Mapping of Research Productivity in Forensic Science: A Scientometric Analysis

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Abstract

An analysis of 10464 publications published by scientists during 1989 to 2015 and indexed by Web of Science online Database indicates that the publication output in the Forensic Science Research Publications at global. This work is to provide a profile of research in forensic Science research publication. This includes tracking the number of papers, scatter of papers over journals, and its effect on publication output, authors' institutional affiliations and authorship patterns from the Histcite, Vosviwer and CitNetExplorer software..

Keywords

Scientometrics; Forensic Science; Science Citation Index; Global Citation Score; h-index; degree of collaboration; authorship pattern

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Introduction

The present study takes effort to determining the research performance of Forensic science at world scientists, based on sample records from the Web of Science database. Further this study corresponds to an assessment of bibliometric/Scientometric analysis of the pattern of publication, authorship, growth rate of publications and journals coverage by the scientists. This study used technique whether called scientometrics, bibliometrics or by any other name has nowadays become a standard basis of classifying, mapping and assessing journals. In the cited study, Scientometrics has been used to represent the journals and other forms during the 1989 to 2015 periods. The meaning of Forensic science is the application of science to criminal and civil laws, mainly on the criminal side during criminal investigation, as governed by the legal standards of admissible evidence and criminal procedure.

Related Review Literature

Review of literature is of pivotal importance in any research investigation. Further it aims to analyse the past trends, emerging new areas of research, growth of literature, productivity of researchers and performance of research institutions. Manimekalai, A & Amsaveni, N (2012) has analyzed the growth of research publications and the authorship pattern on Genetics and other related subject has been analyzed for the data taken from the articles listed in Web of Science covering the period 1998 to 2011. The records considered for the study is 871 and the pattern of productivity of various author categories are identified. The total of authors downloaded (4433) papers were divided into different categories, namely all authors, first authors, non-collaborative authors and co-authors. Amsaveni, N et.al (2013) has studies the authorship pattern of collaborative research in Bioinformatics, deals with the authorship collaboration research. The team authored work has been well recognized feature of the modern science and there has been a reliable trend towards enlarged collaboration in all branches of science and technology during the present century. Totally 91655 authors were produced 17318 articles in this subject of bioinformatics. 9.77 percent of articles were single authors' contribution. 90.17 percent of articles produced by collaborative authors. Two authors team has produced more articles and six authors team has highest number of authors.

Objectives

The main objective of this study was to use Scientometric mapping and analyze the key features of forensic science research activities:

- To identify and analyse the rate of growth of research productivity
- To identify that the document wise distribution of publications;
- To analyses the authorship pattern and examine the extent of research collaboration;
- To identify the ranking of authors based on publications;
- To identify journal wise distribution of publications;
- To assess the Institution wise research concentration

Methodology

This analytical study encompassing records output on Science from Science Citation Index (SCI) available on online (Web of Science). The present study aims at analyzing the research output of researchers in the field of forensic Science. The growth rate of output in terms of research productivity is analyzed from 1989 to 2015. The authorship pattern and author productivity are examined to identify the pattern of research contribution in the field of forensic science. Further, an attempt is made to measure the performance of researchers and their research concentration in this field and it is also analytical in nature in strengthening the empirical validity due to application of suitable statistical tools. In this research data were downloading from Web of Science. The research papers published by researchers in the field of forensic science covered in the annual version of Science Citation index database were taken as the prime source for this present study.

Analysis And Interpretation

Relative Growth Rate of Publications

To analyze the year wise publication of research on forensic science, the data has been extracted used the software of HisCite presented in below table 1. The research output on forensic science publications has taken as a tool to evaluate the performance at various levels. It also shows that chronological histogram of citations, demonstrating that citation frequency grew steadily from 1989; it reached a maximum GCS of 9231 in 2002 and LCS of 2019 in 2001.

Table 1: Shows relative growth rate of Forensic Science Publications

S.No	Year	Pubs.	%	W_1	W_2	R(a) = W_2-W_1	Dt	TLCS	TGCS	NA
1	1989	34	0.3	-	3.526	-	-	76	152	52
2	1990	21	0.2	3.526	3.045	-0.482	-1.438	126	616	42
3	1991	97	0.9	3.045	4.575	1.530	0.453	365	1374	237
4	1992	84	0.8	4.575	4.431	-0.144	-4.816	332	1115	200
5	1993	77	0.7	4.431	4.344	-0.087	-7.964	264	829	168
6	1994	80	0.8	4.344	4.382	0.038	18.131	351	1173	205
7	1995	127	1.2	4.382	4.844	0.462	1.499	429	1679	297
8	1996	265	2.5	4.844	5.580	0.736	0.942	909	3957	777
9	1997	347	3.3	5.580	5.849	0.270	2.571	1201	5900	1054
10	1998	386	3.7	5.849	5.956	0.107	6.506	1533	7123	1218
11	1999	388	3.7	5.956	5.961	0.005	134.095	1289	6767	1249
12	2000	428	4.1	5.961	6.059	0.098	7.063	1299	1091	1551
13	2001	562	5.4	6.059	6.332	0.272	2.544	**2019**	8309	2073
14	2002	512	4.9	6.332	6.238	-0.093	-7.437	1199	**9231**	1853
15	2003	486	4.6	6.238	6.186	-0.052	-13.297	1427	8018	1846
16	2004	392	3.7	6.186	5.971	-0.215	-3.224	1113	4972	1484
17	2005	414	4.0	5.971	6.026	0.055	12.691	1155	5707	1634
18	2006	409	3.9	6.026	6.014	-0.012	-57.033	1246	6205	1586
19	2007	445	4.3	6.014	6.098	0.084	8.215	1305	6296	1547
20	2008	452	4.3	6.098	6.114	0.016	44.401	1347	6346	1562
21	2009	497	4.7	6.114	6.209	0.095	7.302	1241	6658	1727
22	2010	547	5.2	6.209	6.304	0.096	7.229	1063	5310	2058

23	2011	627	6.0	6.304	6.441	0.136	5.077	1032	5290	2330
24	2012	598	5.7	6.441	6.394	-0.047	-14.634	688	3478	2306
25	2013	707	6.8	6.394	6.561	0.167	4.139	552	3149	2760
26	2014	678	6.5	6.561	6.519	-0.042	-16.546	275	2066	2832
27	2015	**804**	7.7	6.519	6.690	0.170	4.066	60	884	**3245**
Total		**10464**	**100**			**0.11**	**5.2**	**23896**	**113695**	**37893**

Table 1 could clearly see that during the period 1989 to 2015 a total of 10464 publications were retrieved. The highest publications are 804 in 2015 with 884 TGCS followed by 707 papers in 2013 with 3149 TGCS and 678 papers in 2014 with 2066 TGCS. The lowest publication is 21 in 1990 with 616 TGCS. It shows that even minimum numbers of records were scored higher global citations. It is observed that its relative growth rates have declined from -0.482 in 1989 to 0.04 in 2010. The whole study period records the mean relative growth rate of 0.11. Contrarily, the doubling time for publications at the aggregate level has been computed as 5.2 years. The growth rate calculation result shows that fluctuation trend in over all sample period. The above figure 1 histogram clearly shows that the year wise publications in forensic science during the study period.

Documents types and citations

Table 2 reveals that there are 17 types of documents were found the research articles in forensic Science research. Among those the article (journal) format has highest number of articles with highest citations. Followed by the format of articles in Conference proceedings articles were having highest contributions.

Table 2: Types of documents cited

S. No	Types of Document	Pub.	%	TLCS	TGCS	S.No	Types of Document	Pubs.	%	TLCS	TGCS
1	Article	7811	74.6	16961	84142	10	News Item	38	0.4	11	52
2	Article; Proceedings Paper	991	9.5	3249	15108	11	Biographical-Item	14	0.1	0	18
3	Unknown	500	4.8	1475	-	12	Article; Book Chapter	9	0.1	41	114
4	Review	390	3.7	1395	11295	13	Review; Book Chapter	8	0.1	21	233
5	Editorial Material	309	3.0	262	1115	14	Correction	6	0.1	0	1
6	Meeting Abstract	119	1.1	4	7	15	Item an Individual	4	0.0	2	17
7	Note	99	0.9	429	1433	16	Reprint	4	0.0	0	13
8	Letter	87	0.8	45	146	17	Correction, Addition	3	0.0	0	0
9	Book Review	72	0.7	1	1						

It could be found from this table analysis, the journal articles were contributed highest number of publications and highest number of TLCS and TGCS in forensic Science research output. The articles from conference proceedings and the format of discussion were also having highest citation scores.

Most Productive authors

Table 3 indicates ranking of authors by number of publications. Author of "Budowle B" affiliated from Royal Canadian Mounted Police, Canada has published highest number of articles for the study period with 145 records he starts his research at 1991 with 29 h-index value, next to consecutive author of "Byard RW" affiliated from University Adelaide, Department of Peadiatric, Australia has published highest number of articles (100) with 17 h- index values and he contributes many single authored articles. Thus the most cited authors are distinguished from the most-published ones.

Table 3: Most productive authors in forensic Science research output

Author	Affiliation	Started year	Pubs.	%	TLCS	TGCS	TLCR	h-index	Solo contributions

Budowle B	Royal Canadian Mounted Police,Canada	1991	145	1.4	772	2770	353	29	2
Byard RW	Univ adelaide, dept paediat, Australia.	1996	100	1.0	141	886	132	17	12
Hou YP	W China Univ Med Sci, Inst Forens Med, Chengdu China.	1999	66	0.6	51	129	39	4	0
Roux C	Univ lausanne, Unil,inst police sci & criminol, switzerland.	1996	61	0.6	353	842	245	16	2
Li YB	Sichuan Univ, Inst Forens Med, China.	1999	55	0.5	49	112	27	4	0
Wu J	Sichuan Univ, Coll Publ Hlth, China.	1999	55	0.5	49	123	34	4	0
Parson W	Univ Innsbruck, Inst Legal Med, Austria	1997	52	0.5	263	1245	228	21	0
Zhang J	W China Univ Med Sci, Sichuan Univ, Inst Forens Med, China.	2001	47	0.4	52	142	46	4	0
Ubelaker DH	Natl museum nat hist,dept anthropol,washington,dc, USA.	1990	46	0.4	230	658	149	15	14
Cattaneo C	Univ Milan, Dipartimento Sci Biomed Salute, Sez Med Legale, LABANOF,Lab Antropol & Odontol Forense, Italy.	1995	44	0.4	80	360	274	10	0

The most productive author analysis result has been derived according to VOSviewer software analysis, totally 21080 authors were contributed but 330 authors were contributed more than 10 articles.

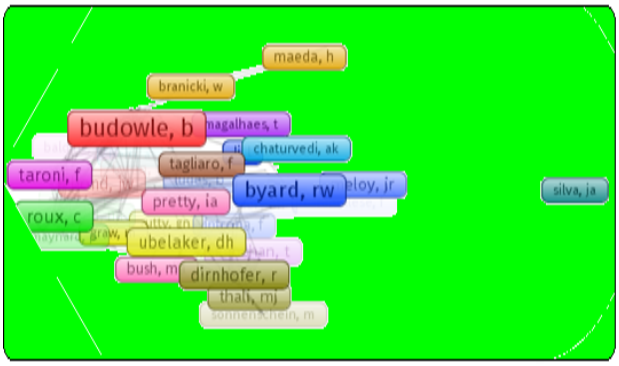


Figure 1: Most productive authors using from Vosviewer software

Single Vs. Multiple Authors

It is found from the study that multiple authors' (specially two authors team) research is ensured between the authors in forensic Science of publications made by multiple authors.

Table 4: Authorship pattern of forensic Science research output

Authorship pattern	**publications**	**Cum. Pubs.**	**%**	**Cum. %**	**Degree of Collaboration**
Single authors	1783	1783	17.04	17.04	0.83
Two Authors	2161	3944	20.65	37.69	
Three authors	2019	5963	19.29	56.99	
Four authors	1610	7573	15.39	72.37	
Five authors	1100	8673	10.51	82.88	
Six authors	769	9442	7.35	90.23	
Seven authors	403	9845	3.85	94.09	
Eight authors	224	10069	2.14	96.23	
Nine authors	149	10218	1.42	97.65	
Ten and above authors	246	10464	2.35	100.00	
Total	**10464**		**100**		

It is found from the study that collaborative research is ensured between the authors in Food Science and Technology research as 20.65 % of publications made by two authors. More than 60% of the research papers are published by other type of authorship pattern. It is also found that the papers published by more than 10 authors. Degree of collaborative value is 0.83, i.e., 83 percent of articles were published by collaborative pattern.

Journal wise Distribution of Publications

The study found that the total research output of the Forensic Science for the study period (1989to 2015) published difference journals. As the major portion of the research productivity (74.6%) a covered journal article that is coincide with the theory of Bradford's Law of scattering of journals in research productivity.

The below mentioned top ten most productive journals were produced 75.12 percent of the research output. The journal "Journal of Forensic Sciences" topped with 5229 publications with the Global Citation Score of 52698; next "Forensic Science international" has 1215 publications with the Global Citation Score of 18035. The same result has been derived from the VOSviewer analysis. Remaining journals were produced below 100 numbers of articles in forensic Science during sample period.

Table 5: Most productive journals in forensic Science research output

Journals	Pubs.	%	TLCS	TGCS
Journal of Forensic Sciences	5228	50.0	13637	52698
Forensic Science International	1215	11.6	3680	18035
Science & Justice	673	6.4	1695	4267
Forensic Science International-Genetics	164	1.6	518	2124
International Journal of Legal Medicine	143	1.4	403	1986
American Journal of Forensic Medicine And Pathology	121	1.2	127	839
Journal of Forensic And Legal Medicine	92	0.9	45	396
Abstracts of Papers of The American Chemical Society	91	0.9	0	0
Australian Journal of Forensic Sciences	84	0.8	62	185
Forensic Science Medicine and Pathology	50	0.5	51	301

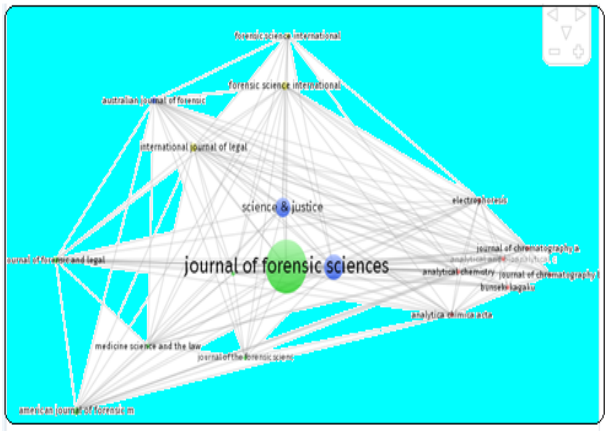


Figure 2: Most Productive journals in forensic Science using VOSviewer softare

Funding Agency

Various funding agencies are supported for this kind of research. Particularly in this forensic science filed, below mentioned funding agencies were supported for many articles through some projects. Remaining funding agencies are supported by below 13 numbers of articles.

Table 6: Most supporting Funding Agencies in forensic Science research output

Funding Agencies	Pubs.
National institute of justice office of justice programs u s department of justice	48
National natural science foundation of china	42
National institute of justice	35
National science foundation	28
Nigms nih hhs	23
Australian research council	23
Swiss national science foundation	19
Australian federal police	14
Nsf	13
Department of health	13

Histriographic analysis of LCS and GCS mapping

For the citation score map, the data sample was based on 10464 documents (nodes). For the LCS map, due to the top publication (top 30) number (21) of links, and to have a clear graph a minimum of 35 local citation scores to maximum 98 local citation scores was derived. For those thirty nodes, during 1990 to 2009 occurred 8 different types of journals are repeated links between the LCS values has measured. Among the selected thirty nodes, the journal of "Journal of Forensic Science (occurred 14 times)", "Forensic science International (occurred in 8 times)" and "Science and Justice (occurred 3 times)" and the remaining 5 types of journals were occurred each one time of the selected thirty nodes. It could be noted that the journal of "Journal Of Forensic Sciences" has highest links (4238th article at 2004) between the selected thirty nodes from this analysis; and the journal of "Science and Justice" has maximum (4560th article at 2005) LCS scores measured. Among the selected thirty nodes, more than 120 authors were contributed their research publications in the field of forensic science. It could be noted that the authors are "Collins PJ, Hennessy LK, Leibelt CS, Roby RK, Reeder DJ, et al." has highest links (4238th article at 2004) between the selected thirty nodes from this analysis; and the authors are "Saks MJ, Koehler JJ" has maximum (4560th article at 2005) LCS scores measured.

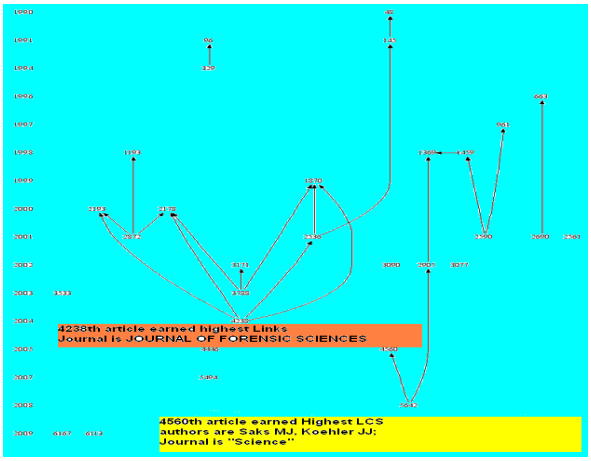


Figure 3: LCS historiography mapping for Authors and journals (Nodes:30, Links:21, Min: 35, Max: 98)

For the citation score map, the data sample was based on 10464 documents (nodes). For the GCS map, due to the top publication (top 30) number (7) of links, and to have a clear graph a minimum of 154 local citation scores to maximum 544 local citation scores was derived. For those thirty nodes, during 1990 to 2011 occurred 19 different types of journals are repeated links between the LCS values has measured. Among the selected thirty nodes, the journal of "Journal of Forensic Science (occurred 8 times)", "Journal of Chromotography A (occurred in 4 times)" and "Nature Review Genetics (occurred 2 times)" and the remaining 16 types of journals were occurred each one time of the selected thirty nodes. It could be noted that the journal of "Journal Of Forensic Science International" has highest links (329th article at 1994) between the selected thirty nodes from this analysis; and the journal of "Human Mutation" has maximum (6098th article at 2005) GCS scores measured. It could be noted that the authors are "Balding DJ, Nichols RA" has highest links (329th article at 1994) between the selected thirty nodes from this analysis; and the authors are "Van Oven M, Kayser M " has maximum (6098th article at 2005) GCS scores measured.

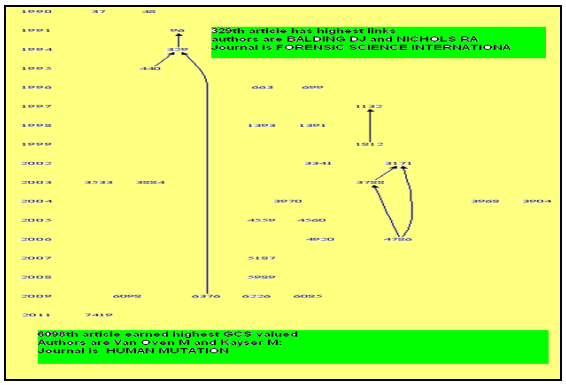


Figure 4: GCS historiography mapping for Authors and journals (Nodes:30, Links:7, Min:154, Max:544)

Highly Cited References

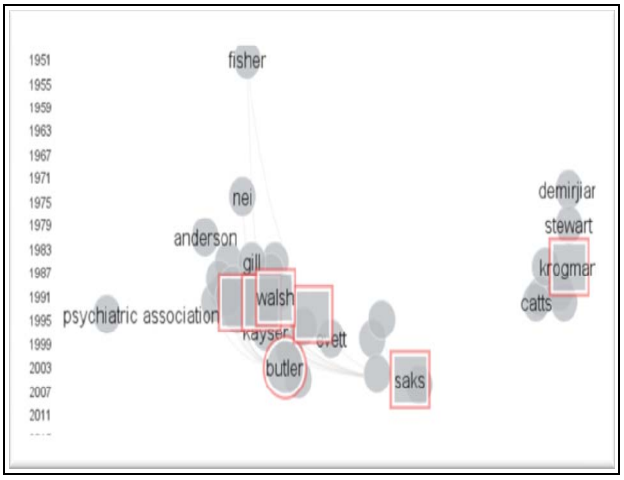
CitNetExplorer is recently introduced software tool that have developed for analyzing and visualizing direct citation networks. Builds on Garfield's work on algorithmic historiography, compared with HistCite, CitNetExplorer can handle much larger citation networks, possibly including millions of publications and citation relations. The data for Forensic Science during 1929 to 2015 were downloaded from the web of Science and imported into CitNetExplorer, author obtains a citation network consisting of 11800 publications and 49272 citation links during the sample periods. Those publications, which have cited by at least ten citations included in the data collection.

Table 7: Highly Cited References in sample data during 1989 to 2015

Authors	Sources	Year	Citation Scores
WALSH, PS	BIOTECHNIQUES	1991	330
KROGMAN, WM	HUMAN SKELETON FOREN	1986	121
GUO, SW	BIOMETRICS	1992	121
EDWARDS, A	GENOMICS	1992	108
SAKS, MJ; KOEHLER, JJ	SCIENCE	2005	98
AITKEN, CGG	STAT EVALUATION EVID	2004	96
GILL, P	NATURE	1985	94
SAMBROOK, J	MOL CLONING LAB MANU	1989	94
EDWARDS, A	AM J HUM GENET	1991	92
KAYSER, M	INT J LEGAL MED	1997	90
BALDING, DJ; NICHOLS, RA	FORENSIC SCIENCE INTERNATIONAL	1994	85

EVETT, I	INTERPRETING DNA EVI	1998	82
ANDERSON, S	NATURE	1981	78
SMITH, KG	MANUAL FORENSIC ENTO	1986	78

Results derived from HistCite software, highly cited authors are "Walsh PS", followed by "Guo SW", "Krogman WM" and "Edwards A" respectively. The highly cited journals are "Biotechniques", "Biometrics", "Human Skeleton Forensic" and "Genomics". The same result has derived from CitNet Explorer software. The below diagram clearly mentioned the citation links amongst the sample data.



Conclusion

"Budowle B" is the author who has contributed the highest number of articles from Canada. He has received the most number of citations and h-index values during the sample period of study. The journal of "Journal of Forensic Science" and "Forensic Science International" has highest citations and contributions. Degree of collaboration analysis shows that the difference between the number of single author and multiple authors. The collaboration and team work are most important and necessities of scientific and technological work now a days. This study identifies that the thrust areas of research in Forensic Science and its sub divisions and also suggest the neglect areas that necessitate concentration from all kinds of researcher.

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