

# A bibliometric analysis of the 100 most influential papers on COPD

Wenchao Gu<sup>1</sup>  
Yaping Yuan<sup>1</sup>  
Hua Yang<sup>1</sup>  
Guangsheng Qi<sup>1</sup>  
Xiaoyan Jin<sup>2</sup>  
Jin Yan<sup>2</sup>

<sup>1</sup>Department of Respiratory Medicine, People's Hospital of Shanghai, Pudong New Area, <sup>2</sup>Department of Respiratory Medicine, Tongren Hospital, Shanghai, People's Republic of China

**Objective:** We aimed to identify the 100 top-cited articles published on chronic obstructive pulmonary disease (COPD) and to analyze their characteristics so as to provide information on the achievement and development in COPD research over the past decades.

**Methods and materials:** A comprehensive list of citation classics in COPD was generated by searching the Science Citation Index expanded database, using the keywords "COPD" or "chronic obstructive pulmonary disease" or "chronic obstructive pulmonary diseases". The 100 top-cited research papers were retrieved by reading the abstract or full text if needed. All eligible articles were read for basic information, including country of origin, organizations, article type, journals, research field, and authors.

**Results:** The 100 top-cited articles on COPD were published between 1966 and 2010. The number of citations ranged from 254 to 2,164, with a mean of 450 citations for each article. These citation classics were from 32 countries, with 38 from the United States. The Imperial College London led the list of classics, with 16 papers. The 100 top-cited articles were distributed in 18 journals, with the American Journal of Respiratory, Critical Care Medicine, and Journal of the American Medical Association topping the list. Among the various fields, both respiratory system (63%) and general internal medicine (63%) were the most common fields of study for the 100 articles.

**Conclusion:** Our bibliometric analysis provides a historical perspective on the progress of scientific research on COPD. Articles originating from the United States and published in high-impact specialized respiratory journals are most likely to be cited in the field of COPD research.

**Keywords:** citation analysis, top-cited, chronic obstructive pulmonary disease

## Introduction

Chronic obstructive pulmonary disease (COPD) continues to be an important cause of morbidity, mortality, and health care costs worldwide. As the global population ages, the burden of COPD will increase in the years to come.<sup>1-3</sup> Numerous specialists and researchers have focused their efforts on COPD in an attempt to gain a better understanding of how comorbid diseases, different phenotypes, and risk factor affect the outcome of COPD patients. A great numbers of articles have been published annually and have given new insights into the mechanism or treatment of COPD.<sup>4-6</sup> However, there still exists a lack of knowledge regarding the quality of scientific yield in relation to this area.

It is generally believed that publications represent the central part of a research process. In medicine, the number of times a paper is cited by other authors has been established as a widely used and logical measure of how much academic influence it has had in its subject area. The reporting of this type of citation analysis is widespread

Correspondence: Xiaoyan Jin  
Department of Respiratory Medicine,  
Tongren Hospital, No 738, Yuyuan Road,  
Shanghai, 200050, People's Republic of  
China  
Email dotjin@126.com

in the medical literature.<sup>7–16</sup> One way to measure the academic importance of an article is the rate at which the work is quoted or referenced by other authors.<sup>7,11,16</sup> The article referenced by another peer-reviewed article receives a “citation.” The total number of citations that an article receives is not necessarily a measure of its academic quality or even its influence upon the practice of the author’s or authors’ peers.<sup>17</sup> Nevertheless, it does testify to the readership of the particular article and the influence of the article in generating changes in practice, controversy, discussion, or further research. Citation is viewed as a direct measure of the recognition an article has received in its field. Citation analysis in specific journals and specific subject areas has become a popular method to assess the citation impact of a journal, article, or author.<sup>8,10–13,18–23</sup>

The Institute for Scientific Information (ISI) has been collecting citation and other academic impact information since 1945 and has been available electronically since 1979. ISI (now a subsidiary of Thomson Corp) calls their newest journal citation system “Science Citation Index® (SCI) Expanded,” and it is one of the databases available under the banner of Web of Science. Citation data from peer-reviewed articles are indexed from more than 10,000 high-impact journals, not only from the sciences and social sciences but also, from the arts and humanities.

This search used the electronic version of this database to determine which published articles in medical journals have been cited most often by other authors, by ranking the 100 top-cited works. By analyzing characteristics of these articles, we intended to determine what qualities make a COPD article important to the specialty.

## Materials and methods

On June 30, 2014, authors searched Web of Science and identified the 100 top-cited articles relating to COPD (Table 1) published in professional journals from 1945 to date. The articles entitled using the terms “COPD” or “chronic obstructive pulmonary disease” or “chronic obstructive pulmonary diseases” were included in the research.

Each article in the most cited 100 was reviewed, and the basic information collected included authors, year of publications, source journal of the article, geographic origin of the authors, and study field (general internal medicine, respiratory system, cardiovascular system cardiology, immunology, microbiology, physiology, research experimental medicine, sports science, or surgery). The full texts were mainly selected by PubMed or ScienceDirect. In addition, other methods were also used to search for articles that were not found in the aforementioned database, for example,

interlibrary lending and requests for help on the PubMed.cn website (<http://paper.pubmed.cn/>). This website is a Chinese language-based platform used by scholars to request and share literatures. Several articles were cited more often than others because of the difference in time since publication. Thus, a citation index was also determined for each article to control this error. The citation index was defined as the mean number of citation times per year.

Statistical analysis was performed using SPSS 17 (SPSS Inc., Chicago, IL, USA). Spearman correlation analysis was used to test the total citation times and number of citation times per year, with an alpha level of 0.05. Descriptive statistics were quantified as counts or percentages of parameters.

As this was a bibliometric analysis, it was not necessary to obtain Internal Review Board approval.

## Results

A total of 22,210 papers were identified in the initial search for the period from 1960 to present, with 12,098 published as “article” and 1,436 classified as “review”. Among them, 623 articles were cited more than 100 times. One hundred selected articles were published from 1966 to 2010, of which about 55% were published after 2000. The mean number of citations was 450 (range 254 to 2,164), and seven papers were cited more than 1,000 times (Table 1). Annual average number of citations were correlated by total number of citations ( $r_s=0.659$ ,  $P<0.0001$ ).

The most cited paper, published by Rabe et al<sup>24</sup> in 2007, was an executive summary describing the global strategy for the diagnosis, management, and prevention of COPD. Interestingly, the second most cited paper, by Celli et al<sup>25</sup> received 1,659 citations and was also a summary of standards for the diagnosis and treatment of patients with COPD, published in 2004. The third article, by Hogg et al<sup>26</sup> was a randomized controlled trial (RCT) – the paper proved that 1) progression of COPD is associated with the accumulation of inflammatory mucous exudates in the lumen and infiltration of the wall by innate and adaptive inflammatory immune cells that form lymphoid follicles, and 2) these changes are coupled to a repair or remodeling process that thickens the walls of these airways. The most recent paper came from 2010 and was cited 367 times. This paper<sup>27</sup> proposed use of the “frequent exacerbation phenotype” to predict COPD exacerbations, implicating an important target of exacerbation-prevention strategies across the spectrum of disease severity. The last paper on the most cited list was a cohort study, authored by Marquis et al from 2002 and cited 254 times to date, which

Table 1 The 100 most cited papers in COPD

Rank	First author	No of citations	Publication year	Citations/ year	New rank*	Rank	First author	No of citations	Publication year	Citations/ year	New rank*	Rank	First author	No of citations	Publication year	Citations/ year	New rank*
1	Rabe KF <sup>24</sup>	2,164	2007	270.50	1	35	Gosselink R <sup>66</sup>	407	1996	21.42	62	69	Barnes PJ <sup>99</sup>	303	2009	50.50	14
2	Celli BR <sup>25</sup>	1,659	2004	150.82	2	36	Seemungal T <sup>67</sup>	400	2001	28.57	46	70	Jones PW <sup>100</sup>	303	1997	16.83	80
3	Hogg JC <sup>26</sup>	1,246	2004	113.27	4	37	Ito K <sup>68</sup>	394	2005	39.40	25	71	Montuschi P <sup>101</sup>	301	2000	20.07	67
4	Celli BR <sup>25</sup>	1,177	2004	107.00	5	38	Szafranski W <sup>69</sup>	394	2003	32.83	35	72	Mahler DA <sup>102</sup>	297	1999	18.56	75
5	Calverley PMA <sup>36</sup>	1,146	2007	143.25	3	39	Saetta M <sup>70</sup>	383	1998	22.53	60	73	Nava S <sup>103</sup>	297	1998	17.47	78
6	Anthonisen NR <sup>37</sup>	1,129	1987	40.32	23	40	Anthonisen NR <sup>71</sup>	383	1986	13.21	93	74	Cazzola M <sup>104</sup>	296	2008	42.29	20
7	Siafakas NM <sup>38</sup>	1,006	1995	50.30	15	41	Hogg JC <sup>72</sup>	379	2004	34.45	33	75	Monso E <sup>105</sup>	293	1995	14.65	87
8	Brochard L <sup>39</sup>	834	1995	41.70	21	42	Landbo C <sup>73</sup>	379	1999	23.69	58	76	Renzetti AD <sup>106</sup>	292	1966	5.96	100
9	Keatings VM <sup>40</sup>	791	1996	41.63	22	43	Soler-Cataluna JJ <sup>74</sup>	373	2005	37.30	28	77	Maltais F <sup>107</sup>	289	1996	15.21	83
10	Seemungal TAR <sup>41</sup>	768	1998	45.18	17	44	Kuwano K <sup>75</sup>	372	1993	16.91	79	78	Wilson DO <sup>108</sup>	289	1989	11.12	95
11	Burge PS <sup>42</sup>	765	2000	51.00	12	45	Hurst JR <sup>76</sup>	367	2010	73.40	7	79	Seneff MG <sup>109</sup>	285	1995	14.25	90
12	Tashkin DP <sup>43</sup>	669	2008	95.57	6	46	Lacasse Y <sup>76</sup>	366	1996	19.26	72	80	Scanlon PD <sup>110</sup>	284	2000	18.93	74
13	Donaldson GC <sup>44</sup>	663	2002	51.00	13	47	Saint S <sup>77</sup>	366	1995	18.30	77	81	Paggiaro PL <sup>111</sup>	283	1998	16.65	81
14	Barnes PJ <sup>45</sup>	654	2000	43.60	19	48	Barnes PJ <sup>78</sup>	359	2008	51.29	11	82	Celli BR <sup>112</sup>	282	2008	40.29	24
15	Gan WQ <sup>46</sup>	597	2004	54.27	10	49	Niewoehner DE <sup>79</sup>	358	1999	22.38	61	83	Vestbo J <sup>113</sup>	279	1996	14.68	86
16	Barnes PJ <sup>47</sup>	556	2003	46.33	16	50	Bernard S <sup>80</sup>	358	1998	21.06	64	84	Papi A <sup>114</sup>	277	2006	30.78	42
17	Cooper JD <sup>48</sup>	555	1995	27.75	50	51	Bourbeau J <sup>81</sup>	357	2003	29.75	44	85	Saetta M <sup>115</sup>	277	2001	19.79	69
18	Calverley P <sup>49</sup>	540	2003	45.00	18	52	O'Donnell DE <sup>82</sup>	354	2004	32.18	38	86	Diffrancia M <sup>116</sup>	277	1994	13.19	94
19	Bestall JC <sup>50</sup>	518	1999	32.38	36	53	Pitta F <sup>83</sup>	347	2005	34.70	32	87	Schols A <sup>117</sup>	275	1996	14.47	88
20	Buist AS <sup>51</sup>	510	2007	63.75	8	54	Keatings VM <sup>84</sup>	346	1997	19.22	73	88	Rahman I <sup>118</sup>	274	2006	30.44	43
21	Pauwels RA <sup>52</sup>	501	1999	31.31	39	55	O'Donnell DE <sup>85</sup>	344	2001	24.57	56	89	Sethi S <sup>119</sup>	272	2001	19.43	71
22	Schols A <sup>53</sup>	484	1998	28.47	48	56	Wiggs BR <sup>86</sup>	343	1992	14.91	84	90	Wedzicha JA <sup>120</sup>	268	2008	38.29	26
23	Ries AL <sup>54</sup>	482	1995	24.10	57	57	Pauwels RA <sup>87</sup>	342	2004	31.09	41	91	Dekhuijzen PNR <sup>121</sup>	267	1996	14.05	91
24	Repine JE <sup>55</sup>	457	1997	25.39	55	58	Halbert RJ <sup>88</sup>	337	2006	37.44	27	92	Donohue JF <sup>122</sup>	266	2002	20.46	65
25	Casaburi R <sup>56</sup>	456	2002	35.08	30	59	Murphy TF <sup>89</sup>	331	1992	14.39	89	93	Nishimura K <sup>123</sup>	263	2002	20.23	66
26	Mannino DM <sup>57</sup>	440	2007	55.00	9	60	McSweeney AJ <sup>90</sup>	329	1982	9.97	96	94	Menezes AMB <sup>124</sup>	262	2005	26.20	52
27	Rahman J <sup>58</sup>	432	1996	22.74	59	61	Schols A <sup>91</sup>	327	1993	14.86	85	95	Patel IS <sup>125</sup>	259	2002	19.92	68
28	Sethi S <sup>59</sup>	431	2002	33.15	34	62	Calverley PM <sup>92</sup>	326	2003	27.17	51	96	O'Donnell DE <sup>126</sup>	259	1998	15.24	82
29	Plant PK <sup>60</sup>	430	2000	28.67	45	63	Bhowmik A <sup>93</sup>	321	2000	21.40	63	97	Aaron SD <sup>127</sup>	258	2007	32.25	37
30	Sin DD <sup>61</sup>	428	2003	35.67	29	64	Lopez AD <sup>94</sup>	314	2006	34.89	31	98	Weitzenblum E <sup>128</sup>	258	1981	7.59	99
31	Seemungal T <sup>62</sup>	428	2000	28.53	47	65	Agusti AGN <sup>95</sup>	309	2003	25.75	54	99	Kanner RE <sup>129</sup>	257	2001	18.36	76
32	Altose MD <sup>63</sup>	422	2000	28.13	49	66	Traver GA <sup>96</sup>	308	1979	8.56	97	100	Marquis K <sup>130</sup>	254	2002	19.54	70
33	Vestbo J <sup>64</sup>	414	1999	25.88	53	67	Lambert RK <sup>97</sup>	304	1993	13.82	92						
34	Vincken W <sup>65</sup>	407	2002	31.31	40	68	Wagner PD <sup>98</sup>	304	1977	8.00	98						

Note: \*The "new rank" was sorted by the average annual number of citations.

Abbreviation: COPD, chronic obstructive pulmonary disease.

**Table 2** Top-ten sources that contribute most articles to the top-100 papers

Journal	Number
<i>American Journal of Respiratory and Critical Care Medicine (Am J Respir Crit Care Med)</i>	30
<i>European Respiratory Journal (Eur Respir J)</i>	14
<i>New England Journal of Medicine (N Engl J Med)</i>	12
<i>Lancet</i>	10
<i>Thorax</i>	8
<i>American Review of Respiratory Disease (Am Rev Respir Dis)</i>	7
<i>Annals of Internal Medicine (Ann Intern Med)</i>	4
<i>Chest</i>	3
<i>Archives of Internal Medicine (Arch Intern Med)</i>	2
<i>Journal of the American Medical Association (J Am Med Assoc)</i>	2

found that the mid thigh muscle cross-sectional area was a better predictor of mortality than body mass index (BMI) in COPD patients; these findings suggest that the assessment of body composition may be useful in clinical practice.<sup>28</sup>

The 100 top-cited articles were published in 18 journals, predominantly in *American Journal of Respiratory and Critical Care Medicine* (n=30), followed by *European Respiratory Journal* (n=14) and *New England Journal of Medicine* (n=12) (Table 2).

The greatest number of top-cited articles were published in 1996, 2000, and 2002 (n=8 each). The least number of articles was published in the 1960s (n=1 [decade]). Articles on the list were divided into three periods, 1960 to 1989 (n=8), 1990 to 1999 (n=37), and after 2000 (n=55) (Table 3).

The country origins of the articles included: the United States (n=38), England (n=34), Canada (n=20), Netherlands (n=12), Italy (n=10), Belgium (n=9), Spain (n=8), Denmark (n=7), Australia (n=6), and Scotland (n=5). The rest of the countries had less than five publications. Table 4 shows the distribution of top-cited articles over the countries of origin. Given some articles were authored with multiple sources of origin, especially those in the form of international research collaborations, the total number of countries of origin exceeded 100. The leading institutions are shown in Table 5. Imperial College London was found to be the most productive institution (n=16), followed by the University of London (n=10) and GlaxoSmithKline (n=9).

Among the 100 top-cited articles in COPD, the overwhelming majority (n=63 each) were studies belonging to “general internal medicine” and “respiratory system”, followed by two studies in “cardiovascular system cardiology”. Other fields, like “immunology”, “microbiology” and “physiology” only had one article each (Table 6).

The top-cited papers were written by 749 authors and ranged from 1 to 70 per article. Three articles had one author, followed by eight articles with two authors, and eight articles with three authors. Table 7 presents a list of the most productive authors, showing that Barnes and Wedzicha each authored ten articles, followed by Vestbo (n=8), Jones (n=7), Buist (n=6), Calverley (n=6), Hogg (n=6), Anthonisen (n=5), Celli (n=5), Maltais (n=5), and Seemungal (n=5) (Table 7).

## Discussion

In medical literature, the number of times other authors reference an article is one measure of the influence of the publication, and this type of citation analysis strategy is widely used as a bibliometric study. The evaluation of specialty-wide citation analyses has been reported in other areas of medicine.<sup>7–9,18–21,23</sup> However, the establishment of a citation rank list across a specialty, comprising many journals specific to an area of medicine, is a more complex process than citation analysis for one journal, although such analyses have been reported in some other areas of medicine.<sup>31–34</sup>

In this review, researchers ranked the top 100 articles by number of citations, in the specialty of COPD. The top article had 2,164 citations. Seven papers were cited more than 1,000 times, of which three were summaries of the most well-known international COPD management guidelines, by different research institutions or in different periods. However, they all represented the latest achievements of COPD development in their period and have played profound influence in COPD treatment and research development around the world. While the third-place paper was classic RCT research, the findings created a new therapy targets for COPD treatment. The fourth paper also was classic; the authors proved a multidimensional grading system (the BODE [BMI, airflow obstruction, dyspnea, and exercise] index) assessing the respiratory and systemic expressions of COPD would better categorize and predict outcome in COPD patients than the forced expiratory

**Table 3** Decades distribution of the top-100 most cited papers

Year	Number	Mean number of citations	Minimum number of citations	Maximum number of citations
–1980s	8	412	258	1,129
1990s	37	413	259	1,006
2000s	55	481	254	2,164

**Table 4** Countries that contributed more than four papers in the 100 most influential papers

Country	Number
USA	38
England	34
Canada	20
Netherlands	12
Italy	10
Belgium	9
Spain	8
Denmark	7
Australia	6
Scotland	5

volume in one second (FEV<sub>1</sub>). The fifth and sixth papers were specialized in the exploration of COPD drug therapy, and both of their groundbreaking discoveries have provided new directions for COPD treatment. In sum, the main reason for being so widely referenced is that the findings or conclusions reported in these papers have produced historical influence in COPD treatment and research history. However, every article on the list can be considered a citation “classic” by the frequently used, but somewhat arbitrary, marker of 100 pieces as the benchmark.<sup>29</sup>

This review of the most cited articles in COPD may be worthwhile for several reasons. First, the observations suggest the authors of citation classics in COPD have produced more highly cited articles than many of their colleagues in other specialties. Second, this study has successfully identified several attributes of articles in citation, indicating that journal and country of origin are very important factors. Finally, this paper might be considered as the first report on the most cited papers in COPD.

The study characteristics revealed here echo those found in similar reviews. The majority of articles originated in the United States. This result is in line with previous studies and is in accordance with the reported strong influence of

**Table 5** The top-ten institutions contributing to the most cited articles in COPD

Institute	Number
Imperial College London	16
University of London	10
GlaxoSmithKline	9
St Georges University London	8
University of British Columbia	8
University of California System	8
Oregon Health Science University	7
Oregon University System	7
Queen Mary University London	7
University of Copenhagen	7

**Abbreviation:** COPD, chronic obstructive pulmonary disease.

**Table 6** Research field of the most cited articles in COPD

Field	Number
General internal medicine	63
Respiratory system	63
Cardiovascular system cardiology	2
Immunology	1
Microbiology	1
Physiology	1
Research experimental medicine	1
Sport sciences	1
Surgery	1

**Abbreviation:** COPD, chronic obstructive pulmonary disease.

the United States in research related to health science,<sup>8,12,14</sup> indicating that American authors may be at an advantage. On the contrary, in Asian countries, although the scientific research has achieved rapid development in recent years, authors did not have a place in the COPD research field since their contribution in research productivity was rather disappointing. European countries, like England, Netherlands, Italy, etc, also showed a higher productivity. This finding seems to conform to the phenomenon “the better the economic ranking of a country, the higher the quantity and quality of its biomedical publications”.<sup>30</sup>

Financial support from public foundations or commercial companies has evolved over time in response to changes in professional codes, laws, and markets. Public funds have given a great push to the development of medical research and public health. Industry-funded science has been widely debated because of the susceptibility to various kinds of biases. Nevertheless, it has played and will continue to play a critical role in the research process. Although this research did not analyze financial support separately, our findings showed that there was a commercial company ranked among the top-ten prolific institutions, which contributed a total of nine articles.

Although researchers were expecting a higher number, only 18% of the papers were review articles, whereas the majority were original research articles, which might be attributable to a preference for referencing experimental evidence rather than review articles or expert opinion.

It has been reported that scientific articles begin to be cited 1 or 2 years after publication and reach a maximum citation rate 7 to 10 years later after publication.<sup>26–28</sup> It has also been reported that the “older” articles are, the greater the likelihood that they have attained more citations, purely because their citable period was longer. However, in our study, the citation rate gradually rose over the last decade and is indicative of an increasing consideration for the field of COPD.

Authors have to acknowledge that our study has several possible methodological limitations. First and foremost, this

**Table 7** The authors who contribute more than four articles to the top-100 papers

Author	Number of citation classics	Position on author list
Barnes PJ <sup>24,40,45,47,68,78,84,99,101,104</sup>	10	First author – 4, fourth – 3, sixth – 1, seventh – 1, others – 1
Wedzicha JA <sup>27,41,44,50,62,67,93,104,120,125</sup>	10	First author – 1, fourth – 2, fifth – 1, sixth – 3, others – 3
Vestbo J <sup>25,27,36,49,64,73,112,113</sup>	8	First author – 2, second – 1, third – 1, fourth – 1, sixth – 1, eighth – 1, others – 1
Jones PW <sup>36,42,49,50,56,100,104</sup>	7	First author – 1, third – 2, fifth – 1, sixth – 2, others – 1
Buist AS <sup>24,25,51,57,88,110</sup>	6	First author – 1, second – 1, fifth – 1, sixth – 2, others – 1
Calverley PMA <sup>24,36,42,49,92,120</sup>	6	First author – 1, second – 2, seventh – 1, ninth – 1, tenth – 1
Hogg JC <sup>26,68,72,75,86,97</sup>	6	First author – 2, fourth – 1, fifth – 1, sixth – 1, tenth – 1
Anthonisen NR <sup>37,63,71,108,129</sup>	5	First author – 2, second – 1, fourth – 1, others – 1
Celli BR <sup>25,35,36,99,112</sup>	5	First author – 3, second – 1, tenth – 1
Maltais F <sup>28,80,81,107,127</sup>	5	First author – 1, third – 1, fourth – 1, seventh – 2
Seemungal TAR <sup>41,44,93,120,125</sup>	5	First author – 2, second – 3

survey was restricted with the word “COPD” or “chronic obstructive pulmonary disease” or “chronic obstructive pulmonary diseases” in their titles. In other words, some significant COPD articles published under other titles might not have been included, and it is possible that these were good-quality articles with a high number of citations. 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. Also, there are some intrinsic problems in using this method alone to evaluate the academic importance of one article, an author’s or authors’ publications, or the performance of a journal overall. First, this type of citation analysis does not account for self-citation, citations in textbooks and lectures, and an author’s or authors’ potential preference to cite articles in the journal in which they seek to publish their work.<sup>29</sup> Second, language of publication plays a major role, with an obvious bias for articles published in English language journals. Third, there are biases inherent in the age of the database as any articles published in the 19th or early 20th century would be excluded, which likely causes some true “classic” articles to be excluded. Finally, previous study<sup>16</sup> would tell us that in a scientific community, there is a tendency for adherence to a paradigm. In this context, this would mean that there is “snowball effect” to citations and that other authors are more likely to cite it because of previous citations, rather than for its content or quality. Despite these obvious defects, the data presented here do provide insight into the achievement and development of COPD research over the past decades.

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## Author contributions

Xiaoyan Jin and Wenchao Gu participated in the study design. Wenchao Gu, Yaping Yuan, Hua Yang, Guangsheng Qi, Xiaoyan Jin, and Jin Yan performed the data extraction and analysis. Hua Yang, Yaping Yuan, Guangsheng Qi and Jin Yan drafted the article. Xiaoyan Jin and Wenchao Gu wrote the manuscript.

## Disclosure

The authors report no conflicts of interest in this work.

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