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Review article

The 100 most influential publications in asthma from 1960 to 2017: A bibliometric analysis

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ABSTRACT

Background: The area of asthma medicine has produced a large volume of important clinical and scientific papers that can be found in those most influential journals. The purpose of our study was to identify the 100 most cited papers in asthma research and to analyze their characteristics.

Methods: We used the Institute for Scientific Information Web of Knowledge Database to identify the most frequently cited articles published from 1960 to December 2017. Original articles and reviews were included in the study. The 100 top-cited articles were then analyzed with regard to number of citations, publication year, journals, institution, research type and field, authors and countries of authors of publications.

Results: The 100 top-cited articles in asthma were published between 1960 and 2011 with a median of 933 citations per article (range, 701–2947). The number of citations per article was greatest for articles published in the 1990s. The United States of America contributed most of the classic articles, followed by England. The leading institutions were Imperial College London, McMaster University, Erasmus University Rotterdam. The 100 top-cited articles were published in twenty-five journals, led by *The New England Journal of Medicine* (21 articles), followed by *American Journal of Respiratory and Critical Care Medicine* (19 articles), *Lancet* (11 articles), respectively. Among the 100 classics, 50% articles were clinical research articles.

Conclusions: Our study provides a historical perspective on the progress of research on asthma. Studies conducted in well-developed European countries and North America, published in high-impact journals had the highest citations.

1. Introduction

Asthma is a serious global health problem. People of all ages throughout the world are affected by this chronic airway disorder that, when uncontrolled, can place severe limits on daily life and is sometimes fatal. The prevalence of asthma is increasing in most countries, especially among children [1–3]. During the past decades, many scientific advances have improved our understanding of asthma and our ability to manage and control it effectively. These advancements are reflected in scientific articles, particularly in those most influential papers.

Bibliometrics is a statistical and quantitative analysis designed to analyze the academic impact and characteristics of publications within a research field [4]. Since Eugene Garfield, the founder of bibliometrics, published the first bibliometric article in the Journal of the American Medical Association (JAMA) in 1987 [5], this field of information science has evolved. Citation analysis is one method of bibliometric analysis that has been used to quantify the relative importance of a scientific publication by examining the citations attributed to that paper. It is postulated that the importance of a scientific paper to a particular area is echoed in the quantity of citations obtained from other researchers [6–8]. Citation classics in several medical fields have been published [9–11]. However, to the best of our knowledge, this type of identification has not been used in the field of asthma.

This review, we used the electronic version of ISI database to determine which published articles in asthma research have been cited most often by other authors by ranking the 100 top-cited works and analyze their characteristics. The expectation was to provide a

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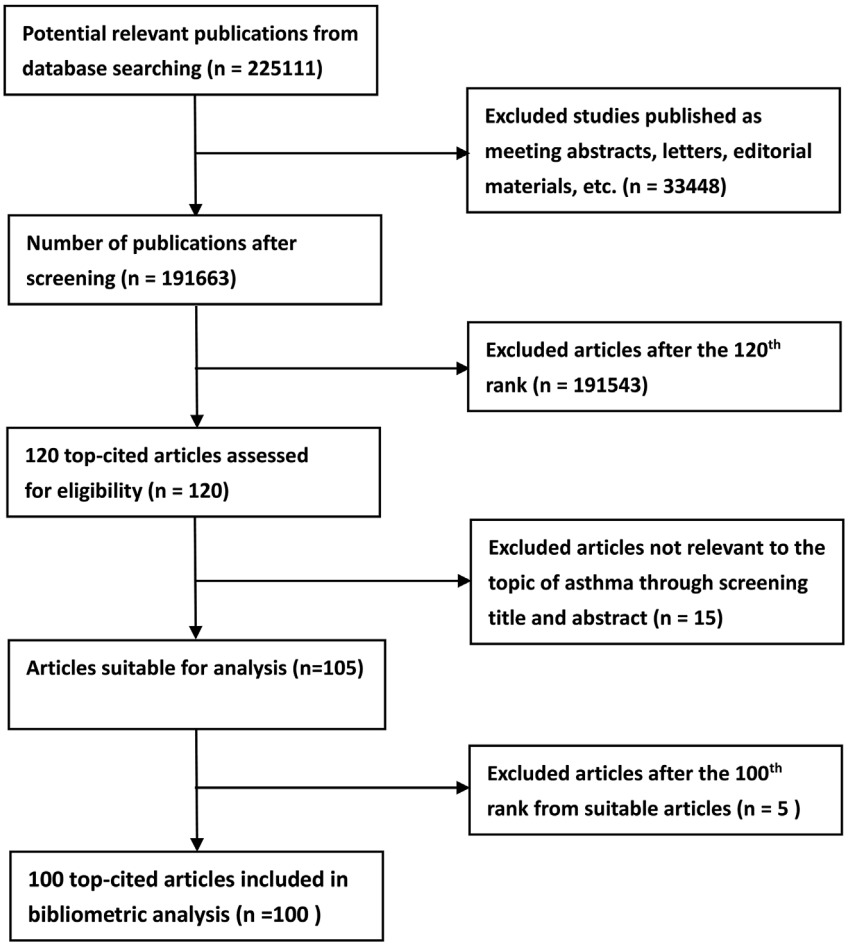

Fig. 1. Flow chart of the selection process.

bibliometric perspective of the progress in asthma research. We also intended to identify factors contributing to the successful citation such as journals in which the articles were published and related countries.

2. Methods

The database of the Science Citation Index (SCI) of the Institute for Scientific Information (ISI) was used to identify the most cited papers in asthma research because this database has been used to identify top-cited articles in many other medical specialties. The SCI is an index of citations produced by the ISI and is made available online through the Web of Science database, a part of the Web of Knowledge collection of databases. The overall search was conducted in February 2018. Ethical approval was not required in this study, because no human subjects were enrolled.

The keywords used for the search were “asthma*” as the “topic” (title, abstract, author's keywords, and KeyWords Plus), a year-of publication range from January 1960 until December 2017, and the document type “original articles and reviews”. No language was restricted in this search. The selection process of the articles is shown in Fig. 1. Data extraction process was performed independently by three researchers (YQ, CZ and SL), and any disagreement was resolved in a consensus meeting. The abstract of each search result was read thoroughly to judge the relevance of the article. Then, the top-100 articles were ranked by the number of citations listed on the Web of Science. Within these top-cited articles, the following information was recorded: authors, country of origin, year of publication, institution, journal name, total number of citations for the article, overall citation rate (total citations/the number of years since publication), research nature (basic science, clinical research or review), and research field. Country of origin was defined based on the first author's address. Once the journal impact factors (IFs) had been obtained from the Journal Citation Report 2016, we investigated the correlation between each journal's IF and the number of top 100 articles it published. We also studied the correlation between the total number of citations and overall citation rate.

The 100 papers were inputted into SPSS software (SPSS Inc., Chicago IL). A citation index was calculated for each article to control the error of citations from different publication time. Statistical analysis was performed using SPSS 19. Descriptive statistics were quantified as counts or percentages of parameters. The Spearman rank correlation (r) was employed to test for correlations among non-parametric variables. The Mann-Whitney test was used to see whether there was any significant difference in the citations of original articles and review. P values < 0.05 were considered significant.

3. Results

3.1. Citation count and citations per year

The search period were from 1960 to December 2017. The 100 top-cited articles were published from 1960 to 2011, and were identified among 191663 articles. The median number of citations was 933 (range 701–2947), 43 papers were cited more than 1000 times and eight paper was cited more than 2000 times. The 100 articles are listed in Table 1 and are in descending order, according to the number of citations that they have received [12–111]. The number of citations per year ranged from 16.9 to 207.7. Annual average cited times were positively

Table 1
The 100 most cited papers in asthma.

Rank	First author	No. of citations	Citations/ year	[a]New rank	Rank	First author	No. of citations	Citations/ year	[a]New rank	Rank	First author	No. of citations	Citations/ year	[a]New rank
1	Chen, W	2947	184.19	2	35	Foster, PS	1118	48.61	46	69	Corren, J	830	103.75	8
2	Samuelsson, B	2731	75.86	24	36	Boushey, HA	1105	28.33	89	70	Jeffery, PK	827	27.57	90
3	Martinez, FD	2457	102.38	9	37	Green, RH	1084	63.76	35	71	Lanham, JG	819	23.40	98
4	Robinson, DS	2409	89.22	15	38	Nathan, RA	1081	72.07	27	72	Wills-Karp, M	814	40.70	63
5	Bousquet, J	2285	207.73	1	39	Shirakawa, T	1066	48.45	47	73	Moore, WC	798	88.67	16
6	Bousquet, J	2054	70.83	28	40	Burney, PG	1066	42.64	60	74	Lange, P	794	37.81	68
7	Asher, MI	2047	157.46	3	41	Hamelmann, E	1020	46.36	51	75	Nair, P	789	78.90	21
8	Asher, MI	2019	84.13	17	42	Zhu, Z	1019	50.95	44	76	Azzawi, M	787	27.14	91
9	Wills-Karp, M	1967	93.67	14	43	Beasley, R	1006	33.53	77	77	Wierenga, EA	787	27.14	92
10	Cockcroft, DW	1902	45.29	54	44	Keatings, VM	996	43.30	58	78	Pin, I	785	29.07	82
11	Masoli, M	1767	117.80	5	45	Stein, RT	966	48.30	48	79	Weiss, KB	784	29.04	83
12	Bousquet, J	1737	96.50	11	46	Spitzer, WO	948	35.11	71	80	Van E	779	45.82	52
13	Bateman, ED	1575	143.18	4	47	Haldar, P	946	94.60	13	81	Mitenko, PA	777	16.89	100
14	Palmer, Colin NA	1458	112.15	6	48	Cockcroft, DW	946	22.52	99	82	Nicholson, KG	776	29.85	80
15	Grunig, G	1424	67.81	29	49	Neill, DR	943	104.78	7	83	Sanderson, CJ	775	28.70	85
16	Mannino, DM	1408	82.82	19	50	Dahlen, SE	940	24.10	97	84	Dunnill, MS	775	28.70	86
17	Busse, WW	1367	75.94	23	51	Sears, MR	926	31.93	78	85	Juniper, EF	773	28.63	88
18	Sporik, R	1301	44.86	57	52	Akbari, O	923	51.28	43	86	Dweik, RA	772	96.50	12
19	Burrows, B	1283	42.77	59	53	Rosenstreich, DL	923	41.95	62	87	Brightling, CE	769	45.24	55
20	Johnston, SL	1281	53.38	41	54	Moffatt, MF	902	75.17	25	88	Hamid, Q	760	27.14	93
21	Wide, L	1261	24.25	96	55	Wardlaw, AJ	889	28.68	87	89	Greening, AP	753	30.12	79
22	Bousquet, J	1233	64.89	34	56	Moffatt, MF	887	98.56	10	90	Nelson, HS	744	57.23	40
23	Leckie, MJ	1198	63.05	36	57	Alving, K	882	33.92	76	91	Wenzel, SE	731	36.55	69
24	Juniper, EF	1190	59.50	37	58	Roche, WR	877	29.23	81	92	Bousquet, J	731	34.81	72
25	Juniper, EF	1187	47.48	49	59	Eder, W	874	67.23	32	93	Galli, SJ	730	66.36	33
26	Laitinen, LA	1165	34.26	73	60	Peters, A	864	39.27	66	94	Hirai, H	722	40.11	64
27	De Monchy, JG	1165	34.26	74	61	Sallusto, F	859	39.05	67	95	Sears, MR	719	44.94	56
28	Braun-Fahrlander, C	1150	67.65	30	62	Marsh, DG	855	34.20	75	96	Brozek, JL	712	79.11	20
29	Djukanovic, R	1150	39.66	65	63	Riedler, J	843	46.83	50	97	Lynch, KR	710	35.50	70
30	Soumelis, V	1144	67.29	31	64	Haldar, P	838	76.18	22	98	Dixon, AL	704	58.67	39
31	Kharitonov, SA	1142	45.68	53	65	Wegner, CD	836	28.83	84	99	Walker, C	704	26.07	95
32	Pauwels, RA	1140	51.82	42	66	Galli, SJ	833	59.50	38	100	Hamid, Q	701	26.96	94
33	Sampson, HA	1136	42.07	61	67	Eisenbarth, SC	833	49.00	45					
34	Bateman, ED	1127	75.13	26	68	Reddel, HK	832	83.20	18					

[a] "New rank" was sorted by the average annual number of citations.

Table 2
Citations per type of article.

Research nature	Citations per type of article			P*		
	N	Range (Min/ Max)	Mean (± SD)	*Gr1 vs Gr2*	*Gr1 vs Gr3*	*Gr2 vs Gr3*
Basic research (Gr1)	34	701/2947	1083 (± 579)	0.115	0.145	0.285
Clinical research (Gr2)	50	712/2457	1070 (± 365)			
Review article (Gr3)	16	730/2285	1241 (± 490)			
Total	100	701/2947	1102 (± 467)	* *Mann-Whitney test*		

correlated by total cited times (r = 0.482, p < 0.01). Of the 100 articles, 34 were basic research, 50 were clinical research, and 16 were review articles. Considering the number of citations per type of article, no statistically significant difference were only found between the groups of basic research, clinical research and review (Table 2).

The most cited paper, by Chen et al., published in *the Journal of Experimental Medicine* in 2003 [87]. Authors reported that co-administration of the TGF-beta-induced suppressor T cells prevented house dust mite-induced allergic pathogenesis in a murine asthma model. The most recent paper was a clinical trial from 2011 and it was cited 830 times [110]. Whereas the 100th paper authored by Hamid et al., which had 701 citations [45]. The earliest seminal paper published in 1960 authored by Dunnill et al., researchers analyzed the pathological features of 20 cases dying in status asthmaticus, ranked 84th in the 100 top-cited list [12].

3.2. Year of publication, origins and authorship

The 1990s produced the most citation classics with 40 articles. Overall, more than 80% of the 100 top-cited articles were published after 1990. The publication years of these top-cited papers are shown in Fig. 2.

The 100 top-cited articles originated from 46 countries, with the United States (n = 11) and England (n = 9) contributing the majority of papers, followed by France (n = 7), Canada (n = 6), the Netherlands (n = 4) and Australia (n = 4), respectively. Table 3 shows the distribution of these top-cited articles over the countries of origin. As some articles were authored with multiple sources of origin, the country of origin was defined by the address of the first author.

The top-cited papers were written by 8 authors, the number of authors ranged from one to 38. Table 4 presents a list of the most productive authors, led by Bousquet J with 9 articles, and all of the authors list in this table authored four or more articles. Among the first authors, Bousquet J led the table with five papers, followed by Bateman ED (2 articles). Most of the authors in the table are from the United Kingdom.

3.3. Journal, institutional affiliations and topical distribution

Twenty-five journals contributed all the 100 top-cited articles, led by *The New England Journal of Medicine* (21 articles) and followed by *American Journal of Respiratory and Critical Care Medicine* (19 articles), *Lancet* share the third with 11 articles. Table 5 presents the top 10 journals that published the highest number of top-cited papers. We

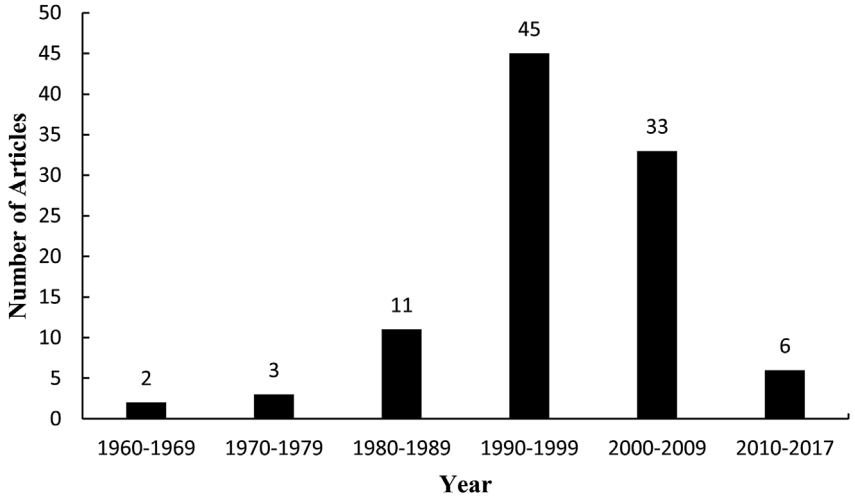

Fig. 2. Number of articles by decade of publication.

Table 3
Countries which contributed more than 2 papers in the 100 top-cited articles.

Country	Number
United States	11
England	9
France	7
Canada	6
Australia	4
Germany	4
The Netherlands	4
Scotland	4
Denmark	3
Japan	3
South Africa	3

Table 4
The authors who contributed more than 3 papers in the 100 top-cited articles.

Author	Number	Position on author list	Country
Bousquet J	9	First author – 5, second – 1, third – 1, fourth – 1, sixth – 1	France
Busse WW	6	First author – 1, third – 1, fourth – 1, sixth – 1, others – 2	USA
Holgate ST	6	Second author – 1, fourth – 3, seventh – 1, others – 1	UK
Wardlaw AJ	5	First author – 1, second – 2, fifth – 3	UK
Barnes PJ	5	Third author – 1, fourth – 1, sixth – 2, others – 1	UK
Pavord ID	5	Second author – 1, sixth – 1, eighth – 1, others – 2	UK
Wenzel SE	4	First author – 1, third – 1, others – 2	USA
Jeffery PK	4	First author – 1, second – 1, third – 1, tenth – 1	UK
Brightling CE	4	First author – 1, second – 2, sixth – 1	UK
Bateman ED	4	First author – 2, third – 1, others – 1	South Africa
Beasley R	4	First author – 1, second – 1, fourth – 2	UK
Kay AB	4	Fifth author – 2, ninth – 1, tenth – 1	UK
von Mutius E	4	Third author – 1, tenth – 1, others – 2	Germany
Collins JV	4	Fourth author – 2, eighth – 1, ninth – 1	UK

found a positive correlation between the impact factors of the journals and the number of top-cited articles they published ($r = 0.696$; $p < 0.01$).

The leading institutions which produced more than 3 papers in this 100 top-cited list are shown in Table 6. Imperial College London was found to be the most productive institution (n = 6), followed by McMaster University (n = 5) and Erasmus University Rotterdam (n = 4), respectively.

Table 5
Top-ten journals that contribute most articles to the top-100 papers.

Journal	Number	2016 Impact Factor
New England Journal of Medicine	21	72.41
American Journal of Respiratory and Critical Care Medicine	19	13.20
Lancet	11	47.83
Science	7	37.21
Nature	6	40.14
European Respiratory Journal	4	10.57
Journal of Experimental Medicine	4	11.99
Journal of Allergy and Clinical Immunology	4	13.08
Allergy	2	7.36
Annual Review of Immunology	2	28.40

Table 6
Institutions which contributed more than 3 papers in the 100 top-cited articles.

Institution	Number	Country
Imperial College London	6	UK
McMaster University	5	Canada
Erasmus University Rotterdam	4	Netherlands
Institut National de la Sante et de la Recherche Medicale Inserm	4	France
University of Paris-Saclay	4	France
University of Aberdeen	4	UK
University of Leicester	4	UK

Among the 100 top-cited articles in asthma, the majority (n = 84) were studies in “Respiratory system”, followed by 83 articles studies in “Allergy”. Other fields like “Immunology” and “Biochemistry Molecular Biology” aspects also have a considerable proportion of research, according to the study field classification by Web of Science (Table 7).

4. Discussion

In this study, we used bibliometric analysis to identify the 100 top cited articles in the field of asthma research over the past decades. By reading through the 100 most frequently cited papers, it is hard not to impressive the classic papers that are present on the list. These are representative of the many landmarks that have occurred in asthma research over the past decades.

However, many important papers relating to asthma are not found on this top 100 list. An example of an important paper that failed to

Table 7
Top-ten research fields in the 100 top-cited articles.

Institution	Number
Respiratory system	84
Allergy	83
Immunology	47
Biochemistry Molecular Biology	41
Hematology	33
Pediatrics	27
Anatomy morphology	22
Pharmacy Pharmacology	22
Cell biology	18
Genetics Heredity	16

qualify into the top 100 was the 1989 paper from Barnes, in which the author summarized the research progress in 1980s, and pointed out the development direction in asthma research in the future, and the later researches had been greatly influenced by the new concepts raised in this paper [112]. Unfortunately, this paper has been cited 430 times to date and narrowly missed out in being included in the top 100. Another seminal paper that did not make the most cited list authored by Matsuoka et al., published in 2000 in Science [113]. Their distinguished work found that prostaglandin D-2 functions as a mast cell-derived mediator to trigger asthmatic responses. Actually, there were still many important papers relating to asthma are not found on this top 100 list and this is a limitation of this type of study. This indicates that the number of citations a paper has received may not reflect its overall importance historically.

The year span of 1990–1999 had the highest number of top cited articles, followed by 2000s. Actually, more than 80% of them published after 1990, while only 5 papers published before 1980. It was reported that, scientific papers are usually cited one or two years after publication and reach peak citation about 10 years after publication [114]. The citation rate has gradually risen over the last decade and is indicative of an increasing consideration for the field of asthma. Our research also supporting that the peak recognition of important papers in a field can be obtained in a 10- to 20-year period [115].

Throughout the top list, majority included clinical research articles, whereas basic research article accounted for less than 40%. These findings might be associated with a preference for referring to clinical evidence rather than basic research results. A clinical research, especially a randomized controlled trial, is an important part of clinical practice. On the other hand, among the top-cited articles, 34 articles were related to basic sciences. Therefore, many readers of the general medical journals seem to be interested in fundamental science rather than just applied science.

Among the top cited articles, the majority originated from European developed countries and the United States. The United States ranking first in quality of scientific production in asthma research, followed by England. Only 3% of the top cited articles came from Asia. Although the scientific research has achieved rapid development in recent years, authors in most Asian countries did not have a place in the field of asthma research. It was reported that biomedical research productivity world-wide is largely dependent on each country's per capita gross national product and the expenditure allotted for research and development [116].

In the current study, majority of the top cited papers were published in journals with high impact factors, including New England Journal of Medicine, lancet, Science and Nature. Thirty-five percent of the top-cited papers were published in asthma dedicated journals, such as Journal of Allergy and Clinical Immunology. This seems supporting that the impact factor of the original publishing journal was the widely effective predictor of citations each year, rather than the methodology or quality of the research [117]. Our research indicating that the actual citation of the individual article might positively related to the impact factor of the journal.

Although we spared no effort to eliminate potential defects in this citation analysis, some limitations related to its inherent problems were inevitable. First, we used the key word “asthma*” for the search, which may miss some relevant articles that did not include this specific term. Second, the journals have different approaches to accept or reject a submitted manuscript. Thus, particular journals could have stricter selection criteria that might have affected the clinical applicability or quality of their publications. The criteria could be a reason why most top cited papers were found in one journal. Third, challenges and problems might arise from citation counts, such as ignoring potential citations in book chapters, considering self-citations, peers' preference to cite papers from the journal they submit their work, and preference to cite review articles or full-length articles. Forth, the number of citations and overall citation rate of a particular paper could be influenced by its publication year because some journals check the quality of a submitted work based on the usage of recently published papers. Despite these obvious defects, the data presented here provide insight into the achievement and development of asthma research over the past decades.

5. Conclusion

To our knowledge, this study might be considered as the first report on the most cited papers in asthma. It also gives an interesting insight into the history and development in asthma over the half past century. The findings indicate that studies conducted in well-developed European and North America countries, published in high-impact journals and were written in English had the highest citations.

Abbreviations

SCI: Science Citation Index; ISI: Institute for Scientific Information; GM-CSF: granulocyte-macrophage colony stimulating factor.

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Authors' contributions

The work presented here was carried out in collaboration between all authors. YQ, CZ, ZH, YS and CB conceived and designed the study. YQ, CZ and ZH designed database searching methods and data analysis; SL, CK and YN collected the data; YQ, CZ, SL, CK and YN analyzed the data; YQ, CZ and ZH drafted the manuscript; YS and CB critically revised the manuscript. All authors have contributed to, seen and approved the manuscript.

Ethics approval and consent to participate

Not applicable.

Conflicts of interest

The authors declare that they have no competing interests.

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