

Bibliometric Analysis of Extracorporeal Shock Wave Lithotripsy Research from 1991 to 2013

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Received date: 12 May 2024; **Accepted date:** 23 May 2024; **Published date:** 30 May 2024

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Citation: Guang-Dar Juang, Su-Man Lin, Cheng-Han Juang, Bibliometric Analysis of Extracorporeal Shock Wave Lithotripsy Research from 1991 to 2013. Journal of Medical and Clinical Case Reports 1(3). <https://doi.org/10.61615/JMCCR/2024/MAY027140530>

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Abstract

In the early 1980s, extracorporeal shock wave lithotripsy (ESWL) was introduced not only in research but also in clinical practice, by Chaussy and associates. [1-3] It has been a popular technique for non-surgical treatment for most upper ureteric and renal calculi since then.

This study aimed to identify and analyze the characteristics of the highly cited articles in extracorporeal shock wave lithotripsy (ESWL) related to urological publications in the Science Citation Index (SCI) between 1991 and 2013. The analyzed aspects covered the distribution of annual production and its citations per publication, journals, countries, institutions, authors, and the top cited articles.

Results

There were 1722 publications found with the keywords 'extracorporeal shock wave lithotripsy' in the titles, abstracts, or keywords from the SCI from 1991 to 2013. In total, 1147 publications related to stones in the genitourinary system were analyzed in this study. Of total publications, 50% had 3 or 4 authors. The highest percentage of published documents were journal articles (81%), followed distantly by letters (5.4%). The core journal is the Journal of Urology (US). Articles were primarily written in English (93%). Authors from the US (30%) ranked highest in publication activity, followed by those from Germany (8.0%) and Turkey (7.1%). The publication rate of ESWL articles decreased steadily during the period of this study. In addition, a simulation model was applied to describe the relationship between the cumulative number of publications and year.

Conclusions

The largest number of publications originates from the US, and the journal with the greatest influence is the Journal of Urology. The annual number of publications decreased each year.

Keywords: Scientometrics, SCI, Extracorporeal Shock Wave Lithotripsy, Urology.

Introduction

Open surgical techniques were traditionally used for the treatment of stone disease in the kidneys. In the early 1980s, extracorporeal shock wave lithotripsy (ESWL) was introduced not only in research but also in clinical practice by Chaussy and associates. [1-3] It has been a popular technique for non-surgical treatment for most upper ureteric and renal calculi since then. This technique uses shock waves generated outside the body to disintegrate stones lying in the kidney or the ureter, thus allowing the fragments to pass out of the body in the urine.[4] In the last 3 decades, numerous scientific

papers related to extracorporeal shock wave lithotripsy were published. Bibliometrics is a research method used in the library and information sciences. The number of research publications in scientific journals of any category is almost impossible to analyze. One common way of conducting bibliometric research is to use the Science Citation Index (SCI). Covering numerous medical topics, the SCI has been used for bibliometric analyses, which have included research contributions in ophthalmology[5], quantitative trends of patent ductus arteriosus treatment research[6], SARS-

related publications in the early stage[7], and bibliometric analysis of homeopathy research.[8] In addition, urologic topics have also been analyzed by bibliometric methods using the MEDLINE and EMBASE biomedical databases[9], and include national biases in citations in urology journals.[10]

Our purpose was to study the extracorporeal shock wave lithotripsy (ESWL) research performance based on the Science Citation Index (SCI)-indexed periodicals between 1991 and 2013. These documents were analyzed and evaluated according to publication distribution and were used to determine the quantitative characteristics of extracorporeal shock wave lithotripsy research.

Materials and Methods

The 2013 edition of the Journal Citation Reports (JCR), published by the Institute for Scientific Information (ISI), lists 7509 journals in the SCI. Documents used in this study were based on the database of the SCI obtained by subscription from the ISI Web of Science, Philadelphia, PA, USA. 'Extracorporeal shock wave lithotripsy' was used as the keywords to search titles, abstracts, and keywords. We then categorized the search results into 5 categories, including stones in the genitourinary system, stones in the biliary system, stones in the salivary gland, stones in the musculoskeletal system, and others, which included documents with the keyword, shock wave lithotripsy (SWL), but which were not related to this study topic.

Articles, corrections, editorial materials, letters, meeting abstracts, notes, and reviews were obtained from the results of the search for document types. Articles originating from England, Scotland, Northern Ireland, and Wales were grouped under the UK heading. The impact factor (IF) of a journal was determined for each document as reported in the year 2013 JCR. Collaboration type was determined by the address of each author, where 'independent' was assigned if no international collaboration was presented. 'International collaboration' was assigned if the paper was cosigned by researchers from more than 1 country.

Results and Discussion

There were 1722 publications found with the keywords 'extracorporeal shock wave lithotripsy' in titles, abstracts, or keywords from the SCI from 1991 to 2013. Each paper was categorized from the title and abstract by senior professional medical surgery urological doctors. The documents were categorized into stones in the genitourinary system (1147), stones in the biliary system (357), stones in salivary glands (17), stones in the musculoskeletal system (9), and others which included documents not related to the topic in this study (192). We analyzed the 1147 documents related to

stones in the genitourinary system in this study.

Documents were analyzed according to their type, language of publication, publication output, authorship, publication patterns, country of publication, and most frequently cited paper.

Type of Document

The distribution of document types identified by ISI was analyzed. From this analysis, 7 document types were found. The paper article was the most frequently used document type, comprising 81% of the total production. Letters (62, 5.4%), notes (42, 3.7%), meeting abstracts (40, 3.5%), editorial materials (39, 3.4%), reviews (28, 2.4%), and corrections (1, 0.11%) showed much-lesser significance than articles. The high distribution of articles is usually found for most topics in bibliometric analysis. For example, 73.7% of drug documents and 83.5% of surgery documents were original articles on patent ductus arteriosus treatments.[6] Analysis of Mexican scientists in the fields of biomedicine, chemistry, physics, astronomy, astrophysics, and geosciences showed that 80.5% of the total production of papers were scientific articles.[11] However, for a new research topic in the beginning stage, the distribution of articles could be much lower. Analysis of severe acute respiratory syndrome (SARS)-related research in the beginning stage showed that only 22% of documents were articles.[7]

Language of Publication

The language in which the documents were published was dominated by English (1066, 93%) followed distantly by German (39, 3.4%), French (37, 3.2%), Spanish (4, 0.34%), Russian (3, 0.26%), Italian (2, 0.17%), and Japanese (1, 0.11%). Garfield and Welljamsdorof (1992) reported that English is the main language of microbiology research, accounting for 90% - 95% of all SCI papers.[12] On the other hand, a probable reason for the high English publication distribution may be that developed countries such as the US, UK, Canada, and Australia conduct more research and have more journals published in English in SCI coverage. Publications on pediatric anesthesia also indicated a high proportion of English articles originating in the US and UK.[13] For a new research topic in the beginning stage, for example, SARS, 98% of total journal papers were published in English.[7] Moreover, from empirical evidence, there is a language bias in the coverage of the SCI, and this has consequences for international comparisons of national research performance.[14] Therefore, the high distribution of English articles on extracorporeal shock wave lithotripsy research is not surprising.

Publication Output

During the period from 1991 to 2013, the publication output steadily decreased each year (**Table 1**): in 1991, 115 papers were published, while in 2013, only 16 were. A correlation between the yearly cumulative number of publications and the year published was studied using mathematic models for homeopathy [8] and patent ductus arteriosus research.[6]

Table 1. Annual production of extracorporeal shock wave lithotripsy research, number of authors, and mean number of authors per paper.

Year	No. of documents	No. of authors	Mean no. of authors per paper
1991	115	454	3.95

1992	131	541	4.13
1993	112	428	3.82
1994	70	279	3.99
1995	66	251	3.80
1996	56	225	4.02
1997	52	215	4.13
1998	53	256	4.83
1999	55	224	4.07
2000	44	195	4.43
2001	39	172	4.41
2002	43	213	4.95
2003	47	219	4.66
2004			
2005	36	151	3.91
2006			4.19
2007			
2008			
2009			
2010			
2011			
2012			
2013			

Figure 1. Relationship between cumulative number of publications and year.

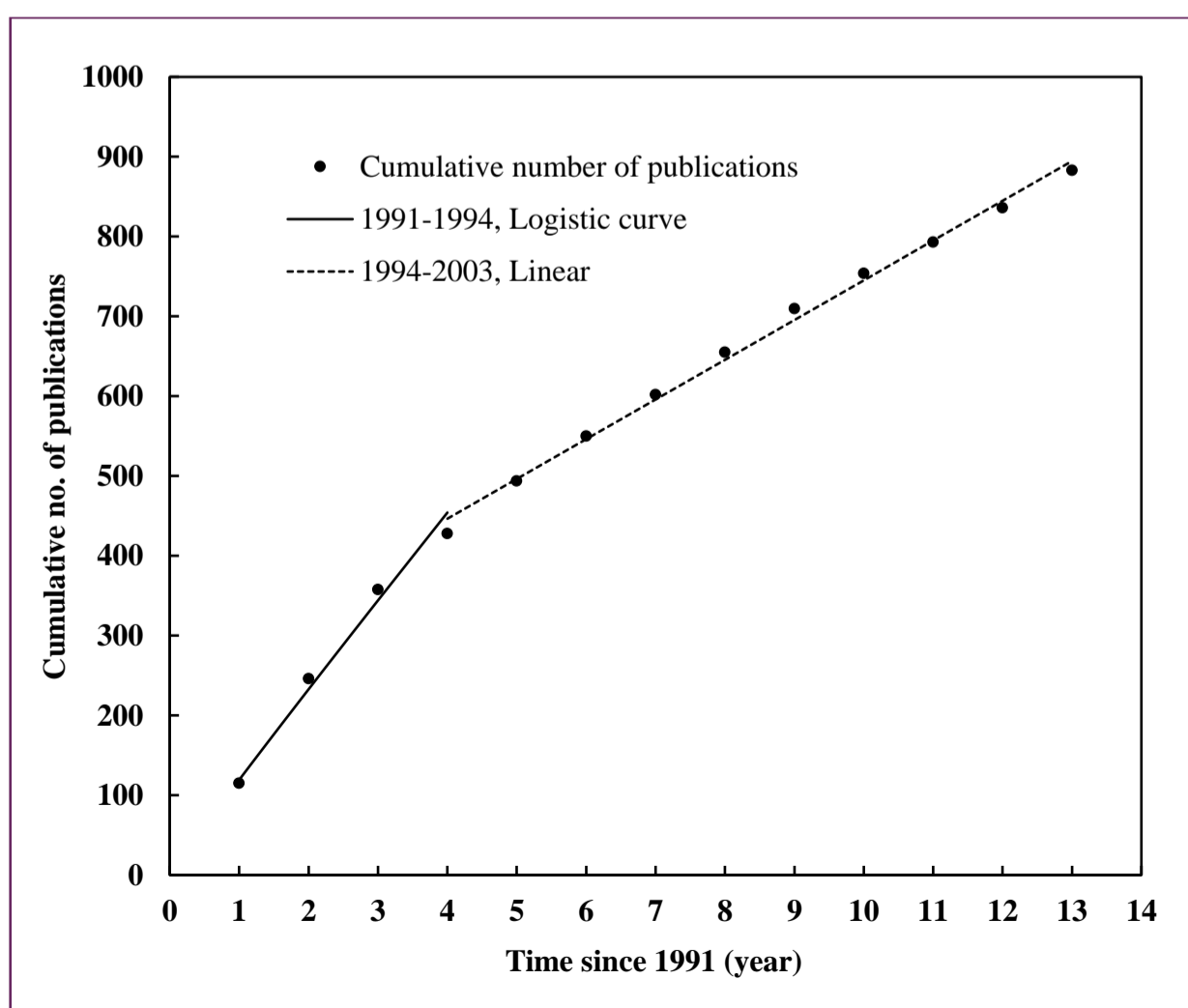


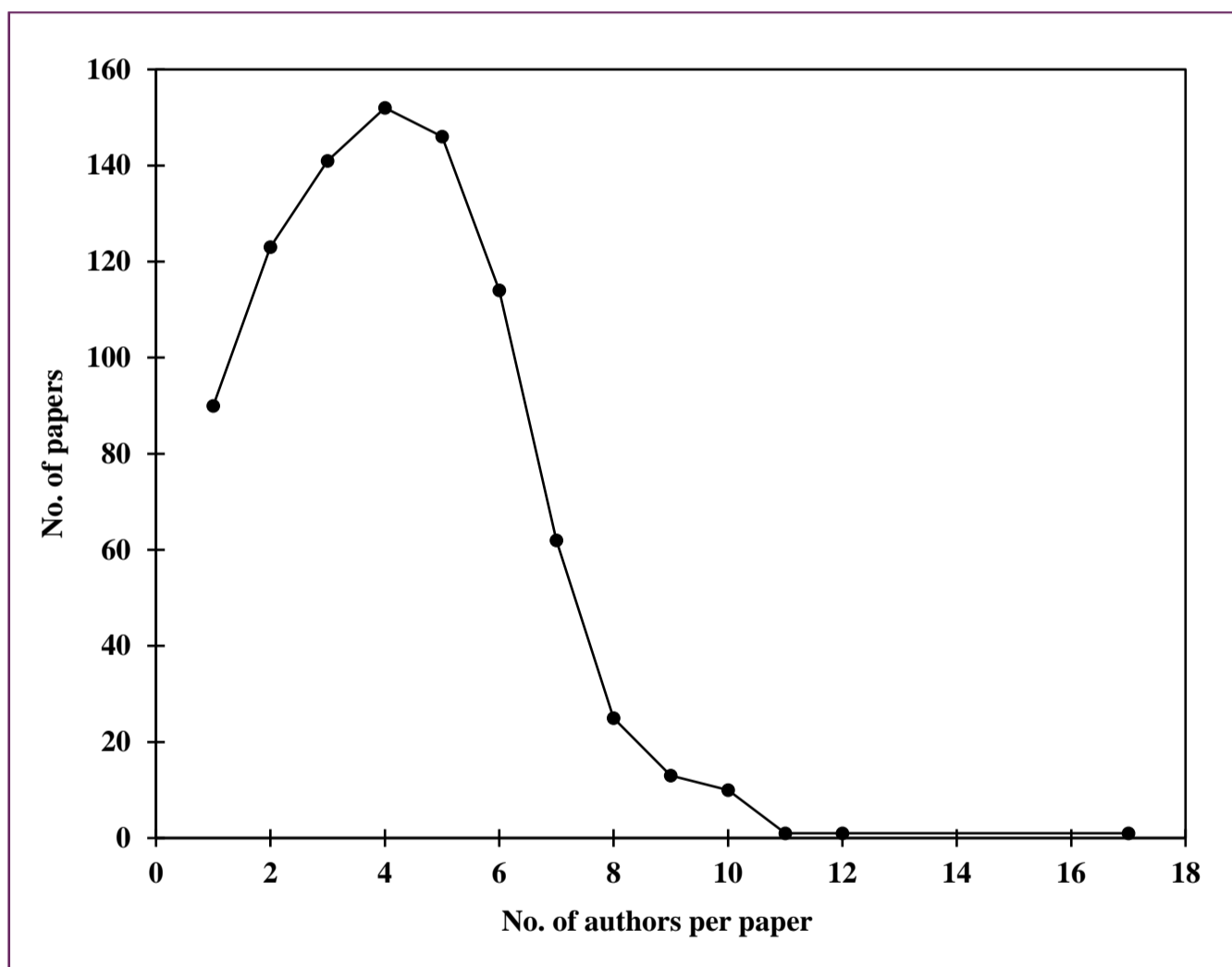
Figure 1 shows that a significant correlation between the yearly cumulative number of publications and the year published was made, with 2 linear relations having a high coefficient of determination. The difference in the cumulative trend was significant between the 2 periods from 1991 to 1994 and 1994 to 2013. A double logarithmic and linear plot of data for the 2 periods showed that there was a relationship between data and models with a high coefficient of determination ($r^2 > 0.991$). Logistic curve and linear fitting for the 2 periods of 1991 to 1994 and 1994 to 2013 suggested that the yearly cumulative number of publications was consistently sustained in each year. However, the yearly publications decreased each year. It can be concluded that the number of publications on research on the topic of extracorporeal shock wave lithotripsy did not grow in the study period.

Authorship

The average number of authors per document from 1991 to 2013 was 4.2. Figure 2 shows the distribution of the number of authors per paper. The maximum distribution was found for papers written by 4 authors with a smooth decay towards larger numbers. Seventeen authors were the maximum for a multi-author paper. The most frequent numbers of authors were 2 to 6, accounting for 878 (77%) papers. Average authors per document may differ from field to field and also from research topic to topic. The mean numbers of authors per paper for different medical sub-fields were 3.8 in dietetics, 5.2 in multiple sclerosis, 2.1 in nursing research, 1.9 in occupational therapy, 2.0 in physiotherapy, 4.3 in primary health care, and 2.7 in speech and language

therapy.[15] For 5 information systems journals, different mean numbers of authors per paper were shown: for Journal of Systems Management, it was 1.5; Information Systems Research was 2.2; Strategic Information Systems was 1.7; Management Information Systems Quarterly was 2.3, and Decision Support Systems was 2.1.[16] The mean number of authors per paper slightly increased, but the number of publications decreased during the period 1991 to 2013 for ESWL (Table 1). The phenomenon of an increase in the mean number of authors per paper was also found in other medical studies. [17, 18] It seems that more collaboration occurred as more journals were listed in the SCI.

Figure 2. Distributions of the number of authors per paper.



Publication Patterns

In total, 1147 papers were published in 148 journals, including specialty journals but also journals of other disciplines. Out of the 148 journals, 74 (50%) journals contained only 1 document, 31 (21%) journals contained 2 documents, and 14 (9.5%) journals contained 3 documents. Table 2 shows the distribution of cited journals and publications, which are divided into three zones. Only 2 core journals (1.4%) accounted for 34.0% of the

publications (300) in Zone 1, and 9 journals (6.1%) and another 32.4% of the publications (286) in Zone 2. The remaining 33.6% were provided by 137 journals (92.6%) in zone 3. The Journal of Urology was the leading journal with 307 documents (27%), followed by the Urology and British Journal of Urology, with the same number of documents (75, 6.53%) in zone 1.

Table 2. Distribution by zone of cited journals and publications.

Zones	Journal	Publication	Cumulative total
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	No.	(%)	No.	(%)	
Zone 1	2	1.4	390	34.0	390
Zone 2	9	6.1	372	32.4	762
Zone 3	137	92.6	385	33.6	1147
Total	148	100	1147	100	1147

These journals and the 9 journals in Zone 2 are shown in **Table 3** with their impact factor, the ISI category to which they belong, the position of the journal in its category, the number of papers, and the percentage of total publications. Journals in Zone 1 may be of vital interest to extracorporeal shock wave lithotripsy research worldwide, while other journals in Zone 2 are also important because, for instance, they reflect activities in the country of a respective reader. [13]

Table 3. Zone 1 and 2 journals with the impact factor (IF), the ISI category of the journal, the position of the journal in its category, and the number of papers (P)

Journal	IF	P (%)	ISI category	Position
Journal of Urology	3.297	307 (27.4)	Urology and Nephrology	6/49
British Journal of Urology	-	75 (6.57)	-	-
Urology	2.782	75 (6.57)	Urology and Nephrology	10/49
Urologia Internationalis	0.525	65 (5.66)	Urology and Nephrology	41/49
European Urology	2.247	52 (4.53)	Urology and Nephrology	13/49
Journal of Endourology	1.262	52 (4.53)	Urology and Nephrology	25/49
Scandinavian Journal of Urology and Nephrology	0.612	37 (3.28)	Urology and Nephrology	40/49
BJU International	1.642	31 (2.72)	Urology and Nephrology	19/49
Anesthesia and Analgesia	2.21	23 (2.01)	Anesthesiology	4/22
Ultrasound in Medicine and Biology	2.033	18 (1.56)	Radiology, Nuclear Medicine and Medical Imaging Acoustics	25/83 1/28
Journal of Stone Disease	-	18 (1.56)	-	-

The impact factor (IF) of a journal is defined by the JCR and is derived by dividing the number of current citations to articles published in the previous 2 years by the total number of articles published in the previous 2 years. It is a measure of the frequency with which the average article in a journal has been cited in a particular year. The IF is used to evaluate a journal's relative importance, especially when compared to others in the same field. The distribution of papers by reference to their IF was as follows: 1.8% of total papers had an IF of > 5, 1.8% had an IF of 4-5, 30% had an IF of 3-4, 17% had an IF of 2-3, 15% had an IF of 1-2, 21% had an IF of 0-1, and 13% had no information on IF. The mean impact factor of the journals was 1.96, excluding the journals with no information on IF. The journal with the highest

IF (18.316) was Lancet.

Country of Publication

There were 367 (32%) papers without author address information on the ISI Web of Science. For this reason, only 780 papers were included in this analysis. Among the 780 papers with author address information published from 1991 to 2013, 21 (2.7%) publications were international collaborations, and 759 (97%) were independent publications. They were diverse, representing 48 different countries, with most papers originating from the US (234, 30%), followed distantly by Germany (62, 8.0%), Turkey (50, 7.1%), the UK (44, 5.6%), France (39, 5.0%), and Japan (36, 4.5%). Turkey being

ranked third is not usual for other research fields, as the 7 major industrial countries (G7) normally occupy the top positions. [5, 6, 13] This is probably due to Gazi University at Ankara being active in ESWL research, as 20 papers were published by researchers at the university. Four countries had no

independent, and 29 countries had no international collaborative publications. Seventeen countries contributed only 1 or 2 independent publications, and 17 countries contributed only 1 or 2 international collaborative publications (Table 4).

Table 4. Publications by country from 1991 to 2003

Country	IP	CP	P	P%
USA	224	10	234	30
Germany	56	6	62	8.0
Turkey	50	0	50	7.1
UK	40	4	44	5.6
France	35	4	39	5.0
Japan	33	3	36	4.5
Austria	24	0	24	3.0
India	19	1	20	2.7
Belgium	18	2	20	2.7
Canada	18	2	20	2.7
Spain	16	3	19	2.5
Italy	16	2	18	2.3
The Netherlands	14	2	16	2.2
Sweden	13	3	16	2.2
Switzerland	13	2	15	2.0
Egypt	10	2	12	1.5
Greece	10	2	12	1.5
Saudi Arabia	9	3	12	1.5
Taiwan	9	3	12	1.5
Denmark	8	2	10	1.3
Brazil	7	1	8	1.0
Ireland	6	2	8	1.0
Norway	5	2	7	0.83
Pakistan	5	2	7	0.83
Yugoslavia	5	1	6	0.71
Peoples R China	4	2	6	0.71

Mexico	3	1	4	0.50
Croatia	3	0	3	0.37
Hong Kong	3	0	3	0.37
Kuwait	3	0	3	0.37
Oman	3	0	3	0.37
Russia	2	1	3	0.37
Singapore	2	1	3	0.37
South Korea	2	1	3	0.37
United Arab Emirates	2	1	3	0.37
Chile	1	2	3	0.37
Finland	1	0	1	0.13
Hungary	1	0	1	0.13
Iran	1	0	1	0.13
Lebanon	1	0	1	0.13
Morocco	1	0	1	0.13
New Zealand	1	0	1	0.13
Poland	1	0	1	0.13
Thailand	1	0	1	0.13
Argentina	0	1	1	0.13
Algeria	0	1	1	0.13
South Africa	0	1	1	0.13
Colombia	0	1	1	0.13

Figure 3. Cumulative percentage of extracorporeal shock wave lithotripsy papers and countries

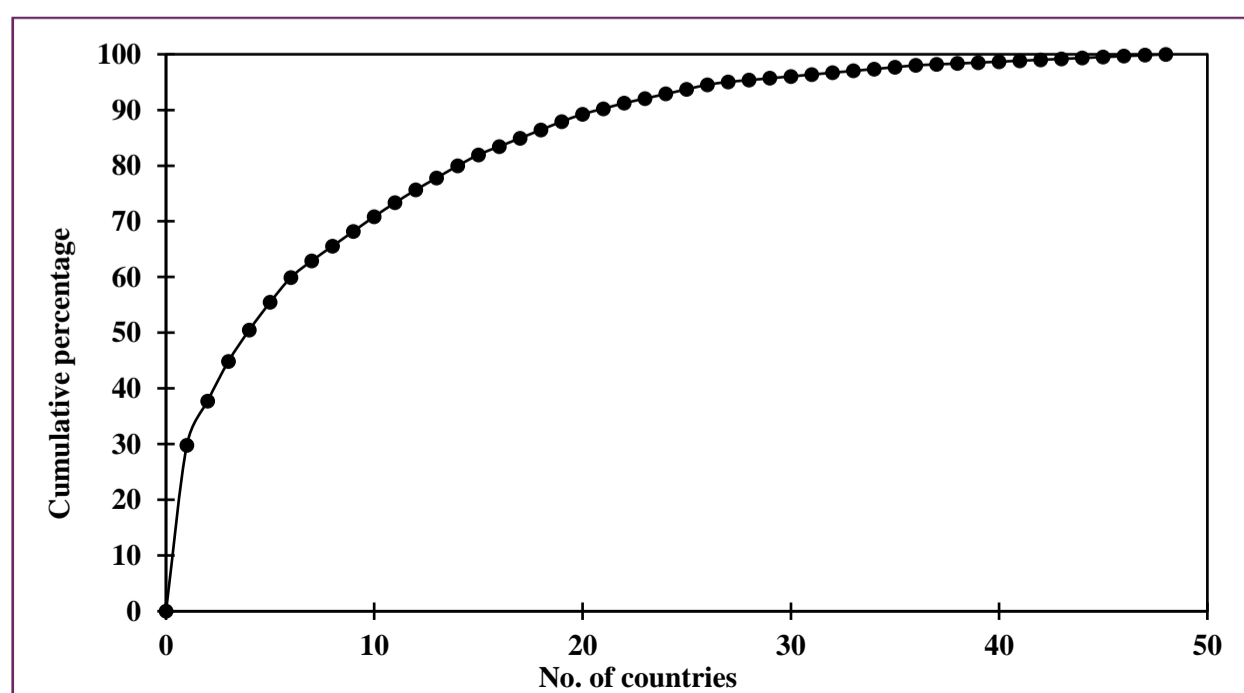
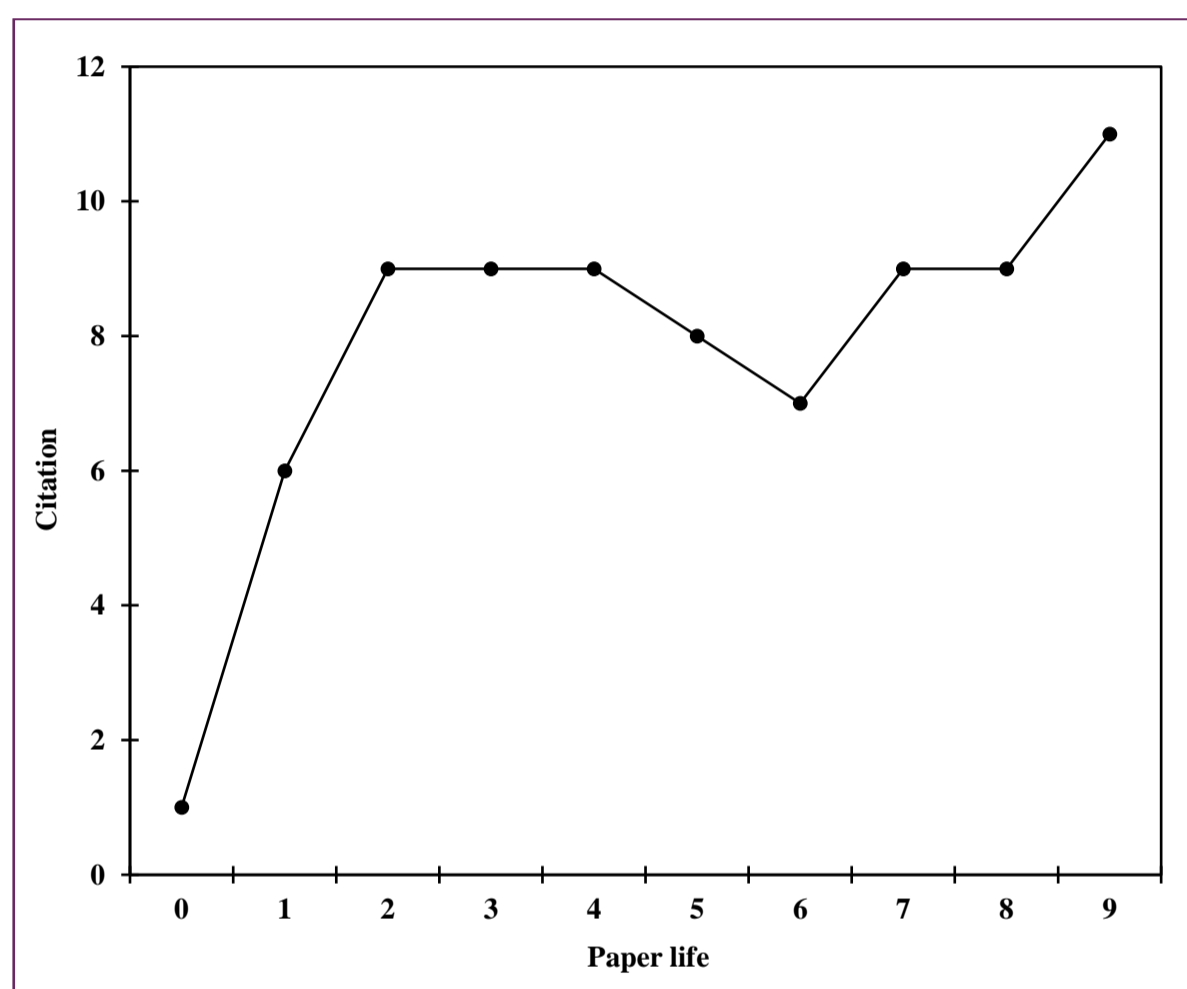


Figure 3 shows the relationship of the cumulative percentage of publications against the number of countries, and it indicates that 15 countries accounted for 80% of the papers on extracorporeal shock wave lithotripsy research. The geographic distribution of independent publications showed that 285 papers were from Europe (36% by 18 countries), 256 were from the Americas (33%, 7 countries), 165 were from Asia (21%, 17 countries), 25 were from Oceania (3.2%, 2 countries), and 12 were from Africa (1.7%, 2 countries). The results showed that research is diversified in these areas because ESWL research is a well-developed topic. The US had the greatest number of independent publications at 30% of all independent publications, followed by Germany with 7.7% and Turkey with 7.5%. The US had the most frequent partners, accounting for 25% of the international collaborative publications, followed by Germany with 13%.

Most-Frequently Cited Paper

The time dependence for a single article is called its history and may be viewed as the ‘sales figure’ of the article.¹⁹ Among ESWL-related articles, the most frequently cited was ‘Management of lower pole nephrolithiasis: a critical analysis.’ This article, in 1994 by Lingeman et al. from the US, was published in the Journal of Urology (with an IF of 3.297) and was cited 101 times since its publication until 2013. The citation history of the most frequently cited paper is shown in Fig. 4.

Figure 4. Citation history of the most frequently cited papers.



The citations reached a maximum of 2 years after publication. The peak position depends on the research discipline and shifts to about 4 years in the case of technical sciences^[19] and patent ductus arteriosus treatments in surgery.^[6] In addition, different fields show dissimilar citation frequencies where the present IF accounts for citations for only 2 years after publication.^[20] The citation pattern of the most-cited extracorporeal shock wave lithotripsy article indicated that the IF accounted for just the 2-year period as per the definition of ISI.

Conclusions

The publication rate of ESWL articles decreased steadily during the period in this study, from 115 in 1991 to 16 in 2013. Two linear relations between the yearly cumulative number of publications and year were obtained for the 2 periods from 1991 to 1994 and 1994 to 2013. The highest percentage of published documents was journal articles, followed distantly by letters. English remains the dominant language. The average number of authors per document was 4.2, and 4 authors were the most popular authorship. The top 3 ranking countries of publication were the US, Germany, and Turkey. The core journals of *Urologia Internationalis*, *British Journal of Urology*, *Urology*, and *Journal of Urology* in the ISI category of Urology and Nephrology are popular journals for extracorporeal shock wave lithotripsy research, as they accounted for 46% of all publications in the ESWL research field. The most frequently cited paper was published in the *Journal of Urology*, and the citations reached a maximum of 2 years after publication.

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