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Crème de la crème in forensic science and legal medicine

The most highly cited articles, authors and journals 1981–2003

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Abstract The importance and prestige of a scientific journal is increasingly being judged by the number of times the articles it publishes are cited or referenced in articles published in other scientific journals. Citation counting is also used to assess the merits of individual scientists when academic promotion and tenure are decided. With the help of Thomson, Institute for Scientific Information (Thomson ISI) a citation database was created for six leading forensic science and legal medicine journals. This database was used to determine the most highly cited articles, authors, journals and the most prolific authors of articles in the forensic sciences. The forensic science and legal medicine journals evaluated were: Journal of Forensic Sciences (JFS), Forensic Science International (FSI), International Journal of Legal Medicine (IJLM), Medicine, Science and the Law (MSL), American Journal of Forensic Medicine and Pathology (AJFMP), and Science and Justice (S&J). The resulting forensics database contained 14,210 papers published between 1981 and 2003. This in-depth bibliometric analysis has identified the crème de la crème in forensic science and legal medicine in a quantitative and objective way by citation analysis with focus on articles, authors and journals.

Keywords Bibliometrics · Citations · Impact factors · Forensic science · Journals · Legal medicine

Introduction

Success in science is closely related to prolific authorship of research papers that become highly cited in the papers penned by other scientists [1–3]. Highly cited scientists often achieve greatness and citation analysis has been used

with moderate success to predict winners of the Nobel Prize [3]. Every substantive scientific paper contains a list of references or footnotes and these are the starting point for citation indexing and evaluating scientific impact with the underlying assumption that the number of citations to a particular article reflects its significance in the field [4, 5]. Citations therefore create links with previously published work deemed relevant for preparing the work in question. It is generally accepted that a citation is a form of peer recognition or acknowledgement, which is necessary to expand on previously published work [3–5].

Accumulating a long list of publications that subsequently become highly cited is crucial to achieve success in academia [6–8]. Garnering a large number of citations enhances promotion prospects and helps to obtain research funding and “citation superstars” are often awarded medals and prizes for scientific achievements [3, 9]. Indeed, the quantity and quality of an applicant’s published work has a major influence on outcome in all kinds of peer evaluation [10–12]. In this connection, citations are increasingly being used to evaluate the research production of university departments, entire universities and also the scientific productivity and impact of nations [13, 14]. In recent years more and more emphasis has been given to the prestige of the journals where a person publishes papers more so than the total number of papers on a person’s CV [2, 14–16].

Scientific journals can be compared and contrasted in a number of ways, such as by the size of the circulation, readership numbers, the number of items received for publication and the prestige and scientific standing of the editor and the editorial board members [9, 15]. Another way that has attracted considerable attention, as well as much debate and discussion, is the so-called journal impact factor [15–20]. The impact factor is a ratio between the number of citations to a journal’s articles and the number of citable items over a given time period, usually 2 years after the year the article appeared in print. Dividing by the number of citable items normalizes for journals of different size and frequency of issues and therefore the numbers of papers published each year.

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Impact factors (IF) of the journals covered by Thomson ISI range from zero for the least cited journals to about 50 for the most cited journal (median 0.91 for $N=5,907$ journals). A journal with an impact factor of 50 (e.g. in 2003) means that citations received in 2003 to articles published in the previous 2 years (2002 and 2001) were cited on average 50 times per year. One should realize that the impact factor refers to the citation frequency of the average article in a journal and not a specific article, which implies that publishing in a high-impact journal does not necessarily guarantee that your article gets highly cited. A significant proportion of articles published remain uncited, whereas others are cited hundreds or thousands of times and become known as citation classics [3, 21–23].

Here I present a bibliometric evaluation of the leading forensic science and legal medicine journals with the main focus on the most prolific authors, the most highly cited articles and journals, and the impact factors of these journals.

Institute for Scientific Information (ISI)

The database of forensic science and legal medicine journals used in this study was provided by the Thomson Institute for Scientific Information (ISI, Philadelphia, PA) [21, 24]. This organization is best known for producing Current Contents and the Science Citation Index as well as Journal Citation Reports (JCR), which contains among other things the impact factors of several thousand scientific journals [21, 24]. The JCR includes forensic science and legal medicine journals within the sub-category “Medicine, Legal” and in 2003 this comprised 9 titles.

Several of the journals currently listed under ISI’s “Medicine, Legal” category seemingly have little to do with mainstream forensic science and legal medicine. These journals were Expert Opinion on Therapeutic Patents (IF=1.64), Regulatory Toxicology and Pharmacology (IF=1.44) and Journal of Law and Medical Ethics (IF=1.37). Accordingly, the citation records of these journals were omitted from the present bibliometric evaluation.

The journals included in this survey are listed in Table 1 along with the year-by-year changes in their impact factors from 1997 to 2003. As mentioned above, the impact factor is a ratio between recent citations to articles published in the target journal and the number of citable items published. The 2003 impact factor is calculated by taking the number of citations in 2003 to items published in the journal over the previous 2 years and dividing by the number of articles published in the same 2-year period.

Impact factor (IF) =

$$\frac{\text{Citations in 2003 to articles published in 2002 and 2001}}{\text{Number of citable items published in 2002 and 2001}}$$

The citable items represent the number of articles and reviews published in the journal within the 2-year citation window. The abbreviations of the journals in Table 1 and

Table 1 Year-by-year changes in impact factors for the six leading forensic science and legal medicine journals and the average impact factor between 1997 and 2003

Journal abbreviation	1997	1998	1999	2000	2001	2002	2003	1997–2003 average
Int J Legal Med	1.95	1.81	1.63	1.50	1.13	1.92	2.09	1.71
Forensic Sci Int	1.32	0.82	1.39	0.83	1.05	1.02	1.61	1.14
J Forensic Sci	1.40	0.77	0.99	0.94	0.88	0.79	1.23	1.00
Sci Justice	1.10	0.71	1.07	0.91	0.56	0.33	0.79	0.78
Am J Foren Med Path	0.39	0.60	0.37	0.60	0.41	0.52	0.52	0.48
Med Sci Law	0.39	0.29	0.41	0.47	0.40	0.37	0.36	0.38

elsewhere are those used by ISI and do not necessarily agree with the MEDLINE and PUBMED databases.

Trends in journal impact factor

Year-by-year changes in the impact factors for six forensic and legal medicine journals are shown in Table 1. The journals are rank-ordered according to the highest average impact factor over the 7-year period. One journal stands out from the rest, namely International Journal of Legal Medicine (IJLM), which has consistently dominated in terms of impact factor over the time period studied. For a journal with an impact factor of 1.0, this means that in the current citing year, the average article published in the journal in the previous 2 years was cited once per year.

The most highly cited journals are given in Table 2 rank-ordered after their citation impact (cites/paper). Topping the list was International Journal of Legal Medicine with a citation impact of 7.19 followed by Journal of Forensic Sciences with a citation impact of 4.90.

Most cited articles

Papers that attract many citations are often referred to as citation classics. The citation frequency of an article depends very much on the particular scientific discipline and articles appearing in forensic and legal medicine journals

Table 2 The most highly cited forensic science and legal medicine journals ranked by their citation impact

Cited journal	Total cites	Total papers	Citation impact (Cites/paper)
Int J Legal Med	7,515	1,045	7.19
J Forensic Sci	23,969	4,890	4.90
Forensic Sci Int	16,646	4,375	3.80
Am J Foren Med Path	5,543	1,849	3.00
Med Sci Law	3,832	1,618	2.37
Sci Justice	747	433	1.73

Table 3 The 10 most highly cited papers published in the leading forensic science and legal medicine journals between 1981 and 2003

Rank	Cites	N*	First author	Journal	Vol	First page	Year	Title of the highly cited work
1	284	3	Kasai, K	JFS	35	1196	1990	Amplification of a variable number of tandem repeats (VNTR) locus (pMCT118) by the polymerase chain reaction (PCR) and its application to forensic science
2	216	30	Kayser, M	IJLM	110	125	1997	Evaluation of Y-chromosomal STRs: a multicenter study
3	169	3	Baumgartner, WA	JFS	34	1433	1989	Hair analysis for drugs of abuse
4	134	4	Piercy, R	IJLM	106	85	1993	The application of mitochondrial-DNA typing to the study of white Caucasian genetic identification
5	126	30	De Knijff, P	IJLM	110	134	1997	Chromosome Y microsatellites. Population genetic and evolutionary aspects
6	118	4	Urquhart, A	IJLM	107	13	1994	Variation in short tandem repeat sequences—A survey of 12 microsatellite loci for use as forensic identification markers
7	118	4	Wiegand, P	IJLM	105	315	1993	Forensic validation of the STR systems SE 33 and TC 11
8	105	3	Jobling, MA	IJLM	110	118	1997	The Y chromosome in forensic analysis and paternity testing
9	102	6	Rand, S	IJLM	104	329	1992	Population genetics and forensic efficiency data of 4 AMPFLPS
10	98	7	Holland, MM	JFS	38	542	1993	Mitochondrial DNA sequence analysis of human skeletal remains: identification of remains from the Vietnam War

*Number of co-authors on the highly cited paper.

cannot be compared with articles from molecular biology, biochemistry and immunology journals. Nevertheless, Table 3 lists the 10 most highly cited articles in the target

journals from Table 1. Of these articles seven appeared in IJLM and three were published in JFS with the number of citations ranging from 98 to 284. However, there was only a

Table 4 Top 3 most highly cited articles published in each of the 6 major forensic science and legal medicine journals 1981–2003

Journal	First author	Cites	Vol	First page	Year	Full or shortened title of the highly cited article
Med Sci Law	Sarvesvaran, R	68	26	35	1986	Sudden natural deaths associated with commercial air-travel
	Hodgkinson, PE	57	25	288	1985	Patient assaults on staff in a psychiatric hospital—A 2-year retrospective
Am J Foren Med Path	Anderson, RA	45	22	35	1982	Fire deaths in the Glasgow area: III. The role of hydrogen cyanide
	Coe, JI	46	14	91	1993	Post-mortem chemistry update—Emphasis on forensic application
	Gilbert-Barnes, E	46	12	27	1991	Hazards of mattresses, beds and bedding in deaths in infants
	Byard, RW	43	19	261	1998	Amphetamine derivative fatalities in South Australia—Is “ecstasy” the culprit?
Int J Legal Med	Kayser, M	216	110	125	1997	Evaluation of Y-chromosomal STRs: a multicenter study
	Piercy, R	134	106	85	1993	The application of mitochondrial-DNA typing to the study of white Caucasian genetic identification
	De Knijff, P	126	110	134	1997	Chromosome Y microsatellites: population genetic and evolutionary aspects
Forensic Sci Int	Jeffreys, AJ	97	56	65	1992	Identification of skeletal remains of Josef Mengele by DNA analysis
	Balding, DJ	94	64	125	1994	DNA profile match probability calculation—How to allow for population stratification, relatedness
	Pounder, DJ	86	45	253	1990	Postmortem drug redistribution—A toxicological nightmare
J Forensic Sci	Kasai, K	284	35	1196	1990	Amplification of a variable number of tandem repeats (VNTR) locus (PMCT118) by polymerase
	Baumgartner, WA	169	34	143	1989	Hair analysis for drugs of abuse
	Holland, MM	98	38	542	1993	Mitochondrial-DNA sequence analysis of human skeletal remains: Identification of remains from
Sci Justice	Cook, R	27	38	231	1998	A hierarchy of propositions—deciding which level to address in casework
	Cook, R	17	38	151	1998	A model for case assessment and interpretation
	Gillan, R	17	35	169	1995	Comparison of cannabis-sativa by random amplification of polymorphic DNA (RAPD) and HPLC

weak correlation between the number of citations and the number of years the article was in print and visible for being cited (Pearson's $r=0.29$, $p>0.05$). The most highly cited papers dealt with modern aspects of forensic genetics and identification with DNA fingerprinting and the PCR technique.

The same analysis as above was done for the six forensic and legal medicine journals individually and the top three most highly cited papers in each journal were identified and are listed in Table 4. The least cited articles were published in Science & Justice being a more recent name (since 1995) for Journal of the Forensic Science Society.

Articles most frequently cited by the forensic journals

The articles most often cited in the reference lists of the forensic and legal medicine journals investigated are listed in Table 5. Without exception, all these papers deal with aspects of forensic and population genetics and especially the methods used to extract and analyze DNA and its many applications in forensic identification.

Most prolific and most cited authors

Table 6 identifies the top-10 most prolific authors publishing papers in the 6 leading forensic and legal medicine journals between 1981 and 2003. The names of the scientists are sorted according to the number of publications (research

Table 5 The top-10 articles most highly cited by articles published in forensic science and legal medicine journals 1981–2003

Rank	Cites	First author	Journal	Vol	First page	Year	Title of the article
1	267	Walsh, PS	Biotechniques	10	506	1991	Chelex-100 as a medium for simple extraction of DNA for the PCR-based typing from forensic material
2	219	Guo, SW	Biometrics	48	361	1992	Performing the exact test of Hardy-Weinberg proportion for multiple alleles
3	184	Edwards, A	Genomics	12	241	1992	Genetic variation at 5 trimeric and tetrameric tandem repeat loci in 4 human population groups
4	151	Budowle, B	Am J Hum Genet	48	137	1991	Analysis of the VNTR locus D1S80 by the PCR followed by high resolution PAGE
5	145	Edwards, A	Am J Hum Genet	49	746	1991	DNA typing and genetic-mapping with trimeric and tetrameric tandem repeats
6	141	Nei, M	Genetics	76	379	1974	Sampling variances of heterozygosity and genetic distance
7	115	Fisher, RA	Heredity	5	95	1951	Standard calculations for evaluating a blood-group system
8	114	Kasai, K	J Forensic Sci	35	1195	1990	Amplification of a variable number of tandem repeats (VNTR) locus (PMCT118) by polymerase chain reaction (PCR) and its application to forensic science
9	114	Waye, JS	Biotechniques	7	852	1989	A simple and sensitive method for quantifying human genomic DNA in forensic specimen extracts
10	110	Kayser, M	Int J Legal Med	110	125	1997	Evaluation of Y-chromosomes STRs: A multicenter study

Table 6 Top-10 most prolific authors of papers published in the leading forensic science and legal medicine journals 1981–2003 ranked by total number of articles

Rank	Author	Total papers	Total cites	Citation impact (cites/papers)	Main area of research
1	Budowle, B	180	2,241	12.45	Forensic and population genetics, DNA-PCR
2	Brinkmann, B	132	1,528	11.58	Forensic medicine, population genetics, DNA-PCR technique
3	Carracedo, A	90	826	9.14	Forensic and population genetics, DNA-PCR
4	Mangin, P*	76	799	10.51	Forensic medicine and toxicology
5	Kintz, P*	75	846	11.28	Forensic and analytical toxicology
6	Byard, RW	69	278	4.03	Forensic and population genetics, DNA-PCR
7	Madea, B	67	202	3.61	Forensic medicine and toxicology
8	Pounder, DJ	66	486	7.36	Forensic medicine and toxicology
9	Taff, ML	64	124	1.94	Forensic medicine, death investigations
10	Betz, P	63	426	6.76	Forensic medicine, genetics and toxicology

*Co-authors on many of the same articles.

Table 7 Top-10 most cited authors publishing articles in the 6 major forensic science and legal medicine journals 1981–2003 ranked by total citations

Rank	Cited author	Total citations	Total papers	Citation impact cites/paper	Main area of research
1	Budowle, B	2,241	180	12.45	Forensic and population genetics, DNA-PCR techniques
2	Brinkmann, B	1,528	132	11.58	Forensic medicine, forensic and population genetics, DNA-PCR
3	Gill, P	1,227	44	27.89	Forensic and population genetics, DNA-PCR
4	Kintz, P*	846	75	11.28	Forensic and analytical toxicology
5	Carracedo, A	826	90	9.14	Forensic genetics, DNA-PCR technology
6	Mangin, P*	799	76	10.51	Forensic medicine and toxicology
7	Schneider, PM	775	33	23.48	Forensic genetics
8	Wiegand, P	608	34	17.88	Forensic and population genetics
9	Meyer, E	546	12	45.50	Forensic genetics and toxicology
10	Roewer, L	535	15	35.67	Forensic genetics, DNA-PCR techniques

*Co-authors on many of the same articles.

articles, reviews, case reports, short communications, letters to the editor etc) on which their name appeared as author or co-author. Also shown is the total number of citations garnered by these articles in all other scientific journals covered by ISI (including forensic journals) as well as the ratio of citations to articles (citation impact). Note that if these individuals published articles in other scientific journals over the same time period this is not counted so these statistics do not represent the total out-put of papers. The area of research or field of interest and expertise of these prolific authors was also identified.

In contrast to Table 6, the data in Table 7 shows the names of the most highly cited authors who published work in the leading forensic science and legal medicine journals. Here the criterion for ranking is total citations and although many names are the same as in Table 6, some new names appear. When looking at citation impact one notices that a few individuals (e.g. Gill, Prinz, and Roewer) published relatively few articles but these attracted many citations. These individuals specialize in the field of forensic genetics and DNA fingerprinting for identification purposes. Indeed, most citations were given to a few works that represented multi-national, multi-center, and multi-author collaborative work. Sometimes as many as 30 co-author names were listed on the articles (Table 3). Other examples of teamwork also existed such

as Kintz and Mangin in the field of forensic toxicology who were co-authors on many highly cited articles. It is common knowledge that collaboration can boost the total output of papers and citations. The disciplines of forensic genetics and DNA fingerprinting as well as forensic toxicology seemingly attract most citations.

Table 8 gives the number of citations received by the top-5 most highly cited articles containing the names of the authors listed. This form of presentation makes it obvious that many of the names in the list were co-authors of the same highly cited work; the number of citations is identified with bold text. These top-cited articles accounted for between 22% and 91% of all citations to papers published by these individuals. Attributing credit for co-authored articles is a sensitive and difficult task and few guidelines exist [6, 8].

Concluding remarks

Besides the forensic and legal medicine journals discussed in this review, a few more recent titles exist, namely “Legal Medicine” (Elsevier) and “Journal of Clinical Forensic Medicine” (Elsevier). However, neither of these is included in ISI’s database and therefore they do not have an impact factor. Another complicating factor is when a

Table 8 Citations to the five most highly cited articles by each cited author with co-authored works identified by bold text

The last column shows the percentage contribution of the five articles to the author’s total citation count.

Rank	Cited author	Total citations	Total papers	Citations received by the 5 most highly cited articles					Sum (%)
1	Budowle, B	2,241	180	118	102	96	96	80	482 (22%)
2	Brinkmann, B	1,528	132	118	102	91	73	70	454 (30%)
3	Gill, P	1,227	44	134	118	88	75	73	488 (40%)
4	Kintz, P	846	75	48	39	38	34	33	192 (23%)
5	Carracedo, A	826	90	73	48	45	36	34	236 (29%)
6	Mangin, P	799	76	48	39	38	34	33	192 (24%)
7	Schneider, PM	775	33	216	126	57	45	40	484 (62%)
8	Wiegand, P	608	34	118	102	48	46	46	360 (59%)
9	Meyer, E	546	12	216	126	91	35	29	497 (91%)
10	Roewer, L	535	15	216	126	31	30	27	430 (80%)

journal undergoes a change in name over the citation period studied (1981–2003). The 2004 issue of *Science & Justice* is listed as volume 44 but prior to 1995 this journal was known as *Journal of the Forensic Science Society* (JFSS). Any highly cited articles in JFSS would not be included in the present survey. Similarly, the *International Journal of Legal Medicine* (Springer) was earlier known as *Zeitschrift für Rechtsmedizin* and became an English language periodical in 1990. Obviously, any highly cited papers from the German language version between 1981 and 1989 are not included in the data evaluated for this article. However, these changes in name do not skew the computation of journal impact factor, which is based on citations to recent articles.

Counting citations has become an integral part of information science and a vast body of literature has developed on the subject known as bibliometrics [2, 21, 24]. Citation analysis is increasingly used to assess the quality of articles, the prestige of the journal where these are published and not least the reputation and impact of the authors of these works [10, 16, 18]. Productivity and success in science is closely linked with prolific authorship and a long list of publications in peer-reviewed journals with high impact factor is a pre-requisite for success and advancement in science [14, 15, 25, 26]. However, more important than the number of articles listed in a person's bibliography is the number of times these works are subsequently cited in reference lists of articles penned by other scientists. The number of citations provides an objective way to evaluate the impact and importance of a person's work by documenting how often it was acknowledged and found useful by other scientists.

When people submit their CV's for peer evaluation, it has become customary to include the impact factors of the journals where the articles are published and the number of citations received by these articles. Such information is now fairly easy to obtain thanks to on-line databases such as *Journal Citation Reports* and *Web-of-Science*, both produced by Thomson ISI. In any kind of faculty evaluation it is crucial not to compare journals, articles or scientists across different disciplines. For example, a citation classic in a relatively small field like forensic science might be justified with 50 or 100 citations whereas 500 citations might be necessary for an article dealing with a hot topic like immunology or molecular biology [21–23]. The journal impact factors differ widely for different disciplines, hence the need to subdivide journals into different subject categories when comparing and contrasting different journals.

Forensic science has no strong roots in academia and unlike university scientists there is less pressure on them to embark on basic research projects and to publish papers in scientific journals. It seems that forensic scientists are less motivated to write articles for publication because prolific authorship carries less weight when promotion and salary increments are an issue. In forensic science laboratories it appears that administrative duties and responsibility for staff are considered more meritorious for promotion than research and publication. However,

this might not hold for legal medicine because many of these departments are affiliated with university teaching hospitals where the academic climate of publish or perish still exists to some extent. Forensic science as opposed to forensic medicine is traditionally done at government or private enterprise laboratories far removed from academia. This might explain, at least in part, the poor publication track records of those working at the government-run forensic laboratories.

The emphasis given to peer-review and publication for admission of expert evidence should send a message to police, prosecutors and others who make use of forensic scientists to provide expert testimony [27]. The testimony of an expert witness who is able to document his or her expertise on a topic by having pertinent publications in refereed journals should be given close attention. This does not mean that forensic scientists who do not publish papers are ambivalent about the scientific literature. They certainly need to read and review articles and keep up-to-date with developments in their speciality. Some forensic practitioners prefer to write books rather than journal articles as a device to document their knowledge and expertise and in many ways this is a much more lucrative practice.

Forensic science and legal medicine are relatively small disciplines compared with academic subjects like chemistry, human biology and many of the life sciences. As an example it can be mentioned that the current membership (2003) of the American Academy of Forensic Sciences is 5,520, which can be compared with current membership in the American Chemical Society, which is close to 150,000. This vast difference in size of the field and the fact that most forensic scientists work at government laboratories and not at universities accounts, at least in part, for the relatively small numbers of scientific articles and the relatively low impact factors of journals specializing in forensic science and legal medicine. However, three of the journals listed in Table 1 had impact factors above the median for all ISI journals (0.91).

Many articles published in the literature remain un-cited not even receiving a self-citation, i.e., when an author cites his or her own previously published work [28, 29]. Of the articles in this database, 5,191 or 36% were not cited even once and 1,850 papers (13%) received only 1 citation over the period studied. This helps to reinforce the fact that the articles listed in Table 3 are indeed "citation classics" in the forensic sciences and legal medicine journals. By far the most highly cited mainstream legal medicine journal was *IJLM*, which probably stems from the many articles it publishes dealing with forensic genetics and DNA-related topics.

The present survey is the first in-depth analysis of citation records of the leading forensic science and legal medicine journals and those who publish in them. My aim was to identify the most cited articles and the citation track records of the authors of these works. Much has been written about impact factors of forensic science and legal medicine journals [30, 31] but less attention has hitherto been given to counting citations to the individual articles and authors.

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