

Highly Cited Publications in the Web of Science Category of Anesthesiology in the Science Citation Index Expanded: A Bibliometric Analysis

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ABSTRACT

This study aimed to identify and analyze the characteristics of the highly cited articles in the Web of Science Category of Anesthesiology from 1991 to 2019. Documents that have been cited more than 100 times from Web of Science Core Collection since publication to the end of 2019 were assessed. The analyzed aspects covered distribution of annual production and its citations per publication, journals, countries, institutions, authors, and the top cited articles. Six publication indicators were applied to evaluate publication performance of countries and institutions. Y-index was used to compare authors' research performance. Results shows that most highly cited papers were published in journals with high impact factors. The USA dominated the six publication indicators and eight of the top ten productive institutes were all located in USA. Articles by Farrar *et al.* in 2001 and Breivik *et al.* in 2006 were highly cited and also high impact in 2019. Results from Y-index shows that highly cited authors published more corresponding-author articles than first-author articles.

Keywords: Anesthesiology, Bibliometric, Clarivate Analytics, TC_{year} , C_{year} , CPP_{year}

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INTRODUCTION

There is a long history of anesthesia.^[1] In 1980s, the father of anesthesia, Henry Hickman, who published 'A letter on suspended animation, containing experiments shewing that it may be safely employed during operations on animals, with the view of ascertaining its probable utility in surgical operations on the human subject'.^[2] Robinson and Toledo^[1] presented pioneers of anesthesia including Gardner Quincy Colton (1814–1898): nitrous oxide in dentistry,^[3] William Thomas Green Morton (1819–1868): ether, provided first documented general anesthesia,^[4] John Collins Warren (1778–1856): first surgeon with anesthesia,^[5] James Young Simpson (1811–1870): chloroform,^[6] Sigmund Freud (1856–1939): cocaine,^[7] Carl Koller (1858–1944): topical cocaine,^[8] and Arthur Guedel (1883–1956): promoted the use of cuffed tubes.^[9] In 1939, the term of 'anesthesiology' was presented in the article entitled 'The relation of anesthesiology to medical

education'.^[10] In the following years, anesthesiology related topics were also published.^[11–14]

Publications in the Web of Science category of anesthesiology were started from 1945 in Science Citation Index Expanded. The highly cited publications with 100 citations or more from Web of Science Core Collection since publication to the end of the most recent year in a medical related Web of Science category^[15] was concerned in recent years, for example health care sciences and services^[15] and dentistry, oral surgery and medicine^[16] in SCI-EXPANDED. The classic publications with 1,000 citations or more in a medical related Web of Science category^[17] were also presented including surgery,^[17] psychology,^[18] neurosciences,^[19] and orthopedics.^[20] In these studies, the six publication indicators^[21,22] including total number of articles (*TP*), independent articles (*IP*), collaborative articles (*CP*), first-author articles (*FP*), corresponding-author articles (*RP*), and single-author articles (*SP*) as well as three citation indicators such as the total citation number from Web of Science Core Collection since publication to the end of the most recent year, TC_{year} ,^[23,24] the number of citations in the most recent year, C_{year} ,^[25] and citations per publication, CPP_{year} ^[26] were employed to characterize the highly cited articles.

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The documents analyzed in the present work were those in the Web of Science Category of anesthesiology, having 100 citations or more. This study identified and examined the characteristics with the six publication indicators and the three citation indicators. In addition, Y-index was also applied to evaluate authors' publication performance.

METHODOLOGY

The data relevant to present study were derived from the Science Citation Index Expanded (SCI-EXPANDED), in Clarivate Analytics (formerly known as the Thomson Reuters and the Institute for Scientific Information) Web of Science Core Collection. According to Journal Citation Reports (JCR) of 2018, it indexes 9,258 journals with citation references across 58 Web of Science categories in SCI-EXPANDED. There were 31 journals listed in Web of Science category of anesthesiology. In total, 197,224 documents (including 94,908 articles) were found in Web of Science category of anesthesiology from 1991 to 2019 based on SCI-EXPANDED (updated on May 01, 2020). Two citation indicators TC_{year} and C_{year} were employed to characterize the highly cited articles. TC_{year} is the total citation number from Web of Science Core Collection since publication to the end of the most recent year.^[23,24] C_{year} is the number of citations in the most recent year. C_{2019} means the number of citations in 2019. $TC_{year} \geq 100$ was used to retrieve the highly cited articles.^[15] This study selected the articles with $TC_{2019} \geq 100$ as highly cited articles. All document information from SCI-EXPANDED was checked and downloaded into Microsoft Excel 2016.^[27,28] Affiliations in England, Scotland, Northern Ireland, and Wales were reclassified as being from the United Kingdom (UK).^[29] Affiliations in Hong Kong before 1997 were included in the China category.

The Y-index is related to the number of first author publications (FP) and corresponding author publications (RP) was proposed to evaluate performance of highly cited authors.^[25,30] The Y-index combines two parameters (j, h), to assess both the publication potential and characteristics of the contribution as a single index.^[31] The Y-index is defined as^[25,30,31]

$$j = FP + RP \tag{1}$$

$$h = \tan^{-1} \left(\frac{RP}{FP} \right) \tag{2}$$

where j is the publication potential which is a constant related to publication quantity, and h is publication characteristics which can describe the proportion of RP to FP. The greater the value of j , the more the contribution of the first author and corresponding author articles. Different values of h represent different proportions of corresponding author articles from first author articles.

$h = 0$: authors published only first author articles, j is the number of first author articles

$h < 0.7854$: authors published more first author articles

$h = 0.7854$: authors published the same number of first author and corresponding author articles

$h > 0.7854$: authors published more corresponding author articles

$h = \pi/2$: authors published only corresponding author articles, j is the number of corresponding author articles

RESULTS AND DISCUSSION

Document type and language of publication

A total of 4,316 highly cited documents (2.2% of the 197,224 documents in category of anesthesiology in SCI-EXPANDED) with $TC_{2019} \geq 100$ were found within eight document types indexed in the Web of Science. In order to have scientific results, which can be repeated and checked, Ho's group proposed idea of TC_{year} that is number of citations since publication to the end of the most recent year^[23,24] and citations per publication ($CPP_{year} = TC_{year}/TP$).^[28] Relationship among document types and their citations per publication^[32] and number of authors per publication (APP) were recently presented.^[33] Table 1 shows characteristics of the eight document types, including 3,515 articles (81% of 4,316 documents) with number of authors per publication (APP) of 6.2. The 716 reviews with TC_{2019} of 156,313 and the highest CPP_{2019} of 218. Editorial materials, letters, and articles also had higher CPP_{2019} . In total of 716 reviews were published in 28 journals mainly in *Pain* (175 reviews; 24% of 716 reviews), *British Journal of Anaesthesia* (117; 16%), *Anesthesiology* (102; 14%) and *Anesthesia and Analgesia* (98; 14%). It should also be noticed that documents could be classified in two document types in Web of Science. For example, 317 highly cited documents were classified in both document types of articles and proceedings papers.

Table 1: Citations and authors according to document type.

Document type	TP	%	TP*	AU	APP	TC ₂₀₁₉	CPP ₂₀₁₉
Article	3,515	81	3,506	21,894	6.2	624,629	178
Review	716	17	716	2,780	3.9	156,313	218
Proceedings paper	317	7.3	316	1,747	5.5	56,239	177
Editorial material	51	1.2	49	131	2.6	10,695	210
Note	20	0.46	20	65	3.3	2,729	136
Letter	13	0.30	13	30	2.3	2,508	193
Book chapter	1	0.023	1	1	1.0	117	117
Reprint	1	0.023	1	32	32	116	116

TP: number of articles; AU: number of authors; APP: number of authors per publication (AU/TP); TC₂₀₁₉: total citations from Web of Science Core Collection since publication to the end of 2019; CPP₂₀₁₉: citations per paper (TC₂₀₁₉/TP).

Therefore, the total percentage of document types in Table 1 was higher than 100%. Ten classic reviews with $TC_{2019} \geq 1,000$ ^[17] were found in the Web of Science category of anesthesiology including reviews by Vlaeyen and Linton^[34] with TC_{2019} of 2,234, Dworkin et al.^[35] with TC_{2019} of 1,721, Apkarian et al.^[36] with TC_{2019} of 1,628, Woolf^[37] with TC_{2019} of 1,590, Tjølsen et al.^[38] with TC_{2019} of 1,550, Coderre et al.^[39] with TC_{2019} of 1,475, Sullivan et al.^[40] with TC_{2019} of 1,257, Dworkin et al.^[41] with TC_{2019} of 1,172, Watcha and White^[42] with TC_{2019} of 1,086, and Woolf and Chong^[43] with TC_{2019} of 1,026. ‘Practice guidelines for sedation and analgesia by non-anesthesiologists: An updated report by the American Society of Anesthesiologists task force on sedation and analgesia by non-anesthesiologists’^[44] was the only classic editorial material with TC_{2019} of 1,142.

Only articles were used for subsequent analysis because they included complete research ideas and results.^[21] As a result, we identified 3,515 highly cited articles (3.7% of the 94,908 articles) in the category of anesthesiology, only seven of which were published in non-English including four in French and three in German.

Publication distribution

A relationship between total number of highly cited articles in a year (TP) and their citations per publication ($CPP_{year} = TC_{year}/TP$) by the years in a Web of Science category was presented for publication trends and impacts.^[45] Altogether 3,515 highly cited articles from 1991 to 2017 in category of anesthesiology were analyzed. The maximum value of TC_{2019} was 2,629 and the average 178. Figure 1 shows the distribution

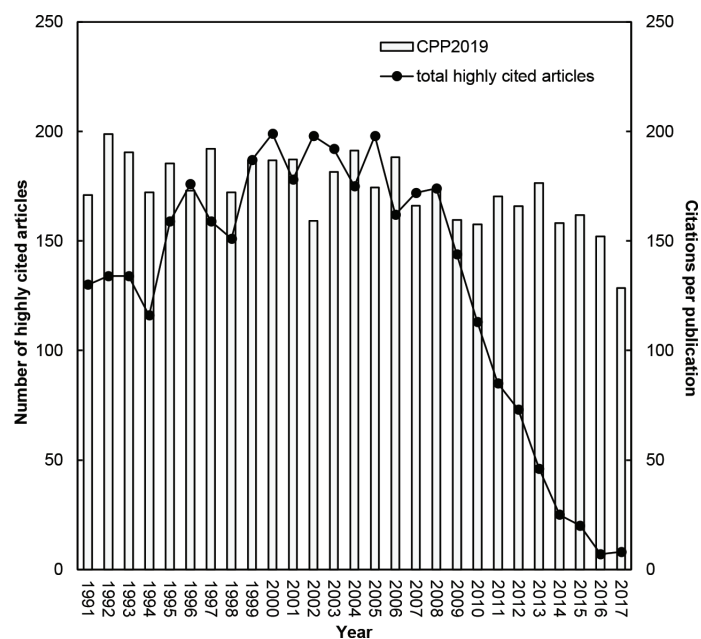


Figure 1: Number of highly cited articles and citations per publication by year.

of these 3,515 articles over the years, and their citations per publication (CPP_{2019}). No highly cited article was identified after 2017. CPP_{2019} were fluctuated from 129 in 2017 to 199 in 1992. Based on Figure 1, it takes $CPPs$ about a decade to reach a plateau. It was reported that to evaluate impact of papers, citations accumulated at least one decade is needed.^[46] To emphasize this point, a total of 1,642 articles (47% of 3,515 articles) had no citations in the publication year with C_0 of 0. Although with an increasing number of journals in SCI-EXPANDED, journals have had higher impact factor and articles also have had higher citations in the publication year (C_0) in recent years.^[22] In addition, among the top 100 C_0 articles, only 10% and 22% of them were among the top 100 TC_{2019} and C_{2019} articles respectively.

Journals

A total of 31 journals were classified in the category of anesthesiology in 2018. The 3,515 highly cited articles were published in 28 of these journals (90% of 31 journals), and in four other anesthesiology journals that were no longer in Web of Science category of anesthesiology as of 2018 (Table 2). The *Pain* with IF_{2018} of 6.029 (rank 3rd of 31 anesthesiology journals in SCI-EXPANDED) published the largest number of highly cited articles with 1,160 articles (33% of 3,515 highly cited articles), followed by *Anesthesiology* ($IF_{2018} = 6.424$; rank 1st) with 887 and *Anesthesia and Analgesia* ($IF_{2018} = 3.489$; rank 8th) with 531. Six journals in Web of Science category of anesthesiology had no highly cited articles such as *Anaesthesia Critical Care and Pain Medicine* ($IF_{2018} = 2.734$; rank 16th), *BMC Anesthesiology* ($IF_{2018} = 1.619$; 24th), *Journal of Anesthesia*

Table 2: The ten most productive journals with highly cited articles in Web of Science category of anesthesiology.

Journal	TP (%)	IF ₂₀₁₈ (R)	CPP ₂₀₁₉
Pain	1,160 (33)	6.029 (3)	194
Anesthesiology	887 (25)	6.424 (1)	178
Anesthesia and Analgesia	531 (15)	3.489 (8)	163
British Journal of Anaesthesia	303 (8.6)	6.199 (2)	168
Clinical Journal of Pain	118 (3.4)	2.893 (13)	176
Anaesthesia	86 (2.4)	5.879 (4)	145
Acta Anaesthesiologica Scandinavica	68 (1.9)	2.228 (18)	168
European Journal of Pain	63 (1.8)	3.188 (10)	196
Regional Anesthesia and Pain Medicine	48 (1.4)	5.113 (5)	141
Canadian Journal of Anaesthesia- Journal Canadien d Anesthésie	45 (1.3)	3.374 (9)	149

TP: total number of highly cited articles; IF_{2018} : journal impact factor for 2018; R: rank in Web of Science category of anesthesiology; CPP_{2019} citations per paper (TC_{2019}/TP).

($IF_{2018} = 1.462$; 25th), *Revista Brasileira de Anestesiologia* ($IF_{2018} = 0.968$; 28th), *Anesthesiologie and Intensivmedizin* ($IF_{2018} = 0.723$; 30th), and *Anesthesiologie Intensivmedizin Notfallmedizin Schmerztherapie* ($IF_{2018} = 0.265$; 31th).

Countries, institutions, and authors

There were 3,505 highly cited articles (99.7% of 3,515 highly cited articles) with author affiliation information in SCI-EXPANDED from 56 countries. A total of 2,904 (83% of 3,505 articles) were single country articles from 38 countries and 601 (17%) were internationally collaborative articles from 54 countries. Six publication indicators^[21,22] including total number of articles (*TP*), single country articles (*IP*), internationally collaborative articles (*CP*), first author articles (*FP*), corresponding author articles (*RP*), and single author articles (*SP*) as well as citations per publication (CPP_{2019}) were applied to compare the top 11 productive countries (Table 3). The top 11 most productive countries published 89% of the 3,505 highly cited articles and contributed 90% of TC_{2019} of 621,932. Eight European countries, two American countries, and one Oceania country, were ranked on the top 11 of publications. Japan with 71 articles and South Africa with 21 articles ranked top in Asia and Africa respectively. The USA dominated in the six publication indicators with *TP* of 1,581 highly cited articles (45% of the 3,505 highly cited articles), *IP* of 1,251 articles (43% of 2,904 single country articles), *CP* of 330 articles (55% of 601 internationally collaborative articles), *FP* of 1,049 articles (40% of 3,505 first-author articles), *RP* of 1,273 articles (39% of 3,228 corresponding-author articles), and *SP* of 50 articles (42% of 119 single-author articles). The UK with 454 articles had the highest CPP_{2019} of 189 followed by France and Australia while Sweden had lower CPP_{2019} of 170. In total, 1,497 highly cited articles (43% of the 3,505 highly cited articles) were single institute articles and 2,008 (57%)

were inter-institutionally collaborative articles. Six publication indicators^[47] such as total articles (*TP*), single institute articles (*IP*), inter-institutionally collaborative articles (*CP*), first author articles (*FP*), corresponding author articles (*RP*), and single author articles (*SP*) as well as citation indicator (CPP_{2019}) were also applied to compare the top 10 institutes (Table 4). Among these 10 institutions, eight of them derived from the USA and two from Canada.

University of Washington in USA dominated in the four publication indicators with *TP* of 134 highly cited articles (3.8% of the 3,505 highly cited articles), *IP* of 46 articles (3.1% of 1497 single institute articles), *FP* of 83 articles (2.4% of 3,505 first-author articles), and *RP* of 77 articles (2.4% of 3,228 corresponding-author articles). Harvard University in USA ranked top in two publication indicators with *CP* of 96 articles (4.8% of 2,008 inter-institutionally collaborative articles) and *SP* of six articles (5.0% of 119 single-author articles). Duke University in USA had higher CPP_{2019} of 234 while University of California San Francisco in USA had lower CPP_{2019} of 166.

In total, 3,101 articles (88% of 3,515 highly cited articles) in the Web of Science category of anesthesiology with both first and corresponding author information in the SCI-EXPANDED were considered to calculate *Y*-index for highly cited authors. A total of 3,101 articles were contributed by 13,931 authors. Altogether, 11,280 authors (81% of the 13,931 authors) had no any first and corresponding author with Y -index = (0, 0); 592 (4.2%) authors had only first author articles with $h = 0$ and $j \neq 0$; 48 (0.34%) authors had more first author articles with $0 < h < 0.7854$; 1,512 (11%) authors had the same numbers of first author and corresponding author articles with $h = 0.7854$; 1,674 (12%) authors had more corresponding author articles with $\pi/2 > h > 0.7854$; and 337 (2.4%) authors had only corresponding author articles with $h = \pi/2$ and $j \neq 0$. Figure 2 shows

Table 3: Top 11 most productive countries with *TP* > 100.

Country	<i>TP</i>	<i>TPR</i> (%)	<i>IPR</i> (%)	<i>CPR</i> (%)	<i>FPR</i> (%)	<i>RPR</i> (%)	<i>SPR</i> (%)	CPP_{2019}
USA	1,581	1 (45)	1 (43)	1 (55)	1 (40)	1 (39)	1 (42)	183
UK	454	2 (13)	2 (10)	2 (25)	2 (10)	2 (10)	2 (22)	189
Canada	317	3 (9.0)	3 (7.4)	4 (17)	3 (7.5)	3 (7.4)	3 (8.4)	182
Germany	302	4 (8.6)	4 (5.7)	3 (23)	4 (6.3)	4 (6.7)	6 (3.4)	173
France	212	5 (6.0)	5 (4.9)	8 (11)	5 (4.8)	5 (5.0)	11 (0.84)	186
Netherlands	168	6 (4.8)	8 (3.0)	5 (13)	7 (3.4)	6 (3.6)	N/A	180
Australia	158	7 (4.5)	9 (3.0)	7 (12)	8 (3.3)	7 (3.4)	4 (5.0)	185
Denmark	155	8 (4.4)	6 (3.5)	11 (8.7)	6 (3.5)	8 (3.3)	6 (3.4)	173
Sweden	149	9 (4.3)	7 (3.1)	10 (10)	9 (3.3)	9 (3.0)	5 (4.2)	170
Switzerland	118	10 (3.4)	13 (1.5)	6 (12)	10 (2.0)	10 (2.0)	N/A	182
Belgium	110	11 (3.1)	13 (1.5)	9 (11)	11 (1.8)	11 (1.9)	N/A	182

TP: total number of highly cited articles, *TPR* (%): rank and percentage of total articles, *IPR* (%): rank and percentage of single country articles, *CPR* (%): rank and percentage of internationally collaborative articles, *FPR* (%), rank and the percentage of first author articles, *RPR* (%), rank and the percentage of the corresponding author articles; *SPR* (%), rank and the percentage of the single author articles; CPP_{2019} : citations per publication (TC_{2019}/TP); N/A: not available.

Table 4: Top 10 most productive institutions with TP ≥ 50.

Institute	TP	TPR (%)	IPR (%)	CPR (%)	FPR (%)	RPR (%)	SPR (%)	CPP ₂₀₁₉
University of Washington, USA	134	1 (3.8)	1 (3.1)	2 (4.4)	1 (2.4)	1 (2.4)	4 (2.5)	199
University of California San Francisco, USA	121	2 (3.5)	2 (3.0)	3 (3.8)	2 (2.3)	2 (1.9)	4 (2.5)	166
Harvard University, USA	115	3 (3.3)	7 (1.3)	1 (4.8)	5 (1.3)	5 (1.2)	1 (5.0)	190
University of Toronto, Canada	105	4 (3.0)	4 (2.3)	4 (3.5)	3 (1.6)	3 (1.5)	4 (2.5)	201
Duke University, USA	74	5 (2.1)	6 (1.3)	5 (2.7)	7 (1.1)	6 (1.1)	19 (0.84)	234
University of Texas, USA	72	6 (2.1)	3 (2.5)	11 (1.7)	4 (1.4)	4 (1.3)	10 (1.7)	209
Stanford University, USA	64	7 (1.8)	21 (0.80)	6 (2.6)	16 (0.63)	19 (0.59)	19 (0.84)	202
University of California San Diego, USA	62	8 (1.8)	9 (1.1)	7 (2.2)	6 (1.1)	7 (1.0)	4 (2.5)	185
University of Florida, USA	51	9 (1.5)	9 (1.1)	13 (1.7)	8 (0.91)	8 (0.93)	N/A	222
McGill University, Canada	50	10 (1.4)	11 (1.1)	13 (1.7)	11 (0.8)	10 (0.87)	19 (0.84)	175

TP: total number of highly cited articles, TPR (%): rank and the percentage of total articles, IPR (%): rank and percentage of single institute articles, CPR (%): rank and percentage of inter-institutionally collaborative articles, FPR (%): rank and the percentage of first author articles, RPR (%): rank and the percentage of the corresponding authored articles; CPP₂₀₁₉: citations per publication (TC_{2019}/TP); N/A: not available.

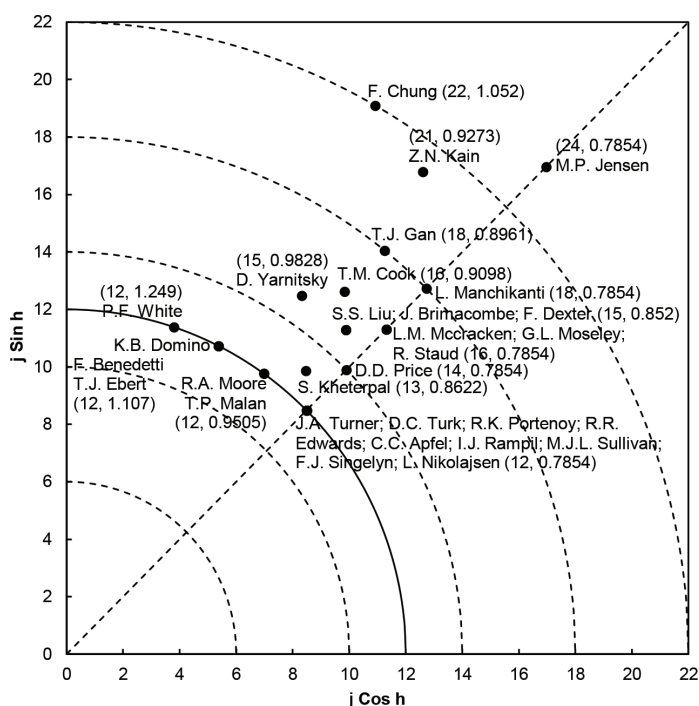


Figure 2: Distribution of the top 30 authors with their Y-index values ($j \geq 12$).

distribution of the Y-index (j, h) of the top 30 authors with $j \geq 12$. Each dot represents one value that could be one author or many authors,^[48] for example L.M. Mccracken, G.L. Moseley, and R. Staud had the same Y-index of (16, 0.7854). M.P. Jensen from University of Washington in USA had the highest publication potential with j of 24, who published 22 highly cited articles, including 12 first authors, 12 corresponding authors with Y-index (24, 0.7854). F. Chung from University of Toronto in Canada, published eight first author and 14 corresponding author articles with Y-index (22, 1.052). Z.N. Kain from University of California

Irvine in USA, published nine first author and 12 corresponding author articles with Y-index (21, 0.9273). Fifteen of the top highly cited authors published the same number of first author articles and corresponding author articles in category of anesthesiology. Other 15 authors had more highly cited articles with corresponding author than those with first author. The advantage of the Y-index is that, when j of authors are the same, publication characteristics of authors can be indicated by h .^[25,30] It indicated that the top productive authors contributing to Web of Science Category of anesthesiology were more likely to be designated as the corresponding-authors. The j of, P.F. White, K.B. Domino, R.A. Moore, and J.A. Turner were all the same of 12 and located on the same curve in Figure 2. However h of White was 1.249; Domino was 1.107; Moore was 0.9505, and Turner was 0.7854. White had the greatest proportion of corresponding-author articles to first-author articles, then Domino, Moore, and Turner.

Citation history of highly cited articles

Due to the citations of publications in Web of Science Core Collection were updated weekly, the total number citations of an article since its publication to the end of 2019 (TC_{2019}) was utilized.^[23,24] TC_{2019} remain invariable and ensure repeatability compared with the index of citation from Web of Science Core Collection.^[18] Table 5 shows the 11 classic articles with $TC_{2019} \geq 1,000$ in category of anesthesiology with both citation numbers and rankings for TC_{2019} and C_{2019} . TC_{2019} shows impact or visibility of an article in a research field. C_{2019} can be an indicator to evaluate article impact in the most recent year. Nine of the classic articles were published in *Pain* with IF_{2018} of 6.029 (ranked 3rd in anesthesiology), and one in each of *European Journal of Pain* with IF_{2018} of 3.188 (ranked 10th) and *Anesthesia and Analgesia* with IF_{2018} of 3.489 (ranked 8th). Clifford J. Woolf is the recipient of the 2004 American

Table 5: Eleven classic articles in Web of Science category of anesthesiology.

Rank (TC ₂₀₁₉)	Rank (C ₂₀₁₉)	Article title	Country
1 (2,629)	2 (253)	Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale ^[49]	USA
2 (2,385)	30 (80)	An experimental model for peripheral neuropathy produced by segmental spinal nerve ligation in the rat ^[50]	USA
3 (2,294)	1 (266)	Survey of chronic pain in Europe: Prevalence, impact on daily life, and treatment ^[51]	Norway, UK, Italy
4 (1,684)	8 (128)	Grading the severity of chronic pain ^[52]	USA
5 (1,673)	17 (101)	A fear-avoidance beliefs questionnaire (FABQ) and the role of fear-avoidance beliefs in chronic low back pain and disability ^[53]	UK
6 (1,455)	209 (29)	The induction and maintenance of central sensitization is dependent on N-methyl-D-aspartic acid receptor activation; implications for the treatment of post-injury pain hypersensitivity states ^[54]	UK
7 (1,203)	24 (87)	Fear of Movement/(re)injury in chronic low back pain and its relation to behavioral performance ^[55]	Netherlands
8 (1,129)	13 (117)	Quantitative sensory testing in the German Research Network on Neuropathic Pain (DFNS): Standardized protocol and reference values ^[56]	Germany
9 (1,114)	16 (102)	Spared nerve injury: An animal model of persistent peripheral neuropathic pain ^[57]	USA
10 (1,027)	9 (125)	Comparison of pain syndromes associated with nervous or somatic lesions and development of a new neuropathic pain diagnostic questionnaire (DN4) ^[58]	France
11 (1,018)	28 (82)	Postoperative pain experience: Results from a national survey suggest postoperative pain continues to be undermanaged ^[59]	USA

TC₂₀₁₉: total citations from Web of Science Core Collection since publication to the end of 2019; C₂₀₁₉: citations in 2019 only.

Society of Anesthesiologists Excellence in Research Award.^[60] Woolf was the only one author, who published two of the classic articles in Web of Science Category of anesthesiology. ‘The induction and maintenance of central sensitization is dependent on N-methyl-D-aspartic acid receptor activation; implications for the treatment of post-injury pain hypersensitivity states^[54]’ was published by Woolf as both first- and corresponding-authors with affiliation of University College London in the UK. ‘Spared nerve injury: An animal model of persistent peripheral neuropathic pain^[57]’ was published by Woolf as corresponding-authors with affiliation of Massachusetts General Hospital and Harvard Medical School in USA. Similarly, only Duke University in USA had two classic articles anesthesiology.

The highly cited articles would not always have high influence or visibility in research society.^[32] The history of an article’s citations with time is needed to understand impact of highly cited articles. The citation history shows characteristics of the influence of an article after its publication. Only four of the top 10 classic articles (TC₂₀₁₉ ≥ 1,000) still have a C₂₀₁₉ ranked in the top 10 including articles by Farrar *et al.*,^[49] Breivik *et al.*,^[51] Vonkorff *et al.*,^[52] and Bouhassira *et al.*^[58] Figure 3 shows the citation history of the 11 classic articles. Article ranked 3rd by Breivik *et al.*^[51] with TC₂₀₁₉ of 2,294 and article ranked the top one by Farrar *et al.*^[49] with TC₂₀₁₉ of 2,629 had a sharply increasing trend of citations to reach C₂₀₁₉ of 266 (ranked 1st) and 253 (ranked 2nd) respectively. Article by Woolf and Thompson^[54] had a sharply increasing trend of citations in

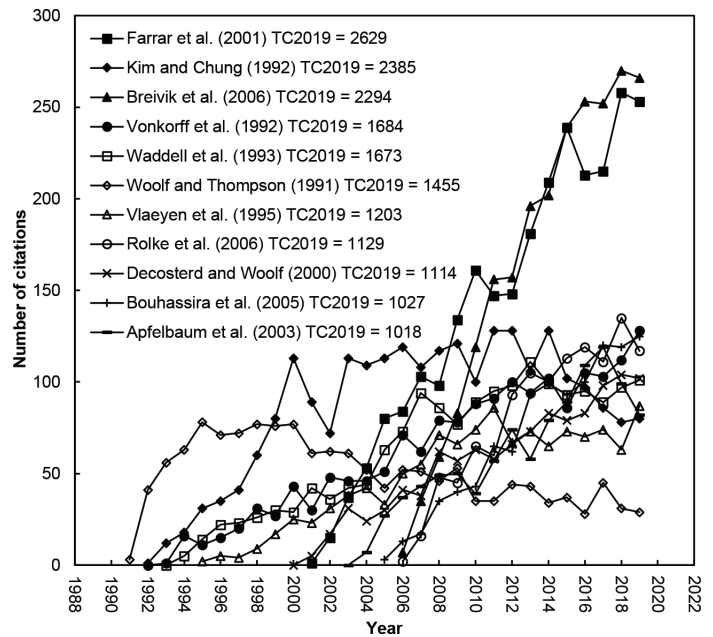


Figure 3: Citation history of the 11 classic articles in the Web of Science Category of anesthesiology (TC₂₀₁₉ ≥ 1,000).

four years after its publication and then reach a plateau for 25 years. Article by Kim and Chung^[50] also had similar citation history pattern with maxima annual citation of 128.

In addition, indicator of C₂₀₁₉ would be interesting to show high impact in 2019. Recent published articles for example

'Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults'^[61] and 'The erector spinae plane block: A novel analgesic technique in thoracic neuropathic pain'^[62] had high impact in 2019 with C_{2019} of 188 (ranked 3rd) and C_{2019} of 179 (ranked 4th) respectively. However, these two articles had TC_{2019} of 597 ranked 52th and TC_{2019} of 317 ranked 261st. Time is needed for the accumulation of citations. It is clear that citation history and citations in the most recent year should be considered to evaluate impact of an article.

CONCLUSION

During the period from 1991 to 2019, 4,316 highly cited documents in eight document types were published in Web of Science category of anesthesiology. A total of highly cited 3,515 articles were published in 32 journals by authors from 56 countries. The top three productive journals such as *Pain*, *Anesthesiology*, and *Anesthesia and Analgesia* published 73% of the 3,515 articles. Highly cited articles were published not only in high impact factor journals, but also in lower impact factor journals. USA contributed the most total, independent and internationally collaborative articles, as well as most first-, corresponding-, and single-author articles while the UK had the highest citations per publication. Institutionally, the top three productive institutes were all located in USA including University of Washington, University of California San Francisco, and Harvard University. The article by Farrar *et al.* in 2001, ranked first by citation indicator of total citations since publication to the end of 2019. The article by Breivik *et al.* in 2006 had the highest citations in 2019. From Y-index analysis results, M.P. Jensen had the highest publication potential, and published same number of first- and corresponding-author articles.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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