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Impact of COVID-19 Pandemic on Biomedical Publications and Their Citation Frequency

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ABSTRACT

Background: The coronavirus disease 2019 (COVID-19) pandemic has resulted in enormous related publications. However, the citation frequency of these documents and their influence on the journal impact factor (JIF) are not well examined. We aimed to evaluate the impact of COVID-19 on biomedical research publications and their citation frequency.
Methods: We searched publications on biomedical research in the Web of Science using the search terms "COVID-19," "SARS-Cov-2," "2019 corona*," "corona virus disease 2019," "coronavirus disease 2019," "novel coronavirus infection" and "2019-ncov." The top 200 journals were defined as those with a higher number of COVID-19 publications than other journals in 2020. The COVID-19 impact ratio was calculated as the ratio of the average number of citations per item in 2021 to the JIF for 2020.
Results: The average number of citations for the top 200 journals in 2021, per item published in 2020, was 25.7 (range, 0–270). The average COVID-19 impact ratio was 3.84 (range, 0.26–16.58) for 197 journals that recorded the JIF for 2020. The average JIF ratio for the top 197 journals including the JIFs for 2020 and 2021 was 1.77 (range, 0.68–8.89). The COVID-19 impact ratio significantly correlated with the JIF ratio (r = 0.403, P = 0.010). Twenty-five Korean journals with a COVID-19 impact ratio > 1.5 demonstrated a higher JIF ratio (1.31 ± 0.39 vs. 1.01 ± 0.18, P < 0.001) than 33 Korean journals with a lower COVID-19 impact ratio.
Conclusion: COVID-19 pandemic infection has significantly impacted the trends in biomedical research and the citation of related publications.

Keywords: COVID-19; Journal; Publication; Impact Factor; Citation; Research

INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic has evoked an unprecedented global health crisis.[1] The prevention, diagnosis, and treatment of the new viral disease have been a major concern of biomedical societies in both academia and industry.[2,3] Therefore, urgent and rapid communication of biomedical information is necessary. As a result, publications on COVID-19 contributed to a dramatic increase in the total number of biomedical publications, as well as their citation. More than 260,000 COVID-19-related articles have been published to date and listed in PubMed. We aimed to evaluate the impact of COVID-19 on biomedical research publications and their citation frequency.

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METHODS

We searched publications on biomedical research in PubMed and the Web of Science (Clarivate Analytics) with the following search terms: "COVID-19," "SARS-Cov-2," "2019 corona*," "corona virus disease 2019," "coronavirus disease 2019" "novel coronavirus infection," and "2019-ncov." The top 200 journals were defined as those with a higher number of COVID-19 publications in the Web of Science than in other journals in 2020. The COVID-19 impact ratio was calculated as the ratio of the average citations per item in 2021 to the journal impact factor (JIF) for 2020. The JIF ratio was calculated as the ratio of the JIF for 2021 to that for 2020. The correlation between the COVID-19 impact ratio and JIF ratio was evaluated using the Pearson correlation test (SPSS version 27.0; IBM SPSS Statistics, Armonk, NY, USA). In addition, the COVID-19 impact ratio and JIF ratio were evaluated for Korean journals listed in the Web of Science.

Ethics statement
Institutional Review Board approval was waived for this study, because this study was based on publication data of the PubMed and Web of Science.

RESULTS

As of June 30, 2022, 267,549 documents regarding COVID-19 have been published and listed in PubMed (National Library of Medicine) (50 in 2019, 91,548 in 2020, 136,961 in 2021, 67,372 in 2022 until June 30). Among these, 58,344 documents published in 2020 and 90,642 documents published in 2021 are listed in the Web of Science. Regarding the document types published in 2020, articles comprised 49.0% of all documents, review articles 11.3%, editorial materials 18.8%, and letters 20.9% (**Table 1**).

According to the categories of the Web of Science, 7,444 documents (12.8%) in 2020 belonged to general medicine, followed by public environmental occupational health (5,013, 8.6%), infectious diseases (3,991, 6.8%), surgery (2,877, 4.9%), and immunology (2,797, 4.7%) (**Table 2**). They received 232,696 total citations (average citation per item, 31.3; top citation, 7,016) in 2021 in general medicine; 85,602 total citations (average citation per item, 17.1; top citation, 1,570) in 2021 in public environmental occupational health; 109,518 total citations (average citation per item, 27.4; top citation, 2,821) in 2021 in infectious diseases; 24,511 total citations (average citation per item, 8.5; top citation, 1,019) in 2021 in the surgery; and 86,393 total citations (average citations per item, 30.9; top citations, 2,821) in 2021 in immunology. Documents according to the categories recorded the highest of 73.3 citations per item.

Table 1. Types of COVID-19-related documents published in the Web of Science in 2021 and 2022

Document types	COVID-19 publications	
	2020	2021
Articles	28,586 (49.0)	61,765 (68.1)
Review articles	6,609 (11.3)	10,383 (11.5)
Editorial materials	10,942 (18.8)	8,392 (9.3)
Letters	12,207 (20.9)	10,102 (11.1)
Total	58,344 (100)	90,642 (100)

Values are presented as number (%).
COVID-19 = coronavirus disease 2019.

Table 2. Top 20 categories of COVID-19-related documents published in 2020 and their citation frequency in 2021

Web of Science category	COVID-19 publications in 2020	Total citations in 2021	Average citations per item in 2021	Top citations recorded in 2021
Medicine general internal	7,444	232,696	31.3	7,016
Public environmental occupational health	5,013	85,602	17.1	1,570
Infectious diseases	3,991	109,518	27.4	2,821
Surgery	2,877	24,511	8.5	1,019
Immunology	2,797	86,393	30.9	2,821
Medicine research experimental	2,237	50,039	22.4	1,003
Pharmacology pharmacy	2,233	34,496	15.4	882
Cardiac cardiovascular systems	2,220	37,092	16.7	989
Multidisciplinary sciences	2,137	95,340	44.6	1,875
Clinical neurology	2,122	34,977	16.5	1,599
Psychiatry	2,046	55,895	27.3	1,229
Environmental sciences	1,969	49,874	25.3	1,570
Pediatrics	1,779	25,566	14.4	917
Health care sciences services	1,744	20,094	11.5	328
Oncology	1,730	18,766	10.8	808
Microbiology	1,682	59,120	35.1	2,821
Biochemistry molecular biology	1,640	63,162	38.5	4,099
Virology	1,586	38,530	24.3	603
Respiratory system	1,512	31,979	21.2	2,030
Radiology nuclear medicine medical imaging	1,372	25,170	18.3	1,251
Average	2,507	58,941	22.9	1,863

COVID-19 = coronavirus disease 2019.

The average number of publications in 2020 in the top 200 journals was 126 (range, 57–778) (**Table 3**). The average number of total citations in 2021 for publications in 2020 was 3,671 (range, 4–54,682) for the top 200 journals. The average number of citations for the top 200 journals in 2021 per item published in 2020 was 25.7 (range, 0–270.0). The average COVID-19 impact ratio was 3.84 (range, 0.26–16.58) for 197 journals that recorded JIFs for 2020. The average JIF ratio for the top 197 journals that had JIFs for 2020 and 2021 was 1.77 (range, 0.68–8.89). The COVID-19 impact ratio significantly correlated with the JIF ratio (r = 0.403, P = 0.010; **Fig. 1**). For these journals, the JIFs for 2020 and 2021 strongly correlated (r = 0.939, P = 0.010).

For the Korean journals, the average number of COVID-19 publications in 2020 in 58 Korean journals, with both JIF 2020 and JIF 2021 and listed in the Web of Science, was 5.50 (range, 0–126). They received 8.8 citations (range, 0–61.0) per item in 2021 (**Table 4**). The COVID-19 impact ratio was 2.97 on average (range, 0–24.67) for the Korean journals. The average JIF ratio for Korean journals was 1.14 (range, 0.50–2.49). Twenty-five Korean journals with a COVID-19 impact ratio > 1.5 demonstrated a higher JIF ratio (1.31 ± 0.39 vs. 1.01 ± 0.18, P < 0.001) than 33 Korean journals with a lower COVID-19 impact ratio.

Among the journals in the category of "medicine general internal" of the Web of Science, top 20 journals, that recorded JIFs for 2020, showed 199 (range, 95–597) COVID-19 publications in average, average total citations of 9,805.0 (281–54,682), 36.2 average citations per item in 2021 (range, 2.4–164.7), COVID-19 impact ratio of 2.69 (range, 0.62–6.36) and JIF ratio of 1.86 (range, 0.96–4.62) (**Supplementary Table 1**). The *Journal of Korean Medical Science* showed the highest COVID-19 impact ratio (6.36) among the 20 journals in this category.

Table 3. Top 20 journal titles with COVID-19-related documents published in 2020 and their citation frequency in 2021

Journals	COVID-19 publications in 2020	Total citations in 2021	Average citations in 2021 per item	JIF 2020	JIF 2021	JCR impact factor ratio[a]	COVID-19 impact factor ratio
Journal of Medical Virology	778	17,459	22.4	2.327	20.693	8.89	9.64
International Journal of Environmental Research and Public Health	747	16,184	21.7	3.390	4.614	1.36	6.39
PLoS One	707	12,863	18.2	3.240	3.752	1.16	5.62
BMJ British Medical Journal	597	14,746	24.7	39.890	93.333	2.34	0.62
Lancet	447	49,965	111.8	79.323	202.731	2.56	1.41
International Journal of Infectious Diseases	359	9,850	27.4	3.623	12.074	3.33	7.57
Sustainability	337	4,024	11.9	3.251	3.889	1.20	3.67
JAMA Journal of the American Medical Association	336	32,858	97.8	56.274	157.335	2.80	1.74
Medical Hypotheses	333	2,630	7.9	1.538	4.411	2.87	5.14
New England Journal of Medicine	332	54,682	164.7	91.253	176.079	1.93	1.80
Frontiers in Public Health	319	3,993	12.5	3.709	6.461	1.74	3.37
Critical Care	293	5,345	18.2	9.097	19.334	2.13	2.01
Journal of Medical Internet Research	275	4,982	18.1	5.428	7.076	1.30	3.34
Journal of Clinical Medicine	273	5,349	19.6	4.242	4.964	1.17	4.62
Dermatologic Therapy	268	1,539	5.7	2.851	3.858	1.35	2.01
Journal of Infection	265	9,096	34.3	6.072	38.637	6.36	5.65
Frontiers in Medicine	263	2,258	8.6	5.093	5.058	0.99	1.69
Scientific Reports	254	4,745	18.7	4.380	4.996	1.14	4.27
Frontiers in Immunology	233	5,882	25.2	7.561	8.786	1.16	3.34
European Review for Medical and Pharmacological Sciences	218	1,763	8.1	3.507	3.784	1.08	2.31
Average	381.7	13,010.7	33.9	16.803	39.093	2.34	3.81

Journal of Biomolecular Structure Dynamics was excluded, as the journal had no record of JIF for 2020. *Journal of Biomolecular Structure Dynamics* had 262 COVID-19 publications in 2020, 3,961 total citations in 2021, and 15.1 citations per item on average in 2021.
COVID-19 = coronavirus disease 2019, JIF = journal impact factor, JCR = Journal Citation Report.
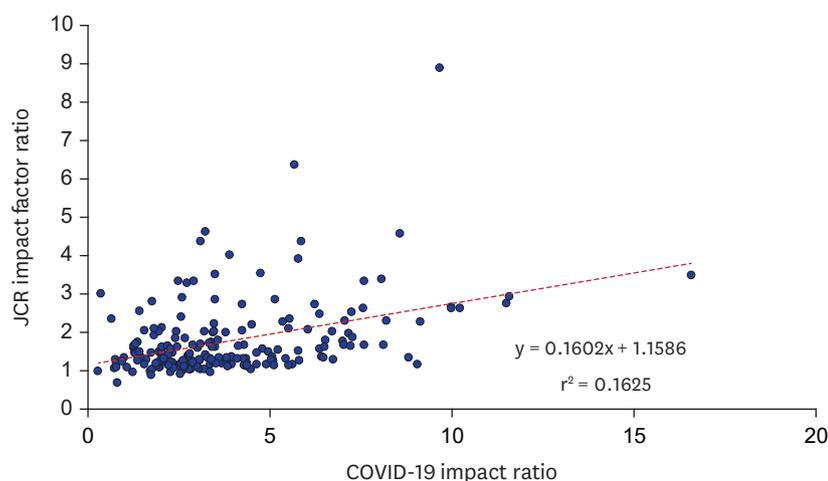[a]The JIF ratio was calculated as the ratio of the JIF for 2021 to the JIF for 2020.

Fig. 1. Correlation between journal impact ratio and COVID-19 impact ratio. The COVID-19 impact ratio significantly correlated with the JIF ratio (r = 0.403, *P* = 0.010).
COVID-19 = coronavirus disease 2019, JIF = journal impact factor, JCR = Journal Citation Report.

DISCUSSION

Our study showed that COVID-19 pandemic influenced the citation frequency of publications and that a 3.8-fold increase in citations in 2021 for the documents published in 2020 as compared with JIF 2020 was observed in the top 197 journals with a higher number of COVID-19 publications. The average JIF ratio for the top 197 journals with JIFs for 2020 and

Table 4. Fourteen Korean journal titles with COVID-19-related documents published in 2020 and their citation frequency in 2021

Journals	COVID-19 publications in 2020	Total citations in 2021	Average citations in 2021 per item	JIF 2020	JIF 2021	JCR impact factor ratio[a]	COVID-19 impact factor ratio
Journal of Korean Medical Science	126	1,724	13.7	2.153	5.354	2.49	6.36
Korean Journal of Radiology	37	581	15.7	3.500	7.109	2.03	4.49
Epidemiology and Health	25	395	15.8	3.282	5.919	1.80	4.81
Korean Journal of Internal Medicine	12	66	5.5	2.884	3.165	1.10	1.91
Diabetes & Metabolism Journal	11	92	8.4	5.376	5.893	1.10	1.56
Neurospine	9	15	1.7	3.492	3.374	0.97	0.48
Journal of Gynecologic Oncology	7	46	6.6	4.401	4.756	1.08	1.49
Psychiatry Investigation	7	215	30.7	2.505	3.202	1.28	12.26
Yonsei Medical Journal	7	120	17.1	2.759	3.052	1.11	6.21
Journal of Stroke	6	33	5.5	6.967	8.632	1.24	0.79
Korean Circulation Journal	6	6	1.0	3.243	3.101	0.96	0.31
Safety and Health at Work	6	126	21.0	2.707	4.045	1.49	7.76
Annals of Laboratory Medicine	4	105	26.3	3.464	4.941	1.43	7.58
Journal of Microbiology and Biotechnology	4	232	58.0	2.351	3.277	1.39	24.67
Average	19.1	268.3	16.2	3.506	4.701	1.39	5.76

Journals with more than five COVID-19-related publications in 2020 or more than 100 citations in 2021 for COVID-19-related publications in 2020 were included. *Korean Journal of Anesthesiology* was excluded, as the journal had no record of JIF for 2020. *Korean Journal of Anesthesiology* had seven COVID-19 publications in 2020, 46 citations in 2021, and 6.6 citations per item on average in 2021.
COVID-19 = coronavirus disease 2019, JIF = journal impact factor, JCR = Journal Citation Report.
[a]The JIF ratio was calculated as the ratio of the JIF for 2021 to the JIF for 2020.

2021 was 1.77, and the COVID-19 impact ratio significantly correlated with the JIF ratio. Korean journals with a COVID-19 impact ratio > 1.5 showed a higher JIF ratio than those with a lower COVID-19 impact ratio. General medicine in the Web of Science category, had the most documents (12.8%) published in 2020, followed by public environmental occupational health (8.6%), infectious diseases (6.8%), surgery (4.9%), and immunology (4.7%).

Gong et al.[4] found that the number of COVID-19-related publications demonstrated a high growth trend in the first 10 days of February 2020, and that China published the largest number of studies, as the country was the most affected by the pandemic in its early stages. The Scopus database search for the first year of the COVID-19 pandemic between January 1, 2020, and December 31, 2020, revealed that, among the 20 highest-ranked countries by the gross domestic product, the United States of America was the most productive country (n = 13,491) in the COVID-19 and COVID-19-related domains, with one and a half times or more publications than any other country.[5]

Another bibliometric analysis of COVID-19 during the early stages of the outbreak (December 2019 to June 19, 2020) indicated that articles (9,140 of 19,044 publications, 48.0%) were the most prevalent document type, followed by letters (4,192, 22.0%) and reviews (1,797, 9.4%).[6] According to another analysis of the early phase publications, in the 16,670 relevant articles dated between February 14, 2020, and June 1, 2020, the most common topics were health care responses (2,812, 16.9%) and clinical manifestations (1,828, 10.9%).[7] Research on clinical manifestations and protective measures has shown an increasing trend, whereas research on disease transmission, epidemiology, health care response, and radiology demonstrates a decreasing trend.[7] Artificial intelligence-based bibliometric analysis has shown the potential of exploring many academic publications during a public health crisis. The dominant topics related to the spread of COVID-19 were public health response, clinical care practices, clinical characteristics, risk factors, and epidemic models.[8]

An analysis of the recent documents published between January 1, 2019 and January 1, 2021, in 10 high-impact medical and infectious disease journals (*New England Journal of Medicine*,

Lancet, *Journal of the American Medical Association*, *Nature Medicine*, *British Medical Journal*, *Annals of Internal Medicine*, *Lancet Global Health*, *Lancet Public Health*, *Lancet Infectious Disease*, and *Clinical Infectious Disease*) showed that 1,022 (16.2%) of 6,319 studies were related to COVID-19.[9] In this meta-analysis, the authors estimated that the COVID pandemic was associated with an 18% decrease in the production of non-COVID-19 documents owing to editorial strategies using simulation models. They also found a significant decrease in the number of original articles for COVID-19 research compared with non-COVID-19 research (47.9% vs. 71.3%, $P < 0.001$). More authors were associated with COVID-19 publications, especially case reports, than with non-COVID-19 publications (median, 9.0 authors ([interquartile range {IQR}, 6.0–13.0] vs. 4.0 [IQR, 3.0–6.0], $P < 0.001$). The scientific quality of COVID-19-themed research was estimated to be below average with lower levels of evidence during the early period of the COVID-19 pandemic (from March 12 to April 12, 2020) in the three highest-ranked journals (*New England Journal of Medicine*, *Journal of the American Medical Association*, *Lancet*).[10]

A study reported an increase in the retraction rate related to an upsurge in the publication rate from January 1, 2020 to October 10, 2021.[11] The data from the Retraction Watch database (http://retractiondatabase.org/) showed a total of 157 withdrawn articles on COVID-19. "No information" was a reason for retraction in the half (50%) of the articles, while other reasons for retraction included concern/issues about data, duplication, journal error, lack of approval from a third party, plagiarism, etc. Another cross-sectional study reported that more than half (59%, 27/46) of retracted COVID-19 articles remained available as original unmarked electronic documents (33% as full text and 26% as an abstract only) and that sources of articles after retraction were preprint servers, ResearchGate and, less commonly, websites including PubMed Central and the World Health Organization.[12]

One study showed that the top 100 highly cited COVID-19 articles in 2020 had citations ranging from 1,147 to 20,440. The median number of citations was 1,970 (IQR, 1,456–2,939).[13] Most of the first authors were from China (58%), followed by the United States of America (16%), and the United Kingdom (7%). *New England Journal of Medicine*, *Journal of the American Medical Association*, and *Lancet* comprised 37% of these documents. Most of the top 100 highly cited COVID-19 documents were descriptive studies focusing on the epidemiology (48%) and clinical course (60%) of COVID-19.[13]

Brandt et al.[14] compared citation rates between COVID-19 and non-COVID-19 articles published over a period of 24 months (from January 1, 2020 to December 31, 2021) in 24 major scientific journals in eight selected fields. The results showed that a COVID-19:non-COVID-19 per-article citation ratio was 5.58. COVID-19 documents have showed more than 80% increase in citations relative to non-COVID-19 documents, when the influence of other variables were minimized with negative binomial regression.

Social media has the potential as a vehicle for disseminating scientific information during a public health crisis.[15] According to Taneja et al.,[15] during the first six months of the pandemic, from December 2019 through May 2020, strong correlations were identified between Twitter activity trends and preprint and publication activity ($P < 0.001$ for both). Sharing and spreading information on COVID-19 in a timely manner on social media was achieved at a much faster pace. According to a study involving an artificial neural network model, the Pearson correlation coefficient between the JIF of papers with COVID-19 as a topic and its Altmetric scores was 0.185 with $P < 0.01$.[16] However, Altmetric score was not precise to describe the immediacy of citations of academic publication on COVID-19 research.[16]

COVID-19 continues to disrupt scientific and clinical studies and to shift research, publishing ethics, and the dynamics of the peer reviewing process to a new normal.[17,18] However, research quality and integrity should not be compromised despite the innovations in research methodology and situations related to the current health crisis.

In conclusion, COVID-19 pandemic significantly impacted the trends in biomedical publications and their citations.

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SUPPLEMENTARY MATERIAL

Supplementary Table 1
Top 20 journal titles in the category of "medicine general internal" with COVID-19-related Documents Published in 2020 and their citation frequency in 2021

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