ORIGINAL PAPER

Bibliometric Analysis of Major Neurosurgical Publications 2011–2020, Part 2: Journal, Author, Yearly Publication Trends, and Citation Related Metrics

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ABSTRACT

Background: Scientometrics, a subfield of bibliometrics, examines scientific publications by using bibliometric methods. The aim of a scientometric study is to study the various citation-based metrics of scientific articles, such as parameters pertaining to authors (including institutions and country of origin), articles, journals, and other citation related metrics. **Objective:** In this second part of our scientometric analysis of the 6 major neurosurgical journals from 2011–2020, we study journal and author trends, yearly publication trends, and citation related metrics in *Neurosurgery*, *Journal of Neurosurgery*, *Journal of Neurosurgery: Spine*, *Journal of Neurosurgery: Pediatrics*, *Operative Neurosurgery*, and *World Neurosurgery.* **Methods:** We analyzed parameters, including article and journal metrics (total articles published per journal per year, breakdown of the Bradford's law distribution of journals, and Lotka's law, journal impact factors), author metrics (country of origin, collaborations), citation totals, and keyword counts. **Results and Discussion:** The highest number of published articles from all journals occurred in 2011, the lowest in 2016. *World Neurosurgery* published the most. The author collaboration index has declined since 2016 with a notable drop in 2020 when the COVID-19 pandemic began. Impact factors remained stable, except for Operative Neurosurgery, which experienced a steep decline in 2020, and *World Neurosurgery*, which experienced a mild decline in 2020. Canadian authors were the most likely to participate in multi-country collaborations. **Conclusion:** The most articles were published in *Journal of Neurosurgery*, followed by *Neurosurgery*, *Spine*, and *World Neurosurgery*.

Keywords: Bibliometrics, Scientometrics, Neurosurgical journals, Publication trends, Citations.

1. BACKGROUND

Scientometrics, a subfield of bibliometrics, examines scientific publications by using bibliometric methods. The aim of a scientometric study is to study the various citation-based metrics of scientific articles, such as parameters pertaining to authors (including institutions and country of origin), articles, journals, and other citation related metrics. Bibliometric studies are important because they can provide longitudinal information, illuminating various publication trends.

In Part 1 of this series, we presented a scientometric analysis of publications found in the 6 major neurosurgical journals - as determined by journal impact factor - over a 10-year period, with a focus on geographical trends (i.e., regional, national, and continental) as well as article type (1).

2. OBJECTIVE

The purpose of the current study (Part 2) is to analyze annual publication trends and citation-related metrics based on authorship (number of authors, country of origin of authors, and levels of collaboration) and articles (number of published articles and article citations), as well as to discuss the trends observed during this analysis. We also include a hypothesis to our initial JCR IF analysis from Part 1.

Description	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Sources (Journals, Books, etc)	5	5	5	6	6	6	6	6	6	6
Documents	2701	2532	2789	2479	2751	3371	4165	5338	6811	6302
Average years from publication	10	9	8	7	6	5	4	3	2	1
Average citations per documents	15.5	13.92	12.44	12.48	9.816	8.151	6.242	3.914	1.926	0.9124
Average citations per year per doc	1.409	1.392	1.382	1.56	1.402	1.358	1.248	0.9785	0.6421	0.4562
References	38829	35754	40324	39830	39884	56429	66686	82086	93115	84061
DOCUMENT TYPES										
Original article	1330	1203	1337	1319	1334	1996	2426	3065	3561	2979
Biography	6	2	2	1	6	19	11	3	2	7
Correction	21	12	18	18	14	26	39	55	55	55
Editorial material	842	757	744	769	642	532	479	809	1301	837
Letter to editor	185	165	274	291	190	313	394	501	517	804
News item	30	32	28	21	41	41	19	4	12	38
Review article	86	59	54	60	97	214	285	457	625	481
DOCUMENT CONTENTS										
Keywords Plus (ID)	4417	4045	4434	4376	4416	5526	6327	7348	6838	6048
Author's Keywords (DE)	3834	3380	3879	3756	4007	5646	6700	8396	9603	8427
AUTHORS										
Authors	7017	7065	7730	6919	8753	11097	13578	16686	19693	19730
Author Appearances	11665	11488	12618	11222	13844	18182	23700	30743	40132	38740
Authors of single-authored documents	343	267	298	289	244	301	276	323	362	358
Authors of multi-authored documents	6674	6798	7432	6630	8509	10796	13302	16363	19331	19372
AUTHOR COLLABORATION										
Single-authored documents	475	370	432	401	342	373	398	488	663	487
Documents per Author	0.385	0.358	0.361	0.358	0.314	0.304	0.307	0.32	0.346	0.319
Authors per Document	2.6	2.79	2.77	2.79	3.18	3.29	3.26	3.13	2.89	3.13
Co-Authors per Documents	4.32	4.54	4.52	4.53	5.03	5.39	5.69	5.76	5.89	6.15
Collaboration Index	3	3.14	3.15	3.19	3.53	3.6	3.53	3.37	3.14	3.33
Meeting abstracts	198	288	284	NA	403	209	465	408	687	1044
article; proceedings paper	3	12	23	NA	NA	21	33	33	51	21
Book review	0	2	0	0	0	0	13	2	0	36
Retraction	0	0	0	0	0	0	1	1	0	0

Table 1. Characteristics of neurosurgical publications (2011–2020).

3. MATERIAL AND METHODS

We searched the Web of Science (WoS) database on 8th March 2021 for all articles published over a 10-year period from January 1, 2011 to December 31, 2020 in journals dedicated solely to neurosurgery (2).

For the current analysis of author metrics, we focused our search on the following neurosurgical journals, which we examined in Part 1 (1): *Neurosurgery (NS)*, *Journal of Neurosurgery (JNS)*, *Journal of Neurosurgery: Spine (JNSS)*, *Journal of Neurosurgery: Pediatrics (JNSP)*, *Operative Neurosurgery (ONS)*, and *World Neurosurgery (WNS)*. These 6 journals were selected based on 2019 impact factors (IFs) reported by *Journal Citation Reports* (JCR), which were released by the Web of Science Group on 30th June 2020 (3): *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 *WNS's* (1.829), as well as what we consider "combined journals" that published both neurosurgical and neurological articles and other "Topic Based" neurosurgical journals (outside of *JNSS* and *JNSP*). Our analysis of overall author/article influence, however, included articles chosen by citation count, regardless of journal. Data points collected include the mean number of authors per article, articles authored by single authors, and multi-country author collaborations. We also provide a refined looked at JCF IFs and trends among the 6 journals to extend our original analysis from Part 1.

We included several specific analyses for this study. The JCR IF of an academic journal is a scientometric index that reflects the yearly mean number of citations of articles published in the previous 2 years in a given journal, as indexed by WoS. As a journal-level metric, it is frequently used as a representation for the relative importance of a journal within its field (4). Bradford's law describes the dispersion of journal-level citations in a subject by separating all citations into groups - or "zones"- of journals with equal numbers of citations in each zone (5). A ratio with 3 zones is typically $1:n:n^2$, with citations in zone 1 coming from a single journal and citations in zone 2 coming from a core group of journals. Citations in any remaining zone(s) will come from larger numbers of journals. The Collaboration Index measures the degree of collaboration among different authors, which we used to determine collaboration across countries (6). Lotka's Law of Scientific Productivity describes the frequency of the articles published by each author in a given field (7).

Statistical analysis

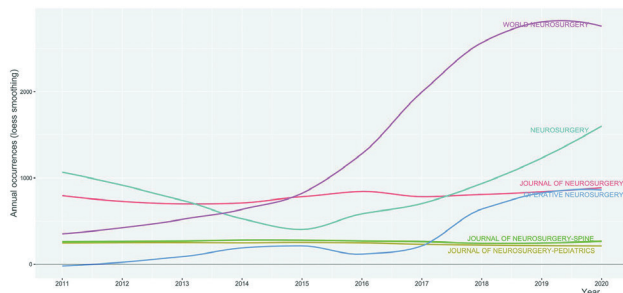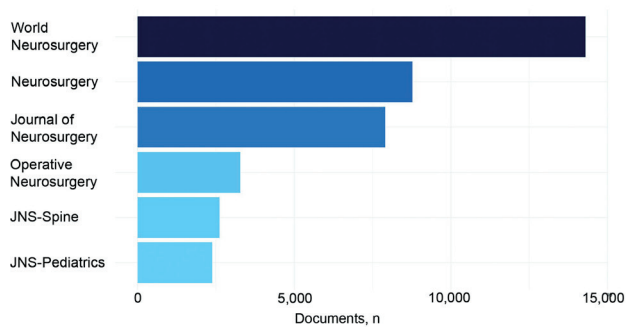Statistical analysis was performed using R (R Founda-

Figure 1. Analysis of articles per journal. (Top) Articles (n) published per journal from 2011–2020. (Bottom) Change in the number of published articles by each journal from 2011–2020.
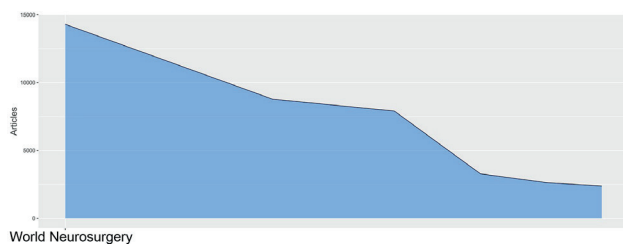

Figure 2. Graphic representation of Bradford's law applied to the dataset.

tion for Statistical Computing, Vienna, Austria) version 4.0.3, employing the "bibliometrix" package (8). Various plots were drawn using the "ggplot" package (Tidyverse, https://ggplot2.tidyverse.org). Non-parametric data were expressed as numbers (percentage) and analyzed using the Chi-Square test wherever relevant. Parametric data were analyzed using t-test or ANOVA, depending on the number of variables. Shapiro test was used to check for normality; 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 $P<0.05$.

4. RESULTS

Table 1 shows the primary findings about articles published in the 6 journals during the 10-year study period (only 5 journals were included from 2011–2013 because *ONS* did not publish during those years). A total of 39,239 articles were published, which were authored by 61,070 individuals who made 212,334 appearances in total. Out of these 39,239 articles, 4,429 articles were authored by a single author. Out of the 61,070 authors, 1843 were involved in documents published by a single author while the remaining authors (n = 59,227) were involved in documents published by multiple authors. The average number of authors per document was 1.56 and the av-
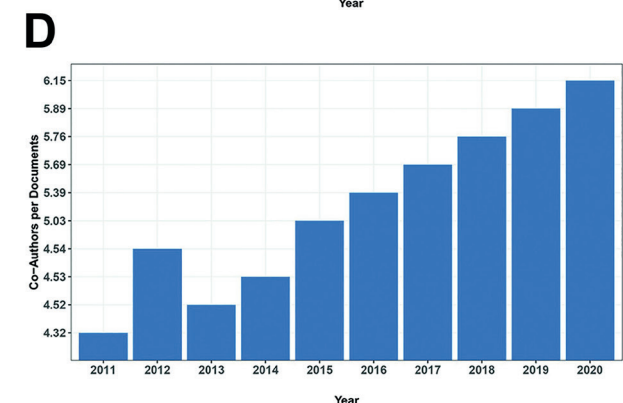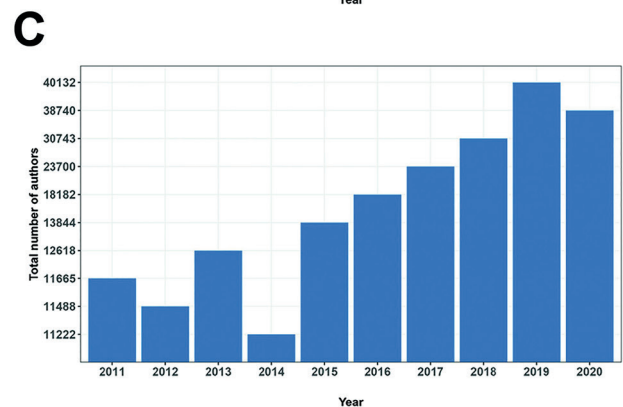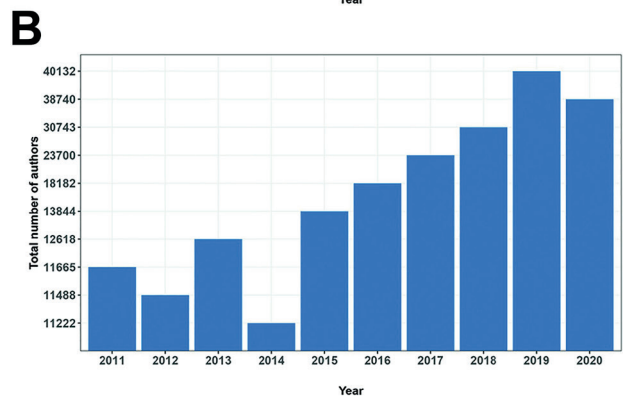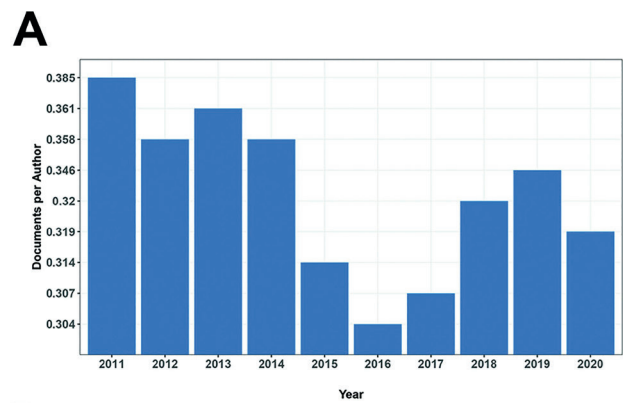
Figure 3. Author-based statistics. (A) Annual distribution of published documents per author. (B) Annual distribution of the total authors. (C) Published single-authored documents (n). (D) Published multi-authored documents (n).

erage number of co-authors per document was 5.41.

Article metrics

In our journal-specific findings, *WNS* published the highest proportion of the articles, followed by *NS* and *JNS* (Figure 1A). Figure 1B shows the change in the number of articles published in the journals over time - we found

Figure 4. (A) Collaboration index results. (B) Graphic representation of Lotka's law applied to the dataset.

Figure 5. (A) Published documents per author (n). (B) Country of origin of the corresponding author of multi-country collaborative publications.

Figure 6. (A) Journals with the highest number of citations (including journals outside of the 6 primary neurosurgical journals). (B) Citations for author country of origin.

Figure 7. Graphic representation of keyword use.

that the number of articles published per year increased tremendously for *WNS* and *ONS*, while they remained stable for *JNS*, *JNSS,* and *JNSP*. We next examined journal citations with Bradford's law, which shows that *WNS* lies in Zone 1 (Figure 2). Zone 2 journals include *NS* and *JNS*. Zone 3 journals include *ONS, JNSS* and *JNSP*.
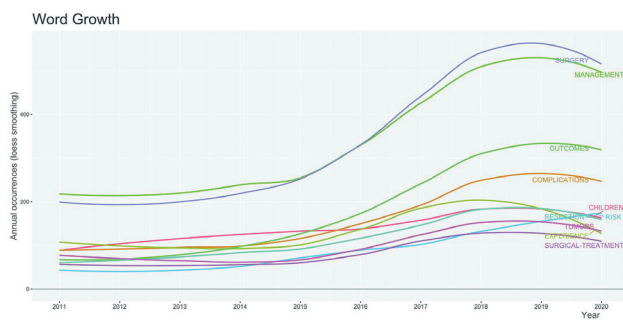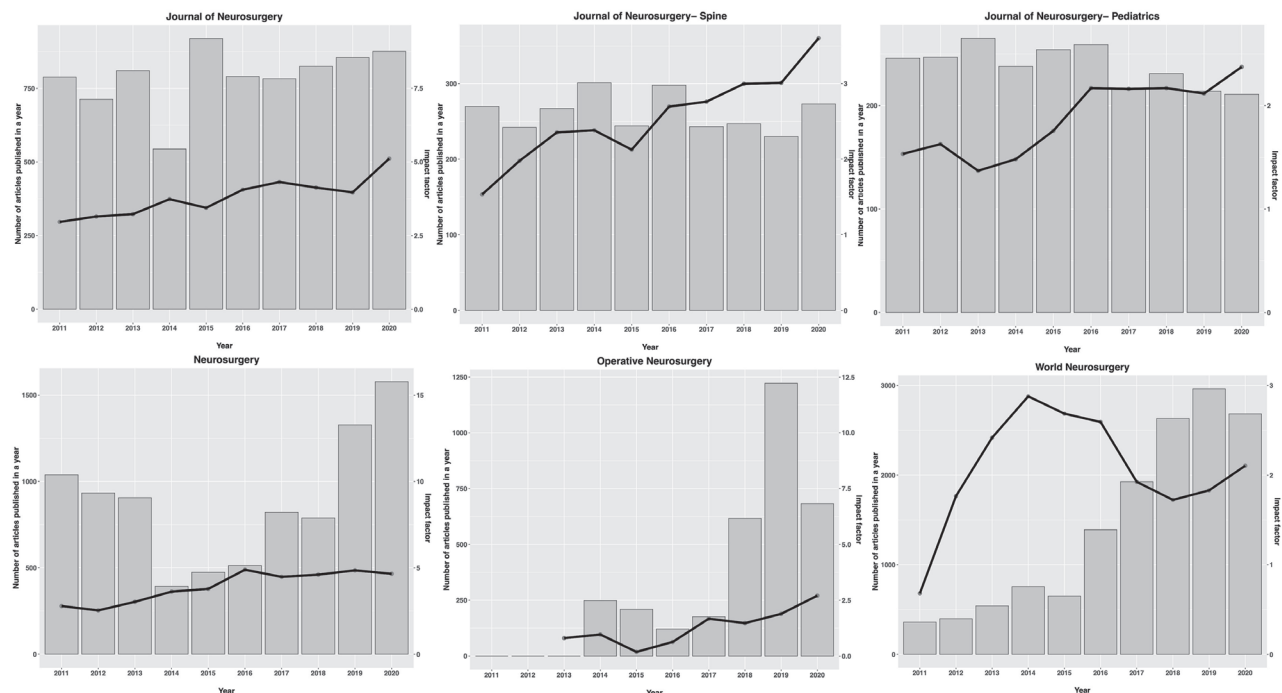
The annual distribution of published documents per author is shown in Figure 3A. The lowest number occurred in 2016 and the highest amount occurred in 2011. Figure 3B shows the annual distribution of the total number of authors among the published articles, with the lowest number occurring in 2014 and the highest number occurring in 2019. The number of single-authored published documents was lowest in 2015 and highest in 2019 (Figure 3C). The number of co-authors per published document increased gradually from 2011 to 2020, except in 2013 when a slight drop occurred (Figure 3D).

Author metrics

The Collaboration index for our dataset increased from 3 in 2011 to 3.6 in 2016; it then decreased for the next several years with a steep increase in 2020 (Figure 4A). Figure 4B shows the graphic representation of Lotka's law of the data set—over 10 years, 55% of the authors in our dataset contributed to 1 article and 16.3% of authors contributed 2 articles. The number of authors contributing to more than 50 and 100 articles was 300 and 61 authors, respectively. The highest number of articles per author occurred in 2011 and lowest number occurred in 2016 (Figure 5A). Authors from Canada were the most involved in multi-country collaborations among the top 10 coun-

Figure 8. Keywords changes over time 2011–2020.

Figure 9. Journal impact factors of the 6 neurosurgical journals from 2011–2020.

tile, while *WNS* and *ONS* fell into the second quartile.

5. DISCUSSION

Research plays an important role in the progress of any specialty. Journal impact factor, which is based on the number of citations received by a journal's published articles, is the most common parameter used to measure the impact of journals, publications, and authors in a specific field. However, the impact factor is only one metric that can be used. Bibliometrics, on the other hand, examines various other parameters to provide a holistic view of the publications in a specialty. This property has made bibliometrics a popular tool to study scientific publications. It is important for researchers to study bibliometric trends of publications in a field of study since it identifies journals, authors, countries, and institutions with maximum impact. Moreover, bibliometric analysis of articles published over time highlights publication trends.

Findings

We found that published documents per author were the lowest in 2016 and the highest in 2011. There appears to be a clear difference in the articles per author occurring before and after 2015, which could be due to the increase in the number of neurosurgeons and increased participation of neurosurgeons in research activities - this is evident from Figure 3b, which shows a consistent increase in the total number of authors who were involved in publishing articles after 2014. Moreover, the number of co-authors per publication has increased consistently over time.

Author metrics

There was an increase in the number of authors contributing to articles published by single authors from 2017, which might be due to the increase noted in the number of published *letters to editor*, which are typically authored by a single author (Table 1). The substan-

tries of origin (Figure 5B). Canadian authors also published the highest number of collaborative articles; Indian authors were the least likely to participate in multicountry collaborations.

Citations and keywords

Figure 6A shows the journals whose articles received the highest number of citations in our study, which includes articles from other journals in addition to the 6 we examined. Articles published in *JNS* were cited the most, followed by *NS*, the journal *Spine,* and *WNS*. Articles published by authors from the USA were cited the most (n = 150,000), followed distantly by the articles published by authors from China and Japan (Figure 6B). Figure 7 shows which keywords were used the most in the articles, and Figure 8 shows change in the use of keywords over time.

Impact factors and number of articles

Figure 9 shows yearly changes in the number of articles published per journal and also in JCR IFs. *JNS, JNSS, JNSP,* and *ONS* experienced a gradual increase in impact factor, which was steeper than in the year 2020. The impact factor for *NS* increased gradually until 2016; after which there has been no major change. *WNS* experienced a steep drop in 2017, after which it has gradually increased, but has yet to reach its 2017 level. When divided into quartiles by impact factor, *JNS, JNSS,* and *JNSP* all fell into the first quar-

tial 55.51% increase from 2019 (n=517) to 2020 (n=804) is likely related to COVID-19 restrictions - academic neurosurgeons with more free time possibly due to canceled surgeries increased their academic productivity, inundating journals with quickly completed works, like editorials and letters to the editor. The collaboration index increased from 2011 to 2016, after which the index decreased; however, we found a sudden increase in 2020. This latter observation may also be due to increased academic productivity with collaborators after the onset of COVID-19 restrictions, although further study would be needed to fully understand the connection between work collaborations and restriction-related free time. Most of the authors (71.3%) contributed either 1 or 2 articles; 6.2% of authors contributed more than 10 articles over the 10 years study period. The number of authors contributing more than 50 and 100 articles was 300 (0.5%) and 61(0.1%), respectively.

We feel that an important reason for the increase in the yearly number of publications is the increase in multi-country collaboration. Among the top 10 countries from where the highest number of articles came, collaboration was the highest for articles published by Canadian corresponding authors, while it was the lowest for authors from Japan and India (Figure 5). The lower levels of collaboration in Japan and India may be ascribed to the availability of research infrastructure, government policies, and language barriers, however, further study is needed to fully determine this.

Journal metrics

Articles published in *JNS* were cited the most (Figure 6A), which may represent the quality of research and the impact of these articles. Similarly, articles published from authors in the USA received the highest number of citations (Figure 6B), which exceeds the number of published US articles (n = 15208). The average citations per article, however, is 10.362 for authors based in Germany, 9.868 for the USA, 6.829 for Japan, and 4.964 for China.

Citation metrics

The most cited article published in the 6 journals we focused on in this study from the previous 10 years was "Guidelines for the Management of Severe Traumatic Brain Injury, Fourth Edition" published in *NS* in 2017 (9). This article is a review article that summarized the existing literature and tried to formulate guidelines for the management of severe traumatic brain injury. The second most cited article ("An extent of resection threshold for newly diagnosed glioblastomas") published in *JNS* in 2011 described the positive impact of aggressive tumor resection in patients with glioblastomas (10). The third most cited article was "Endoscopic endonasal skull base surgery: analysis of complications in the authors' initial 800 patients," published in *NS*, which described the authors' experience of endoscopic endonasal approaches in a large patient subset (11).

The most cited reference in the articles published over the last 10 years, including all neurosurgical journals, was "Unruptured intracranial aneurysms: natural history, clinical outcome, and risks of surgical and endovascular treatment" published in *Lancet* in 2003 (12), which

was cited 360 times in the included journals during the study period. This article was followed closely by "Radiotherapy plus concomitant and adjuvant temozolomide for glioblastoma" published in the *New England Journal of Medicine* (13).

Impact Factor

Finally, it is evident from our data, which we reported in Part 1 of our study, that the increase in the number of yearly publications was the highest for *WNS* from 2011–2020. This increase in the annual publications in *WNS* was mostly responsible for the overall increase in the number of publications over the last 10 years in the neurosurgical journals that we analyzed (Figure 1B). *ONS* also showed a substantial increase in the number of publications. Both journals are relatively new compared to the other journals we examined (*WNS* began as a new journal in 2010 that spun-off from the defunct journal *Surgical Neurology*, and *NS* began publication of *ONS* in 2014). *NS* experienced a decrease in yearly publications until 2015, after which an increase was experienced. The number of publications in *JNS*, *JNSP*, and *JNSS* has remained nearly the same over the past 10 years. We hypothesize that the internal policies of the editorial board of each journal are responsible for these variations. The total number of publications have increased consistently, suggesting that the research output of neurosurgeons is increasing, which can be explained by the increasing number of neurosurgeons and better infrastructure for research and collaboration between different institutes within and outside countries.

The impact factors of most journals are generally increasing over time, most likely as a result of increasing numbers of accepted articles. One interesting finding we discovered is related to the decrease in the JCR IF for *WNS* between 2014 and 2018 (Figure 5), which occurred despite the dramatic overall increase in published material by *WNS* during the same time period (Figure 1B). We suggest that the steep increase in the annual number of articles (which is used as a denominator for calculating impact factor), outpaced the number of citations received (the numerator): $\text{citations}_x / \text{publications}_{x-1} + \text{Publications}_{x-2}$. The higher number of articles thus had the effect of lowering *WNS's* JCR IF.

Study limitations

Limitations to this study include our primary focus on the 6 neurosurgical journals, although some of our author/article-specific data included other journals. We were also dependent on the WoS for the accuracy of our data. Though we have analyzed many parameters, we might have missed some important parameters for which we did not have data.

6. CONCLUSION

In this second part of our scientometric analysis of the 6 major neurosurgical journals from 2011–2020 and highly cited authors and articles, we studied article, author, and annual publication trends, and citation related metrics. Journal, author, and yearly publication trends, as well as citation related metrics are important parameters in bibliometric analysis of neurosurgical publications. The number of publications increased consistently

over the last 10 years. Most of this increase is attributed to the increase in the number of publications in *WNS* and *ONS*. (*WNS* was the zone 1 journal following analysis with Bradford's Law). The number of authors and collaboration between authors have also increased over the years. There was a gradual increase in the number of articles with co-authors. Canadian authors participated in the greatest number of multi-country author collaborations. A disproportionately high number of articles came from authors in the USA; Germany and then the USA had the highest average citations per article. The impact factors of all the 6 journals have gradually increased over the past 10 years, except for *WNS* whose JCR IF experienced a 4-year decline as a result of a substantial increase in published documents. WNS's JCR IF is increasing but has yet to recover to its highest point in 2014.

- **Author's contribution:** All authors were involved in all steps of the preparation this article, including: conceptions and design. drafting data, data collection and analysis, interpretation of data and critical revision of the manuscript. Final proofreading was made by K.G. and K.A.
- **Conflict of interest:** The authors declare no conflict of interest.
- **Financial support and sponsorship:** Nil.

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