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A SCIENTOMETRIC ANALYSIS OF HIGHLY CITED PUBLICATIONS AND A SUMMARY OF TOP 25 ARTICLES REGARDING COVID-19

Ali Kemal Erenler[1+]

Mehmet Oguzhan Ay[2]

Ahmet BAYDIN[3]

[1]*Associate Professor in Emergency Medicine Hitit University, School of Medicine, Department of Emergency Medicine, Corum, Turkey.*
Email: akerenler@hotmail.com Tel: +905324475563

[2]*Associate Professor in Emergency Medicine SBU Bursa Yuksek Ihtisas Education and Research Hospital, Department of Emergency Medicine, Bursa, Turkey.*
Email: droguzhan2006@mynet.com

[3]*Professor in Emergency Medicine Samsun Ondokuzmayis University, School of Medicine, Department of Emergency Medicine, Samsun, Turkey.*
Email: abaydin@omu.edu.tr

(+ Corresponding author)

ABSTRACT

Scientometric analyses allow to shed light to status of the current literature and provide guidance to future studies. We aimed to analyze highly cited articles in terms of study fields, authors, organizations and countries. We also summarized top 25 articles for future perspectives. The Web of Science database which allows statistical analysis of a specific subject was used for data collection. We obtained highly cited publications (cited ≥6 times) and investigated them in terms of categories, countries, authors, organizations, languages, countries and journals. We also analyzed top 25 articles from full-texts and summarized them. Majority of the highly cited articles were about General Internal Medicine. Huazhong University of Science Technology was on the top of the list followed by Harvard University. Majority of the highly cited articles were published by authors from China. Journal of Medical Virology was the leading journal followed by Science of the Total Environment. English was the most common language used in articles. Clinical characteristics, diagnostic tools and treatment methods were the popular study fields when top 25 articles were considered. Scientometric analysis of the highly cited publications revealed that China, as the origin of the pandemic, was the leading country in terms of citations. Publishers and authors should be aware of inconveniences caused by rapid publication.

Contribution/Originality: This is also the unique study to summarize the top 25 articles on COVID-19 to guide future studies in this field.

1. INTRODUCTION

In December 2019, a series of pneumonia cases of unknown origin were identified in Wuhan region of China. Lately, the etiological agent was defined as the 2019 novel coronavirus (2019-nCoV), and the disease was recently declared by the World Health Organization (WHO) as coronavirus disease 2019 (COVID-19) [1]. Coronaviruses belong to Coronaviridae family and are the agents of a disease in a clinical spectrum ranging from common cold to severe acute respiratory syndrome (SARS) and the Middle East respiratory syndrome (MERS) [2]. Coronaviruses are distributed widely in humans and other mammals as enveloped non-segmented positive-sense RNA viruses [3]. The signs and symptoms of the disease such as fever, cough and shortness of breath are well-described in the literature and appear 2–14 days after an exposure to virus. While Real time Polymerase chain reaction (Rt-PCR) is

24

a practical test in detecting both symptomatic and asymptomatic patients, computed tomography is often required in many patients in order to determine the progression of the disease towards pneumonia [4]. Until now, this pandemic has reached every corner of the planet, and similar to previous pandemics, as well as causing substantial medical, economic, and social disruption, it caused loss of many people's lives [5]. According to WHO COVID-19 dashboard, there have been 65,257,767 confirmed cases of COVID-19, including 1,513,179 deaths globally, as of 5 December 2020 [6].

Speaking of such a pandemic, it is not surprising that more and more COVID-19-related articles are being published. Researchers all around the World are racing to find solutions to stop rapid transmission of the disease, diagnosis, treatment, prevention and vaccination [7]. Investigation of scientific literature has numerous benefits for public health. A useful method for literature analysis is scientometrics, also known as "Science of science" [8]. It allows researchers to recognize gaps and lack of knowledge on a specific field of science. Considering the increasing number of publications on COVID-19, scientometric analysis may also help identify the different research areas and to determine the most frequently cited publication. In this article, we aimed to perform an analysis of the highly cited COVID-19 articles in order to guide researchers in this field. To our knowledge, even though there are studies on COVID-19 articles in the literature, there is a lack of information on highly cited articles.

2. MATERIALS AND METHODS

For this scientometric analysis, we entered the keyword "COVID-19" to the Web of Science® (WoS, Thomson Reuters, New York, NY) Scientific Database as of December 7th. WoS is the standard database for citation analyses, as it provides more details compared with other medical databases [9]. Then, the publications were arranged according to number of citations. When a filter was applied for highly cited (number of citations ≥6) publications, a total of 1661 publications were obtained. Then, number of citations was determined. The publications were filtered according to article type, organizational sources, funding agencies, first authors, journals, countries and language. The data was entered to Microsoft Excel® Program for analysis. The data was given as numbers and percentages.

And then, we also determined the top 25 mostly cited articles and analyzed them according to article information, category and study design, country, and number of times cited. Titles, abstracts and full-texts of the articles were investigated and analyzed.

Since this was a meta-data analysis of published work, ethics committee approval was not required.

3. RESULTS

During the study period, a total of 55,361 articles regarding COVID-19 were determined. Of these articles, 1,661 were named as "highly cited". When highly cited publications were investigated, it was determined that sum of times cited was 146,887 (141,620 without self-citations), average citations per publication was 88.43 and mean h-index was 177. All highly cited articles were published in 2020. Types of publications were original article (n=1,297), review (n=364), early access (n=76), data paper (n=1) and proceeding paper (n=1), respectively. When publications were categorized, 170 was in general internal medicine, 125 was in infectious diseases, 97 was in biochemistry and molecular biology, 89 was in pharmacology. Number of publications regarding emergency medicine was 8.

When organizational sources of the publications were investigated; 133 was from Huazhong University of Science Technology, 87 was from Harvard University, 80 was from Wuhan University and 75 was from University of California System.

Top first authors of the highly cite articles were Wang Y (n=29), Liu Y (n=27), Wang J (n=26), Liu L (n=25) and Liu J (n=24).

The highly cited articles were published in Journal of Medical Virology (n=47), Science of the Total Environment (n=41), Journal of Biomolecular Structure Dynamics (n=27), Nature (n=26) and Lancet (n=24), respectively.

Distribution of the highly cited publications according to countries were as follows: China; 598, the USA: 573, Italy: 248, England: 213, Canada: 99, France and Germany: 98, Australia: 84, Spain: 71, Netherlands: 65, India: 56, Switzerland: 53, Singapore: 47, Iran: 37 and Japan: 36 publications.

Of the highly cited publications, 1,648 was in English, 7 was in German, 4 were in Spanish and 2 were in French language. Characteristics of highly cited publications are presented in Table 1 details.

Table-1. Characteristics of the highly cited publications.

Categories	n	%	Ranking
General Internal Medicine	170	10.2	1
Infectious Diseases	125	7.5	2
Biochemistry and Molecular Biology	97	5.8	3
Pharmacology	89	5.3	4
Public Environmental and Occupational Health	89	5.3	5
Immunology	86	5.1	6
Medicine Research Experimental	85	5.1	7
Environmental Sciences	84	5	8
Surgery	84	5	9
Virology	79	4.7	10
Radiology and Nuclear Medicine Imaging	78	4.6	11
Multidisciplinary Sciences	75	4.5	12
Cardiovascular System	68	4	13
Microbiology	66	3.9	14
Clinical Neurology	63	3.7	15
Cell Biology	59	3.5	16
Psychiatry	58	3.4	17
Peripheral Vascular Disease	49	2.9	18
Oncology	47	2.8	19
Hematology	46	2.7	20
Neurosciences	42	2.5	21
Pediatrics	41	2.4	22
Obstetrics and Gynecology	36	2.1	23
Respiratory System	36	2.1	24
Gastroenterology and Hepatology	34	2	25
Type of Publications			
Original Article	1297	78	1
Review	364	21.9	2
Early Access	76	4.5	3
Data Paper	1	0.06	4
Proceedings Paper	1	0.06	5
Institution			
Huazhong University of Science Technology	133	8	1
Harvard University	87	5.2	2
Wuhan University	80	4.8	3
University of California System	75	4.5	4
University of London	75	4.5	5
Harvard Medical School	63	3.7	6
Chinese Academy of Medical Sciences Peking Union Medical College	48	2.8	7
University of Hong Kong	43	2.5	8
Institut National de la Sante et de la Recherche Medicale Inserm	40	2.4	9
Columbia University	39	2.3	10
University College London	39	2.3	11
Fundan University	38	2.2	12
University of Washington	38	2.2	13
University of Washington Seattle	38	2.2	14

Funding Agencies			
National Natural Science Foundation of China (NSFC)	182	10.9	1
United States Department of Health Human Services	138	8.3	2
National Institutes of Health (NIH) USA	133	8	3
National Key Research and Development Program of China	28	1.6	4
National Institute for Health Research (NIHR)	27	1.6	5
Bill Melinda Gates Foundation	25	1.5	6
NIH National Institute of Allergy Infectious Diseases (NIAID)	21	1.2	7
Authors			
Wang Y	29	1.7	1
Liu Y	27	1.6	2
Wang J	26	1.5	3
Liu L	25	1.5	4
Liu J	24	1.4	5
Zhang Y	22	1.3	6
Hu Y	20	1.2	7
Wang L	20	1.2	8
Zhang L	19	1.1	9
Li L	18	1	10
Journals			
Journal of Medical Virology	47	2.8	1
Science of the Total Environment	41	2.4	2
Journal of Biomolecular Structure Dynamics	27	1.6	3
Nature	26	1.5	4
Lancet	24	1.4	5
International Journal of Environmental Research and Public Health	23	1.3	6
Science	23	1.3	7
International Journal of Antimicrobial Agents	21	1.2	8
Journal of Infection	20	1.2	9
Nature Medicine	20	1.2	10
Countries			
China	598	36	1
USA	573	34.4	2
Italy	248	14.9	3
England	213	12.3	4
Canada	99	5.9	5
France	98	5.9	6
Germany	98	5.9	7
Australia	84	5	8
Spain	71	4.2	9
Netherlands	65	3.9	10
Languages			
English	1648	99.2	1
German	7	0.4	2
Spanish	4	0.2	3
French	2	0.1	4

When top 25 articles were investigated, the article entitled "Clinical Characteristics of Coronavirus Disease 2019 in China" by Guan W et al. was in the first place with 4865 citations (last accessed in December, 2nd). Top 3 articles were about clinical findings and factors regarding mortality. In the top 25 articles, majority of the authors were from China (n=16), followed by Italy (n=2) and the USA (n=2). JAMA was the most popular journal (n=8), followed by Lancet (n=6). The articles were analyzed and summarized in Table 2.

Table-2. A Brief summary of top 25 articles.

Article Information (Reference no)	Category and Study Design	Country	Times Cited	Summary
Guan, et al. [10]	Clinical findings and mortality Retrospective Multicenter Study	China	4865	Involved 1099 patients with COVID-19 from 552 hospitals. The median incubation period was 4 days the most common symptoms were fever and cough. Death rate: 1.4%.
Zhou, et al. [11]	Clinical findings and mortality Retrospective Multicenter Study	China	4108	191 patients. Death rate: 28.2%. Older age, high SOFA score, and d-dimer greater than 1 µg/ml are associated with poor prognosis. The longest observed duration of viral shedding in survivors was 37 days.
Wu and McGoogan [12]	Clinical findings and mortality Viewpoint	China	2409	A summary of 44,672 confirmed cases. Death rate: 2.3%. 14% of the cases were severe. Includes suggestions on prevention methods and next steps to be taken. Compares SARS, MERS and COVID-19. Despite much higher case fatality rates for SARS and MERS, COVID-19 has led to more total deaths due to the large number of cases. Emphasizes the rapid spread of the disease.
Mehta, et al. [13]	Pathogenesis Correspondence	England	1686	Emphasizes hyperinflammation resulting in fatal hypercytokinaemia with multiorgan failure in COVID-19. Steroids, intravenous immunoglobulin, selective cytokine blockade are suggested as therapeutic options.
Xu, et al. [14]	Pathogenesis. Case Report	China	1626	A 50-year-old man with fever, chills, cough, fatigue and shortness of breath following a travel to Wuhan. Postmortem histological examination was performed after his death and revealed acute respiratory distress syndrome. Blood analyses revealed overactivation of T cells, manifested by increase of Th17 and high cytotoxicity of CD8 T cells, as an indicator of severe immune injury.

Gautret, et al. [15]	Treatment methods Clinical Trial	France	1261	36 patients. Azithromycin added to hydroxychloroquine was found to be significantly efficient for virus elimination.
Zou, et al. [16]	Diagnosis. Correspondence	China	1124	Viral load detection in 18 patients. Higher viral loads were detected soon after symptom onset, with higher viral loads detected in the nose than in the throat. Asymptomatic patients may also transmit the virus. Viral shedding pattern of SARS-CoV-2 resembles influenza.
Cao, et al. [17]	Treatment method Randomized, controlled, Original Article	China	1098	199 patients. Lopinavir–ritonavir was administered to 99. Lopinavir–ritonavir showed no benefit when compared to standard therapy.
WuáC and CaiáY [18]	Clinical findings and mortality. Retrospective cohort study	China	1089	201 patients with confirmed pneumonia. Patients with older age, neutrophilia, and organ and coagulation dysfunction tend to develop ARDS. Methylprednisolone administration may be beneficial in patients with ARDS.
Richardson, et al. [19]	Clinical findings and outcomes. Retrospective Analysis	USA	1037	5,700 patients. On admission, 30.7% of patients were febrile, 17.3% had a respiratory rate greater than 24 breaths/min, and 27.8% received supplemental oxygen. The rate of respiratory virus co-infection was 2.1% Death rate was 21% in hospitalized patients.
Mao, et al. [20]	Clinical findings Retrospective, Observational Study.	China	919	214 patients. 36.4% of the patients presented neurologic abnormalities. Patients with more severe infection had neurologic manifestations, such as acute cerebrovascular diseases, impaired consciousness, and skeletal muscle injury.
Ai, et al. [21]	Diagnosis. Retrospective Study.	China	898	1,014 patients. The performance of CT compared to PCR test in COVID-19 patients was analyzed. Based on positive PCR test results, the sensitivity of chest CT in diagnosis was 97%. Chest CT was recommended as a primary tool for the current COVID-19 detection in epidemic areas.

Wang, et al. [22]	Diagnosis. Original Article	China	893	Besides nasopharyngeal swabs; blood, sputum, feces, urine, and nasal samples of 205 patients were collected. Bronchoalveolar lavage fluid specimens showed the highest positive rates (93%), followed by sputum (72%), nasal swabs (63%), fibrobronchoscope brush biopsy (46%), pharyngeal swabs (32%), feces (29%), and blood (1%). Urine tests showed no positivity.
Wolfel, et al. [23]	Pathogenesis. Original Article.	Germany	858	Virological analysis of 9 cases of COVID-19 proved active virus replication in tissues of the upper respiratory tract. The virus was isolated from samples derived from the throat or lung, but not from stool samples.
Chen, et al. [24]	Pathogenesis and transmission. Retrospective Analysis Case Series.	China	824	9 pregnant COVID-19 patients. Based on the clinical status of the newborns, no evidence for intrauterine infection was obtained.
Ruan, et al. [25]	Clinical findings and mortality. Retrospective multicenter analysis. Letter to the Editor.	China	824	Using the database of 2 hospital, 68 death cases and 82 discharged cases with laboratory-confirmed infection of SARS-CoV-2 were involved. Predictors of a fatal outcome in COVID-19 cases included age, the presence of underlying diseases, the presence of secondary infection and elevated inflammatory indicators in the blood. COVID-19 mortality might be due to virus-activated "cytokine storm syndrome" or fulminant myocarditis.
Bai, et al. [26]	Pathogenesis and transmission. Case Series.	China	816	A study on 5 family members. Transmission of the disease from an asymptomatic individual with normal CT findings was confirmed.
Grasselli, et al. [27]	Clinical findings and mortality. Retrospective Analysis	Italy	802	1,591 cases with confirmed COVID-19. Among 1300 patients with available respiratory support data, 1287 (99%) needed respiratory support, including 1150 (88%) who received mechanical ventilation and 137 (11%) who received noninvasive ventilation. 405 (26%) patients had died in the ICU.

Varga, et al. [28]	Pathogenesis Correspondence Case Series	Switzerland	766	Small bowel biopsies of 3 patients. Viral elements within endothelial cells and an accumulation of inflammatory cells were determined. Due to viral involvement and the host inflammatory response, endotheliitis. The induction of apoptosis and pyroptosis may have an important role in endothelial cell injury in patients with COVID-19.
Dong, et al. [29]	Patient tracking. Correspondence	USA	763	Patient tracking system in China is explained and suggestions for the future are presented.
Klok, et al. [30]	Complications. Retrospective Analysis.	Netherlands	735	184 ICU patients with proven COVID-19 pneumonia. Death rate: 13%. Incidence of thrombotic complications (VTE in 27% and arterial thrombotic events in 3.7%) in ICU patients with COVID-19 infection is 31% despite systematic thrombosis prophylaxis
Onder, et al. [31]	Clinical findings and mortality. Retrospective Analysis	Italy	734	The overall case-fatality rate in Italy is 7.2%. High number of deaths may be related to high proportion of old population. Transparency in test result reporting was suggested.
Shi, et al. [32]	Diagnosis Retrospective Analysis	China	730	81 patients. Focal unilateral to diffuse bilateral ground-glass opacities progressed to or co-existed with consolidations within 1-3 weeks was common even in asymptomatic patients.
Lai, et al. [33]	Epidemiology. Review	China	729	A review on epidemiology, clinical manifestations, imaging, potential treatment options, outcomes, prevention and future perspectives on COVID-19.
Gao, et al. [34]	Treatment method Letter to the Editor	China	727	Pharmacokinetics usefulness of chloroquine phosphate in COVID-19 is discussed. Chloroquine phosphate is recommended for treatment.

4. DISCUSSION

During the first two months of the outbreak, COVID-19 spread quickly throughout China. The first articles on COVID-19 were published at the beginning of 2020 [35]. Since then, a growing amount of articles were published from all over the World. It is important to analyze the coronavirus literature since it helps us understand the progression of the disease. For instance, before 2019, A total of 13,833 documents indexed in WoS Core Collection

were found in coronavirus literature and most of them identified the virus only as an animal disease the studies were focused on biological and genetic structure of the virus. Before pandemics the USA ranked in the first place in terms of contribution to the scientific literature [36]. In a study investigating the contributions of the countries during pandemics, the USA was the leading country to publish COVID-19 related articles with 1,806 research items followed by China (n=1,306), Italy (n=856) and the UK (n=817) [37]. Nevertheless, our results revealed that when highly cited articles are considered, China was determined to be the leading country. As mentioned above, as the source of the pandemics China published substantial amount of articles. Accordingly, Chinese authors put more articles on the highly cited list when compared to other countries.

In a previous bibliometric study, virology, clinical characteristics, and epidemiology of COVID-19 were found to be the major research foci with the highest volume of papers [38]. In our study, top WoS topics of research were found to be general internal medicine, infectious diseases and, biochemistry and molecular biology. In a systematic review, 27,370 COVID-19-related articles retrieved from PubMed database January 1 to July 1, 2020 were analyzed. It was reported that trend curves of topic popularity indicated that the most important issue was the prevention and control of COVID-19. Additionally, drug therapy was emphasized as the weak point in COVID-19 literature [7]. In a study on COVID-19 and SARS-CoV-2-related documents published until 23 April 2020, reports on the clinical and laboratory characteristics of the confirmed cases are of the most interest [39]. In a previous study, it was stated that most articles were published in the topic "General & Internal; Medicine" instead of the topic "Virology". The reason for this choice may the higher impact factors of the journals in the category of "General & Internal; Medicine" [40]. In a study covering the period until May, the categories with the most COVID-19 related articles were "Medicine, internal and general" and "Infectious diseases" Remarkably, the number of studies in "Virology" and "Microbiology" was relatively low (less than 1% and 2%) [41]. In a more detailed study, publications were classified according to keywords. According to this classification, Infectious diseases and Pharmacology was the most common field of interest [39]. Accordingly in our study, the topic "virology" ranked 10th. Publications regarding "General Internal Medicine" were on the top of the list.

When highly cited articles were investigated, we observed that Huazhong University of Science Technology was in the first place regarding productivity. Accordingly, in a study investigating the ranking of universities, it was determined that Huazhong University of Science and Technology from China was the most productive institute on the number of publications, and University of Toronto from Canada ranked as Top 1 institute for global research collaboration [7]. In the beginning of the pandemic, researchers benefited from experiences of China since it was the origin of pandemic. Hence, publications from China were cited frequently. Nevertheless, need for a rapid experience sharing may cause some problems. Acceleration of publication production process in medical journals may result in decreased peer-review times. In this period, it was reported that time Indeed, the turnover time from submission to acceptance reduced by 49% [42]. Moreover, Some manuscripts were actually accepted on the day of submission [37]. Inevitable consequence of this rush is loss of quality and mistakes.

When entire literature was investigated in a study, publications came from 94 countries worldwide [43]. Even though our study include only highly cited publications, the number of countries involved is 97 since this is the latest research in this field. It is known that leading international journals published by commercial publishers or big research communities with ample resources and staff, quickly responded to this challenge and adopted their working style accordingly [44].

The "BMJ" published the highest number of papers (n=129) and "The Lancet" had the most citations (n=1439) [43]. However, in our study, when highly cited articles are considered, Journal of Medical Virology had the largest number. The primary COVID-19 related publications contribution is made by major research centers such as the United States, China, and European countries [39]. Accordingly in our study, highly cited publications were produced by China, the USA, Italy and the UK, respectively.

5. CONCLUSION

Literature on COVID-19 is rapidly growing. Rapid publication of research data is a necessity for information and experience sharing of different facilities and organizations. Our results revealed that highly cited publications are produced by large establishments from highly capitalized organizations and countries. However, a special attention must be paid for keeping the quality of the publications high and number of retractions and errors low. Satisfactory time for peer-review processes must be maintained even in high rank journals [37]. We found that Chinese authors were mostly cited. When top cited 25 articles were analyzed, clinical characteristics, diagnostic tools and treatment methods were mostly investigated. We agree with Tran et al. that there is a lack of research on the social stigma and discrimination toward people, places caused by COVID-19 [39].

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