Bibliometric Analysis of Publications From 2011–2020 in 6 Major Neurosurgical Journals (Part 1): Geographic, Demographic, and Article Type Trends

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Key words
- Article types
- Bibliometrics
- Neurosurgical journals
- Publication trends
- Scientometrics

Abbreviations and Acronyms
GDP: Gross Domestic Product
JCR IF: Journal Citation Reports impact factor
JNS: *Journal of Neurosurgery*
JNSP: *Journal of Neurosurgery: Pediatrics*
JNSS: *Journal of Neurosurgery: Spine*
NS: *Neurosurgery*
ONS: *Operative Neurosurgery*
WFNS: World Federation of Neurosurgical Societies
WNS: *World Neurosurgery*

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■ INTRODUCTION: **Scientometrics is a subfield of bibliometrics that statistically analyzes publications trends. The aim of this initial study was to investigate trends in the 6 major neurosurgical journals from the last 10 years.**

■ METHODS: **We searched Web of Science and Scopus for articles published in *Neurosurgery, Journal of Neurosurgery, Journal of Neurosurgery: Spine, Journal of Neurosurgery: Pediatrics, Operative Neurosurgery,* and *World Neurosurgery* from January 1, 2011, to December 31, 2020. Statistically analyzed parameters included national and continental distribution of articles, population density, density of neurosurgeons per 100,000 inhabitants, national per capita GDP, and national literacy rates. Bibliometric parameters assessed included total number of articles, H-indices, absolute/average number of citations per article, and article types.**

■ RESULTS: **A total of 39,239 articles were published in the 6 journals. *Journal of Neurosurgery* and *Neurosurgery* had the strongest source impact. The most productive year was 2019 with 6811 published articles. Corresponding authors from the USA, China, Japan, Western Europe, and Turkey were the most productive. Articles published by authors from the USA received the majority of citations. Publication numbers increased in proportion with increases in country population, literacy rate, per capita GDP, and neurosurgeon density. The highest number of articles were published in 2016, and the fewest were published in 2020.**

■ CONCLUSIONS: **Geographic trends in the diversity of neurosurgical publications sustained its steady increase in most developed counties. Simultaneously, the publication gap between developed and developing countries has remained stagnant.**

INTRODUCTION

Bibliometrics is a methodologic approach from the library sciences that statistically analyzes the citation counts of books, articles, and other publications to determine influence and impact. Scientometrics is a subfield of bibliometrics that studies science publications by using bibliometric methods to find author, article, and journal-level metrics. Many scientometric analyses (although they have been mislabeled as bibliometric studies) have been done in various specialties, including spine surgery,[1,2] radiology,[3] and general surgery,[4] as well as articles related to specific disease states (e.g., epilepsy[5] and stroke[6]). In neurosurgery, for example, bibliometrics has been used to find the 100-most cited articles on carotid stenting,[7] endovascular treatment of aneurysms,[8] craniopharyngiomas,[9] pediatric neurosurgery,[10,11] and skull base neurosurgery.[12] It has been used to analyze specific journals,[13,14] pediatric patient databases,[15] U.S. National Institutes of Health funding and research,[16] and the publication output of residency programs[17] and academic neurosurgical departments.[18] However, to the best of our knowledge, a detailed scientometric analysis of the primary neurosurgical publications of the past 10 years has not yet been performed.

Medical specialties that developed later than other specialties, such as neurosurgery, are constantly changing with new concepts and techniques. A 1973 editorial published in *New England Journal of Medicine*, for example, expressed concerns about the future of neurosurgery, suggesting that the specialty may die because neurosurgeons have less time to conduct research versus physicians in other fields.[19] Obviously, this has been proven wrong by the ever-increasing number of publications in the neurosurgical field.[1,2]

The purpose of this study (Part 1) is to conduct a scientometric analysis of publications found in the 6 major neurosurgical journals from the last 10 years. We sought to investigate and identify publishing trends based on geography (regional, national, and continental differences), as well as article type. We also explored relationships between publications and country's population, literacy rate, per capita gross domestic product (GDP), and neurosurgeon density and tested different relationships statistically.

METHODS

Data Collection

We searched the Web of Science database for all articles published during a 10-year period from January 1, 2011, to December 31, 2020, in journals dedicated solely to neurosurgery on March 8, 2021. We limited our search to the following neurosurgical journals: *Neurosurgery* (NS), *Journal of Neurosurgery* (JNS), *Journal of Neurosurgery: Spine* (JNSS), *Journal of Neurosurgery: Pediatrics* (JNSP), *Operative Neurosurgery* (ONS), and *World Neurosurgery* (WNS). These journals were selected based on their 2019 impact factors derived from the Journal Citation Reports (JCR) released by Web of Science Group, part of Clarivate Analytics, on June 30, 2020.[3] The 2019/2020 impact factors (JCR IFs) of these 6 journals are as follows: *NS* (JCR IF, 4.853); *JNS* (JCR IF, 3.968); *JNSS* (JCR IF, 3.011); *JNSP* (JCR IF, 2.117); *ONS* (JCR IF, 1.886); *WNS* (JCR IF, 1.829). We excluded neurosurgical journals with JCR IFs lower than that of WNS (JCR IF, 1.829), as well as "combined neurosurgical journals" that published both neurosurgical and neurologic articles. Finally, we excluded "Review" (a Web of Science designation of document type) and other "Topic Based" (i.e., subspecialty-focused) neurosurgical journals (outside of JNSS and JNSP) from this study.

Various data points studied include national and continental distribution of articles according to the country-of-origin affiliation of the corresponding author (i.e., the location of the corresponding author's home institution, not necessarily the author's nationality). National demographic data—like population density, per capita GDP, and literacy rate—were taken from the World Bank and United Nations databases. Data regarding the density of neurosurgeons per 100,000 inhabitants were taken from the World Federation of Neurosurgical Societies Web site (https://www.wfns.org/menu/61/global-neurosurgical-workforce-map). Other parameters assessed included total number of articles, common bibliometric parameters such as H-index, and the absolute/average number of citations per article. Finally, we divided types of articles into the following Web of Science assigned document type descriptions found in the results:[20] *Articles, Abstracts from Scientific Meetings (Meeting Abstracts), Review Articles, Editorials (Editorial Material), Technical Notes,* and *Letters to the Editor (Letter).* Following Web of Science's descriptions, *Articles* were defined as any original study with a non-review focus; *Review Articles* were defined as any study with a review of the literature as its primary focus, such as a systematic review, meta-analysis, or other smaller scale review of other studies.

The source impact of the journals was determined by H-index. Although used more frequently as a measure of author productivity and impact, the H-index can also be applied to groups, institutions, and journals.[21,22] It is determined by finding the greatest number of published papers from a journal (h) that is equal to or greater than the number of citations acquired by the journal (h). Source impact was determined for the 10-year period of our analysis as opposed to the lifetime productivity of the journals (lifetime impact is usually standard for determining H-index).

Statistical Analysis

Data from numeric and categorical variables were compiled from Web of Science with Excel (Microsoft, Redmond, WA). Statistical analyses was performed using R (R Foundation for Statistical Computing, Vienna, Austria) version 4.0.3, using the *bibliometrix* package.[23,24] Various plots were drawn using the *ggplot* package (Tidyverse, https://ggplot2.tidyverse.org). Nonparametric data were expressed as numbers (percentage) and analyzed using the χ^2 test wherever relevant. Parametric data were analyzed using t test or analysis of variance, depending on the number of variables. The Shapiro test was used to check for normality, and nonparametric test equivalents of parametric tests like Mann-Whitney U test and Kruskal-Wallis test were used in case the condition of normality of data was not fulfilled for the parametric tests. Statistical significance was set at $P < 0.05$.

RESULTS

A total of 39,239 articles were published in the 6 neurosurgical journals between January 1, 2011, and December 31, 2020. **Figure 1A** shows the distribution of the 6 major journals according to the source impact measured by H-index (as per the publication in the study period). JNS and NS had the strongest source impacts (90 and 80, respectively). **Figure 1B** shows the annual distribution of published articles. The most productive year was 2019 when 6811 articles were published, and the least productive year was 2014, with only 2479 articles. There is a steep rise in publishing during the period 2014–2019. The difference between these years was statistically significant ($P < 0.005$).

Geographical Trends

A world map of scientific publication distribution is depicted in **Figure 2A** showing the United States of America (USA), China, Japan, Turkey, and most of Western Europe as the most productive regions. We describe countries with scarce scientific publishing productivity as "silent" areas; these include the following geographic areas: most African countries (excluding the Republic of South Africa, Egypt, Morocco, Nigeria, Ethiopia, Kenya, and Tanzania); some Middle East countries like Yemen and the United Arab Emirates; most Central Asian countries; some Southeast Asia countries, including Sri Lanka, East Timor, Bhutan, Laos, Taiwan, and North Korea; most Melanesia countries including Papua New Guinea; a few Caribbean, Central America, and Latin America countries like the Dominican Republic, Jamaica, Belize, Guyana, French Guiana, and Paraguay; and several Eastern Europe countries like Latvia, Belarus, and Moldavia, as well as Southeast European countries like Bosnia and Herzegovina, Montenegro, North Macedonia, and Kosovo.

Figure 2B shows the distribution of the number of articles published over the last 10 years by the 20 countries with the highest number of publications. The

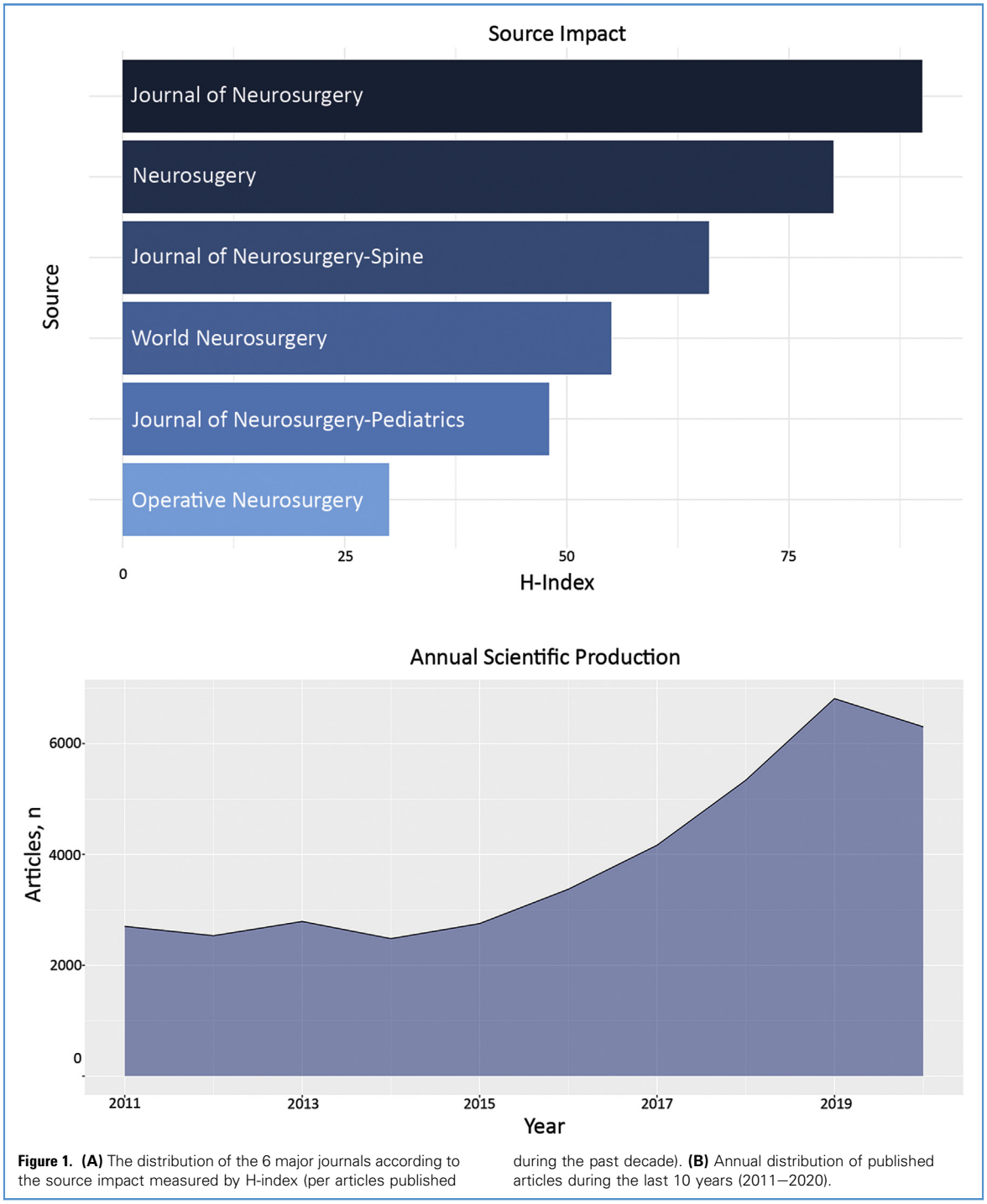

Figure 1. **(A)** The distribution of the 6 major journals according to the source impact measured by H-index (per articles published during the past decade). **(B)** Annual distribution of published articles during the last 10 years (2011–2020).

USA had the highest number of publications, followed by China and Japan. The USA was corresponding author country-of-origin for 48.8% of the articles (n = 15,208). This was followed by China (10.5%; n = 3270), Japan (7.25%; n = 2262), and Italy (3.57%; n = 1114). Iran, Finland, Israel, and Norway were at the bottom of the 20-country list.

The orange color in Figure 2B depicts publications with authors from more than 1 country (i.e., multi-country collaboration), which again are concentrated in the USA, followed by Canada and China. Articles with corresponding authors from Canada had the highest proportion of multi-country collaboration (34.6%), while authors from Japan had the lowest proportion (6.5%). Bibliometric connections among different countries indicated that the USA and China had extensive

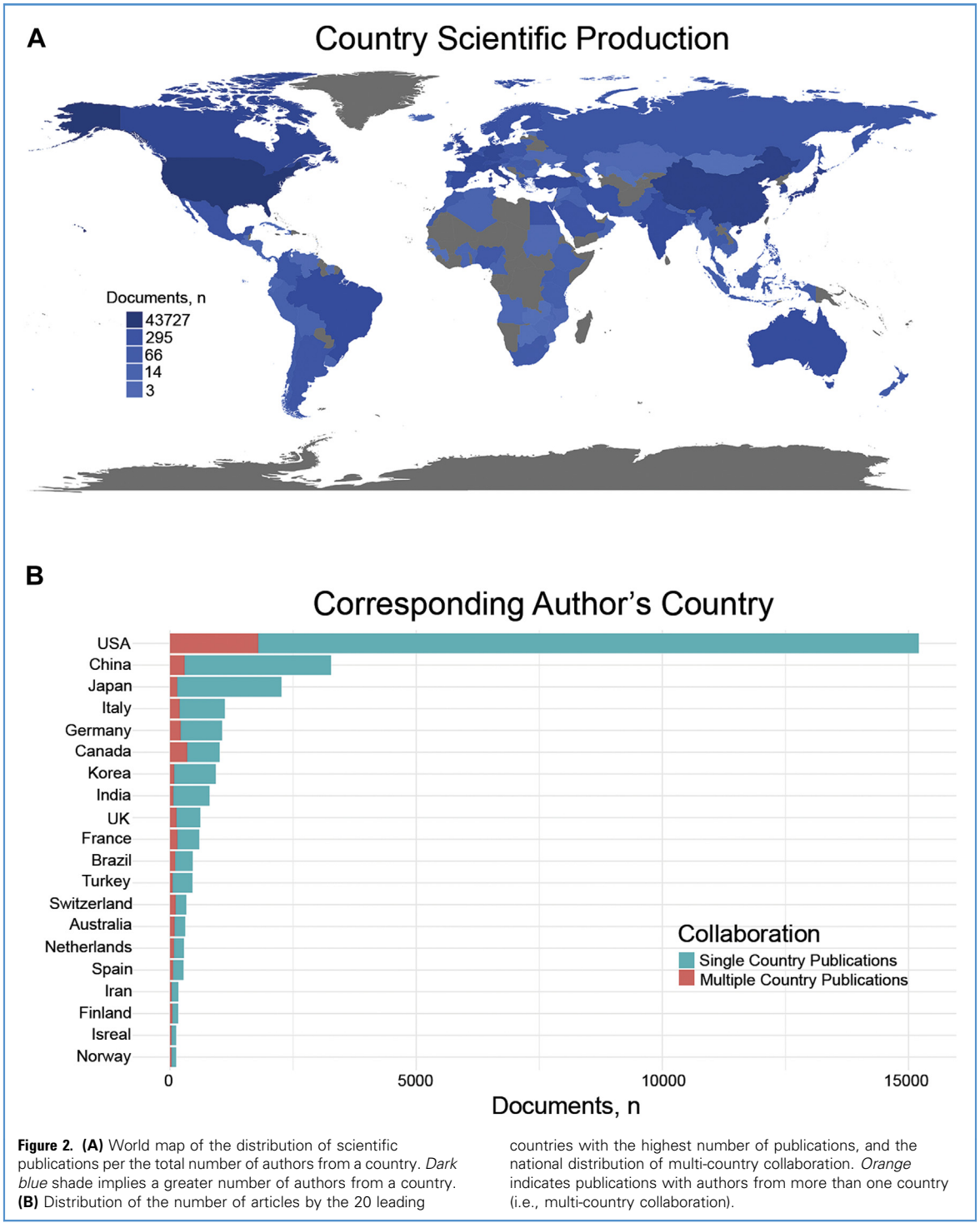

Figure 2. **(A)** World map of the distribution of scientific publications per the total number of authors from a country. *Dark blue* shade implies a greater number of authors from a country. **(B)** Distribution of the number of articles by the 20 leading countries with the highest number of publications, and the national distribution of multi-country collaboration. *Orange* indicates publications with authors from more than one country (i.e., multi-country collaboration).

connections with other countries, while countries like Russia and Lebanon had few connections.

Figure 3A shows the continental distribution of articles published over the last 10 years. North America contributed to the highest number of articles, followed by Asia and Europe. Middle-income countries (lower and upper middle-income) in Asia and South America contributed to publication number considerably.

Figure 3B and C show the change in the proportion of articles published by the top 10 countries and continents over the last 10 years. The second half the decade saw an increase in publications from China, which was associated with a corresponding

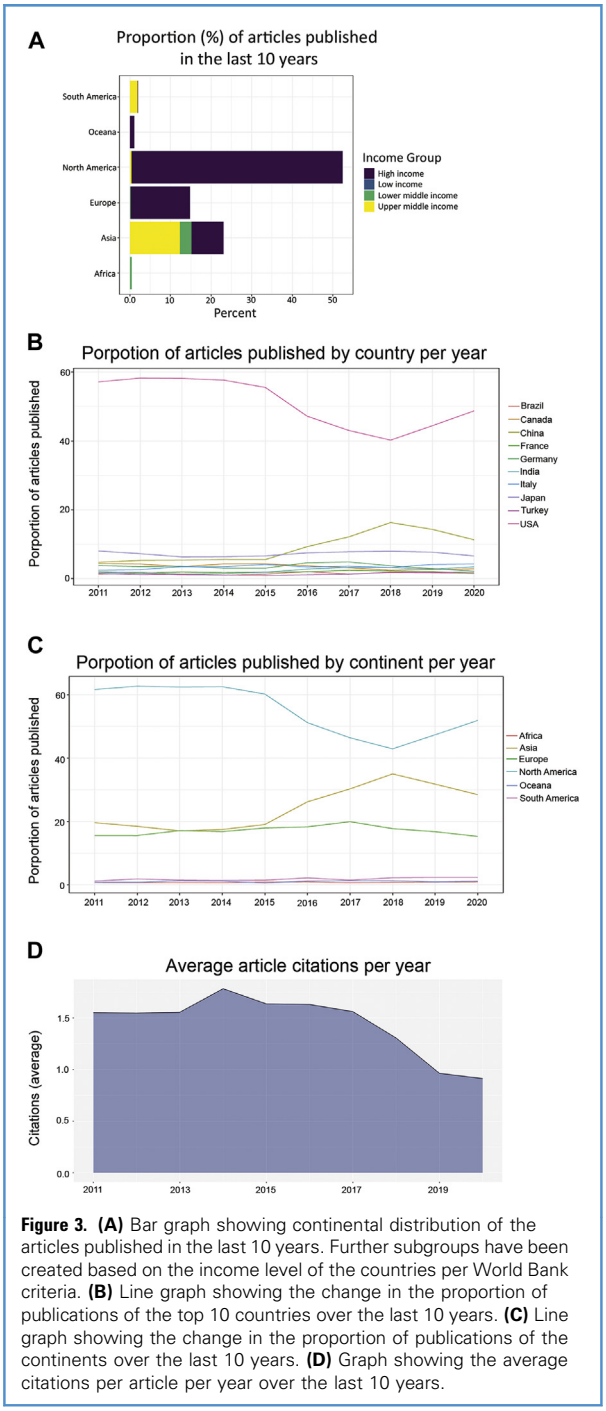

Figure 3. **(A)** Bar graph showing continental distribution of the articles published in the last 10 years. Further subgroups have been created based on the income level of the countries per World Bank criteria. **(B)** Line graph showing the change in the proportion of publications of the top 10 countries over the last 10 years. **(C)** Line graph showing the change in the proportion of publications of the continents over the last 10 years. **(D)** Graph showing the average citations per article per year over the last 10 years.

decline in the publications from the USA. North America was the leading continent in article publishing by far, followed by Asia and Europe.

Article Citations

Articles published in the USA received 150,065 citations (average number of citations per article, 9.87), followed by 16,233 citations from China (average number of citations per article, 4.96), 15,447 from Japan (average number of citations per article, 6.83), and 10,942 citations from Germany (average number of citations per article, 8.87). The countries with the highest average number of citations per article were Norway (12.91), followed by Finland (11.82), Sweden (11.63), and Austria (10.62). Figure 3D shows the change in the average number of citations per article per year, which peaked in 2014 and decreased gradually after that. This decrease probably indicates that articles published after 2014 are recent and still accruing citations.

The number of publications increased in proportion to population (Figure 4A). This difference was statistically significant ($P = 0.0002$). The relationship between the articles and population density was not statistically significant ($P = 0.837$). We found that the USA had the highest number of publications per 100,000 inhabitants in the top 20 countries, followed by countries with smaller populations, like Switzerland, Finland, Canada, and Norway. The difference was not statistically significant ($P = 0.075$) (Figure 4B). The number of publications increased as country per capita GDP increased from US$ 20,000 to US$ 75,000 (Figure 4C). This difference was statistically significant ($P = 0.036$). The number of publications increased as the literacy level of the country increased from 85% to 95% (Figure 5A). The difference was not statistically significant ($P = 0.268$). There was not a statistically significant correlation between the density of neurosurgeons per 100,000 inhabitants (Figure 5B) ($P = 0.057$). The proportion of articles published by countries other than the top 20 countries showed that articles varied annually from 3.9% in 2011 to 6.7% in 2020.

Figure 5C shows the top 20 institutions that contributed the highest number of articles. Corresponding authors from the University of California, San Francisco, contributed to the highest number of articles (n = 1659), followed by the Mayo Clinic (n = 1412), University of Pittsburgh (n = 1161), Barrow Neurological Institute (n = 1115 articles), University of Toronto, Canada (n = 1111 articles), and Capital Medical University, China (n = 781 articles).

Distribution of the 18 U.S. institutions showed that most institutions were located in the northeast U.S. (Columbia University [New York, NY], Cornell University [New York, NY], Harvard [Cambridge, MA], Johns Hopkins

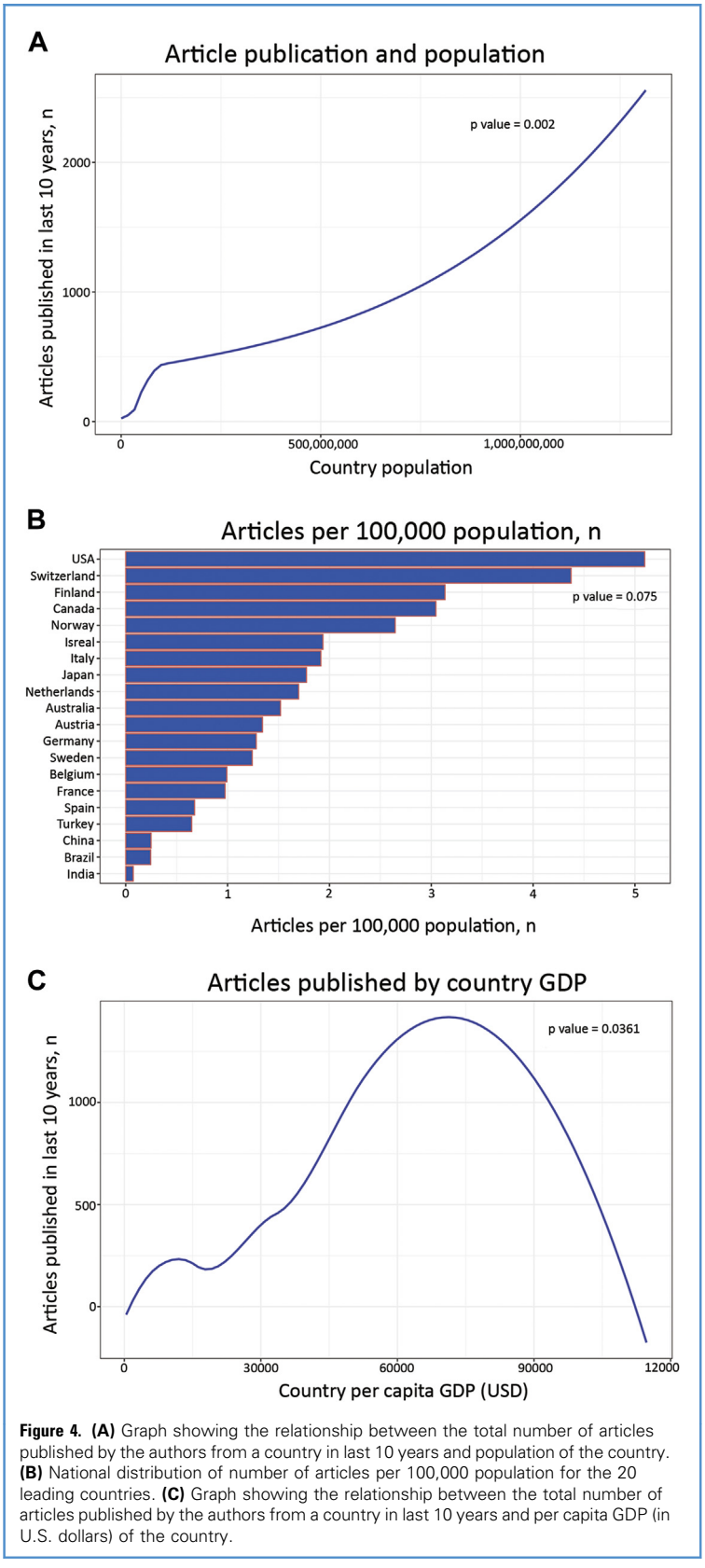

Figure 4. **(A)** Graph showing the relationship between the total number of articles published by the authors from a country in last 10 years and population of the country. **(B)** National distribution of number of articles per 100,000 population for the 20 leading countries. **(C)** Graph showing the relationship between the total number of articles published by the authors from a country in last 10 years and per capita GDP (in U.S. dollars) of the country.

University [Baltimore, MD], and University of Pittsburgh [Pittsburgh, PA]) and the southeast U.S. (Duke University [Durham, NC], Emory [Atlanta, GA], University of Miami [Miami, FL], University of Virginia [Charlottesville, VA], Vanderbilt University [Nashville, TN]). Three institutions were located in Pacific coast states (Stanford University [Stanford, CA], University of California, San Francisco, and University of Washington [Seattle, WA]) and in the Midwest (Mayo Clinic [Rochester, MN], University of Michigan [Ann Arbor, MI], and Washington University [St. Louis, MO]). One institution was located in Rocky Mountain states (University of Utah [Salt Lake City, UT]) and one was located in the desert southwest (Barrow Neurological Institute [Phoenix, AZ]). These 18 institutions represent 15.7% of the 115 U.S. academic neurosurgery programs accredited by the Accreditation Council for Graduate Medical Education.[25]

Trends in Article Types

Figure 6A shows national distribution per article type. The highest number of *Articles* was published in the USA (n = 10,552). The relative proportion of *Articles* was the highest for South Korea (88%; n = 851), followed by Japan (84%; n = 2060) and China (80%; n = 2246). The most *Technical notes* were published in the USA (n = 3349), accounting for 19.33% of all the articles published by American authors. American authors published the highest absolute number of *Review Articles* (8.7% of all articles published by authors from the USA; n = 1498). Canadian authors had the highest proportion of *Review Articles* (11.5% of all articles published by authors from Canada; n = 175) out of all the articles published by the authors from any country. The highest absolute number of *Editorials* was published by the authors from the USA (3.1% of all articles published by authors; n = 542). The proportion of *Editorials* was highest for Canadian authors (4.3% of all articles published; n = 65).

Figure 6B shows the total proportion of the 39,239 different article types published during the study period. There were 20,550 *Articles*, 7712 *Editorials*, 3986 *Abstracts from Scientific Meetings*, 3634 *Letters to the Editor*, and 2418 *Review Articles*. The

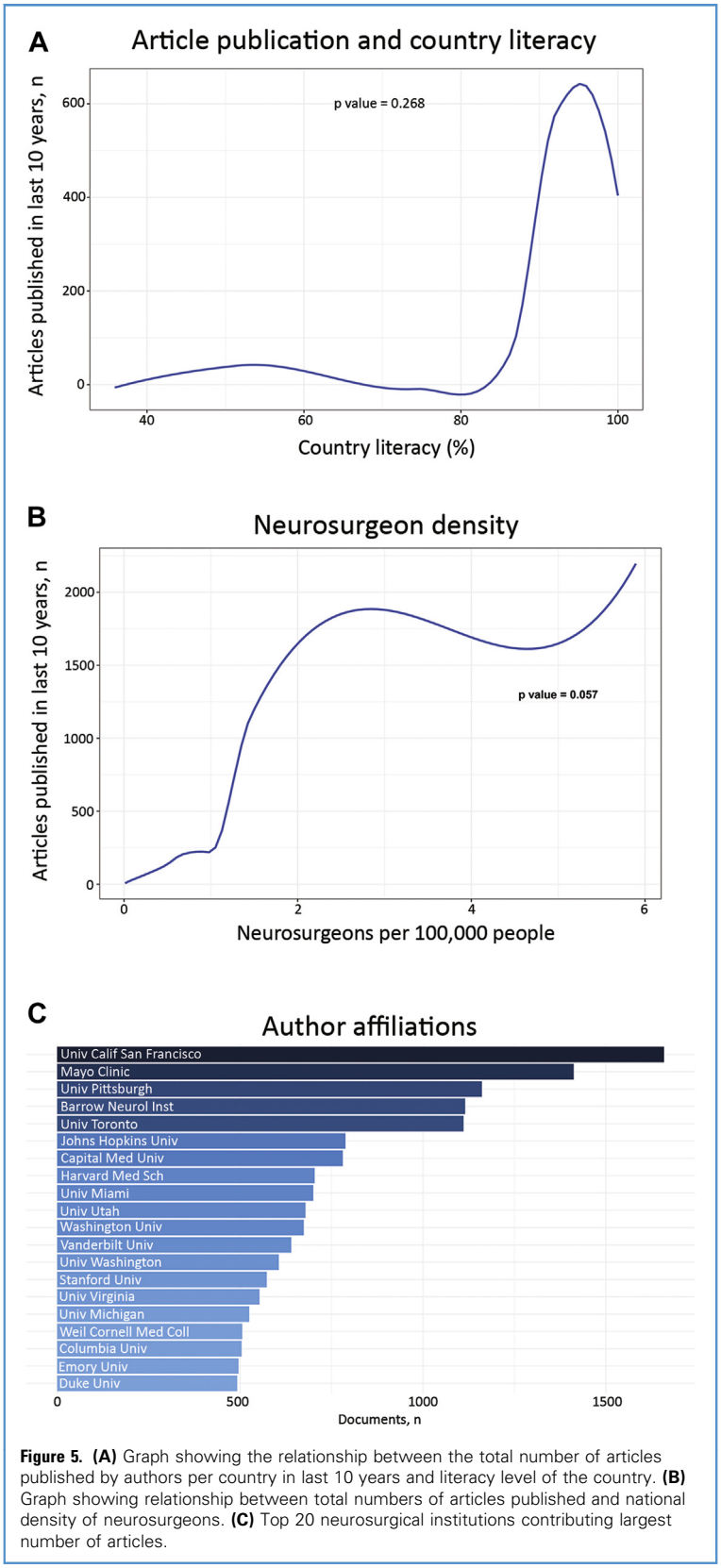

Figure 5. **(A)** Graph showing the relationship between the total number of articles published by authors per country in last 10 years and literacy level of the country. **(B)** Graph showing relationship between total numbers of articles published and national density of neurosurgeons. **(C)** Top 20 neurosurgical institutions contributing largest number of articles.

difference between the proportions of different article types published was statistically significant ($P < 0.05$).

Annual changes in the proportion of article types are shown in **Figure 6C**. The most *Articles* appeared in 2016 (59.2%) and 2017 (58.2%). The fewest appeared in 2020 (47.3%). The difference between years was not statistically significant ($P = 0.86$). The proportion of *Review Articles* increased from 1.9% in 2013 to 9.2% in 2019.

The year 2020 saw a drop in the number of total published articles, as well as in the proportion of *Articles* and *Review Articles*. Article types that were more frequently published in 2020 were *Letters to Editor* (7.6% in 2019 vs. 12.8% in 2020) and *Biographies* (0.03% in 2019 vs. 0.1% in 2020).

DISCUSSION

Findings

We found several trends in our investigation of publications in the last decade. The distribution of the 6 major journals, according to the source impact measured by H-index, indicating that JNS and NS were the 2 leading journals. The total number of articles increased gradually from 2170 in 2011 to 6811 in 2019. (There was a slight drop in the year 2020, possibly due to the COVID-19 pandemic) There was a nearly 2.5-fold increase in the number of publications.

Articles came from 96 countries, with the USA contributing roughly half. The USA was also the corresponding author country-of-origin of the majority of articles. Overall, the USA produced the highest quantity of articles[26]; however, interventional oncology clinical trials in the period between 1996 and 2006 slowed down in the USA but rose globally, particularly in Japan and China.[27] Countries that ranked immediately after the USA in terms of quantity included China, Japan, and Italy. Canadian corresponding authors had the greatest proportion of articles with multi-country collaborations and the greatest ratio of multi-country to single country publications, while those from Japan had the smallest proportion. Of the bottom top-20 countries, Iran, Finland, Israel, and Norway produced the fewest number of

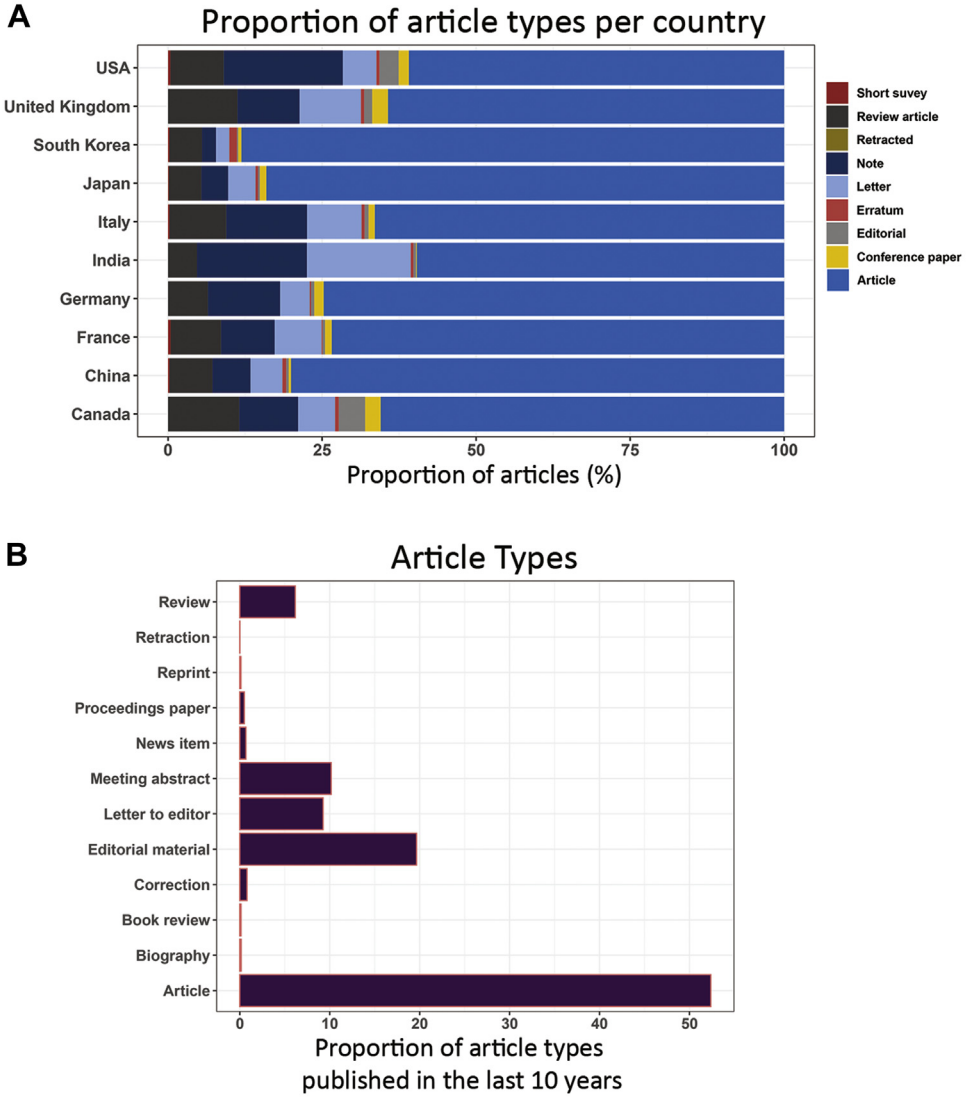

Figure 6. **(A)** Relative proportion of articles published by country. **(B)** Total proportion of articles published in last 10 years. **(C)** Proportion of published articles per year.

articles. The proportion of articles published by countries outside of the top 20 countries remained low, except for a small increase in 2020, which was perhaps related to the COVID-19 pandemic when authors from outside the top-20 countries published their pandemic management strategies. Regionally, North America surpassed other world regions in neurosurgical publishing production by far, with Western Europe a distant second. Asia and Eastern Europe, including Turkey, increased their production noticeably. However, the absolute and relative numbers of publications from developing areas, including Africa, remained extremely scarce, which is consistent with previous research on different pathologies and of different medical fields.[28]

Neurosurgical articles published from the USA received the majority of citations, followed distantly by China, Japan, and Germany. However, the highest average number of citations per article (out of the countries whose articles received more than 1000 citations) came from Norway, Finland, Sweden, and Austria, respectively. This indicates that despite having a lower rate of publishing, articles from these European countries were of high impact and frequently cited.

Among the top 20 institutions that contributed the highest number of articles, corresponding authors from the University of California, San Francisco, contributed the most, followed by authors from Mayo Clinic, the University of Pittsburgh, and Barrow Neurological Institute, respectively. There were only 2 institutions outside the USA in the top 20 institutions—the University of Toronto in Canada, and Capital Medical University in China. Universities from the USA have extensive collaborations with all other institutes from other countries. Interestingly, roughly one-sixth of accredited USA neurosurgical programs made into top-20 publishers.

In our analysis, we found that the number of published articles increased significantly in proportion to increases in country population ($P = 0.0002$). However, the relationship between articles and population density was not statistically significant ($P = 0.837$), which may be due to confounding factors—most high-income countries have low population density, for example. The number of publications increased sharply as country per capita GDP increased. However, there was a steep decline after per capita GDP reached US$ 75,000. Another interesting observation was that middle income countries in Asia and South America contributed considerably to publication number. A study from Southeast Asia confirmed that per capita GDP was associated with higher research output but was not associated with any bibliometric parameters.[29] Not surprisingly, the number of publications increased sharply as the literacy level of the country increased. The number of publications also increased sharply as the density of neurosurgeons increased. Density spiked with Japan, which has the highest density of neurosurgeons (5.895 per 100,000). The correlation between the total number of publications and the density of neurosurgeons was not statistically significant ($P = 0.057$).

Of the publication types, *Articles* were predominantly represented in the 6 major neurosurgical journals analyzed, followed by *Editorials* and *Abstracts from Scientific Meetings*. Annual analysis of changes in the proportion of different types of articles showed that the largest proportion of published *Articles* occurred in 2016 and 2017; afterwards, this proportion dropped gradually. The number of total articles dropped in 2020, as well as in the proportion of *Articles* and *Review Articles*. We speculate that this decline was due to the global spread of COVID-19. *Letters to Editor* were the most frequently published article type in 2020. The most *Articles* were published in the USA; however, the proportion of *Articles* out of the total articles published by country was largest for South Korea, Japan, and China. *Technical Notes* were most common in the USA, accounting for 19.33% of all the articles published in the USA. American authors also published the most *Review Articles*; however, Canadian authors published the greatest proportion of *Review Articles* out of all articles published by the authors of all countries. The highest number of *Editorials* was also published in the USA, but the proportion of *Editorials* was greatest in Canada.

Hauptman et al. studied global trends in research productivity in neurosurgery between 1996 and 2009 and observed that the USA was the biggest contributor to the neurosurgical literature (n = 16,943 articles; 31.7%), followed by Japan (n = 10,802; 20.2%).[2] We observed that authors from the USA contributed 48.8% of total articles from 2011–2020. This higher percentage in our study could be due to the fact that the 6 journals we included are based in the USA, while the earlier study included 22 journals, many of which were non-English language journals. China demonstrated rapid growth in research productivity in both decades according to both studies.

Study Limitations

Study limitations include the fact that we analyzed publications from only 6 major neurosurgical journals in order to make the research more concise. Other important journals that publish neurosurgical articles, such as combined neurosurgical and other specialty journals, review and topic neurosurgical journals, or neurosurgical journals with JCR IFs lower than that of *World Neurosurgery* were excluded. Thus, a large number of articles never made it into our study. Finally, although most journals significantly restricted publication of Case Report articles, Scopus and Web of Science did not identify those as such and distinguish them from other original articles. Both were included in the *Article* characteristic.

CONCLUSIONS

With the exception of 2020, when COVID-19 appeared to slow down publication, it is evident that neurosurgical publications from the last decade continued to increase in productivity, global expansion, and subject diversity. The increase over the past decade was 2.5-fold. The USA contributed roughly half of the publications, followed distantly by China, Japan, and Italy. The USA maintained a dominant position in neurosurgical publications, even when the number of publications was corrected to 100,000 inhabitants per country. However, in that comparison, the USA was followed closely by Sweden, Finland, Canada, and Norway. North America leads in the continental distribution of publications by far, followed by Asia and Europe. Literacy level, density of neurosurgeons, and country per capita GDP all correlated positively to the number of neurosurgical publications of country. Significant contributions of upper

and lower middle-income countries in Asia and South America were also noted, but a substantial publication gap still exists between developed and developing countries—these countries of the "silent world" remain unchanged over the past decade. Most article citations belonged to authors from the USA, followed distantly by China and Japan. However, Norway, Finland, Sweden, and Austria overtake the USA in the number of citations per article. Within the top-20 publishing neurosurgical institutions in the World, 18 are in the USA, and the remaining 2 are in Canada and China, one institution each per country. The number of *Articles* remained steadily high, while the number of *Review Articles* remained roughly the same.

REFERENCES

1. Wei M, Wang W, Zhuang Y. Worldwide research productivity in the field of spine surgery: a 10-year bibliometric analysis. *Eur Spine J*. 2016;25:976-982.
2. Hauptman JS, Chow DS, Martin NA, Itagaki MW. Research productivity in neurosurgery: trends in globalization, scientific focus, and funding. *J Neurosurg*. 2011;115:1262-1272.
3. Pagni M, Khan NR, Cohen HL, Choudhri AF. Highly cited works in radiology: the top 100 cited articles in radiologic journals. *Acad Radiol*. 2014;21:1056-1066.
4. Manuel Vazquez A, Latorre Fragua R, Lopez Marcano A, et al. The top 100: a review of the most cited articles in *Surgery*. *Cir Esp*. 2019;97:150-155.
5. Park KM, Kim SE, Lee BI, et al. Top 100 cited articles on epilepsy and status epilepticus: a bibliometric analysis. *J Clin Neurosci*. 2017;42:12-18.
6. Malhotra K, Saeed O, Goyal N, Katsanos AH, Tsivgoulis G. Top-100 highest-cited original articles in ischemic stroke: a bibliometric analysis. *World Neurosurg*. 2018;111:e649-e660.
7. Cheng W, Kang Q, Xiao Q. Bibliometric analysis of the top 100 influential studies on carotid artery stenting. *World Neurosurg*. 2019;122:e1321-e1331.
8. Zhou KZ, Maingard J, Phan K, et al. The 100 most cited articles in the endovascular treatment of thoracic and abdominal aortic aneurysms. *J Vasc Surg*. 2018;68:1566-1581.
9. Jusue-Torres I, Hulbert A, Germanwala AA, Patel CR, Germanwala AV. The 100 most-cited reports about craniopharyngioma. *World Neurosurg*. 2018;119:e910-e921.
10. Klimo P Jr, Venable GT, Khan NR, et al. Bibliometric evaluation of pediatric neurosurgery in North America. *J Neurosurg Pediatr*. 2014;14:695-703.
11. Wilcox MA, Khan NR, McAbee JH, Boop FA, Klimo P Jr. Highly cited publications in pediatric neurosurgery. *Childs Nerv Syst*. 2013;29:2201-2213.
12. Khan NR, Lee SL, Brown M, et al. Highly cited works in skull base neurosurgery. *World Neurosurg*. 2015;83:403-418.
13. Liu B, Liu S, Alastra AJ, et al. The 100 most cited vs. most relevant articles in the *Journal of Neurosurgery*: a bibliometric analysis. *Cureus*. 2019;11:e4498.
14. Badhiwala JH, Nassiri F, Witiw CD, et al. Highly cited works in spinal disorders: the top 100 most cited papers published in *Spine Journals*. *Spine (Phila Pa 1976)*. 2018;43:1746-1755.
15. Oravec CS, Motiwala M, Reed K, Jones TL, Klimo P Jr. Big data research in pediatric neurosurgery: content, statistical output, and bibliometric analysis. *Pediatr Neurosurg*. 2019;54:85-97.
16. Venable GT, Khan NR, Taylor DR, Thompson CJ, Michael LM, Klimo P Jr. A correlation between National Institutes of Health funding and bibliometrics in neurosurgery. *World Neurosurg*. 2014;81:468-472.
17. Lee RP, Venable GT, Roberts ML, et al. Five-year institutional bibliometric profiles for 119 North American neurosurgical residency programs: an update. *World Neurosurg*. 2016;95:565-575.
18. Khan N, Thompson CJ, Choudhri AF, Boop FA, Klimo P Jr. Part I: The application of the h-index to groups of individuals and departments in academic neurosurgery. *World Neurosurg*. 2013;80:759-765.e753.
19. Bergland RM. Neurosurgery may die. *N Engl J Med*. 1973;288:1043-1046.
20. Web of Science Group. Web of Science Core Collection: Document Type Descriptions. Clarivate. Available at: https://support.clarivate.com/ScientificandAcademicResearch/s/article/Web-of-Science-Core-Collection-Document-Type-Descriptions?language=en_US. Accessed October 10, 2021. Published 2021. Updated September 10.
21. Elsevier. Measuring a journal's impact. Elsevier. Available at: https://www.elsevier.com/authors/tools-and-resources/measuring-a-journals-impact. Accessed May 11, 2021. Published 2021.
22. Hirsch JE. An index to quantify an individual's scientific research output. *Proc Natl Acad Sci U S A*. 2005;102:16569-16572.
23. R Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing. Available at: http://www.R-project.org/. Accessed May 17, 2021. Published 2013.
24. Aria M, Cuccurullo C. bibliometrix: An R-tool for comprehensive science mapping analysis. *J Informetrics*. 2017;11:959-975.
25. Accreditation Council for Graduate Medical Education (ACGME). Public [List of Programs by Specialty]. Accreditation Council for Graduate Medical Education. Availalable at: https://apps.acgme.org/ads/Public; 2021.
26. Swaminathan M, Phillips-Bute BG, Grichnik KP. A bibliometric analysis of global clinical research by anesthesia departments. *Anesth Analg*. 2007;105:1741-1746. table of contents.
27. Chow DS, Itagaki MW. Interventional oncology research in the United States: slowing growth, limited focus, and a low level of funding. *Radiology*. 2010;257:410-417.
28. Falagas ME, Papastamataki PA, Bliziotis IA. A bibliometric analysis of research productivity in parasitology by different world regions during a 9-year period (1995-2003). *BMC Infect Dis*. 2006;6:56.
29. Jalipa FGU, Sy MCC, Espiritu AI, Jamora RDG. Bibliometric analysis of bacterial central nervous system infection research in Southeast Asia. *BMC Neurol*. 2021;21:11.

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