

National representation in the spine literature: a bibliometric analysis of highly cited spine journals

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Abstract

Purpose Significant progress has been seen in the field of spine in recent years as a consequence of worldwide contributions. However, the national productivity to the field of spine is still unclear. The aim of this study was to investigate the national contributions in the field of spine.

Methods Web of Science was searched for articles published in the five highly cited spine journals from 2009 to 2013, including *The Spine Journal*, *European Spine Journal*, *Spine*, *Journal of Neurosurgery: Spine*, and *Journal of Spinal Disorders and Techniques*. The number of total articles, the per capita numbers, impact factors, citations and funding source were recorded and analyzed.

Results A total number of 6920 articles were published in the five journals from 2009 to 2013 worldwide. North America, East Asia, and West Europe were the most productive world areas. High-income countries published 83.97 % of articles, middle-income 16.01 %, and lower-income just 0.01 %. The United States published the most number of articles (35.79 %), followed by China, Japan,

South Korea, and Canada, and had the highest total impact factors and the highest total citations. However, when normalized to population size, Switzerland had the highest number of articles per million populations, followed by The Netherlands and Sweden.

Conclusions The majority of the spine articles are published by authors from high-income countries while few publications from low-income countries. The United States is the most productive country in the field of spine. However, some European countries may be more productive when normalized to population size.

Keywords Spine · Bibliometric analysis

Introduction

Significant growth has been recently observed in the field of spine. The contributions from worldwide authors are responsible for the dramatic development of the care of spinal disorders. Obviously, the scientific contribution to the field of spine should not be equal for each country, because of different healthcare systems, funding sources and scientific research programs in different countries [1, 2].

As an important part of spine research, scientific publication is crucial for the progress of the field of spine. The number of papers originating from a country is an index of its contributions to the creation of new knowledge. Bibliometric analysis is widely used to investigate trends in scholarly publications and the relative importance of articles in a specific field [3–6]. In recent years, bibliometric analysis has also been increasingly performed to evaluate the national representation in various medical fields including emergency medicine [3], anaesthesia [4], plastic

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and reconstructive surgery [5] and critical care medicine [6].

However, to our knowledge, assessment of national productivity in the field of spine has never been reported before. Therefore, the current national representation in the field of spine remains to be established. To address this issue, we conducted this bibliometric analysis to assess the national productivity worldwide in highly cited spine journals from 2009 to 2013.

Materials and methods

In Journal Citation Reports (JCR) for the year 2013 established by the Institute for Scientific Information [7], the subject categories of “Orthopedics” and “Surgery” were screened for the high cited spine journals. A total of five journals related to field of spine, including *The Spine Journal*, *European Spine Journal*, *Spine*, *Journal of Neurosurgery: Spine*, and *Journal of Spinal Disorders and Techniques*, were included in this study (Table 1).

In October 2014, a computerized literature search was conducted in the database of Web of Science, which has been conducted in similar studies [3, 5, 6]. Articles published in the five journals from January 2009 to December 2013 were identified. Only the original articles and reviews were included. Letter, editorial material and correction were excluded. The titles of the journals were used to perform literature search in Web of Science. Where there was more than one institutional affiliation listed, the source nation was taken as the country of the corresponding author.

The number of published articles was considered as an index of quantity of research productivity. The total number of citations was considered as a quality indicator. The primary outcome was the number of articles attributed to each country. To reveal the contribution of different countries, the countries were ranked according to their productivity. Based on the categories of World Bank, we also calculated the proportion of articles that was attributed to high income, upper middle-income, lower middle-income, and low-income countries [8]. This categorization in terms of Gross National Income per capita includes high income, \$12,746 or more; upper middle income, \$4126 to

\$12,745; lower middle income, \$1046 to \$4125; and low income, \$1045 or less [8].

We further comprehensively analyzed the publications of the main productive countries (producing at least 1 % of the total publications), including the total numbers, the per capita numbers, total impact factors (IFs) (the number of articles multiplied by their IFs), mean IF, total citation (the number of articles multiplied by their citations) and mean citation. The IFs were according to 2013 JCR [7]. Population size for each country was gathered from the Central Intelligence Agency for the most recent report [9]. The publication in the five journals from the top five countries was generated, and the top five countries in the five journals were listed. Moreover, the information of funding source was extracted from the acknowledgments or disclosure section of each study. The type of funding source was classified as commercial funding, noncommercial funding, or no funding [10]. Our goal was to describe trends and not to test hypotheses regarding the relative contributions of different countries, so only descriptive statistics (e.g., sum and mean) were conducted.

Results

In the years 2009–2013, the total number of articles published in the five chosen journals was 6920. This figure represents contributions from 58 countries. The world map of the productive regions is shown in Fig. 1, indicating that North America, East Asia, and West Europe were the most productive areas from 2009 to 2013. High-income countries published 5811 articles (83.97 %), and middle-income countries (sum of upper middle-income and lower middle-income countries) published 1108 articles (16.01 %). However, low-income countries published only 1 article (0.01 %) (Fig. 2).

There were 16 main productive countries (producing at least 1 % of total articles) (Table 2). Most of them were high-income countries (13). The 2nd and 13th ranked nations (China and Turkey, respectively) were classified as upper middle-income countries, and the 14th ranked nation (India) was a lower middle-income country. The 16 countries published 91.11 % (6305/6920) of the total articles. The United States published the most number of

Table 1 Journal included in search

Journal	Abbreviation	Impact factor
<i>The Spine Journal</i>	TSJ	2.800
<i>European Spine Journal</i>	ESJ	2.473
<i>Spine</i>	Spine	2.447
<i>Journal of Neurosurgery: Spine</i>	JNS	2.355
<i>Journal of Spinal Disorders and Techniques</i>	JSDT	1.888

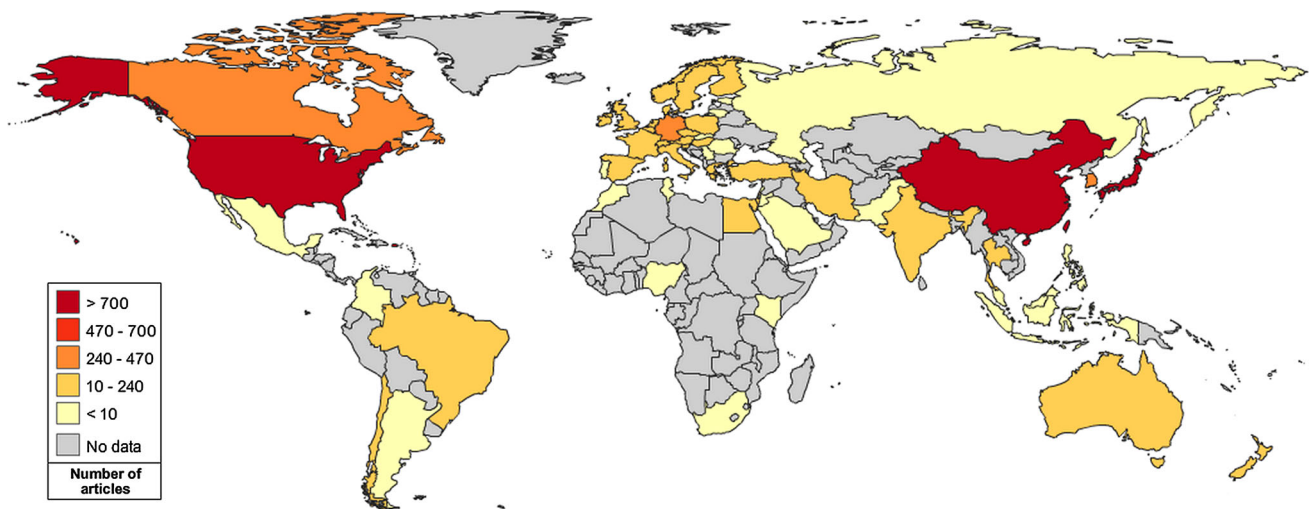


Fig. 1 The world map of the productive regions in 2009–2013

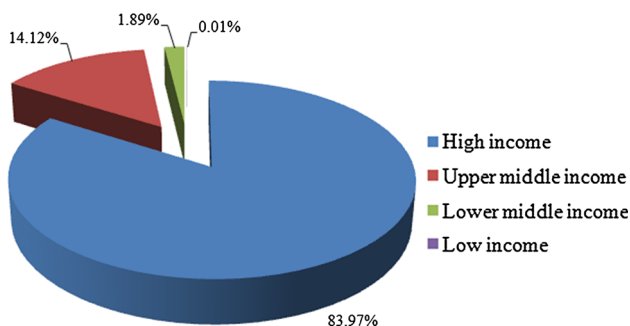


Fig. 2 Publications grouped by gross national income in 2009–2013

articles (2477/6920, or 35.79 %), followed by the China (721/6920, or 10.42 %), Japan (710/6920, or 10.26 %), South Korea (386/6920, or 5.58 %), and Canada (304/6920, or 4.39 %). Regarding the production per capita, Switzerland had the highest number of articles per million populations (15.51), followed by The Netherlands (9.60), and Sweden (9.15).

Among the 16 countries, the United States had the highest total IFs (6058.04), followed by the China (1724.36), Japan (1707.00), South Korea (935.56), and Canada (748.08). The Netherlands had the highest mean IF (2.483), followed by Switzerland (2.476), Spain (2.465), Italy (2.463), and Canada (2.461). The United States had the highest total citations (19,939), followed by the Japan (3285), China (3027), Canada (2595), and Germany (1899). The Netherlands had the highest mean citations (11.04), followed by Canada (8.54), United States (8.05), Sweden (7.94), and Australia (7.13).

The publication from the top five countries is shown in Table 3. Among the top five countries, *Spine* was the most

popular journal in all the top five countries, and *European Spine Journal* was the second most popular journal in three countries, including China, Japan, and South Korea.

The five most productive countries in the five journals are listed in Table 4. The United States was the most productive country in the four journals except *European Spine Journal*, while China was the most productive country in *European Spine Journal*. Japan was the second most productive countries in three journals including *European Spine Journal*, *Spine*, and *Journal of Neurosurgery: Spine*. In addition, the United States, China and Japan appeared in the top five countries in all the five journals. South Korea appeared in the top five countries in four of the five journals, Canada in three journals, Germany in two journals, and Italy in one journal.

A total of 2167 articles (2167/6920, or 31.32 %) reported funding source in support of the researches, while most studies (4753/6920, or 68.68 %) received no funding. Among the funded studies, the largest number of articles (1520/2167, or 70.14 %) was supported by one fund, followed by two funds (410/2167, or 18.92 %), and three funds (139/2167, or 6.41 %). The maximum number of funds received by a study was ten. The majority of funded articles (1597/2167, or 73.70 %) acknowledged the support by noncommercial funding, with the others (570/2167, or 26.30 %) receiving at least one commercial funding. Regarding the noncommercial funding, National Institutes of Health (NIH) supported the largest number of articles (208/2167, or 9.60 %), followed by AO Foundation (137/2167, or 6.32 %), and National Natural Science Foundation of China (79/2167, 3.65 %). In addition, several medical companies (i.e., Medtronic, DePuy, Synthes, and Stryker) actively sponsored a variety of spine researches.

Table 2 Publications from the most productive countries from 2009 to 2013

Country	<i>N</i>	%	<i>N</i> per million population	Total IF	Mean IF	Total citation	Mean citation
United States	2477	35.79	7.77	6058.04	2.446	19939	8.05
China	721	10.42	0.52	1724.36	2.392	3027	4.20
Japan	710	10.26	5.59	1707.00	2.404	3285	4.63
South Korea	386	5.58	7.87	935.56	2.424	1690	4.38
Canada	304	4.39	8.73	748.08	2.461	2595	8.54
Germany	292	4.22	3.61	711.17	2.436	1899	6.50
United Kingdom	234	3.38	3.67	572.63	2.447	1139	4.87
Italy	201	2.90	3.26	495.07	2.463	942	4.69
The Netherlands	162	2.34	9.60	402.20	2.483	1788	11.04
France	151	2.18	2.28	364.24	2.412	580	3.84
Australia	145	2.10	6.44	355.06	2.449	1034	7.13
Switzerland	125	1.81	15.51	309.53	2.476	891	7.13
Turkey	116	1.68	1.42	275.66	2.376	557	4.80
India	105	1.52	0.08	257.14	2.449	379	3.61
Sweden	89	1.29	9.15	218.27	2.452	707	7.94
Spain	87	1.26	1.82	214.48	2.465	484	5.56

N number, *IF* impact factor

Table 3 Articles published on the five journals of the top countries

Rank	USA	China	Japan	South Korea	Canada
1	Spine (1192)	Spine (300)	Spine (321)	Spine (167)	Spine (170)
2	JNS (537)	ESJ (212)	ESJ (171)	ESJ (74)	TSJ (47)
3	TSJ (420)	JSDT (99)	JNS (120)	TSJ (59)	JNS (35)
4	JSDT (189)	JNS (65)	JSDT (64)	JSDT (51)	ESJ (34)
5	ESJ (139)	TSJ (45)	TSJ (34)	JNS (35)	JSDT (18)

TSJ *The Spine Journal*; ESJ *European Spine Journal*; JNS *Journal of Neurosurgery: Spine*; JSDT *Journal of Spinal Disorders and Techniques*

Table 4 Top five countries in the five journals

Rank	TSJ	ESJ	Spine	JNS	JSDT
1	United States (420)	China (212)	United States (1192)	United States (537)	United States (189)
2	South Korea (59)	Japan (171)	Japan (321)	Japan (120)	China (99)
3	Canada (47)	Germany (152)	China (300)	China (65)	Japan (64)
4	China (45)	United States (139)	Canada (170)	Germany (35) ^a	South Korea (51)
5	Japan (34)	Italy (135)	South Korea (167)	South Korea (35) ^a	Canada (18)

TSJ *The Spine Journal*; ESJ *European Spine Journal*; JNS *Journal of Neurosurgery: Spine*; JSDT *Journal of Spinal Disorders and Techniques*

^a Two countries tied for same rank

Discussion

The field of spine has recently experienced a considerable evolution, which can be explained by the greatly development of science and technology, especially scientific contributions by spine researchers and surgeons from all over the world. Scientific publications not only promote the

expansion of new knowledge, but also a key indicator of research productivity. In this study, we found that authors originating from United States published far more articles than any other country. Accordingly, the United States plays an important role in spine research and publication. As we all know, United States has been recognized as the most productive country in the biomedical research for

about several decades. Besides the field of spine, United States had overwhelming dominance in many other sub-fields of biomedical research, such as emergency medicine [3], anaesthesia [4], plastic and reconstructive surgery [5] and critical care medicine [6].

Besides the most number of articles, The United States also had the highest accumulated IFs (6058.04) and total citation (19,939) in the field of spine. Most importantly, the United States also had high mean IF (2.446) and mean citation (8.05). This result is similar with the finding of a recent citation analysis on the most-cited articles in the field of spine [11]. In that study, it is proved that the United States published the majority (60/100, or 60 %) of the 100 top-cited classic papers in spine [11]. Therefore publications originating from the United States had not only large quantity but also high quality. In addition, although the United States has the large population, the per capita numbers of articles remained one of the most numbers per million persons (7.77). These findings further demonstrated that the United States was the most productive country in the field of spine in the world.

Regarding the proportional contributions of different countries, a “10/90” divide is used to describe the proportion between non-high and high income countries [12], which have been demonstrated in many medical fields [3–6]. However, a slight higher proportion was observed in the production of middle income country in our study. This may be attributed to the contributions of three middle income countries in the main productive countries, including China, Turkey and India [3, 4]. The increasing importance of these countries in the biomedical research was proved in many scientific researches [3, 4, 13–16]. This can be a suggestive reflection of the significant development of society and economy in these middle income countries [3, 4, 13, 16]. It could be forecasted that these countries with rapid economic increase could further improve their spine research and may promote their ranks in the future. Moreover, the lack of spine research productivity in low-income countries was observed in this study for only one article included. This may be affected by a combination of factors, such as government policy, medical infrastructures, research fund and researchers [4, 12, 17, 18].

When normalized to population size, some countries in Europe, such as Switzerland, The Netherlands, and Sweden, were more productive with largest number of articles per capita and high mean IF and citations. The productive countries are nearly all developed. Although China is the second productive country in the number of total article, the number of per million populations is rather small, which is followed by India. This indicates that the relative productivity remains very low in these countries and further growth is needed. Obviously, it may make more sense to normalize by the number of researchers and surgeons in each country, not the population size. However, it is rather

difficult to get the number of researchers and surgeons in the field of spine in each country.

United States was the most productive country in the four journals, including *The Spine Journal*, *Spine*, *Journal of Neurosurgery: Spine*, and *Journal of Spinal Disorders and Techniques*. These journals are also the top four popular journals in United States. It should be recognized that these four journals are all published in United States. Therefore, more submissions may be from United States than from other countries. In addition, *Spine* is the most popular journals in all the top five countries. The large number of articles, published in *Spine* every year, and the important influence in the field of spine are the possible reasons. *European Spine Journal*, which is the official publication of The Spine Society of Europe, is ranked the second most popular journal in three of the top five countries, including China, Japan and South Korea, which suggests that this journal is also the popular journal especially in East Asia.

During the study period, approximately one-third of spine publications received research funds, which was similar with the previous study [19]. Overall, spine articles were funded by a wide variety of sources. Most funded studies were supported by noncommercial funding. NIH funding, as the largest funding source for biomedical research in the world, supported the largest number of spine surgery research. Moreover, commercial funding was also an alternative funding source in the field of spine [20]. Many of the papers without noncommercial funding may very well have been funded by industry. The involvement of commercial funding is crucial for spine research, not only because it is an important source of funding, but also because its expertise in conducting translational research and developing products are benefit for patient care [19, 20].

There are some limitations in this study. First, JCR criteria was used for including medical journals in the study. Articles published in non JCR-cited journals were not included, although they contribute to scientific production. Second, only English journals were eventually included, so language bias in the journal source is inevitable in this study. Third, although the journals were selected from the “Surgery” and “Orthopedics” categories of the JCR, some basic science and general orthopedic journals in other categories also published spine-related articles, which could not be included in this study. Nevertheless, the five highly cited journals included in this bibliometric analysis could represent the major journals devoted to the field of spine.

Conclusion

In summary, we evaluated the national research productivity in the field of spine during a 5-year recent period in this study. The results of the present study showed that the

majority of publications was published by high-income countries while few publications by low-income countries. United States is the most productive country in the field of spine. When normalized to population size, some European countries might be more productive.

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Compliance with ethical standards

Conflict of interest None of the authors has any potential conflict of interest.

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