin to publication bias or citation as in language bias.[13,21]

In this study, we attempted to determine whether availability of literature as FUTON causally affected a journal's impact factor and also the visibility of research. We recognized that proving that FUTON journals had higher impact factors would not confirm causality because the corollary that journals with higher impact factors were available as FUTON was not disproved. To ascertain this, we restricted

our primary analysis to journals available in both the pre- and the post-Internet era (n=159). We believed that this was a more accurate measure than cross-sectional ANOVA to assess whether availability as FUTON was related to the impact factor because it ensured that each journal was its own control. An analysis of change in the impact factor for journals in the pre- and the post-Internet era based on availability as FUTON, abstracts only, or NAA was performed. We were unable to show a clear-cut causal relationship for the 159 journals available in both the pre- and the post-Internet era. Although unequivocal causality could not be proved between FUTON and abstract only journals ($P$=.17, Table 1), the median δ of the impact factor of the FUTON journals was approximately 75% greater than that of the abstract only journals. Strikingly, cardiology journals revealed a significant difference between FUTON and abstract only journals ($P$=.04, Table 1). There was significant disparity between the longitudinal and cross-sectional analysis (Tables 1 and 2). One-way ANOVA with Tukey Kramer HSD revealed that the mean impact factor of FUTON journals was significantly higher than that of journals with abstracts only or NAA ($P$<.001, Table 2). Overall, the trend suggests that on-line availability has a tendency to increase the impact factor and that FUTON journals tend to have greater increases in the impact factor.

Access to electronic databases is costly. Even large university libraries are concerned about costs for institutional subscriptions and licensed authorization to databases. For example, the Mayo Foundation Library in Rochester, Minn, pays more than $800,000 annually for access to databases and approximately 400 full-text journals. Despite this investment, our study reveals that only about a third (38.3%) of the journals are available as FUTON at our institution. If this is the extent of accessibility for researchers and clinicians at major academic institutions, the amount of invisible research that may be ignored or overlooked is much higher. Certainly, organizations with low financial reserves are likely to be affected even more. Our study reveals that journals that have abstracts available on electronic databases have statistically significantly higher impact factors compared with journals with NAA (Table 2). Therefore, it is crucial that journals with financial constraints provide a comprehensive abstract in a structured format.[22] Unfortunately, most journals have not adopted this strategy.

Journals that offer free access to users are likely to attract an even wider audience. For example, after the *Journal of Clinical Investigation* offered barrier-free access, it gained an average of 17,000 more users weekly in mid-2003 compared with mid-1997 when it was available in print form only.[11] Our study reveals that, although free FUTON journals comprise less than 10% of all journals, they all have statistically higher impact factors (Table 3) compared with "subscription FUTON" journals available in Ovid MEDLINE (institutional subscription). The latter are mainly available as abstracts only on PubMed. Financial resources perhaps limit the ability of individual journals to be available free immediately after publication. Journals with higher impact factors are likely more reputable, have more funds, and are able to provide free FUTON and therefore improve their impact factor further. Interestingly, many of these free FUTON journals have embargo periods, varying from 6 months to 2 years, from the time of publication. Our study findings suggest that journal editors and commercial publishers should consider having articles that discuss important advances available free on-line at least after a defined period. Alternatively, the risk is that research published in their journal is irrelevant to the average user. One could argue, however, that even short embargo periods are relatively long because of the rapidity of evolving science. We suspect that, as organizations like the Public Library of Science and European Renal Association become prominent, licensed or restricted low-impact non-FUTON resources may find it difficult to make their research visible. Recently, *BMJ* closed its free on-line access. Monitoring its impact factor in the next few years to determine whether it decreases would shed light on the bias of FUTON.

Geographical origin of a journal may affect its impact factor. Journals of US origin are generally thought to have higher impact factors, whereas non-US journals are believed to have lower impact factors. Also, not all non-US journals are available as FUTON. These 2 characteristics could contribute to an apparent difference in impact factors among journals with FUTON, abstracts only, and NAA in the absence of a true difference if most of the journals with abstracts only or NAA in our study were low-impact, non-US journals. This could be an important confounding variable because we considered all journals published worldwide. We therefore attempted to eliminate this bias by exclusively comparing impact factors and on-line availability of journals of US origin (Table 2). The data clearly showed that the difference persisted even in journals of US origin, suggesting that the observed difference in impact factors between FUTON and abstract only journals is indeed real ($P$<.001).

A limitation of our study is that we cannot extend FUTON bias to non-English journals. We opted to exclude non-English journals from our study to reduce confounding variables. Of the approximately 5000 worldwide journals recognized in the Science Citation Index, a substantial bias is toward English publications. Moreover, until 2001, 89% of citations on MEDLINE were in English. Ipso facto, most of the non-English journals available on MEDLINE will

have an impact factor of zero, thereby confounding our ability for true assessment. Another constraint is the inherent limitation of the impact factor—it is a product of a commercial institution, which by definition cannot be free of commercial interests. Also, it is not designed to assess the quality of a journal or grade authors, and there are Machiavellian ways to exploit the method of calculation.[23-25] Therefore, it is possible that some of the journals we identified did not have an impact factor for some of these reasons. However, in the absence of clear alternatives, the impact factor is arguably the best index for a qualitative, intradisciplinary comparison of journals.[26-28]

## CONCLUSION

Access to electronic literature at the bedside, anecdotally at least, has been associated with a significant decrease in library patrons and use of photocopying services in the past 5 years at the Mayo Foundation libraries. This is further underscored by the observation that more than 50% of Internet sessions end with the downloading of a full-text article.[10] As more research is being communicated electronically, health science libraries have increasingly adopted the policy of on-line subscriptions. This trend in conjunction with the FUTON bias may have broad implications for the future of medical education. Residents and younger medical students tend to rely heavily on articles that are available on-line.[13] Although we all have biases in our reading habits, the casual reader is not as well versed with the techniques of detailed literature searches and critical appraisal as is an established researcher and may be confused by the variable quality of free full-text information available.[29-31] Even experienced users rely on poorly rated health information.[30] Therefore, FUTON bias could systematically affect the roots of our medical education.

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