Analysis of Articles on COVID-19: Is Scientific Productivity Parallel to Case Rates Across Countries?

COVID-19 ile İlgili Makalelerin Analizi: Bilimsel Üretkenlik Ülkelerdeki Vaka Oranlarına Paralel Mi?

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ABSTRACT

Introduction: Scientific studies related to COVID-19 are pivotal for uncovering infection characteristics and exploring therapeutic procedures. Scientific data sharing is at the center of these efforts. The aim of this study is to investigate the activity and trends concerning COVID-19 since the beginning of 2020. We also investigated if there is a relationship between the number of cases-deaths and publication productivity of the countries.

Materials and Methods: The word “COVID-19” was searched in the Claritive Analytics®, Web of Science (WOS) searching engine. All the articles indexed in Scientific Citation Index indexed journals were subjected to analysis.

Results: 16,618 articles were published in nine months. Authors from the People’s Republic of China (PRC) and institutions in the United States of America (USA) had the highest publication rates. According to WOS categories, journals about “Medicine-General-Internal” were the most preferred journal category about COVID-19. There was no statistically significant correlation between publication metrics and pandemic statistics. The USA and PRC were the most productive two countries.

Conclusion: Publication productivity on COVID-19 may be the highest for any disease faced so far. Scientific productivity is higher in developed countries with fewer cases. We think scientists who have more comfortable working conditions and governmental support are scientifically more productive.

Key Words: COVID-19; SARS-COV2; Bibliometrics; Scientific productivity
INTRODUCTION

In March 2020, the World Health Organization (WHO) announced the new COVID-19 pandemic, with the virus affecting more than 150,000 people in 154 nations as of March 15\(^1\),\(^2\). Over fifty-five million people have been infected with COVID-19, and this pandemic has consumed more than 1.3 million lives globally in about nine months\(^3\). Due to the rapidly increasing number of patients and severe clinical and public health management difficulties, national medical care systems have been oppressed. After the WHO announcement, global efforts have concentrated on resisting the rising pandemic. In order to overcome the pandemic, scientific data sharing and cooperation between nations have increased rapidly.

Data-sharing is the most critical determinant of the accelerated improvement and progress of science. Today, articles published on-line in international journals are one of the best and reliable ways of sharing information among scientists\(^4\). This data-sharing via scientific publications would ease the delineation of risk factors, clinical characteristics, and treatment strategies for COVID-19\(^5\).

Bibliometric evaluation is the analytical assessment of a scientific publication, and it is an adequate method to estimate the impact of the scientific material in the academic world\(^6\). Besides, since the beginning of the pandemic, there has been an increase in the productivity and sharing of any scientific materials focusing on COVID-19\(^7\).

The presented bibliometric study presents a panorama of scientific research that will assist in evidence-based information, comparisons, and visualizations of research produced in COVID-19. This investigation clarifies the topmost active authors, countries, journals, and institutions, and these studies become a guide for the researchers.
MATERIALS AND METHODS

Study Design

We used, for obtaining the data of the presented study, the search engine of Clarivate Analytics®, Web of Science (WOS) Web site, which is the leading database collecting citation and other academic impact information[8] (http://apps.webofknowledge.com), and PubMed® website (https://pubmed.ncbi.nlm.nih.gov/) which is an essential medical information resource for clinicians and researchers[9].

We performed a search using the keyword “COVID-19” by selecting the “Topic” section on Nov 15, 2020. We sorted the articles in order of date, which is the current WOS default. After this process, we obtained the publication dates of the articles from the PubMed® database.

Inclusion criteria: Publications on the COVID-19 topic published between Jan 1, 2020- Nov 15, 2020 were included into study protocol.

Exclusion criteria: We filtered the results as Article (document type), 2020 (year) as Science Citation Index Expanded (SCIE) (Web of Science Index). Other kind of publications were excluded.

Assessment of publication productivity among countries: As a research of the academic literature for an index, estimating the number of scientific publications and the number of cases affected by pathogen returned, there are no results. We assessed the countries’ scientific productivity by applying a modified index named Scientific Productivity Index (SPI), calculated by the equation: the number of published articles x 100/number of diagnosed cases. Thus, evaluation of the scientific productivity of COVID-19 of the countries became possible.

Evaluation of the collected data: We used the analysis function of the WOS Website for assessment. The publication rates, according to years, countries, and languages, were examined. Citation and h-index data were evaluated. The publication date of the articles was obtained from the PubMed® database. We also collected data about the COVID-19 pandemic from the website of the WHO (https://covid19.who.int/). All data were obtained and saved in Microsoft Excel® format on Nov 15, 2020.

Statistical Analysis

We applied the GNU operating system - PSPP software program for statistical estimation. We practiced descriptive statistical techniques for estimating the data. Spearman’s rank-order correlation analysis was applied to measure the strength of a monotonic relationship between paired data. The estimate of correlation was recognized as 0.26 < r < 0.49: low correlation; 0.50 < r < 0.69: moderate correlation; 0.70 < r < 0.89: high correlation; 0.90 < r < 1.00: Very high correlation[10]. Statistical significance was taken as p< 0.05.

RESULTS

From the beginning of the pandemic up to Nov 15, 2020, 38195 publications focusing on COVID-19 have been published in the sources indexed in SCIE. The distribution of the publications according to document type, Article: 16618 (43.5%), letter: 7951 (20.7%), editorial material: 7371 (19.3%), review: 4175 (10.8%), new items: 985 (2.6%), and others: 1365 (3.5%). We conducted the study with 16618 articles after applying inclusion and exclusion criteria specified in the presented study’s materials methods section.

The five most productive countries were the United States of America (USA), the Peoples’ Republic of China (PRC), Italy, England, and Germany. Publication, citation metrics, an h-index of the most productive ten countries were shown in Table 1. Although the USA is the most productive country in article number, PRC is the first country in citation number and h-index measurement.

The most active organizations/institutions producing scientific material about the COVID-19 topic are Harvard University from the USA, the Huazhong University of Science Technology from the PRC, and the University of London from England. Also, five of the ten most productive institutions were from the USA (Table 1). Unlike organizations/institutions, authors from the PRC were the most active on the COVID-19 topic. Wang J. from Tongde Hospital, PRC, has produced one hundred nineteen articles on COVID-19;
Table 1. Top ten productive countries, organizations-institutions, authors and journals and most preferred web of science category

| Country                     | Article n (%) | Citation n (%), Mean ± SD (min-max) | h-index |
|-----------------------------|---------------|-------------------------------------|---------|
| USA                         | 5004 (30.1)   | 16852 (14.6), 8.3 ± 39.7 (0-1000)   | 90      |
| PRC*                        | 3342 (20.1)   | 20486 (16.6), 19.2 ± 211.5 (0-4441) | 117     |
| Italy                       | 1919 (11.5)   | 9183 (7.4), 8.2 ± 35.7 (0-716)      | 55      |
| England                     | 1568 (9.4)    | 10156 (8.2), 9.8 ± 48.6 (0-1000)    | 56      |
| Canada                      | 757 (4.5)     | 5055 (4.1), 20.7 ± 37.6 (0-445)     | 38      |
| Germany                     | 932 (5.6)     | 7032 (5.7), 10.3 ± 49.8 (0-753)     | 43      |
| Australia                   | 702 (4.2)     | 4150 (3.4), 6.9 ± 39.9 (0-438)      | 31      |
| France                      | 810 (4.8)     | 6212 (5), 10.9 ± 54.8 (0-1162)      | 41      |
| Spain                       | 826 (4.9)     | 4979 (4), 7.6 ± 36.4 (0-632)        | 35      |
| India                       | 827 (4.9)     | 1937 (1.6), 3.5 ± 12.0 (0-194)      | 24      |
| Wos category                |               |                                     |         |
| Medicine general internal   | 1582 (9.5)    | 14265 (11.5), 17.9 ± 161.0 (0-4441) | 68      |
| Public environmental occupational health | 1489 (8.9)    | 4266 (3.5), 4.3 ± 23.4 (0-612)      | 32      |
| Infectious diseases         | 1211 (7.2)    | 8716 (7.1), 12.2 ± 54.5 (0-1162)    | 57      |
| Environmental sciences      | 918 (5.5)     | 1882 (5.5), 5.4 ± 23.8 (0-612)      | 32      |
| Surgery                     | 755 (4.5)     | 1964 (1.5), 5.2 ± 14.6 (0-229)      | 30      |
| Multidisciplinary sciences  | 730 (4.4)     | 5449 (4.4), 13.5 ± 55.4 (0-753)     | 53      |
| Immunology                  | 688 (4.1)     | 4197 (3.4), 9.2 ± 32.8 (0-583)      | 41      |
| Health care sciences services | 648 (3.9)    | 1152 (0.9), 2.5 ± 10.5 (0-169)      | 18      |
| Medicine research experimental | 629 (3.7)     | 4281 (3.5), 9.1 ± 43.3 (0-506)      | 37      |
| Pharmacology pharmacy       | 629 (3.7)     | 3694 (3), 9.2 ± 58.6 (0-1162)       | 32      |
| Organizations - Institutions|               |                                     |         |
| Huazhong University of Science Technology (PRC) | 554 (3.3) | 11212 (9.1), 32.8 ± 217.8 (0-4481) | 61      |
| Harvard University (USA)    | 628 (3.7)     | 5149 (4.2), 9.4 ± 41.0 (0-472)      | 40      |
| University of London (United Kingdom) | 475 (2.8)    | 5194 (4.2), 9.8 ± 46.4 (0-457)      | 35      |
| Wuhan University (PRC)      | 342 (2.0)     | 5488 (4.4), 22.2 ± 69.3 (0-592)     | 43      |
| University of California System (USA) | 455 (2.7)     | 4589 (3.7), 9.2 ± 34.8 (0-318)      | 35      |
| Inst. Nat. De La Sante Et De La Recherche Med. Inserm (France) | 286 (1.7) | 3680 (3), 14.8 ± 81.3 (0-1169) | 26      |
| Assistance Publique Hopitaux Paris APHP (France) | 264 (1.5) | 2523 (2), 10.3 ± 41.3 (0-454) | 23      |
| University of Texas System (USA) | 237 (1.4)    | 1555 (1.3), 5.6 ± 16.2 (0-102)     | 23      |
| Harvard Medical School (USA) | 393 (2.3)    | 4071 (3.3), 12.0 ± 42.8 (0-472)     | 34      |
| University of Toronto (USA) | 235 (1.4)     | 1948 (1.6), 7.4 ± 46.5 (0-444)      | 21      |
| Authors                     |               |                                     |         |
| Wang J (PRC/Tongde Hospital) | 119 (0.7)     | 3150 (2.5), 28.2 ± 109.4 (0-1010)   | 23      |
| Liu Y (England/London School of Hygiene & Tropical Medicine) | 100 (0.6) | 9220 (7.5), 108.7 ± 581.5 (0-4481) | 25      |
| Wang Y (PRC/Wuhan Univ Sci & Technol) | 114 (0.6) | 3246 (2.6), 32.7 ± 118.3 (0-1010) | 23      |
he has 3150 (2.5%) citations with an h-index of twenty-three (Table 1).

The articles have been cited a total of 115424 times (excluding self-citations). Citation numbers by country are shown in Table 1. According to WOS categories, journals about “Medicine-General-Internal” and “Public Environmental Occupational Health” are the most preferred journals about the COVID-19 (Table 1).

Statistics on COVID-19 pandemic: The USA, India, and Brazil are the three leading countries in terms of the number of cases. However, considering the number of deaths per million, Spain, Brazil and England were the first three countries (Table 2).

Correlation among publication- COVID-19 pandemic statistics: There was a positive correlation between publication numbers and citation numbers ($r = 0.98$, $p < 0.001$), but there was no statistically significant correlation between publication metrics and pandemic statistics (Figure 1) (Table 3).

Publication productivity of the countries according to the number of cases: The SPI scores of the most productive ten countries were: Taiwan: 32.9; Vietnam: 6.6; New Zealand: 4.7; PRC: 4.0; Australia: 2.6; Thailand: 2.0; Tanzania: 1.9; South Korea: 1.2; Singapore: 0.4; Cyprus: 0.4, respectively.

**DISCUSSION**

COVID-19 has indisputably become the central issue of scientific organizations worldwide from the beginning of 2020. Sixteen thousand six hundred eighteen published SCIE indexed ar-

### Table 1. Top ten productive countries, organizations-institutions, authors and journals and most preferred web of science category (continue)

| Article n (%) | Citation n (%), Mean ± SD (min-max) | h-index |
|---------------|-------------------------------------|---------|
| Liu J (PRC/Cent South Univ, Xiangya Hosp, Dept Radiol, Changsha) | 92 (0.5) | 5455 (4.4), 62.3 ± 464.7 (0-4481) | 19 |
| Li L (PRC/Fujian Prov Hospital) | 77 (0.4) | 5566 (4.5), 79.1 ± 512.8 (0-4481) | 17 |
| Li Y (PRC/Henan Univ, Key Lab) | 89 (0.5) | 11317 (0.9), 11.9 ± 37.7 (0-247) | 13 |
| Chen Y (PRC/Zhejiang Prov Ctr Dis Control & Prevent, Hangzhou) | 79 (0.4) | 1463 (1.2), 12.3 ± 44.9 (0-237) | 18 |
| Wang L (PRC/Huazhong Univ Sci & Technol) | 82 (0.5) | 1916 (1.5), 24.2 ± 59.7 (0-271) | 20 |
| Zhang Y (PRC/Chinese Acad Med Sci, Peking Union Med Coll) | 104 (0.6) | 3067 (2.5), 41.4 ± 381.8 (0-1010) | 18 |
| Chen J (PRC/Huazhong Univ Sci & Technol) | 78 (0.4) | 1935 (1.6), 27.2 ± 87.0 (0-621) | 20 |

Journals

| Journal | Article n (%) | Citation n (%), Mean ± SD (min-max) | h-index |
|---------|---------------|-------------------------------------|---------|
| Int. J. of Environmental Research and Public Health** | 362 (2.1) | 1078 (0.9), 4.5 ± 33.6 (0-624) | 14 |
| Journal of Medical Virology | 265 (1.6) | 2465 (1.8), 12.0 ± 34.0 (0-293) | 28 |
| Plos one | 260 (1.5) | 402 (0.3), 1.8 ± 8.3 (0-108) | 10 |
| International Journal of Infectious Diseases | 198 (1.2) | 1702 (1.4), 10.0 ± 29.6 (0-342) | 22 |
| Science of the Total Environment | 158 (0.9) | 757 (0.6), 13.9 ± 21.2 (0-99) | 26 |
| Journal of Biomolecular Structure Dynamics | 157 (0.9) | 231 (0.2), 5.5 ± 14.3 (0-80) | 14 |
| Journal of Chemical Education | 155 (0.9) | 6 (< 0.1), 0.1 ± 0.5 (0-5) | 2 |
| Sustainability | 126 (0.7) | 97 (< 0.1), 0.9 ± 2.9 (0-20) | 6 |
| Frontiers in Public Health | 121 (0.7) | 230 (0.2), 1.9 ± 11.6 (0-130) | 6 |
| Journal of Medical Internet Research | 121 (0.7) | 194 (0.1), 2.3 ± 4.8 (0-36) | 10 |

*PRC: People’s Republic of China.  
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Articles, just in nine months, are the most significant proof of this focus. The scientific literature has reacted as promptly as the development of the pandemic. It has exponentially increased the alertness of the scientist and the public on the 92nd day of the pandemic announcement by WHO, three thousand two hundred publications. On the 113th day, 6831 articles declared about COVID-19 (including all index) [11]. These publication productivities mean an extraordinary daily publication number of 34.8 (on 92nd day) and 58.9 (on 113th day) articles. Although we only considered the SCIE indexed articles in the presented study, we see this extraordinary scientific productivity is still increasing with 63.9 articles per day. Although these publication rates are considerably high-rise in such a limited-time for any condition, we consider that there are several unindexed publications on the WOS due to various causes (published as ahead of print or preprint and waiting to be printed in a regular issue of the journal, some scientific journals have an embargo time, some journals are not indexed on the WOS database).

Since the PRC is the birthplace of the COVID-19 pandemic [12], Chinese authors produced most of the COVID-19-related articles as an ex-

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Table 2. Statistics on COVID-19 pandemic according to countries (Source: European Centre for Disease Prevention and Control)

| Country | Case (n) | Cases per million (n) | Total recovery (n) | Death (n) | Deaths per million (n) |
|---------|----------|-----------------------|--------------------|-----------|------------------------|
| USA*    | 10933918 | 33032                 | -                  | 244411    | 754.4                  |
| Brazil  | 5863093  | 27583                 | 5360000            | 165798    | 789.8                  |
| Russia  | 1971013  | 13506                 | 1500000            | 33931     | 232.8                  |
| England | 1390685  | 20485                 | -                  | 52147     | 857.7                  |
| Spain   | 1458591  | 31196                 | 1500000            | 40769     | 885.5                  |
| Italy   | 1205881  | 19944                 | 4580000            | 45733     | 770.5                  |
| India   | 8874290  | 6430                  | 8340000            | 130519    | 95.8                   |
| France  | 1954562  | 29944                 | 1430000            | 44719     | 681.3                  |
| Colombia| 1198746  | 23558                 | 1120000            | 34031     | 642.9                  |
| Argentina| 1310491 | 28995                 | 1150000            | 35436     | 503.4                  |
| PRC†    | 86369    | 60                    | 81411              | 4639      | 3.39                   |

*USA: United States of America, PRC: The peoples republic of China.
†PRC is 62nd according to the number of cases.

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Figure 1. Demonstration of the monthly case, death, and publication statistics.
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Although Argentina and Colombia had 4.6% of all COVID-19-diagnosed cases, they have only produced 159 (0.9%) articles. Although approximately 1% of all COVID-19-diagnosed cases are seen in Chile, Chile has had no contribution to the scientific literature. The reason for this low scientific productivity inconsistent with the high number of cases may be the political strain on the healthcare systems and medical professionals in these countries. Like Chile, Argentina, and Columbia, Russia and Brazil are two other under-productive countries. Although 3.6% of the cases worldwide are in Russia, the rate of scientific articles remained at 0.7%, and 10.0% of all COVID-19 diagnosed patients were in Brazil; Brazil was not in the top ten nations in scientific productivity. However, in 2018, Russia and Brazil ranked 14th and 20th out of 224 countries in the annual scientific study production report[13]. These findings show that the lack of scientific productivity is not due to a lack of scientific experience or qualified academic organizations but rather due to the overstrained medical institutions and medical professionals facing the rapidly spreading COVID-19 pandemic. We assume scientists consider healthcare as the main priority over producing scientific studies. Unlike other countries, we believe that one of the reasons for the high scientific productivity on COVID-19 of PRC is to have more than 3.6 million licensed medical doctors[14].

As a surprising finding of our work, we found that the most productive countries related to COVID-19 case numbers were Taiwan and Vietnam. These rankings about scientific productivity on COVID-19 create a perception that these countries are already scientifically productive. However, in 2018, Taiwan and Vietnam ranked 23rd, 59th out of 224 countries in the annual scientific study production report[13]. When considering the number of COVID-19 cases diagnosed in Taiwan, Vietnam (617 and 1304, respectively), low number of cases may be due to inability or incapacity in diagnosis. We believe defects in diagnosing COVID-19 cases or problems in reporting cases negatively affected the SPI’s reliability in the presented study.

| Table 3. Assessment of the relationship between COVID-19 and publication statistics |
|------------------------------|-----------------|-----------------|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                              | Number of Case | Number of death | Total recovery† | Case per million | Population     | Number of articles | Number of citations |
| Number of case               | r 1.000        |                 |                |                  |                |                  |                  |
|                              | p -            |                 |                |                  |                |                  |                  |
| Number of death              | r 0.8756       | 1.000           |                |                  |                |                  |                  |
|                              | p < 0.001***   |                 |                |                  |                |                  |                  |
| Total recovery               | r 0.1219       | 0.1969          | 1.000          |                  |                |                  |                  |
|                              | p < 0.001***   | 0.0173*         |                |                  |                |                  |                  |
| Case per million             | r 0.2948       | 0.4185          | 0.3312         | 1.000            |                |                  |                  |
|                              | p 0.136        | 0.06            | 0.291          |                  |                |                  |                  |
| Population                   | r -0.0785      | -0.1682         | -0.1377        | -0.4143          | 1.000          |                  |                  |
|                              | p 0.819        | 0.563           | 0.736          | 0.015*           |                |                  |                  |
| Number of articles           | r 0.5969       | 0.3585          | 0.3841         | -0.5254          | 0.5542         | 1.000           |                  |
|                              | p 0.376        | 0.214           | 0.43           | 0.74             | 0.969          |                |                  |
| Number of citations          | r 0.1917       | 0.2651          | 0.0603         | -0.5839          | 0.5392         | 0.9826          | 1.000           |
|                              | p 0.721        | 0.685           | 0.886          | 0.434            | 0.059          | p < 0.001***    | -                |

r: Spearman’s rho.
*p <0.05
**p< 0.01
***p< 0.001
†Due to the lack of data about the number of total recoveries on the data of the World Health Organization, England was excluded from the analysis of the number of patients recovering.
Various high-impact factor scientific journals have published specific issues focusing on the COVID-19 pandemic, providing top-priority and fast-tracking and free-access. Although the publication rate is high, there are only a few high-quality studies published on this topic. The majority of the presented studies are narrative opinions, guidelines, case reports, or series, rather than evidence-based publications like systematic reviews, meta-analysis, and multicenter studies on a more significant number of these cases. We assure, as the medical professionals/scientists get more information about the COVID-19, more powerful, evidence-based studies would be announced. This remarkable scientific productivity on COVID-19 in such a short period is due to numerous reasons: First, this novel pathogen has influenced and alerted humanity. Second, the social-life lockdown has provided more time for scientists to publish on COVID-19, and third, most scientific journals have become more inviting on COVID-19 studies.

**Limitations of the study:** The presented research is the first study focusing on COVID-19 related articles printed in SCIE indexed journals. The presented research’s primary weakness is the lack of investigating other well-known databases like PubMed, Scopus, or Google Scholar, apart from WOS. However, WOS is the most trustworthy information source about publications published in SCIE indexed journals. Including only articles published in SCIE indexed journals can be seen as another limitation of our study; however, to standardize the quality of scientific publications, we only studied SCIE indexed articles.

**CONCLUSION**

We recognized a notable development in the number of articles about COVID-19 since the outbreak began. This high publication speed may be the highest for any disease faced so far. As expected, the USA and PRC are the upmost countries in publication productivity. Scientists who have more comfortable working conditions are scientifically more productive. Studies focusing on therapeutic methods may assist in discovering novel treatment modalities. Raising these interests is necessary to increase the research output on this novel pathogen.

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