

## ORIGINAL RESEARCH



# A bibliometric analysis of highly cited publications in Web of Science category of emergency medicine

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**Abstract**

The highly cited publications in the Web of Science category of emergency medicine were identified and analysed. Articles that have been cited 100 or more times from Web of Science Core Collection since publication year to the end of 2019 were assessed regarding their distribution in indexed journals. Six publication indicators were applied to compare the publication performance of countries and institutes. The *Y*-index was applied to assess publication quantity and the characteristics of contribution to highly cited authors. Words used in the highly cited articles were analysed. Citation histories of the most frequently cited articles and the most impact articles were also compared. Results showed that the USA ranked top in the six publication indicators. The University of California Davis in the USA was the most independent institute.

**Keywords**

Highly cited publications; Emergency medicine; Bibliometric; Web of Science Core Collection;  $TC_{year}$ ;  $C_{year}$ ;  $CPP_{year}$

## 1. Introduction

In the 1970s, a paper that had been cited 80 or more times was considered 'highly cited' in mathematics [1]. Garfield also reported that highly cited articles with 100 or more citations are generally categorized under clinical or general medical journals [2]. It has been reported that most of the classics in a field are still highly cited [3]. Highly cited papers can be useful indicators for identifying 'worldclass' research [4]. Highly cited publications in a Web of Science category in Science Citation Index Expanded were investigated including chemical engineering [5], health care sciences and services [6], horticulture [7], environmental engineering [8], dentistry, oral surgery and medicine [9], and materials science-related categories [10]. Approximately a decade between the year of data collection and the peak output of highly cited papers were generally found. Highly cited publications might not be the most impactful in the most recent year.

In this study, publications with 100 or more citations from the Web of Science Core Collection since their publication year to the end of 2019 in the Web of Science category of emergency medicine were selected as highly cited publications. Basic bibliometric analyses were carried out using Excel. *Y*-index was used to evaluate the publication performance of highly cited authors.

## 2. Methodology

The data relevant to the present study were derived from the Science Citation Index Expanded (SCI-EXPANDED), in the

Clarivate Analytics Web of Science Core Collection. According to Journal Citation Reports (JCR) of 2019, it indexes 9,356 journals with citation references across 178 Web of Science categories in SCI-EXPANDED. There were 31 journals listed in the Web of Science category of emergency medicine. In total, 107,437 documents including 68,694 articles were found in the Web of Science category of emergency medicine from 1965 to 2019 based on SCI-EXPANDED (updated on September 14, 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 the Web of Science Core Collection since publication to the end of the most recent year [11, 12].  $C_{year}$  is the number of citations in the most recent year [5].  $C_{2019}$  means the number of citations in 2019.  $TC_{year} \geq 100$  was used to retrieve highly cited articles [10]. All document information from SCI-EXPANDED were checked and downloaded into Microsoft Excel 2016 for manual analysis [13, 14].

In the SCI-EXPANDED database, the corresponding-author is labeled as reprint author, but in this study, we used the term corresponding-author [5]. Similarly, in a single institutional article, the institution is classified as the first as well as the corresponding-author institution [10]. In multi-corresponding-author articles, only the last corresponding-author, institute, and country were considered [15]. In a single-author article where authorship is unspecified, the single-author is both the first- and corresponding-author [10].

Affiliations to England, Scotland, Northern Ireland, and Wales were reclassified as being from the United Kingdom (UK) [16]. Affiliations to Fed Rep Ger (Federal Republic of

**TABLE 1. Citations and authors according to the document type.**

Document type	<i>TP</i>	%	<i>AU</i>	<i>APP</i>	<i>TC</i> <sub>2019</sub>	<i>CPP</i> <sub>2019</sub>
Article	898	88	4,893	5.5	148,828	166
Proceedings paper	136	13	664	4.9	22,743	167
Review	113	11	595	5.4	20,500	181
Editorial material	11	1.1	29	2.6	1,518	138
Note	4	0.39	12	3	706	177

*TP*: number of articles; %: percentage of publications in all documents; *AU*: number of authors; *APP*: number of authors per publication ( $AU/TP$ ); *TC*<sub>2019</sub>: total citations from Web of Science Core Collection since publication to the end of 2019; *CPP*<sub>2019</sub> citations per paper ( $TC_{2019}/TP$ ).

**TABLE 2. The 14 journals with highly cited articles in the Web of Science category of emergency medicine.**

Journal	<i>TP</i> (%)	<i>IF</i> <sub>2019</sub> (rank)	<i>APP</i>	<i>CPP</i> <sub>2019</sub>
Annals of Emergency Medicine	340 (38)	5.799 (1)	5.4	168
Resuscitation	176 (20)	4.215 (2)	7.9	176
Academic Emergency Medicine	138 (15)	3.064 (6)	4.7	162
Injury-International Journal of the Care of the Injured	104 (12)	2.106 (12)	4	162
American Journal of Emergency Medicine	52 (5.8)	1.911 (13)	5.3	165
Journal of Trauma	19 (2.1)	N/A	2.7	161
Journal of Emergency Medicine	16 (1.8)	1.224 (22)	3.8	160
Journal of Burn Care & Rehabilitation	13 (1.4)	N/A	4.6	130
Emergency Medicine Journal	12 (1.3)	2.491 (7)	3.4	184
Unfallchirurg	8 (0.89)	0.677 (25)	5	133
Pediatric Emergency Care	8 (0.89)	1.170 (23)	5.8	113
Emergency Medicine Clinics of North America	3 (0.33)	1.528 (18)	2.7	142
Journal of Emergency Nursing	3 (0.33)	1.430 (20)	6	149
Prehospital Emergency Care	3 (0.33)	2.290 (9)	6.7	116
Injury-The British Journal of Accident Surgery	1 (0.11)	N/A	2	110
European Journal of Trauma and Emergency Surgery	1 (0.11)	2.139 (11)	1	114
Scandinavian Journal of Trauma Resuscitation & Emergency Medicine	1 (0.11)	2.370 (8)	8	143

*TP*: total number of highly cited articles; *IF*<sub>2019</sub>: journal impact factor for 2019; *APP*: number of authors per article; *CPP*<sub>2019</sub> citations per paper ( $TC_{2019}/TP$ ), N/A: not available.

Germany) were reclassified as being from Germany [5].

### 3. Results and discussion

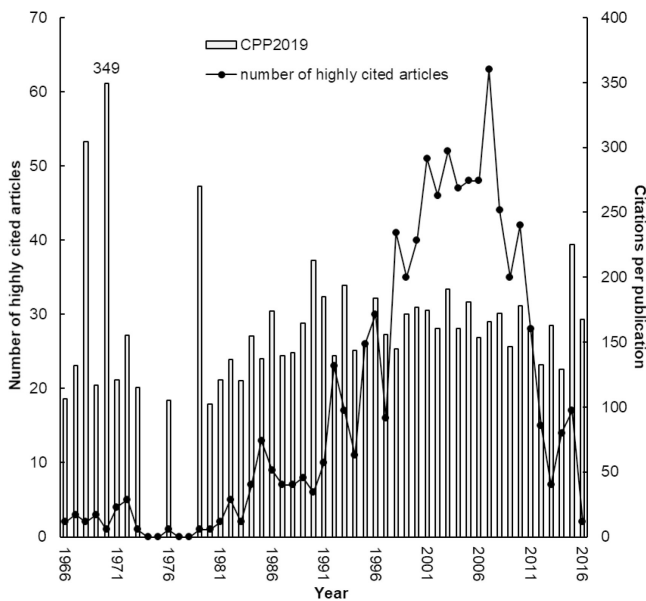
#### 3.1 Document type and language of publication

A total of 1,026 highly cited publications (0.95% of 107,437 documents in the category of emergency medicine in SCI-EXPANDED) with  $TC_{2019} \geq 100$  were found including 898 highly cited articles (0.95% of 68,694 articles). It was reported that the percentage of highly cited documents was 0.68% in the category of health care sciences and services [6], and the percentage of highly cited articles in the category of dentistry, oral surgery and medicine was 1.8% [9]. To have scientific results, which can be repeated and checked, Ho's group proposed citation indicator  $TC_{year}$ , the number of citations from Web of Science Core Collection since publication year to the end

of the most recent year [11, 12] and citations per publication ( $CPP_{year} = TC_{year}/TP$ ) [14]. Analysis of document types and their citations per publication was proposed earlier [17]. Table 1 shows the characteristics of the five document types with the total number of publications (*TP*), the number of authors per publication (*APP*), and citations per publication (*CPP*<sub>2019</sub>) [18]. Document type of articles was the most popular with 898 articles (88% of 1,026 highly cited documents) and the number of authors per publication (*APP*) of 5.5. Reviews had the highest *CPP*<sub>2019</sub> with 181, which is slightly higher than articles with *CPP*<sub>2019</sub> of 166. In total, 113 highly cited reviews were published in 12 journals, mainly in *Annals of Emergency Medicine* (31 reviews; 27% of 113 reviews) with *CPP*<sub>2019</sub> of 171, *Resuscitation* (24; 21%) with *CPP*<sub>2019</sub> of 209, and *Injury-International Journal of the Care of the Injured* (24; 21%) with *CPP*<sub>2019</sub> of 229. The most frequently cited review entitled 'Epidemiology of adult fractures: A review'

[19] was published in *Injury-International Journal of the Care of the Injured* with  $TC_{2019}$  of 894. It has been noticed that documents could be classified within two document types in Web of Science, resulting in the sum of percentages greater than 100% [20]. For example, 136 documents were classified in both document types of articles and proceedings papers.

Only document type of articles was considered for further analysis because they include more complete information such as introduction, method, results, discussion, and conclusions [21]. As a result, 898 highly cited articles were identified in the Web of Science category of emergency medicine in SCI-EXPANDED. Only eight non-English highly cited articles were published in German. All the eight articles were published in *Unfallchirurg* with  $CPP_{2019}$  of 133.



**FIGURE 1.** Number of highly cited articles and citations per publication by year.

### 3.2 Publication distribution

A relationship between the total number of highly cited articles in a year ( $TP$ ) and their citations per publication ( $CPP_{year} = TC_{year}/TP$ ) by the decades [5] and the years [22] in a Web of Science category in SCI-EXPANDED has been proposed. Altogether, 898 highly cited articles in emergency medicine were found between 1966 and 2016 with total  $TC_{2019}$  of 148,828 with an average of 166 and the maximum value of  $TC_{2019}$  was 1,062. Fig. 1 shows the distribution of these 898 highly cited articles over the years and their citations per publication ( $CPP_{2019}$ ). Only two highly cited articles were found in 1966 and no articles were identified after 2016. The year 2007 was the most prolific in terms of highly cited articles in emergency medicine. The highest  $CPP_{2019}$  of 349 in 1970, which can be attributed to the only highly cited article entitled ‘Acute arterial injuries in Vietnam: 1,000 cases’ [23] in the *Journal of Trauma* with  $TC_{2019}$  of 349. The earliest highly cited articles in emergency medicine were ‘Bullet velocity and design as determinants of wounding capability: An experimental study’ [24] and ‘Tolerance curves of acceleration

and intracranial pressure and protective index in experimental head injury’ [25] published in *Journal of Trauma* in 1966 with  $TC_{2019}$  of 107 (ranked 747<sup>th</sup>) and 106 (ranked 770<sup>th</sup>), respectively. The latest highly cited articles were found in 2016, entitled ‘EuReCa ONE-27 Nations, ONE Europe, ONE Registry A prospective one month analysis of out-of-hospital cardiac arrest outcomes in 27 countries in Europe’ [26] in *Resuscitation* and ‘Multicenter evaluation of a 0-hour/1-hour algorithm in the diagnosis of myocardial infarction with high-sensitivity cardiac troponin T’ [27] in *Annals of Emergency Medicine* with  $TC_{2019}$  of 200 (ranked 160<sup>th</sup>) and 135 (ranked 415<sup>th</sup>), respectively.

### 3.3 Journals

A total of 31 journals were classified under the Web of Science category of emergency medicine in 2019. The 898 highly cited articles were published in 14 of these journals (45% of 31 journals), and in four other emergency medicine journals that were no longer tracked by the Web of Science category of emergency medicine as of 2019 (Table 2). Eighty-five percent of the highly cited articles were published in four journals: *Annals of Emergency Medicine* (340 articles; 38% of 898 articles), *Resuscitation* (176; 20%), *Academic Emergency Medicine* (138; 15%), and *Injury-International Journal of the Care of the Injured* (104; 12%). *Annals of Emergency Medicine* not only published the most highly cited articles but also had the highest  $IF_{2019}$  of 5.799 in the category of emergency medicine. *Scandinavian Journal of Trauma Resuscitation & Emergency Medicine* had the highest  $APP$  of 8.0, followed by *Resuscitation* with an  $APP$  of 7.9. A total of 12 highly cited articles were published in the *Emergency Medicine Journal* with the highest  $CPP_{2019}$  of 184. *Unfallchirurg* had the lowest  $IF_{2019}$  of 0.677 (ranked 25<sup>th</sup>) and published eight highly cited articles with  $CPP_{2019}$  of 133.

### 3.4 Countries, institutions, and authors

There were 857 highly cited articles (95% of 898 highly cited articles) with author affiliation information in SCI-EXPANDED from 46 countries. Altogether, 749 (87% of 857 articles) were single country articles from 29 countries and 108 (13%) were internationally collaborative articles from 43 countries. Six publication indicators listed below were applied to compare the top ten productive countries (Table 3) [21, 28]: total highly cited articles ( $TP$ ), independent articles ( $IP$ ), internationally collaborative articles ( $CP$ ), first-author articles ( $FP$ ), corresponding-author articles ( $RP$ ), and single-author articles ( $SP$ ). The top 10 most productive countries published 811 articles (95% of the 857 articles and 95% of  $TC_{2019}$  of 142,076). Seven European countries, two American countries, and one Oceania country were ranked in the top 10 publications. Japan with eight highly cited articles ranked top in Asia. The USA dominated in the six publication indicators with  $TP$  of 565 highly cited articles (66% of 857 highly cited articles),  $IP$  of 500 articles (67% of 749 independent articles),  $CP$  of 65 articles (60% of 108 internationally collaborative articles),  $FP$  of 538 articles (63% of 857 first-author articles),  $RP$  of 507 articles (62% of 813 corresponding-author articles), and  $SP$  of 28 articles (58% of 48 single-author articles).

**TABLE 3. Top 10 most productive countries.**

Country	TP	TPR (%)	IPR (%)	CPR (%)	FPR (%)	RPR (%)	SPR (%)
USA	565	1 (66)	1 (67)	1 (60)	1 (63)	1 (62)	1 (58)
UK	104	2 (12)	2 (8.0)	2 (41)	2 (9.5)	2 (9.5)	3 (6.3)
Canada	70	3 (8.2)	3 (5.6)	3 (26)	3 (5.8)	3 (5.9)	3 (6.3)
Germany	53	4 (6.2)	4 (3.6)	4 (24)	4 (4.1)	4 (4.3)	8 (2.1)
Australia	37	5 (4.3)	5 (2.9)	9 (14)	5 (2.9)	5 (3.0)	6 (4.2)
Sweden	34	6 (4.0)	6 (2.8)	10 (12)	6 (2.7)	6 (2.7)	2 (10)
Norway	26	7 (3.0)	7 (1.3)	8 (15)	7 (1.6)	7 (1.6)	N/A
Italy	25	8 (2.9)	8 (1.1)	6 (16)	10 (1.1)	9 (1.1)	N/A
Switzerland	25	8 (2.9)	9 (0.93)	5 (17)	8 (1.5)	7 (1.6)	3 (6.3)
Netherlands	23	10 (2.7)	11 (0.8)	6 (16)	9 (1.2)	9 (1.1)	N/A

TP: total highly cited articles; TPR (%): total number of articles and the 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 authored articles; SPR (%), rank and the percentage of the single authored articles; CPP<sub>2019</sub>: citations per publication (TC<sub>2019</sub>/TP); N/A: not available.

In total, 417 highly cited articles (49% of 857 highly cited articles) instituted independent articles and 440 (51%) were inter-institutionally collaborative articles. Six publication indicators [29] were applied to compare the top 15 institutions with  $TP > 15$  (Table 4). Harvard University in the USA with 36 highly cited articles (4.2% of 857 highly cited articles) and CP of 31 articles (7.0% of 440 inter-institutionally collaborative articles) ranked top, respectively. The University of California Davis in the USA dominated in three publication indicators with IP of nine articles (2.2% of 417 institutionally independent articles), FP of 12 articles (1.4% of 857 first-author articles), and RP of 12 articles (1.5% of 813 corresponding-author articles). Also, Western Hospital in Australia, the University of Gothenburg in Sweden, and the University of Lund Hospital in Sweden published two single-author articles, respectively.

Ho proposed the  $Y$ -index indicator, which is related to the number of first-author highly cited articles (FP) and corresponding-author highly cited articles (RP). The  $Y$ -index combines two parameters ( $j$ ,  $h$ ) to assess both the publication potential and the characteristics of the contribution as a single index. This indicator has also been applied to compare highly cited authors in Web of Science categories of health care sciences and services [6] and dentistry, oral surgery and medicine [9]. The  $Y$ -index is defined as [5, 10]

$$j = FP + RP \quad (1)$$

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

where  $j$  (a constant related to publication quantity) is the publication potential, and  $h$  (describes the proportion of RP to FP) is publication characteristics. The greater the value of  $j$ , the more the first- and corresponding-author contributes to the highly cited articles.

$h = \pi / 2$ , indicates an author that has only published corresponding-author articles,  $j$  is the number of corresponding-author articles;

$\pi / 2 > h > 0.7854$  indicates an author with more corresponding-author articles;

$h = 0.7854$  indicates that an author has the same number of first- and corresponding-author articles;

$0.7854 < h < 0$  indicates an author with more first-author articles;

$h = 0$ , indicates an author that has only published first-author articles,  $j$  is the number of first-author articles.

In total, 815 (91% of 898) highly cited articles in the Web of Science category of emergency medicine with both first- and corresponding-author information was used to calculate  $Y$ -index for authors. A total of 815 highly cited articles were contributed by 3,301 authors. Particularly, 2,553 (77% of 3,301 authors) authors did not have any first- or corresponding-author articles with  $Y$ -index = (0, 0); 76 (2.3%) authors only published corresponding-author articles with  $h = \pi / 2$ ; 33 (1.0%) authors published more corresponding-author articles with  $\pi / 2 > h > 0.7854$ ; 518 (16%) authors published the same number of first- or corresponding-author articles with  $h = 0.7854$ ; seven (0.21%) authors published more first-author articles with  $0.7854 > h > 0$ ; and 114 (3.5%) authors published only first-author articles with  $h = 0$ . Fig. 2 shows the distribution of the  $Y$ -index ( $j$ ,  $h$ ) of the top 107 highly cited authors with  $j \geq 3$ . Each dot represents one value that could be one author or many authors. For example, J.M. Pines and S.M. Green with (13, 0.8622) as well as G.D. Perkins and other 42 other authors with (4, 0.7854) and M.S. Eisenberg and 17 other authors with (3, 1.107).

T.L. Litovitz had the highest  $j$  of 18, published 18 highly cited articles on the annual report of the American Association of Poison Control Centers. Only ten of them were selected for  $Y$ -index analysis because they had first- and corresponding-author information. Litovitz was both first- and corresponding-author in nine of the ten articles. Followed by P.V. Giannoudis

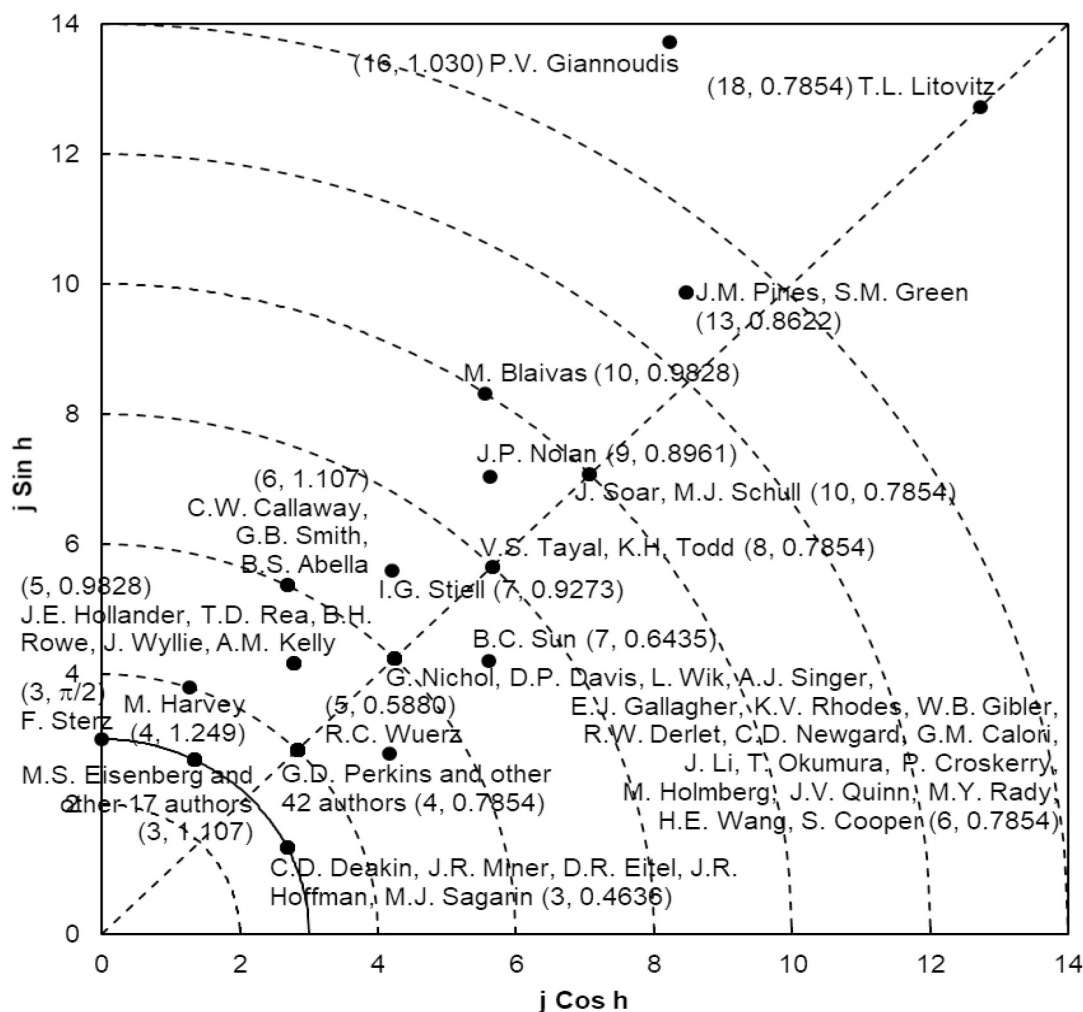


FIGURE 2. Distribution of the top 107 highly cited authors with their Y-index values ( $j \geq 3$ ).

who published 10 highly cited articles, including six first-author and 10 corresponding-author articles with (16, 1.030). M. Blaivas (10, 0.9828) and J. Soar (10, 0.7854) had the same value for  $j$ . It is clear that both of these authors are located on the same curve ( $j = 10$ ) in Fig. 2, indicating that they have the same publication potential with different publication characteristics. Blaivas ( $h = 0.9828$ ) has a higher ratio of corresponding-author articles to first-author articles, than Soar ( $h = 0.7854$ ). Similarly, F. Sterz (3,  $\pi/2$ ), M.S. Eisenberg (3, 1.107), and C.D. Deakin (3, 0.4636) are located on the same curve ( $j = 3$ ). Sterz only published corresponding-author articles, Eisenberg published more corresponding-author articles, and Deakin published more first-author articles.

### 3.5 The most frequently cited articles

The most frequently cited articles with  $TC_{year}$  as citation indicator indicated their impact on a research topic. Citation indicator  $C_{year}$  was proposed to evaluate the most impact articles in the most recent year [5]. These two citation indicators were applied to compare the most frequently cited articles in the Web of Science category of chemical engineering [5]. Table 5 presents the top 10 articles cited more than 600 times ( $TC_{2019} > 600$ ) in the Web of Science category of emergency medicine. Among them, four articles were published in the 2000s, three

in the 1990s, two in the 2010s, and one in the 1980s. The first article with  $TC_{2019}$  of 600 published in 1986 was ‘A practical score for the early diagnosis of acute appendicitis’ [30]. Alvarado reported that eight predictive factors helped diagnose acute appendicitis and came up with a diagnostic score that could help interpret a picture of acute appendicitis. This older article is still highly cited because it is relevant and valuable even to 2019 with  $C_{2019}$  of 23 (rank 49<sup>th</sup>) and  $TC_{2019}$  of 635 (rank 8<sup>th</sup>). Oppenheim and Renn (1978) [31] reported that older papers are still actively being used for historical purposes or the context. Publications with a clear historical significance will be cited for historical reasons [32]. Those which are cited less frequently will not become classics and will not be cited as milestone events [32]. The only classic article with  $TC_{2019} \geq 1,000$  [33] in emergency medicine was entitled ‘Bone substitutes: An update’ [35] with  $TC_{2019}$  of 1,062 by P.V. Giannoudis, H. Dinopoulos, and E. Tsiridis from St James’s University Hospital in the UK. Giannoudis *et al.* (2005) [34] presented an overview of bone grafts and graft substitutes available for clinical applications in the classic article in 2005.

The journals in which these top 10 articles published were *Annals of Emergency Medicine* ( $IF_{2019} = 5.799$ ; ranked 1<sup>st</sup>) with five articles, *Resuscitation* ( $IF_{2019} = 4.215$ ; ranked 2<sup>nd</sup>)

**TABLE 4. Top 15 most productive institutions.**

Institute	TP	TPR (%)	IPR (%)	CPR (%)	FPR (%)	RPR (%)	SPR (%)
Harvard University, USA	36	1 (4.2)	9 (1.2)	1 (7)	5 (1.2)	3 (1.1)	4 (2.1)
University of Penn, USA	28	2 (3.3)	15 (1.0)	2 (5.5)	2 (1.3)	1 (1.5)	4 (2.1)
University of Colorado, USA	25	3 (2.9)	9 (1.2)	3 (4.5)	2 (1.3)	3 (1.1)	N/A
University of Washington, USA	23	4 (2.7)	9 (1.2)	5 (4.1)	5 (1.2)	8 (1.0)	4 (2.1)
University of California San Diego, USA	21	5 (2.5)	5 (1.4)	8 (3.4)	8 (1.1)	3 (1.1)	N/A
University of Pittsburgh, USA	20	6 (2.3)	5 (1.4)	10 (3.2)	8 (1.1)	8 (1.0)	N/A
Brigham And Women's Hospital, USA	19	7 (2.2)	N/A	4 (4.3)	14 (0.82)	18 (0.74)	N/A
University of Arizona, USA	19	7 (2.2)	5 (1.4)	12 (3.0)	14 (0.82)	18 (0.74)	N/A
University of California Davis, USA	19	7 (2.2)	1 (2.2)	20 (2.3)	1 (1.4)	1 (1.5)	N/A
Medical College of Wisconsin, USA	18	10 (2.1)	23 (0.72)	8 (3.4)	54 (0.35)	73 (0.25)	N/A
Oregon Health & Science University, USA	18	10 (2.1)	34 (0.48)	6 (3.6)	14 (0.82)	11 (0.86)	N/A
University California San Francisco, USA	18	10 (2.1)	5 (1.4)	16 (2.7)	2 (1.3)	3 (1.1)	4 (2.1)
University of Ottawa, Canada	18	10 (2.1)	34 (0.48)	6 (3.6)	24 (0.58)	47 (0.37)	N/A
Massachusetts General Hospital, USA	16	14 (1.9)	23 (0.72)	12 (3.0)	19 (0.70)	11 (0.86)	4 (2.1)
University of California Los Angeles, USA	16	14 (1.9)	2 (1.9)	30 (1.8)	10 (0.93)	11 (0.86)	N/A

TP: total highly cited articles; TPR (%): total number of articles and the percentage of total articles; IPR (%): rank and percentage of single institute articles; NPR (%): rank and percentage of nationally collaborative articles; IPR (%): rank and percentage of internationally collaborative articles; FPR (%): rank and the percentage of first author articles; RPR (%): rank and the percentage of the corresponding authored articles; SPR (%), rank and the percentage of the single authored articles; CPP<sub>2019</sub>: citations per publication (TC<sub>2019</sub>/TP); N/A: not available.

**TABLE 5. The top 10 most frequently cited articles in the Web of Science category of emergency medicine.**

Ran (TC <sub>2019</sub> )	Rank (C <sub>2019</sub> )	Article title	Reference
1 (1,062)	3 (126)	Bone substitutes: An update	[34]
2 (771)	33 (43)	Chart reviews in emergency medicine research: Where are the methods	[44]
3 (752)	89 (25)	European resuscitation council guidelines for resuscitation 2010: Section 1. Executive summary	[36]
4 (749)	26 (48)	Cardiopulmonary resuscitation of adults in the hospital: A report of 14 720 cardiac arrests from the National Registry of Cardiopulmonary Resuscitation	[45]
5 (730)	7 (107)	Reliability of the visual analog scale for measurement of acute pain	[39]
6 (718)	155 (18)	European Resuscitation Council Guidelines for Resuscitation 2010: Section 4. Adult advanced life support	[37]
7 (699)	19 (52)	Clinical significance of reported changes in pain severity	[46]
8 (635)	23 (49)	A practical score for the early diagnosis of acute appendicitis	[30]
9 (633)	69 (29)	Predicting survival from out-of-hospital cardiac arrest: A graphic model	[35]
10 (601)	116 (21)	Overcrowding in the nation's emergency departments: Complex causes and disturbing effects	[47]

TC<sub>2019</sub>: total citations from Web of Science Core Collection since publication year to the end of 2019; C<sub>2019</sub>: citations in 2019 only.

with three articles, *Academic Emergency Medicine* (IF<sub>2019</sub> = 3.064; ranked 6<sup>th</sup>) with one article, and *Injury-International Journal of the Care of the Injured* (IF<sub>2019</sub> = 2.106; ranked 12<sup>th</sup>) with also one article. There was a strong relation between TC<sub>2019</sub> and IF<sub>2019</sub> for the most frequently cited articles in emergency medicine. Seven of the top ten articles published by first-author are from the USA and three from the UK. Only two of the top ten most cited articles in TC<sub>2019</sub> were ranked in

the top ten in C<sub>2019</sub>.

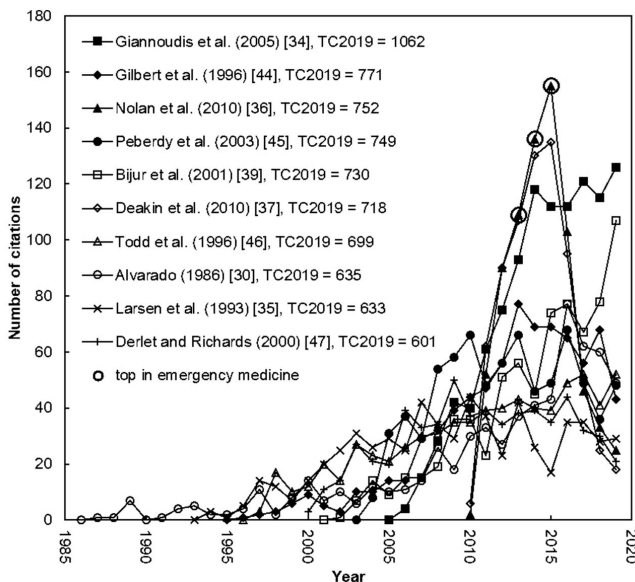
### 3.6 Citation history of articles the top ten articles with the TC<sub>2019</sub>

The citation history of an article shows characteristics of the article's impact after publication. The citation history of the top ten articles (TC<sub>2019</sub> > 600) is shown in Fig. 3. Earlier publications like Larsen *et al.* (1993) [35] had a long history

**TABLE 6. Top 20 most used words in highly cited article title, author keywords, and KeyWords Plus.**

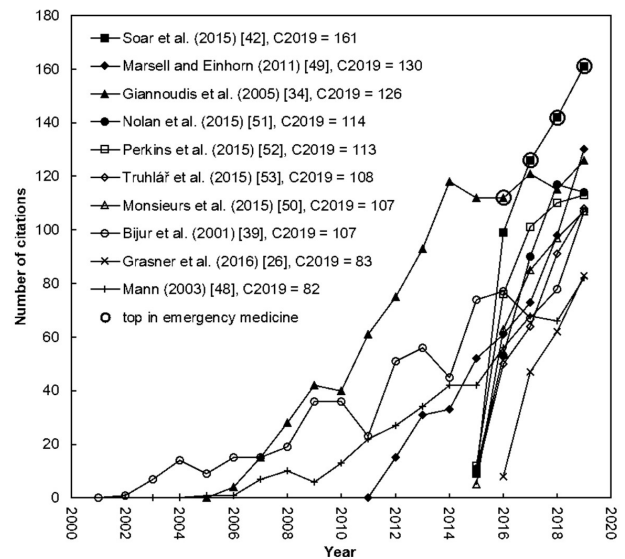
Words in title	TP	R (%)	Author keywords	TP	R (%)	KeyWords Plus	TP	R (%)
emergency	288	1 (32)	cardiac arrest	79	1 (19)	care	77	1 (11)
department	188	2 (21)	cardiopulmonary resuscitation	48	2 (11)	management	58	2 (8.5)
patients	110	3 (12)	emergency department	37	3 (8.8)	cardiopulmonary-resuscitation	49	3 (7.2)
cardiac	98	4 (11)	resuscitation	34	4 (8.1)	survival	43	4 (6.3)
arrest	94	5 (10)	outcome	25	5 (6.0)	hospital cardiac-arrest	39	5 (5.7)
resuscitation	94	5 (10)	emergency medical services	24	6 (5.7)	CPR	32	6 (4.7)
clinical	70	7 (7.8)	heart arrest	24	6 (5.7)	quality	31	7 (4.6)
out-of-hospital	66	8 (7.3)	hypothermia	18	8 (4.3)	children	29	8 (4.3)
care	50	9 (5.6)	emergency medicine	17	9 (4.1)	cardiac-arrest	26	9 (3.8)
acute	49	10 (5.5)	survival	16	10 (3.8)	American-Heart-Association	25	10 (3.7)
cardiopulmonary	47	11 (5.2)	ultrasound	16	10 (3.8)	emergency	23	11 (3.4)
treatment	45	12 (5.0)	epidemiology	15	12 (3.6)	ventricular-fibrillation	23	11 (3.4)
survival	40	13 (4.5)	cardiopulmonary resuscitation (cpr)	14	13 (3.3)	impact	22	13 (3.2)
prospective	39	14 (4.3)	chest compression	14	13 (3.3)	mortality	21	14 (3.1)
fractures	35	15 (3.9)	education	14	13 (3.3)	resuscitation	21	14 (3.1)
system	35	15 (3.9)	out-of-hospital cpr	13	16 (3.1)	life-support	20	16 (2.9)
pain	34	17 (3.8)	trauma	11	17 (2.6)	acute myocardial-infarction	19	17 (2.8)
chest	33	18 (3.7)	overcrowding	10	18 (2.4)	diagnosis	19	17 (2.8)
medical	32	19 (3.6)	medical emergency team	9	19 (2.1)	outcomes	19	17 (2.8)
outcome	32	19 (3.6)	outcomes	9	19 (2.1)	performance	19	17 (2.8)
			pain	9	19 (2.1)			
			ventricular fibrillation	9	19 (2.1)			

TP: total highly cited articles; R: rank



**FIGURE 3. Citation histories of the top 10 most frequently cited articles with  $TC_{2019} > 600$ .**

of impact, but less impactful in recent years. Citation history of articles by Nolan *et al.* (2010) [36] and Deakin *et al.* (2010) [37] were a type of initially much-praised articles named by Avramescu (1979) [38]. The citation history of articles by



**FIGURE 4. Citation histories of the top 10 most impact articles in 2019 with  $C_{2019} > 80$ .**

Giannoudis *et al.* (2005) [34] and Bijur *et al.* (2001) [39] was not recognized initially but has increased its citation with a constantly growing rate as a genial work [38]. Article by Nolan *et al.* (2010) [36] was the most cited in emergency medicine

from 2013 to 2014 with  $C_{year} > 100$ .

### 3.7 Citation history of the top ten articles with the $C_{2019}$

Only 44% of the top 100 articles with  $TC_{2019}$  were ranked on the top 100 with  $C_{2019}$ . Citation indicator  $C_{year}$ , annual citations from Web of Science Core Collection in the most recent year was proposed [5, 40]. In the last decade,  $C_{year}$  was widely applied for the most impactful articles in Web of Science categories of chemical engineering [5], environmental sciences [41], health care sciences and services [6], horticulture [7], and materials science-related categories [10]. The citation history of the top ten articles ( $C_{2019} > 80$ ) is shown in Fig. 4. Five of the ten articles were published in 2015 and one in 2001, 2003, 2005, 2011, and 2016, respectively. Articles by Giannoudis *et al.* (2005) [34] and Bijur *et al.* (2001) [39] were not only ranked the top ten on  $C_{2019}$  but also the top ten on  $T_{2019}$ . The article by Giannoudis *et al.* (2005) [34] was the most cited in 2016 and the article by Soar *et al.* (2015) [42] was the most impactful after 2016 in emergency medicine.

### 3.8 Words in article title, author keywords, and KeyWords Plus

Analysis of used words in article title, author keywords, and *KeyWords Plus* were proposed for the main research topics [43]. In SCI-EXPANDED, 479 (53% 898 articles) and 217 (24%) articles lacked author keywords and *KeyWords Plus* information, respectively. Table 6 shows the top 20 most used words in a highly cited article title, author keywords, and *KeyWords Plus* in emergency medicine. A total of 288 articles (32% of 898 highly cited articles), 79 (19% of 419 articles with author keyword information), and 77 (11% of 681 articles with *KeyWords Plus* information) included ‘emergency’, ‘cardiac arrest’, and ‘care’ in article title, respectively. ‘Resuscitation’ and ‘survival’ listed in the top 20 most used words in article title, author keywords, and *KeyWords Plus*, respectively. ‘Pain’ and ‘outcome’ ranked not only in the top 20 words in article title but also in the top 20 author keywords. ‘Cardiopulmonary resuscitation’, ‘cardiac arrest’, ‘ventricular fibrillation’, and ‘outcomes’ were the top 20 most used author keywords and *KeyWords Plus*, respectively.

## 4. Conclusions

A total of 1,026 highly cited publications with  $TC_{2019}$  of 100 or more citations in the Web of Science category of emergency medicine in SCI-EXPANDED were found within five document types indexed in the Web of Science. Reviews and articles had a similar citation per publication. Reviews were published mainly in *Annals of Emergency Medicine*, *Resuscitation*, and *Injury-International Journal of the Care of the Injured*. The most highly cited articles were published in 2007. Articles published in 1970 had the highest citations per publication. Highly cited articles were published in 14 journals of the 31 journals in emergency medicine in 2019. *Annals of Emergency Medicine* was the most productive journal. Articles published in the *Emergency Medicine Journal* had the highest citations per publication. There is a significant

relationship between highly cited articles and journal impact factors. The USA dominated in all six publication indicators. Harvard University in the USA published the most highly cited articles and was the most frequent partner. The University of California Davis in the USA shows its ability to independently conduct research. From the analysis results of the  $Y$ -index, T.L. Litovitz had the highest publication potential for the highly cited articles. The only classic article in the Web of Science category of emergency medicine in SCI-EXPANDED was published by authors from St James’s University Hospital in the UK. Words such as ‘pain’, ‘cardiopulmonary resuscitation’, ‘cardiac arrest’, and ‘ventricular fibrillation’ were most used in the highly cited articles in emergency medicine.

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## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

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