Analysis of top cited 100 articles about COVID-19

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120 PUBLICATIONS **922** CITATIONS

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ANALYSIS OF TOP CITED 100 ARTICLES ABOUT COVID-19

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ABSTRACT

Introduction: *Following a series of pneumonia cases of unknown origin in Wuhan, China on December, 2019, the World Health Organization (WHO) announced the disease caused by SARS-CoV-2 as "COVID-19" on 11, February. A month later, the WHO declared the pandemic status. Since then, literature on COVID-19 has grown rapidly. In this article, our aim was to provide a scientometric analysis of the most popular publications on COVID-19.*

Materials and Methods: *We analysed the top 100 most cited articles by entering the term "COVID-19" to Web of Science© database. The top 100 articles were extracted and investigated according to citation times, number of citations per publication, countries, journals and study fields. Also, top 10 articles are summarized.*

Results: *All top 100 articles were written in English and published in 2020. Majority of the articles were published in May (n=26). China was the most productive country with 51 publications and a total of 40,973 citations (61.1%). New England Journal of Medicine and the Journal of the American Medical Association (JAMA) were the most popular journals with a total of 24 articles and 20,463 citations. Lancet had the highest rate with a mean of 1276.7 citations per 7 publications. The most commonly studied field was related to the complications of the disease (n=18, a total of 8472 citations, 470.6 citations per publications). However, the most cited field was clinical findings of the disease (n=14, a total of 18255 citations). Publications regarding clinical findings of the disease also had the highest number of citations per publications (citations per publications=1303.9).*

Conclusion: *China ranked in the first place according to number of both publications and citations. New England Journal of Medicine and JAMA shared the first place in popularity. Researchers commonly focused on Complications of the disease, treatment methods and clinical findings.*

Keywords: *COVID-19, scientometrics, publications, pandemic, literature.*

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Introduction

A series of pneumonia cases of unknown origin were identified in Wuhan, China in December 2019. The disease has turned into a pandemic that challenges healthcare systems even in well-developed countries. Following the etiological agent was defined as the 2019 novel coronavirus (2019-nCoV), the World Health Organization (WHO) declared the pandemic as coronavirus disease 2019 (COVID-19) [1]. While many hospitals were re-structured as COVID-19 centers, COVID-19 related projects and articles were prioritized by funding organizations, research offices, drug agencies, ethical committees, health authorities, and editorial boards of scientific journals. So, a vast volume of scientific material was generated in a relatively short time. When all COVID-19 literature is considered, The United States (the US) produced the largest amount of the articles, and together with China and the United Kingdom accounted for 71% of total COVID-19 articles. The remaining 29% originating in 53 other countries[2].

Scientometrics also known as "Science of science," has been used as a popular statistical method for analyzing scientific literature thoroughly in a certain field[3]. It is well-known that COVID-19 articles were exponentially produced in top-ranked scientific journals, especially since the end of March[2]. As the number of publications on COVID-19 rapidly grow, we aimed in this study to determine distribution of

countries, journals and research areas of the most frequently cited top 100 articles in this field. We also aimed to summarize top 10 articles to provide a guidance to researchers in the future.

Materials and methods

We extracted top cited 100 articles from Web of Science© Database by entering the keyword "COV-ID-19" on December 2nd. This platform allows researchers to achieve scientometric and statistical information on a specific subject. From the database, we investigated the distribution of top cited 100 articles according to scientific journals. Number of articles in the list, number of citations and citations per publication for each journal were calculated. Impact factors of the journals were also obtained from official sites of the journals. We also analyzed abstracts and, in case, full-texts of the articles. The analysis was performed by the authors independently and controversies were ended after discussions. Then, we categorized top cited 100 articles into 14 categories according to fields of study as complications, clinical findings, treatment methods, diagnostic methods, pathogenesis, transmission route, epidemiology, risk factors, mortality, web-based systems, outcomes, classification, protective methods and medical resources. We extracted the data regarding number of times cited and calculated citations per publication in order to expose popularity of study fields.

Data were enetered to Microsoft© Excel Programme and results were given as numbers and percentages. Since any living subject was not involved in the study, an ethical approval was not required.

Results

A total of 100 articles according to citation times were selected. There were 4 articles reapeated in the list, so we included articles up to 104.

All top 100 articles were written in English and in 2020. Majority of the articles were published in May (n=27), followed by April (n=26) and March (n=19). China was the most productive country with 51 publications (35 articles, 7 letters, 5 editorials and 4 reviews) followed by the USA with 18 publications (12 articles, 2 reviews, 2 case reports, 1 letter, 1 editorial) and the UK with 6 publications (4 articles, 1 review, 1 editorial). China was also in the first row in terms of number of citations (40,973) and citations per publication (803.3). The article entitled "Clinical characteristics of Coronavirus disease 2019 in Chi-

na" by Guan WJ et al. supported by China Medical Treatment Expert Group for Covid-19 was on the top of the list with 4865 citations. New England Journal of Medicine was also in the first place on the list since this article was published in it. New England Journal of Medicine was also the journal with the highest impact factor (IF: 74.6) on the list.

Countries	Number (Types of Articles)	Total Citations (%)	Citations per publication	Publication Month
China	51 (35 articles, 7 letters, 5 editorials, 4 reviews)	40,973 (61.1)	803.3	2 in February 15 in March 10 in April 12 in May 4 in June 5 in July 3 in August
The USA	18 (12 articles, 2 reviews, 2 case reports, 1 letter, 1 editorial)	9,002 (13.4)	500.1	3 in April 9 in May 3 in June 2 in July 1 in August
The UK	6 (4 articles, 1 review, 1 editorial)	3,815 (5.6)	635.8	2 in March 2 in April 1 in May 1 in June
Italy	4 (2 articles, 2 editorials)	2,492 (3.7)	623	3 in March 1 in May
France	4 (4 articles)	2,366 (3.5)	584	1 in March 1 in June 1 in July 1 in August
Singapore	3 (2 articles, 1 review)	1,222 (1.8)	407.3	2 in April 1 in June
Switzerland	2 (2 letters)	1,408 (2.1)	704	1 in April 1 in May
Germany	2 (2 articles)	1,177 (1.7)	588.5	1 in April 1 in May
Netherlands	2 (2 articles)	1,433 (2.1)	716.5	1 in April 1 in July
Canada	2 (1 article, 1 review)	905 (1.3)	452.5	1 in May 1 in June
Japan	2 (1 article, 1 case report)	706 (1)	353	1 in March 1 in May
Pakistan	1 article	387 (0.5)	387	1 in April
Sweden	1 article	374 (0.5)	374	1 in June
Colombia	1 article	353 (0.5)	353	1 in April
India	1 review	334 (0.4)	334	1 in April

Table 1: Characteristics of top 100 most cited articles According to countries.

When distribution of the articles according to journals was investigated, New England Journal of Medicine and the Journal of the American Medical Association (JAMA) were the most popular journals with 12 articles for each. However, according to citations per publication, Lancet had the highest rate with a mean of 1276.7 citations per 7 publications.

Among journals with more than one citations, Journal of Medical Virology (2 articles, a total of 1066 citations and 533 citations per publications) and International Journal of Infectious Diseases (2 articles, a total of 914 citations and 457citations per publications) had a remarkable performance despite their relatively low impact factors, 2 and 4.7, respectively. However, Nature Reviews Drug Discovery with a quite high impact factor of 64.7 had only one article with 356 citations. When journals with one citation were investigated JAMA Internal Medicine

was on the top of the list with 1089 citations to the publication. The journal with the lowest impact factor on the list was Indian Journal of Pediatrics (IF: 1.5) and had 1 publication with 334 citations. The details are presented in Table 2.

Considering fields of interests, the most commonly studied field was related to the complications of the disease (n=18, a total of 8472 citations, 470.6 citations per publications).

However, the most cited field was clinical findings of the disease (n=14, a total of 18255 citations). Publications regarding clinical findings of the disease also had the highest number of citations per publications (citations per publications=1303.9).

Studies focusing on risk factors of the disease was in the second row in terms of citations per publications (n=4, a total of 3737 citations, 934.2 citations per publication). Medical Resources, Outcomes, Classification and Protective Methods were the least studied fields with one article in each field (433, 425, 421 and 412 citations, respectively). Additionally, there was not any study on vaccines among top cited 100 articles. See Table 3 for details. Also, top 10 articles are summarized in Table 4.

Journal	Number of articles	Number of citations	Citations per publication	Impact factor
New England Journal of Medicine	12	11229	935.7	74.6
JAMA	12	9234	769.5	45.5
Lancet	7	8937	1276.7	60.3
Radiology	5	2526	505.2	7.9
Lancet Infectious Diseases	4	2460	615	25.1
International Journal of Antimicrobial Agents	3	2350	783.3	4.6
Intensive Care Medicine	3	1613	537.6	8.6
Proceedings of the National Academy of Sciences of the United States of America	3	1195	398.3	9.4
Lancet Respiratory Medicine	2	2268	1134	25
Nature	2	1209	604.5	42.7
JAMA Cardiology	2	1059	529.5	12.7
Journal of Medical Virology	2	1066	533	2
Science	2	962	481	20.5
International Journal of Infectious Diseases	2	914	457	4.7
Nature Medicine	2	792	396	30.6
Journal of the American College of Cardiology	2	774	387	20.5
JAMA Internal Medicine	1	1089	1089	18.6
JAMA Neurology	1	919	919	13.6
Thrombosis Research	1	735	735	2.7
Bioscience Trends	1	727	727	1.6
International Journal of Environmental Research and Public Health	1	718	718	2.8
Nature Microbiology	1	698	698	15.5
Annals of Internal Medicine	1	696	696	21.3
Journal of Autoimmunity	1	676	676	7.6
BMJ-British Medical Journal	1	675	675	30.2
Military Medical Research	1	668	668	2.3
Pediatrics	1	666	666	5.4
Allergy	1	645	645	8.7
Clinical Infectious Diseaes	1	618	618	9.1
JAMA Network Open	1	611	611	5
Nature Reviews Cardiology	1	587	587	11.5
Journal of Clinical Investigation	1	580	580	11.8
International Journal of Surgery	1	558	558	3.3
Journal of Travel Medicine	1	500	500	7
Critical Care Medicine	1			7.4
European Archives of Oto-Rhino-Laryngology	1	438	438	1.8
ACS Chemical Neuroscience	1	387	387	4.4
Nature Reviews Immunology	1	379	379	44
Lancet Psychiatry	1	374	374	16.2
Translational Research	1	356	356	5.4
Nature Reviews Drug Discovery	1	356	356	64.7
Kidney International	1	355	355	8.3
Journal of Thrombosis and Haemostasis	1	353	353	4.6
Travel Medicine and Infectious Disease	1	353	353	4.5
Nature Communications	1	348	348	12.1
Clinical Researchin Cardiology	1	345	345	4.9
Eurosurveillance	1	341	341	6.4
General Psychiatry	1	338	338	3.2
Indian Journal of Pediatrics	1	334	334	1.5
Obesity	1	320	320	3.6
Lancet Global Health	1	319	319	21.5

Table 2: List of journals involving top 100 articles.

Category	Number of total articles	Number of total citations	Citation per publication
Complications	18	8472	470.6
Treatment methods	15	8217	547.8
Clinical findings	14	18255	1303.9
Diagnostic methods	13	9715	747.3
Pathogenesis	12	5315	442.9
Transmission route	8	4790	598.7
Epidemiology	7	3426	489.4
Risk factors	4	3737	934.2
Mortality	3	1913	637.6
Web-based systems	2	1212	606
Outcomes	1	425	425
Classification	1	421	421
Protective methods	1	412	412
Medical resources	1	433	433

Table 3: Distribution of articles according to categories.

Article Information (Reference no)	Category and Study Design	Country	Times Cited	Summary
Guan WJ et al. Clinical Characteristics of Coronavirus Disease 2019 in China New England Journal of Medicine[16]	Clinical Findings and Mortality Retrospective Multicenter Study	China	4865	1099 patients with COVID-19 from 552 hospitals. The median incubation period of the disease was found to be 4 days Patients commonly presented with fever and cough. Death rate was 1.4%.
Zhou F et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study Lancet[17]	Clinical Findings and Mortality Retrospective Multicenter Study	China	4108	191 patients were involved. Older age, high SOFA score, and d-dimer greater than 1 µg/ml were associated with poor prognosis. The longest observed duration of viral shedding in survivors was 37 days. Death rate of hospitalized patients was 28.2%.
Wu Z et al. Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72 314 Cases From the Chinese Center for Disease Control and Prevention. JAMA[18]	Clinical Findings and Mortality Viewpoint	China	2409	44,672 confirmed cases14% of the cases were severe. Includes suggestions on prevention methods and next steps to be taken. SARS and MERS were more fatal but COVID-19 has led to more total deaths due to the large number of cases. Death rate was 2.3%.
Mehta P et al. COVID-19: consider cytokine storm syndromes and immunosuppression Lancet[19]	Pathogenesis Correspondence	The UK	1686	Pathogenesis of COVID-19 may be hyperinflammation resulting in fatal hypercytokinaemia with multiorgan failure. Suggested therapeutic methods are steroids, intravenous immunoglobulin and selective cytokine blockade.
Xu Z et al. Pathological findings of COVID-19 associated with acute respiratory distress syndrome. Lancet Respiratory Medicine[20]	Pathogenesis Case Report	China	1626	Case report of a 50-year-old man presented with fever, chills, cough, fatigue and shortness of breath following a travel to Wuhan. Postmortem histological examination was performed and acute respiratory distress syndrome was diagnosed. Blood analyses revealed overactivation of T cells and high cytotoxicity of CD8 T cells, as an indicator of severe immune injury.
Gautret P et al. Hydroxychloroquine and azithromycin as a treatment of COVID-19: results of an open-label non-randomized clinical trial International Journal of Antimicrobial Agents[21]	Treatment Methods Clinical Trial	France	1261	A study on drugs with 36 patients. Azithromycin added to hydroxychloroquine was recommended
Zou L et al. SARS-CoV-2 Viral Load in Upper Respiratory Specimens of Infected Patients. New England Journal of Medicine[22]	Diagnosis. Correspondence	China	1124	Viral load was detected in 18 patients. Higher viral loads were detected soon after symptom onset. Higher viral load was detected in the nose than in the throat. It was stated that asymptomatic patients may also transmit the virus. Viral shedding pattern of SARS-CoV-2 resembles influenza.
Cao B et al. A Trial of Lopinavir-Ritonavir in Adults Hospitalized with Severe Covid-19. New England Journal of Medicine[23]	Treatment Method Randomized, controlled, Original Article	China	1098	199 patients were included. Lopinavir–ritonavir was administered to 99 patients. Lopinavir–ritonavir was not superior to standart therapy.
Wu C et al. Risk Factors Associated With Acute Respiratory Distress Syndrome and Death in Patients With Coronavirus Disease 2019 Pneumonia in Wuhan, China. JAMA Internal Medicine[28]	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 F et al. Presenting Characteristics, Comorbidities, and Outcomes Among 5700 Patients Hospitalized With COVID-19 in the New York City Area. JAMA Journal of the American Medical Association[24]	Clinical Findings and Outcomes. Retrospective Analyisis	The 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.

Table 4: Summary of top ten articles.

Discussion

To our knowledge, this is the most recent up-to-date analysis of top cited articles about COVID-19. The number of publications on COVID-19 has increased since April 2020 (January–March 2020: 2.21% of the publications; April-December 2020: 97.79% of the publications). In a study, between January and July 2020, countries with the highest publication rates were The US, China and Italy with proportions of 26.75%, 14.55% and 12.32%, respectively[4]. In another report, the top three countries involved in COVID-19 research were the US, China, and Italy by June 14th 2020[5].

By 9 April 2020, when all literature is considered, it was reported that China was the origin of nearly 30% of all published studies on COVID-19, followed by the United States accounting for nearly 14%[6]. Accordingly in our study, China was the leading country according to number of articles and

citations in top 100 articles. This finding is not surprising since the pandemic originated from China. The rest of the World obtained information from the initial experiences of Chinese scientists. A similar result was obtained from Pubmed database. China was the most productive country according to the number of COVID-19-related articles publications from January 1 to July 1, 2020[7].

In a previous study on bibliometric publications on COVID-19, it was reported that the journals with the largest number of publications were as follows: Journal of Medical Virology, which has the most publications (n=25), followed by Chinese Journal of Tuberculosis and Respiratory Diseases (n=9), Journal of Travel Medicine (n=8), Journal of Clinical Medicine (n=8), Lancet (n=7), Radiology (n=6) and JAMA (n=5) (4). Another report revealed that the "BMJ" published the highest number of papers (n=129) and "The Lancet" had the most citations (n=1439)[8]. According to our results New

England Journal of Medicine and JAMA were the leading journals when number of publications and citations are considered. Lancet was in the 3rd place but had the highest number of mean citations per publication. Our results revealed that journals with high impact factors before pandemics were preferred by authors. According to our results, the most studied fields were complications related to COVID-19, treatment methods and clinical findings of the disease. In a previous study, it was reported that the the research topic of epidemiology and public health interventions had gathered great attentions[7]. In another study, major themes on COVID-19 were promising therapies for COVID-19 prevention and treatment, and their mechanisms, hot spots of the pandemic and governments' responses and clinical patterns and complications of COVID-19[9]. In a study investigating the publications between January and July 2020, the top 20 most cited articles were in Medicine category. In this group, the viral transmission of SARS-CoV-2, the most frequent symptoms (fever, cough, diarrhea, etc.) and experimental treatment methods such as chloroquine phosphate were frequently investigated[4].

Accordingly in our study, complications related to COVID-19 was one of the most studied fields. In patients with severe COVID-19 infection, cardiovascular complications including hypercoagulability, acute myocardial injury and myocarditis, arrhythmias, and acute coronary syndromes are well-described in the literature[10]. Due to predisposition to thromboembolism in COVID-19; disseminated intravascular coagulation (DIC) leading to venous thromboembolism (VTE) along with arterial thrombosis, pulmonary embolism and cerebrovascular diseases may be observed[11]. In the first months of the disease, scientist might have tried to identify the disease through its complications.

So, studies presumably focused in this field. The second most studied field in top 100 articles was treatment methods. Significant portion of the studies have understandably focused on aspects related to the safety of medicine, treatment and vaccines as one of the most urgent matters in battling this pandemic. Many studies have synthesised the scientific evidence regarding the safety and efficacy of various treatments based on experiences obtained from previous pandemics of similar nature, such as Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome-Coronavirus (MERS-CoV)[6]. Due to theoretical antiviral and immunomodulatory effects, the antimalarial chloroquine and the analogous compound hydroxychloroquine, which have also been used in cases of autoimmune diseases, have been choices for treatment early in the pandemic[4]. Lopinavir/ritonavir, ribavirin, remdesivir, and favipiravir tocilizumab were also tried against COVID-19[12]. Chloroquine, hydroxychloroquine and azithromycin combinations, as well as lopinavir-ritonavir were widely used in the early times. However, their efficiency are quite controversial as we approach to the en of the first year with pandemic[13].

Another popular topic was clinical findings of the disease. In a study, the most ubiquitous topic was found to be clinical features of COVID-19[8]. Thus, symptoms of the disease are well-described in the literature. The most frequent symptoms are fever, dry cough, asthenia, expectoration, dyspnea, a sore throat, headache, myalgia or arthralgia, chills, nausea or vomiting, nasal congestion, diarrhea, hemoptysis and conjunctival congestion[14]. In our study, this topic took place in the third row.

Currently, real time Polymerase Chain Reaction (Rt-PCR) is accepted to be a reliable and quick test in detecting both symptomatic and asymptomatic patients. Additionally, there is almost a consensus on use of a combination of Rt-PCR and chest computed tomography[1]. Thus, studies on diagnostic methods ranked as fourth. The ranking of journals, citation times and countries are considered to change as the studies on a new field, vaccine, progress. Until today, 58 vaccines are evaluated in clinical trials, including 11 in phase III, and 3 of them reported efficacy above 90 %[15].

According to Web of Science, the USA has the leadership in top cited vaccine publication by 12 December, 2020. Even though, there are not any publications on vaccines in the current list, future studies will concentrate on efficiency and outcomes of vaccine administration.

Limitations of the study

Our study has several limitations as in other scientometric analyses. Firstly, investigation of the top cited articles do not reflect the exact situation of literature on COVID-19. When determining the categories, the authors used their own experiences and some alterations may occur according to different researchers. This may be a detrimental factor on objectivity. To maintain objectivity, abstracts and, when necessary full-texts of the articles were analysed independently by authors.

Conclusion

Our results revealed that the most productive country in terms of most cited publications is China. New England Journal of Medicine and JAMA were the most popular journals. Complications of the disease, treatment methods and clinical findings were fields that researchers commonly focused. As the vaccine studies progresses, current ranking will presumably tend to change.

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