

INVITED COMMENTARY

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Citation Trends and Practices in the Journal of Forensic Sciences as Documented by ISI's Journal Citation Report

ISI stands for Institute for Scientific Information, which is a Philadelphia-based organization specializing in retrieving, documenting and evaluating bibliometric information about science, scientists and scientific journals. The company was founded in 1960 by Eugene Garfield Ph.D. and has since grown into a multi-million dollar worldwide organization (1–3). Among the many information products produced by ISI, perhaps the most sophisticated and widely acclaimed is the Science Citation Index (SCI) (4–6). The first edition of SCI was produced in 1963 and in many ways this database is unique because the fate of a published article and the citations it receives can be followed forward in time, whereas other databases permit retrospective searching but not prospective (2). The SCI gives cumulative information about cited articles (volume, page numbers, and year), the frequency of citation, the name, volume, and year of the citing journal, and the names of the authors (2,7). However, citation counts are listed under the name of the first author of the cited article. In 1965, ISI introduced a new product relevant to citation analysis called Journal Citation Reports (JCR), which is a database devoted to the citation practices of the journals covered by SCI.

Both SCI and JCR are now available as CD-ROM versions making them more convenient and easier to use because they contain masses of information derived from several thousand scientific journals covered by ISI. For each journal, JCR contains the names of cited as well as citing journals and the frequency of citation of

articles published in these journals during previous years. Table 1 gives bibliometric information for the Journal of Forensic Sciences (JFS) according to ISI's journal citation reports for the years 1989–1995.²

Listed are the total number of times that other journals cited articles published in JFS including self citations, that is when JFS cited itself, the number of citable items (articles and reviews published in JFS each year), the impact factor, the immediacy index, and the citation half-life.

Impact factor

Probably the most interesting and widely discussed item of information in Table 1 is the journal impact factor (IF). This term was coined by Eugene Garfield for the purpose of ranking, evaluating, and comparing different scientific journals (7–9). The impact factor is a measure of the frequency with which the average article in a journal is cited within a given time frame. The 1995 impact factor for JFS is calculated by dividing the number of citations received in 1995 to articles published in JFS in the previous two years (1993 and 1994), by the number of citable items in 1993 and 1994 (8).

Journal impact factors usually range from 0.00 to about 50.0, which means that the *average* article published in such journals during the two previous years was either never cited at all or the

TABLE 1—Bibliometric data for Journal of Forensic Sciences compiled from ISI's journal citation reports for the years 1989–1995.

Year	Total Cites*	Cites from AC†	Citable Items*	Impact Factor*	Impact Factor‡	Immediacy Index*	Citation Half-life*
1995	1744	164	194	1.22	0.74	0.191	5.8
1994	1341	3	167	0.62	0.61	0.156	6.7
1993	1298	172	172	1.15	0.68	0.116	5.0
1992	1275	7	174	0.66	0.63	0.155	6.6
1991	1295	168	189	1.10	0.57	0.127	5.5
1990	1005	17	162	0.56	0.51	0.055	6.6
1989	992	142	157	0.74	0.35	0.146	5.4

* See text for definitions and meaning of terms.

† Number of cites from Analytical Chemistry to JFS articles published in previous 2-years.

‡ Adjusted for number of citations received from the journal Analytical Chemistry.

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² The Journal Citation Reports for 1995 is the latest edition available. Received 12 Dec. 1997; accepted 2 Jan. 1998.

TABLE 2—Ranking of journals within the subject category “Medicine, Legal” according to the CD-ROM versions of ISI’s Journal Citation Reports for 1994 and 1995.

Journal Abbreviation 1995 (Ranking)	Total Citations 1995 (1994)	Citable Items 1995 (1994)	Impact Factor 1995 (1994)	Immediacy Index 1995 (1994)	Citation Half-Life 1995 (1994)
Int J Legal Med (1)	415 (159)	76 (62)	1.915 (0.851)	0.118 (0.113)	2.6 (2.4)
J Med Ethics (2)	380 (278)	53 (40)	1.342 (0.930)	0.340 (0.350)	4.4 (4.9)
Forensic Sci Int (3)	884 (641)	155 (123)	1.254 (0.492)	0.297 (0.098)	3.7 (5.7)
J Forens Sci (4)	1744 (1341)	194 (167)	1.224 (0.621)	0.191 (0.156)	5.8 (6.7)
J Forens Sci Soc* (5)	234 (209)	0 (32)	0.846 (0.333)	+ + + (0.250)	7.0 (>10)
Reg Toxicol Pharm (6)	492 (414)	66 (69)	0.832 (1.234)	0.212 (0.101)	5.0 (3.9)
Pharmacopeial Forum (7)	93 (41)	33 (30)	0.769 (0.233)	0.273 (0.100)	not given
Med Sci Law (8)	293 (278)	30 (28)	0.380 (0.225)	0.233 (0.036)	8.0 (7.9)
Am J Forens Med Path (9)	256 (216)	67 (63)	0.315 (0.227)	0.0 (0.0)	6.4 (—)
Crime Lab Digest (10)	30 (19)	7 (8)	0.222 (0.056)	0.0	not given

* The name of this journal was changed in 1994 to Science & Justice.

average article was cited 50 times. Clearly, a journal can acquire a high impact factor by publishing many articles that eventually become highly cited within 1–2 years after publication. However, it is important to remember that an article is not necessarily highly cited because it appears in a journal with a high impact factor. In a critique of the use of journal impact factor for evaluating research papers, Seglen (10) has aptly commented “Science deserves to be judged by its contents, not by its wrapping.”

Forensic science journals generally have low impact factors compared with other journals in the life sciences as discussed elsewhere (11,12) but mainly because of the relatively small size of this applied speciality (e.g., compared with biochemistry). Also the publishing practices of forensic scientists, as reflected in the average number of papers they produce, is often very different from those engaged in basic research. To allow a comparison of impact factors for closely related and sometimes rival journals, JCR produces subject category listings of relevant bibliometric data (13). Thus, forensic science journals are grouped into a category called “Medicine, Legal” which currently includes 10 journals and these are rank ordered in Table 2 according to their 1995 impact factor. It can be seen that International Journal of Legal medicine (Springer Verlag) tops the list with an impact factor of 1.915 compared with Journal of Forensic Sciences, which is fourth in the list, having an impact factor of 1.224. Table 2 also gives the corresponding bibliometric information for these same journals in 1994 (values in brackets).

The ready availability of journal impact factors has made them very popular among science administrators as a tool for comparing and evaluating the published work of individual scientists and also entire university department (15–17). Indeed, calculating a total and average impact factor from the articles listed in a person’s bibliography is being used increasingly in connection with making university appointments such as decisions about tenure and the awarding of grants and scholarships (18,19). Librarians are also beginning to look more closely at impact factors when decisions are made about whether or not to continue with a journal subscription (14,20). A journal with a low impact factor tends to suggest that the articles it publishes have not proven sufficiently useful to warrant citation by other scientists in preparing their papers for publication.

Impact factors for forensic science journals (Table 2) are significantly lower than for other disciplines such as biochemistry, immunology, or bacteriology, not to mention molecular biology and cancer research (10,17). Journals that publish many review articles

or methods papers tend to attract lots of citations and therefore attain high impact factors (2,21). The 1995 impact factor for Annual Review of Biochemistry was 40.4, for Annual Review of Immunology 44.4, for Pharmacological Review 30.3, and for Annual Review Neuroscience 29.0. Thus by publishing one or more review articles in every issue of the journal is one approach to attract more citations and therefore eventually boosting the impact factor.

Immediacy Index and Citation Half-Life

Several other bibliometric performance indicators are presented in Table 2 including the immediacy index and the citation half-life although these have not attracted as much interest as impact factor for evaluating published articles and the scientific journals where they appear (13). The immediacy index is the ratio of the number of cites in the current year to the number of citable items published in that same year. The immediacy index therefore gives an indication as to how rapidly recently published articles become cited. The cited half-life is defined as “the number of journal publication years from the current year back whose articles have accounted for 50% of the total citations received in a given year” (13). The cited half-life tells something about the rate of obsolescence of information in a particular subject field, but its significance for comparing different journals remains to be fully evaluated (13,14).

Reasons for Citing

The basic premise of citation indexing is that the contributors (authors) of a published paper consider that information contained in another article (either one of their own or penned by other scientists) is of sufficient interest and relevance to be cited in their publication. However, I sometimes wonder how much thought and deliberation goes into choosing the articles cited in the reference lists at the end of some scientific papers. Unfortunately, few peer-reviewers seem to evaluate critically these reference lists particularly the relevance of the items cited. During my work as peer reviewer, I have sometimes discovered that the references cited in a manuscript have little or no relevance to the point being made or discussed in the body of the text. This haphazard way of choosing references has meant that the papers submitted for review have scored low marks in my peer assessment. Moreover, the accuracy

of the cited references sometimes leaves much to be desired. Errors in the spelling of authors names is very common, the use of non-standard journal abbreviations, volume number, year of publication and page numbers are often incomplete or inaccurate. Several journals have made surveys of the accuracy of cited references in the articles they publish and the results have not been very impressive, which mainly reflects careless authors rather than mistakes made by editorial staff and the peer reviewers (22,23).

Cited versus Citing Journal

Journal Citation Reports contains listings of citing and cited journals that document the frequency of citation between pairs of journals and how these are distributed according to the year of publication. The difference between cited and citing journal is rather subtle. If an article published in JFS cites a paper published in Forensic Science International (FSI), then JFS is the citing journal and FSI receives a citation, thus being the cited journal. The number of times during a particular year that one journal cites articles published in another journal or is cited itself are counted and distributed by year of the publication date of the cited material (13). By looking at trends over time in terms of cited and citing journals and publication dates much useful information can be derived about citation practices and the journal "impact factor" can be calculated (8). The IF has been much discussed and debated in recent years as an index of the quality of a journal, the articles it publishes, and indirectly the authors of these articles (17,18,21). One reason that International Journal of Legal Medicine has more than doubled its impact factor between 1994 and 1995 (Table 2) might be the greater emphasis placed on articles dealing with DNA fingerprinting and application of this techniques in forensic science, forensic pathology, and serology such as in paternity investigations (24).

The impact factor (IF) of a specific journal is defined as the ratio between citations received and citable items published over a defined period of time. The role played by self-citations in boosting a journal's impact factor deserves some consideration (8). Looking at the 1995 citations to International Journal of Legal Medicine for 1993 and 1994 articles, one finds 53% ($n = 107$) are self citations compared with 35% ($n = 140$) for 1994. This compares with 16% and 23% self citations in Journal of Forensic Sciences for 1994 and 1995 respectively. Garfield (8) has proposed a method to adjust the journal impact factors for the number of self citations. After making this calculation for International Journal of Legal Medicine and Journal of Forensic Sciences, I found that the revised impact factors for 1995 were 1.09 and 0.98 respectively, thus giving the same rank ordering but now being much closer together.

What can be done to increase the impact factor of JFS? One way would be to encourage authors to increase the number of items included in the references lists of the articles they submit for publication, and at the same time give preference to articles published in Journal of Forensic Sciences during the previous two years. Although this practice of self-citation of recent articles was recommended by one journal editor, it was criticized by another as being unethical and a rather dubious practice (25). Garfield however endorses this practice (26).

Cited Journal Listing

By examining information about the Journal of Forensic Sciences as the cited journal, one can evaluate which journals cite articles published in JFS, the frequency with which the articles are cited and the development in citation counts over a number of

years. In 1994 and 1995, totals of 122 and 149 different journals cited articles published in JFS. Table 3 gives citation data for 1995 to 1991 but to save space, only the top-6 citing journals are listed for each year. Also the frequency of citations to articles published in JFS has been restricted to those appearing in print during the preceding 6 years. Not surprisingly JFS tends to cite its own articles the most, these being called self-citations. The important numbers in table 3 for calculating the 1995 impact factor are obtained from the columns headed 1994 and 1993 articles. If the sum of these two numbers (177 + 238) is divided by the number of citable items (Table 1) published in 1994 and 1993 (167 + 172), we obtain the 1995 impact factor for JFS as $(177 + 238)/(167 + 172) = 1.224$.

During the preparation of this article, I noticed that the impact factor for JFS fluctuated year-by-year from high to low over the past 7 years (see Table 1 and Fig. 1). Furthermore, the journal entitled Analytical Chemistry played a dominant role as a citing journal to JFS articles in those years when the impact factor was relatively high. Table 3 shows that in 1995, Analytical Chemistry cited 1994 articles published in JFS a total of 80 times and 1993 articles in JFS were cited 84 times giving a total of 164 counts (Table 1) for computing the impact factor. Similar high citation counts were obtained from Analytical Chemistry in 1993 (to 1992 and 1991 articles) and in 1991 (to 1990 and 1989 articles). This cluster of citations from Analytical Chemistry plays a major role in boosting the numerator in the equation for calculating impact factor. By contrast, in the years 1994, 1992, and 1990 the impact factors of JFS were relatively low (Table 1 and Fig. 1) and, interestingly, Analytical Chemistry hardly cited JFS articles published in the previous two important years used for computing impact factors for 1994, 1992 and 1990. The broken line in Fig. 1 shows the trend over time in the impact factor for JFS after eliminating the citations from Analytical Chemistry. After making this adjustment, the year-to-year fluctuation of JFS's impact factor is eliminated and instead one notes a slight increase in the IF between 1989–1995 with an average value of about 0.6.

The reason for this change in citation practice by Analytical Chemistry was easy to discover. Every two years, an issue of Analytical Chemistry is devoted to "Application Reviews" and one of the topics covered deals with developments in the Forensic Sciences over the previous two years (27). This review article is put together by Brettell and Saferstein and is essentially a compilation of references published in the major forensic journals within the two years between successive reviews. Indeed, the reviews, which appeared in 1997, 1995, 1993, and 1991 contained 811, 843, 824, and 681 citations respectively and many of these were to articles published in JFS. This helps to explain the higher impact factors for JFS in 1995 (IF 1.224), 1993 (IF 1.154) and 1991 (IF 1.103) compared with 1994 (IF 0.621), 1992 (IF = 0.655) and 1990 (IF = 0.560). If this argument holds one might predict that JFS's impact factor for 1996 will drop from its current 1995 high value of 1.224 to around 0.6–0.7. This follows because the "Application Reviews" is not published by Analytical Chemistry in 1996, so JFS articles will not receive as many citations from this journal. Application Reviews did not appear in 1994 and Analytical Chemistry gave JFS only 3 citations to its source items published in 1992 and 1993, the critical years for calculating impact factor. Commissioning reviews of progress in forensic sciences would help to increase the impact factors of the journals listed in ISI's sub-category Medicine, Legal.

Citing Journal Listing

The names of the journals most frequently cited in the reference lists of articles published in JFS can be gleaned from looking at

TABLE 3—*Journal Citation Report for Journal of Forensic Sciences as the cited journal for the years 1995 to 1991. Note that only the top-6 citing journals are listed for articles appearing in print for the past 6 years including the target year.*

1995							
Citing Journal (Abbreviation)	All Years	1995 Articles	1994 Articles	1993 Articles	1992 Articles	1991 Articles	1990 Articles
All Journals	1744	37	177	238	131	181	127
J Forens Sci	415	13	28	55	41	54	35
Forens Sci Int	185	1	8	21	13	20	12
Anal Chem	166	0	80	84	0	2	0
J Analyt Tox	69	2	1	5	7	3	5
Int J Leg Med	66	74	7	7	8	5	5
Mol Aspects Med	37	6	7	6	6	2	2

1994							
Citing Journal (Abbreviation)	All Years	1994 Articles	1993 Articles	1992 Articles	1991 Articles	1990 Articles	1989 Articles
All Journals	1341	26	109	106	166	112	107
J Forens Sci	323	5	43	33	40	26	19
Forens Sci Int	160	2	16	10	19	15	8
J Chrom A	91	1	9	11	16	6	5
Anal Chim Acta	81	0	0	5	15	5	5
J Analyt Tox	37	0	2	4	1	4	5
Int J Leg Med	34	0	3	4	7	3	0

1993							
Citing Journal (Abbreviation)	All Years	1993 Articles	1992 Articles	1991 Articles	1990 Articles	1989 Articles	1988 Articles
All Journals	1298	20	169	250	129	80	70
J Forens Sci	381	15	48	72	30	24	18
Anal Chem	192	1	79	93	17	0	0
Forens Sci Int	53	0	2	6	9	2	3
Int J Leg Med	50	0	5	11	10	3	5
J Analyt Tox	45	0	5	3	1	6	1
J Chem Ed	24	0	0	3	3	0	2

1992							
Citing Journal (Abbreviation)	All Years	1992 Articles	1991 Articles	1990 Articles	1989 Articles	1988 Articles	1987 Articles
All Journals	1275	27	102	128	138	85	98
J Forens Sci	359	16	36	30	35	32	27
Forens Sci Int	117	2	7	6	3	7	9
Adv Chromatog	65	0	0	6	13	9	7
J Analyt Tox	62	2	8	6	8	2	2
J Chrom Biomed	44	0	4	8	6	3	3
Int J Leg Med	21	0	5	6	2	1	1

1991							
Citing Journal (Abbreviation)	All Years	1991 Articles	1990 Articles	1989 Articles	1988 Articles	1987 Articles	1986 Articles
All Journals	1295	24	176	176	104	102	112
J Forens Sci	356	16	27	41	32	33	32
Anal Chem	181	1	93	75	1	2	2
Forens Sci Int	84	1	9	3	6	5	11
J Analyt Tox	42	1	6	5	4	0	8
J For Sci Soc	42	0	3	3	3	4	6
Int J Leg Med	33	1	9	2	5	0	2

The cluster of citations received from Analytical Chemistry for the years 1995, 1993, and 1991 can be attributed to the biannual "application review" entitled Forensic Science and compiled by Brettell and Saferstein.

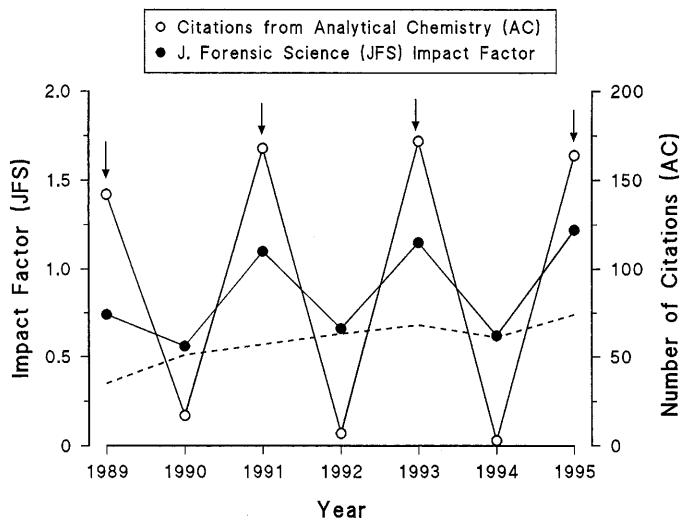


FIG. 1—Variation in impact factor of *Journal of Forensic Sciences* between 1989 to 1995 and the number of citations received from *Analytical Chemistry* as the citing journal to JFS articles published in the previous two years. The arrows indicate years when *Analytical Chemistry* included an issue entitled *Application Reviews* with one chapter devoted to recent developments in forensic sciences. The broken line depicts the change in impact factor over time without including citations from *Analytical Chemistry*.

JCR's citing journal listing. Examining such lists for 1994 and 1995, one finds that 284 and 345 different journals were cited in the reference lists published in JFS articles during these years. Table 4 gives the names of the 5 most highly cited journals during this period and as expected the number of self-citations dominates, that is when JFS cites its own articles. Other forensic journals are clearly well represented including *Forensic Science International* but also *Journal of Analytical Toxicology* (Preston Publications, USA) which had a 1995 impact factor of 2.03. The ratio of citing to cited journals in 1994 and 1995 for JFS was $284/122 = 2.32$ and $345/149 = 2.31$ and these figures may have some significance

as a reflection of the size of the forensic sciences as a research front compared with other disciplines (28).

Conclusions

The field of bibliometrics has grown enormously over the past few decades perhaps because of the interest shown by sociologists of science and science administrators as well as government funding agencies who like to track developments in research in terms of number of publications and citation counts. Also the ready availability of on-line databases and CD-ROM versions of the traditional multi-volume paper bound editions of *SCI* and *JSR*, has made them more user-friendly. The use and misuse of journal impact factor for the purpose of assessing the work of individual scientists and their professional standing and esteem among their peers has been much debated in the correspondence pages of the popular weekly magazines such as *Nature* and *Science* (29–31).

Among academic scientists the concept of "impact factor" is widely known and sometimes also misused as an index of quality; some university deans are seemingly mesmerized by this mark of distinction. The heads of university departments and academic staff are encouraged to submit their articles for publication to journals with impact factors above a threshold of 2.0. Interestingly, none of the forensic journals (Table 2) meet this standard. When assessing track records and the quality of published work, instead of counting the sum and average of the impact factors of the journals where a person publishes his or her work, the number of citations to individual articles should be investigated instead, but this exercise demands much more effort (32,33). A strong case can be made for adjusting impact factors and citation counts for the number of co-authors (contributors) to an article and perhaps the ordering of the names on multi-author articles should also be considered (34,35).

Government forensic scientists probably care little about the notion of journal impact factor because their promotion prospects and salary increments are not connected to scientific productivity as reflected in their publication track records. Indeed, the trend in some countries towards charging a fee for every kind of forensic science service, including information and documentation, will

TABLE 4—*Journal Citation Report for Journal of Forensic Sciences as the citing journal for the years 1995 and 1994. The top 5 cited journals are listed for articles published over a six year period.*

1995							
Cited Journal (Abbreviation)	All Years	1995 Articles	1994 Articles	1993 Articles	1992 Articles	1991 Articles	1990 Articles
All journals	3233	28	176	290	320	329	269
J Forens Sci	415	13	28	55	41	54	35
J Anal Tox	77	0	4	12	13	10	8
Forens Sci Int	69	2	5	7	6	11	91
Am J Hum Genet	61	0	3	7	9	24	6
Int J Leg Med	53	0	4	21	15	13	0
1994							
Cited Journal (Abbreviation)	All Years	1994 Articles	1993 Articles	1992 Articles	1991 Articles	1990 Articles	1989 Articles
All journals	2577	12	148	268	285	222	204
J Forens Sci	323	5	43	33	40	26	19
J Anal Tox	77	1	9	9	7	5	1
Forens Sci Int	70	0	2	5	7	14	7
Am J Forens Med Pathol Science	42	0	5	4	2	4	5
Science	44	1	5	6	13	3	0

probably hamper research and development in this field. The spontaneous writing of articles and case reports for publication in forensic journals to spread knowledge and information to colleagues at home and abroad might become a thing of the past. Writing a scientific paper and getting it published in a peer-review journal is time consuming but not very cost effective. The major focus of the scientific civil service seems to be directed more towards business (attracting customers, covering costs, and breaking even), rather than research and scholarship.

An obvious reason for the low impact of forensic journals is the lack of motivation among forensic scientists to spend their time writing papers. If forensic scientists don't publish papers articles penned by their colleagues and the forensic journals where these appear won't accumulate citations and the impact factors will remain low. In contrast, the rewards of publishing—prestige, grants, promotion, invitations to attend conferences, etc.—are well known to academic scientists, and hence their greater drive to publish papers. Whether forensic science will prosper in the next millennium will depend on the allocation of resources (time and money) for research and scholarship as opposed to business planning meetings and marketing strategy.

The very nature of forensic science, namely the application of science to law enforcement and the fight against crime suggests that one should perhaps look at other indicators of professional standing, competence and expertise, rather than citation counts and journal impact factors as an index of quality. For example, one might investigate how often a scientist's name or his or her published work is cited in criminal and civil litigation, e.g. dealing with topics such as DNA fingerprinting or drunk driving offences. This notion of looking at "court citations" as a mark of distinction and direct usefulness of a scientist's publications, especially for those working in the forensic sciences, might be more relevant but to my knowledge such data have not yet been examined and quantified.

In conclusion, journal impact factors exist and cannot be ignored but they should not be used blindly to compare the work of individual scientists from different disciplines or even those engaged with specialist topics within the same discipline. Furthermore, the observation made here that a single biannual survey of the forensic science literature can make such a big difference to the impact rating of JFS, makes me wonder whether we should be considering impact factors at all when we ponder over which forensic science journal should receive our next paper for peer-review.

Note Added in Proof

After this manuscript was submitted for publication, ISI's Journal Citation Reports for 1996 became available. The 1996 impact factor for Journal of Forensic Sciences had now decreased from 1.22 in 1995 to 0.867. Indeed, JFS articles published in 1995 and 1994 were cited only 8 times by Analytical Chemistry in 1996. After adjusting JFS's 1996 impact factor for the 8 cites from Analytical Chemistry, I arrived at an impact factor of 0.844. For reasons discussed elsewhere in this article JFS's impact factor in 1997 can be expected to increase appreciably and will probably exceed 1.3, owing to the Brettell-Saferstein effect. This follows because in 1997 Analytical Chemistry published its biannual review of the forensic science literature which contained plenty of citations to JFS articles published in 1995 and 1996.

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