

# Global Research on COVID-19 Disease: A Scientific Assessment of Publications during 2020-21

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## ABSTRACT

The study aims to evaluate global research output (103054 records) on coronavirus disease (COVID-19) based on quantitative and qualitative indicators. It presents a bibliometric profile of most influential countries, organizations, authors and journals and their collaborative linkages, besides identifying broad subject areas of research, most significant keywords and highly-cited papers related to COVID-19. During 2020-21, more than 150 countries participated in COVID-19 research, of which top 10 countries accounted for a 82.93% global share. The USA, China and U.K. produced the most articles (25.86%, 10.77% and 10.7% respectively). The top three organizations, namely Harvard Medical School, USA, Huazhong University of S&T, China and Tongji Medical College, China contributed 1755, 1344 and 1267 papers, respectively. The most cited organizations in COVID-19 research are: Peking Union Medical College, China (9741 CPP), University of Hong Kong (82.17 CPP) and Renmin Hospital of Wuhan University, China (59.88 CPP). The top three most productive authors are: V. Wanitlit, E. Mahase and G. Lacobucci (with 152, 135 and 108 papers). The top three most cited authors in terms of citations per paper (CPP) are: Y. Hu (319.82), L. Liu (303.91) and J.F.W. Chan (169.55). The most productive organizations originate from most productive countries and they contribute the most collaborative papers. The top three journals, namely *International Journal of Environmental Research*, *BMJ* and *PLOS One* contributed 961, 854 and 781 papers, respectively. The top three journals in terms of citations per paper (CPP) are *New England Journal of Medicine* (122.78), *The Lancet* (106.3) and *JAMA* (75.17). The most ubiquitous topic was COVID-19 clinical studies, with maximum focus on virological aspects (9.58%), respiratory aspects (6.97%), molecular aspects (3.11%), genetic aspects (3.09%) and immunological aspects (1.3%). The results of this study should be of interest to working scientists, clinicians and policy-makers in improving their understanding of COVID-19 disease and in its management.

**Key words:** COVID-19, Coronavirus Virus Disease 2019, SARS-CoV2, Global Publications, Bibliometrics, Scientometrics.

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## INTRODUCTION

The Coronavirus Virus Disease 2019 (COVID-19) is a contagious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). WHO first learned of this new virus on 31 December 2019, following a report of a cluster of cases of 'viral pneumonia' in Wuhan, China. The disease has since spread world-wide, leading to an ongoing pandemic. The COVID-19 aggressively spread throughout China in the following several weeks and became a world-wide pandemic affecting almost every country in the world within the subsequent few months. Further, according to WHO, the dissemination of this virus has been observed with 111,102, 016 confirmed cases and 2462,911 confirmed deaths in 223 countries, areas or territories as on 22 February 2021.<sup>1</sup>

Coronaviruses (CoVs) are a large family of viruses, several of which cause respiratory diseases in humans, from the common cold to more rare and serious diseases, such as the Severe Acute Respiratory Syndrome (SARS) and the Middle East respiratory syndrome (MERS), both of which have high

mortality rates and were detected for the first time in 2003 and 2012, respectively. CoVs are divided into four genera: alpha-, beta-, gamma- and delta-CoV. All CoVs currently known cause disease in humans belonging to the alpha- or the beta-CoV.<sup>2</sup> Symptoms of COVID-19 are variable, but often include fever, cough, fatigue, breathing difficulties, and loss of smell and taste. Symptoms begin one to fourteen days after exposure to the virus. Of those people who develop noticeable symptoms, most (81%) develop mild to moderate symptoms (up to mild pneumonia), while 14% develop severe symptoms (dyspnea, hypoxia, or more than 50% lung involvement on imaging), and 5% suffer critical symptoms (respiratory failure, shock, or multi-organ dysfunction) [6]. At least a third of the people who are infected with the virus remain asymptomatic and do not develop noticeable symptoms at any point in time, but they still can spread the disease.<sup>3-5</sup>

SARS-CoV-2 is thought to have an animal (zoonotic) origin. Genetic analysis has revealed that the

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coronavirus genetically clusters with the genus Betacoronavirus, in sub-genus Sarbecovirus (lineage B) together with two bat-derived strains. The structural proteins of SARS-CoV-2 include membrane glycoprotein (M), envelope protein (E), nucleocapsid protein (N), and the spike protein (S).<sup>6</sup>

Although COVID-19 mainly affects respiratory and immune systems, other systems likely to be hit are cardiovascular, urinary, gastrointestinal tract, reproductive systems and integumentary systems (skin, hair, nails, and exocrine glands). It is believed that virus can damage almost every part of the body including kidneys, the brain, small intestine and rectum.

In respiratory system, COVID-19 can affect the upper respiratory tract (sinuses, nose, and throat) and the lower respiratory tract (windpipe and lungs). The lungs are the organs most affected by COVID-19 because the virus accesses host cells via the enzyme angiotensin-converting enzyme 2 (ACE2), which is most abundant in type II alveolar cells of the lungs.<sup>7</sup>

The effects and impact of COVID-19 has put unprecedented pressures on healthcare systems worldwide. Although the numbers of confirmed cases and deaths continue to rise, the scientific research community has promptly responded and a number of COVID-19-related clinical trials are currently underway. Research and scientific inquiries are of paramount importance in the wake of pandemics such as COVID-19. The absence of clinically proven curative treatments or vaccines (now available) coupled with paucity in our understanding of the disease and long term clinical sequelae fuels the need for further research to help us better combat the current pandemic.

As COVID-19 spreads rapidly, the research community has been active in publishing novel articles on this dreadful disease. Therefore, it is important to understand the global scientific output of COVID-19 right from the early stage of the outbreak till today. Thus, to track the current hotspots and highlight future directions, we performed a bibliometric analysis to obtain an approximate scenario of COVID-19 research to date. Such efforts will improve clinicians' understanding of the large and growing body of evidence on the topic.

Bibliometrics studies map various disciplines to identify their research trends, discover knowledge structures and monitor research performance at global, national, institutional and individual level. These studies also analyses global research on different metrics of quantity (output) and quality (performance) and by using relational indicators describe relationships between research networks, teams, institutions, and countries. In recent years, bibliometrics have been used to provide strong insights into several subject fields linked to COVID-19 research.<sup>8-17</sup> But most of these bibliometric studies on COVID-19 research are based on a limited data sets covering (2 to 6 months) publications period. Till date, not a single study has been undertaken that attempts to evaluate the status of COVID-19 research in a comprehensive way by covering publication data since the outbreak of COVID-19 disease till today. It is to fill this gap that a comprehensive study on this topic has been planned. This study will therefore attempt to examine and assess the global publications on COVID-19 research since the early stage of the COVID-19 outbreak till date (covering around 13 month publications data) using bibliometric methods. The study will attempt to identify the key countries, organizations and authors in global research, discover global collaborative trends in COVID-19 research, bring out leading source journals on this theme, identify highly cited publications and their bibliometric characteristics, and explore prominent research areas (broad and narrow subject areas) in COVID-19 research. The results from the study will provide policy-makers and scholars a valuable

resource that they could apply to identify national research priorities and draw up future plans in COVID-19 research.

## MATERIALS AND METHODS

The study sourced publications and citations data related to COVID-19 from Scopus database on 15 February 2021. The fact that the Scopus database is the largest abstract and citation database of peer-reviewed scientific literature; it was decided to use it as the bibliometric resource for sourcing data for the present study. A comprehensive search was performed using a set of keywords (shown below) tagged to "Title" or "Keyword" tags in the Scopus database, and limiting the search results to publication years 2020-2021. The search yielded a total of 1, 03, 054 hits. All the data records relevant to COVID-19 were downloaded from the Scopus database. Excel as a tool was used to statistically analyse the total publications output on a series of bibliographic variables.

TITLE ("COVID 19" OR "2019 novel coronavirus" OR "coronavirus 2019" OR "coronavirus disease 2019" OR "2019-novel CoV" OR "2019 related to COVID-19 AND SHOWN BELOWcov" OR covid 2019 OR covid19 OR "corona virus 2019" OR ncov-2019 OR ncov2019 OR "nCoV 2019" OR 2019-ncov OR covid-19 OR "Severe acute respiratory syndrome coronavirus 2" OR "SARS-CoV-2") OR KEY ("COVID 19" OR "2019 novel coronavirus" OR "coronavirus 2019" OR "coronavirus disease 2019" OR "2019-novel CoV" OR "2019 ncov" OR covid 2019 OR covid19 OR "corona virus 2019" OR ncov-2019 OR ncov2019 OR "nCoV 2019" OR 2019-ncov OR covid-19 OR "Severe acute respiratory syndrome coronavirus 2" OR "SARS-CoV-2") AND (LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020)).

## RESULTS

### Overall

As seen from Scopus database, a total of 103,054 publications (2020=87290; 2021=15764) related to COVID-19 had appeared from the early stage of the COVID-19 outbreak till 15 February 2021. Of the global (103,054) publications in the subject, a 32.11% share (33087) resulted from research projects sponsored by 1000+ national and international funding agencies. The top 20 funding agencies that supported research projects in this area are listed in Table 1.

In terms of distribution of global output by document type, it was seen that the bulk of the research output (55.18%) on COVID-19 had appeared as articles, followed by letters and reviews (15.70% and 11.31%), notes and editorials (7.63% and 6.82%), short surveys and erratum (1.51% and 1.06%) and others accounted for a less than 1% share each: book chapters and data papers (0.59% each), books (0.01%), etc. Most of the research output (a 94.13% share) appeared in English language, followed by Spanish (2.35%), Chinese, French and German (1.22%, 1.11% and 1.04%), Portuguese, Russian, Italian (0.54%, 0.43% and 0.35%), and rest in 31 other languages.

### Most Productive Countries in COVID-19 Research

The USA published the largest number of publications on COVID-19 (25.56% share), followed by China and U.K (10.77% and 10.70%). The others in the list of top 20 most productive countries are Italy (9.07%), India (6.95%), Spain, Canada, Germany, France, Australia, Brazil and Iran (from 2.46% to 4.23%), and Turkey, Switzerland, Netherlands, Japan, Saudi Arabia, Singapore, Belgium and South Korea (from 1.24% to 1.97%). The top 1-10 countries and top 11-20 countries together published 85,458 (82.93%) and 18,729 (18.17%) documents (Table 2).

In all, a total of 200 countries had participated in the COVID-19 research. But the distribution of their research output by country of publication is

**Table 1: Leading Funding Agencies Supporting Research on COVID-19.**

S.No	Funding Agencies	Pub. Count	S.No	Funding Agencies	Pub. Count
1	National Natural Science Foundation of China	2329	11	Brazilian Federal Agency for Support and Evaluation of Graduate Education	310
2	National Institutes of Health, USA	2205	12	Pfizer, USA	301
3	National Institute for Health Research, U.K.	536	13	Canadian Institutes of Health Research, Canada	292
4	National Institute of Allergy and Infectious Diseases, USA	479	14	European Regional Development Fund, Belgium	290
5	National Science Foundation, USAa	459	15	Medical Research Council, U.K.	282
6	Wellcome Trust, U.K.	423	16	National Center for Advancing Translational Sciences, USA	278
7	National Council for Scientific and Technological Development, Brazil	411	17	Novartis, Switzerland	269
8	Fundamental Research Funds for the Central Universities, China	347	18	Bill and Melinda Gates Foundation, USA	267
9	National Heart, Lung, and Blood Institute, USA	334	19	National Cancer Institute, USA	256
10	European Commission, Belgium	316	20	German Research Foundaton (DFG), Germany	252

quite skewed. For instance, 106 countries published 1-50 papers each, 20 countries 51-100 papers each, 38 countries 101-494 papers each, 21 countries 1001-4357 papers each, 2 countries 7158-9350 papers each, 2 countries 11000-11104 papers each and 1 country 26339 papers.

### Research Collaboration among top 15 countries

Figure 1 displays country collaborations among top 15 most productive countries. In the network diagram, each node represents a country. The node size and font size corresponds to publications output of the country. The Figure depicts countries in two clusters. Cluster 1 in apricot colour shows nine countries - USA, China, UK, Canada, India, Brazil, Iran, Australia, and turkey. Cluster 2 in brick colour shows six countries - Italy, Germany, France, Spain, Netherlands, and Switzerland. The thickness of the lines between countries indicates the degree of their collaboration in research. In cluster 1, the USA - U.K. lead in research collaboration with 1817 linkages, followed by USA - China (1519 links), USA - Canada (1292 links), USA - Australia (921 links), U.K.- Australia (775 links), USA - India (699 links), China - U.K (612 links), U.K.- Canada (608 links), USA - Iran (321 links), China - Canada (308 links). Inter-cluster collaboration instances include USA - Italy (1346 links), U.K. - Italy (1043 links), USA - Germany (801 links), USA - Switzerland (559 links), U.K. - Spain (550 links) U.K. - France (533 links), USA - Netherland (494 links), U.K.-Germany (682 links), USA-France (672 links), and USA-Spain (639 links). In cluster 2, Italy and Germany dominate in research collaboration with 596 links followed by Italy - France (554 links), Italy - Switzerland (413 links), and Italy - Spain (664 links).

### COVID-19 Research by Population Age Groups

On classifying COVID-19 output by age groups, it was found that the maximum impact of COVID-19 was on “Adults” (15406 papers and 14.95% share), followed by “Middle Aged” (10910 papers and 10.59%



**Figure 1:** Country Collaboration Networks Chart.

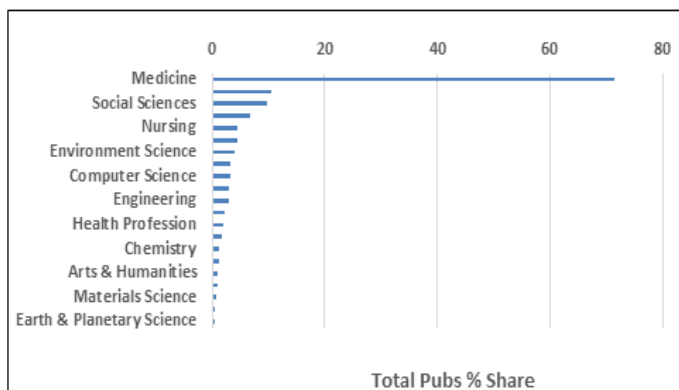
share), “Aged” (10160 papers and 9.86% share), “Adolescents” (3735 papers and 3.62% share) and “Children” (1596 papers and 1.55% share).

### Subject-Wise Distribution

As per the subject classification of Scopus database, the total COVID-19 publication output is distributed across 21 broad subjects. Of these, Medicine accounted for the largest share (71.44%), followed by Biochemistry, Genetics and Molecular Biology (10.61), Social Sciences (9.70%), Immunology and Microbiology (6.71%), Nursing (4.41%), Pharmacology, Toxicology and Pharmaceutics (4.38%), Environment Science (4.02%) and other subjects contributing from 0.56% to 3.22% in global publication share respectively. The subject-wise distribution of COVID-19 reflects the multidisciplinary nature of research as well as its impact in different subjects (Table 3, Figure 2).

**Table 2: Geographical Distribution of Global Output on COVID-19.**

S.No	Name of the Country	No. of Papers (TP)	%TP	S.No	Name of the country	No. of Papers (TP)	%TP
1	USA	26339	25.56	13	Turkey	2034	1.97
2	China	11104	10.77	14	Switzerland	1988	1.93
3	U.K.	11029	10.70	15	Netherlands	1850	1.80
4	Italy	9350	9.07	16	Japan	1660	1.61
5	India	7158	6.95	17	Saudi Arabia	1524	1.48
6	Spain	4357	4.23	18	Singapore	1381	1.34
7	Canada	4321	4.19	19	Belgium	1287	1.25
8	Germany	4041	3.92	20	South Korea	1273	1.24
9	France	3971	3.85		Total of top 10 countries	85458	82.93
10	Australia	3788	3.68		Total of top 11-20 countries	18729	18.17
11	Brazil	3201	3.11		Global total of top 20 countries	104187	100.66
12	Iran	2531	2.46		Global total	103504	



**Figure 2:** Distribution of COVID-19 Research Output by Subject Areas 2020-21.

**Distribution of COVID-19 Output by Broad Sub-fields**

Using different key-word strategies, the COVID-19 research output was studied under various sub-fields and by nature of research. Treatment methods (17.94%) account for the largest publication share (11.90%) of the COVID-19 publication output, followed by clinical studies (11.90%), complications (7.06%), epidemiological studies (3.60%) and pathophysiology (3.55%), etc.

Under clinical studies, Virological studies account for the largest publication share (9.58%), followed by respiratory studies (6.97%), molecular studies (3.11%), genetics studies (3.09%), biological studies (2.85%), immunological studies (1.30%), etc. Under treatment studies, drug therapy accounts for the largest publication share (9.90%), followed by vaccine (1.77%), oxygen therapy (1.19%), immunosuppressive therapy (0.81) and convalescent plasma (0.46%), etc. The maximum impact of COVID-19 was observed on environment studies (4.02%), followed by mental health (3.22%), neurosciences (2.99%), economy (1.76%), cardiovascular disease (1.74%) and dentistry (1.01%) (Table 4).

**COVID-19 Output by Significant Keywords**

As seen from the Scopus database, 185 significant keywords seem to identify and define global literature on COVID-19. The co-occurrence of these keywords in more than one document provide a secondary approach to identify broad research trends in the investigation and

**Table 3: Covid-19 Publications Distribution by Broad Subjects.**

S.No	Broad Subject	TP	%TP
1	Medicine	73625	71.44
2	Biochemistry, Genetics and Molecular Biology	10938	10.61
3	Social Sciences	9999	9.70
4	Immunology and Microbiology	6912	6.71
5	Nursing	4549	4.41
6	Pharmacology, Toxicology and Pharmaceutics	4512	4.38
7	Environment Science	4143	4.02
8	Psychology	3323	3.22
9	Computer Science	3262	3.17
10	Neuroscience	3084	2.99
11	Engineering	3043	2.95
12	Agricultural and Biological Sciences	2408	2.34
13	Health Profession	2091	2.03
14	Economics, Econometrics and Finance	1813	1.76
15	Chemistry	1297	1.26
16	Physics and Astronomy	1260	1.22
17	Arts and Humanities	906	0.88
18	Energy	906	0.88
19	Materials Science	827	0.80
20	Veterinary Science	605	0.59
21	Earth and Planetary Science	581	0.56
	Global Total	103054	100.00

treatment of the COVID-19, and to assess its impact on different subject fields and on various human organs. These keywords have been classified under broad subject headings along with the frequency of keyword occurrence (Table 5).

**Productivity of Most Productive Organizations**

The top 50 organizations involved in COVID-19 research together contributed 32, 653 papers (31.69% share) and 674442 citations, with



**Table 4: Sub-field Distribution of Papers on COVID-19 Research.**

S.No	Subject Areas	Pub. Count	% Share	
1	Clinical Studies	12267	11.90	
	Molecular Aspects	3202	3.11	
	Immunological Aspects	1342	1.30	
	Virological Aspects	9874	9.58	
	Biological Aspects	2940	2.85	
	Respiratory Aspects	7183	6.97	
	Diagnostic Aspects	2543	2.47	
	Genetic Aspects	3182	3.09	
2	Complication	7279	7.06	
	Epidemiology	3708	3.60	
3	Pathophysiology	3661	3.55	
	Treatment	18489	17.94	
5	Convalescent Plasma	470	0.46	
	Treatment Outcome	2732	2.65	
	Vaccine	1824	1.77	
	Drugs Therapy	10200	9.90	
	Oxygen Therapy	1231	1.19	
	Immunosupportive Therapy	839	0.81	
	Biological Therapy	1193	1.16	
	Anti-monoclonal Therapy	860		
	6	Impact of COVID-19 on		
		Diabetes	2516	2.44
		Cardiovascular Disease	1788	1.74
Mental Health		3322	3.22	
Neurosciences		3084	2.99	
Dentistry		1043	1.01	
Economy		1813	1.76	
Environment	4143	4.02		
		103054	100.00	



**Figure 3: Organization Collaboration Network Chart.**

University of S&T, China - Tongji Medical College, China registered the highest number of collaborative linkages (1222), followed Harvard Medical School, USA - Brigham and Women’s Hospital, USA (570 links), Harvard Medical School, USA - Massachusetts General Hospital, USA (557 links), INSERM, France - AP-HP Assistance Publique - Hopitaux de Paris (464 links), Massachusetts General Hospital, USA - Brigham and Women’s Hospital, USA (163 links), University of Oxford, U.K. - Imperial College, London, U.K. (100 links), Harvard Medical School, USA - Icahn School of Medicine at Mount Sinai, USA (63 links), etc.

**Productivity of Most Productive Authors**

The top 50 authors involved in research in COVID-19 together contributed 2635 papers (2.56% share) and 84889 citations, with an average of 32.22 citations per paper since their publication. Their publications productivity per author varied from 37 to 152 papers. Of the top 50 authors, 10 were from U.K., 8 from Italy, 7 from USA, 5 from India, 3 each from France and Hong Kong, 2 each from Belgium and China and 1 each from Columbia, Iran, Malaysia, Switzerland, Canada, Nepal, Saudi Arabia, Indonesia and Singapore. Thirteen of top 50 authors contributed publications above group-50 average (52.7 publications per author). Fourteen of top 50 authors registered their citation performance above the group-50 average (32.22 citations per author). The top 10 authors each in terms of publication productivity and citation impact per papers is listed in Table 7.

**Most Productive Journals**

The top 50 journals involved in research in COVID-19 together contributed 16482 papers and 321093 citations, with average citations per paper of 19.48. These 50 journals contributed 179 to 261 papers each, together they account for 16.27% share of global output. Sixteen of top 50 journals contributed papers above the group-50 average (329.64 papers per journal). Thirteen of top 50 journals registered their citation performance above the group-50 average (19.48 per journal). The top 10 journals each in terms of publication productivity and citation impact per papers are listed in Table 8.

**Highly Cited Papers**

A total of 1360 papers (1.32% share of 103054 global outputs) received 100 to 11778 citations per paper since their publication. These 1360 paper (assumed as highly-cited papers) together received 175386 citations, averaging to 128.96 citations per paper. Of the 1360 high cited papers, 758 were in citations range 100-200, 431 in citation range of 201-500, 108 in citation range 501-999, 57 in citation range of 1001-4999, 5 papers in citation range 5000-7794 and 1 paper 11778 citations. A list of top 10 high cited papers is given in Table 9.

an average of 20.65 citations per paper since their publication. Their publications productivity per organization varied from 425 to 1755 papers. Of the top 50 organizations, 18 were from USA, 7 from Australia, 6 each from China, Italy and U.K., 4 from France, 2 from Canada and 1 each from Brazil, India, Iran, Australia, Singapore, Iran and Hong Kong. Seventeen of the top 50 organizations contributed publications above the group-50 average of 653.06 papers per organization. Only nine of these 50 organizations registered their citation performance above group-50 average of 20.65 citations per organization. The top 10 organizations each are listed in terms of publications productivity and citation impact per paper in Table 6.

**Research Collaboration among top 15 organizations**

Figure 3 displays collaborations among top 15 organizations in four clusters. Cluster 1 in chocolate color shows four organizations - Harvard Medical School, USA, Brigham Women’s Hospital, USA, University of Toronto, Canada, Icahn School of Medicine at Mount Sinai, USA. Clusters 2 in light blue colour shows three organizations - Cluster 3 in lime colour shows two organizations, and cluster 4 in blue colour shows four organizations. The box size and font size of organizations in each cluster is proportional to their collaborative publications. Huazhong

**Table 5: Distribution of Significant Keywords under Broad Sub-fields Clusters.**

S.No	Subject	Keywords (along with the frequency of their occurrence)
1	COVID-19	Coronavirus Disease 2019 (38605), Coronavirus Infection (36847), Pandemic (35944), COVID-19 (34726), SARS-CoV-2(32066)
2	Epidemiology	Epidemiology (6409), Prevalence (3362), Incidence (2565)
3	Genetics	Genetics (3184), Virus Genome (949), Gene Expression (130)
4	Pathophysiology	Pathophysiology (3346), Physiology (2407)
5	Respiratory Aspects	Virus Pneumonia (368243), Adult Respiratory Distress Syndrome (3009), Dyspnea (3395S), Severe Acute Respiratory Syndrome (2293), Respiratory Failure (1722), Lung (1625), Lung Embolism (891), Chronic Obstructive Lung Disease (805), Respiratory Disease (460), Asthma (306), Lung Embolism (243) Pleura Effusion (191), Lung Fibrosis (102), Lung Parenchyma (101), Pulmonary Hypertension (90)
6	Molecular Aspects	Molecular Docking (666), Molecular Dynamics (320), Molecular Models (255), Molecular Evolution (144)
7	Biological Aspects	Biological Markers (1025), Biological Models (426), Computational Biology (205)
8	Immunological Aspects	Immunology (4312), Cytokine Storm (2732), Immune Response (1878), Immunoglobulin G (1260), Immunoglobulin (999), Immunoglobulin M (817), Immunotherapy (620), Immunomodulation (388), Immunosuppressive Treatment (141) Monoclonal Antibodies (857)
9	Virological	Virology (9824), Virus Transmission (5484)
10	Diagnostic	Diagnostic Tests (597), Laboratory Techniques (546), Diagnosing (511), Diagnostic Imaging (509), Computer Assisted Tomography (479), Throx Radiography (366), X-Ray Computerized Tomography (3566), Molecular Diagnosis (304), serology (262), covid-19 Tests (120), Differential Diagnosis (166), NMR Imaging (415), Neuroimaging (201)
11	Gastro	Gastrointestinal Symptoms (493), Gastrointestinal Disease (312), Liver Injury (339), Liver Disease (330), Liver Transplantation (230), Jaundice (40)
12	Mental Health	Psychology (4553), Mental Health (3322), Depression (2212), Anxiety (1879), Mental Stress (1174), Stress (929), Mental Disease (604), Anxiety Disorder (349) Distress Syndrome(470) Psychological Adaptation (270), Sleep Disorders (297), Sleep Wake Disorders (77), Insomnia (411)
13	Brain	Brain Hemorrhage (327), Brain Ischemia (356)
14	Heart	Cardiovascular Disease (1788), Heart Muscle Injury (378), Heart Failure (243) Myocarditis (543), Ischemic Heart Disease (268)
15	Reproductive Organs	Pregnancy (1687), Pregnancy Complications (798), Pregnancy Outcome (310), Reproductive Health (148), Prostate Cancer (216), Infertility therapy (62), Ovary Cancer (56), Infertility (46), Testis (36), obstetric Delivery (208)
16	Kidney	Acute Kidney Failure (839), Chronic Kidney Failure (675), Fertility (618), Kidney Transplantation (353), Kidney Disease (310)
17	Skin	Skin Diseases (365), Dermatology (236), Erythema (202), Skin Defects (154)
18	Neuro	Neurological Disease (654), Neurosurgery (354), Stroke (550), Brain Ischemia (356) Cerebrovascular Accident (648), Seizure (117), Parkinson's Disease (116), Guillain Barre Syndrome (109), Brain Disease (95), Neurology (95), Central Nervous System (78), Myalgia (74), Anosmia (136), Cognitive Defect (74)
19	Pancreases	Diabetes Mellitus (2516), Acute Pancreatitis (72), Pancreas Cancer (62), Pancreatitis (36), Pancreas Disease (19)
20	Drug Therapy	Drug Therapy (1070) Hydroxychloroquine (4253), Azithromycin (2086), Remdesivir (2066), Lopinavir Plus Ritonavir (1954), Tocilizumab (1864), Chloroquine (1638), Drug Repositioning (792), Anti-viral Therapy (740), Favipiravir (704)
21	Rectum	Rectum Hemorrhage (43), Retum Cancer (37)
22	Plasma Therapy	Convalescent plasma (605), Passive Immunization (389)
23	Vaccine	Vaccination (1095), Virus Vaccine (1089), COVID-19 Vaccine (10692), Vaccine (700)
24	Monoclonal Antibody Therapy	Monoclonal Antibody (860), Humanized Monoclonal Antibody (449)
25	Blood Clotting	Blood clotting Disorders (117), Venus Thromboembolism (277), Intravascular Clotting (179), Thrombosis (635)
26	Urinary	Urinary Tract Infection(165), Urology Diseases (65), Urological Surgical (41)
27	Preventive Measures	Quarantine (4668), Social Distancing (2567), Personal Protective Equipment (1947), Social Isolation (1888), Face Masks (496), Hand Wash (1512), Disinfect Surfaces
28	Environment	Air Pollution (315), Atmosphere Pollution (208), Air Pollutants (174), Sustainability (152), Environmental Monitoring (139), Environmental Impact (117), Climate Change (108)
29	Dental Science	Dentistry (123), Dental Procedure (79), Dental Care (64), Dental Practice (32) Maxillofacial Surgery(36), Saliva (34), Oral Health (32)
30	Machine Learning	Deep Learning (308), Machine Learning (210), Artificial Intelligence (185), Learning Systems (172), Convolution Neural Networks (59), Deep Neural Networks (54), Decision Trees (49), Neural Networks (47), Support Vector Machines (46), Decision Support System (36)

**Table 6: Profile of Top 10 Most Productive and 10 Most Cited Organizations.**

S.No	Name of Organization	TP	TC	CPP
Top 10 Most Productive Organizations				
1	Harvard Medical School, USA	1755	25533	14.55
2	Huazhong University of S&T, China	1344	70983	52.81
3	Tongji Medical College, China	1267	69301	54.70
4	INSERM, France	1206	19065	15.81
5	University of Toronto, Canada	1138	12206	10.73
6	University of Milan, Italy	932	14567	15.63
7	University of Oxford, U.K.	903	18884	20.91
8	University College, London, U.K.	877	17950	20.47
9	Sapienza University of Rome, Italy	877	8040	9.17
10	Massachusetts General Hospital, USA	848	10130	11.95
Top 10 Most Cited Organizations				
1	Chinese Academy of Medical Sciences and Peking Union Medical College, China	438	42666	97.41
2	University of Kong Hong	479	39359	82.17
3	Renmin Hospital of Wuhan University, China	439	26287	59.88
4	Tongji Medical College, China	1267	69301	54.70
5	Huazhong University of S&T, China	1344	70983	52.81
6	Fudan University	431	16498	38.28
7	Ministry of Education, China	460	12668	27.54
8	University of Washington, Seattle, USA	631	15593	24.71
9	University of Oxford, U.K.	903	18884	20.91
10	University of Cambridge, U.K.	439	8991	20.48

\*TP=Total publications; TC=Total citations; CPP=Citations per paper

Among the various participating countries in COVID-19 research, China contributed the largest number (535) of highly-cited papers, followed by United States (449 papers), U.K. (192 papers), Italy (162 papers), Germany (91 papers), France (83 papers), Canada (67 papers), Hong Kong (55 papers), Netherland (51 papers), Switzerland (50 papers), Singapore (49 papers), Spain and Australia (48 papers each), India (36 papers), Brazil and South Korea (29 papers each), Japan (25 papers), Sweden (22 papers), Belgium (21 papers), Iran (19 papers), Saudi Arabia (18 papers), Austria (15 papers), South Africa (11 papers), Russia Federation and Ireland (10 papers each), Poland and Mexico (9 papers each), Turkey (7 papers), Pakistan (6 papers), etc.

The top organizations in terms of publication productivity of highly-cited papers were : Huazhong University of S&T, China (101 papers), Tongji Medical College, China (97 papers), University of Kong Hong (53 papers), Harvard Medical School, USA (51 papers), Chinese Academy of Medical Sciences and Peking Union Medical College, China (42 papers), Fudan University, China (41 papers), INSERM, France and Renmin Hospital of Wuhan University, China (39 papers each), Imperial College, London, U.K. (36 papers), University of Oxford, U.K. (34 papers), University College, London, U.K. (30 papers), Brigham and Women's

**Table 7: Profile of Top 10 Most Productive and 10 Most Cited Authors.**

S.No	Name of the Author	Affiliation of the Author	TP	TC	CPP
Top 10 Most Productive Authors					
1	V. Wiwanitlit	Dr D.Y Patil University, Pune	152	541	3.56
2	E. Mahase	British Medical Journal, U.K.	135	938	6.95
3	G. Iacobucci	British Medical Journal, U.K.	108	299	2.77
4	G. Lippi	University of Verona, Italy	103	3965	38.50
5	K. Dhama	Indian Veterinary Research Institute, Bareilly, India	83	1608	19.37
6	A. Rimmer	British Medical Journal, U.K.	70	128	1.83
7	A.J.Rodruquez-Morales.	Technological University of Pereira, Columbia	68	1738	25.56
8	N.Rezaei	Tehran University of Medical Sciences, Iran	65	639	9.83
9	S.S.Hasan	University of Huddersfield, U.K.	60	92	1.53
10	B.M.Henry	Cincinnati Children's Hospital Medical Centre, USA	58	1922	33.14
Top 10 Most Cited Authors					
1	Hu, Y.	Tongji Medical College, China	38	12153	319.82
2	L.Liu	Second Affiliated Hospital of Southern University of S&T, China	45	13676	303.91
3	J.F.W.Chan	University of Hong Kong	40	6782	169.55
4	K.K.W.To	University of Hong Kong	42	6946	165.38
5	J.C.Lagier	The Research Institute for Development (IRD), France	39	3141	80.54
6	P.Gautret	The Research Institute for Development (IRD), France	41	2717	66.27
7	Raoult, D.	The Research Institute for Development (IRD), France	39	2380	61.03
8	Leo, Y.S.	Tan Tock Seng Hospital, Singapore	37	1883	50.89
9	A.Zangrillo	IRCCS San Raffaele Scientific Institute, Italy	48	2393	49.85
10	Plebani, M.	Azienda Ospedaliera di Padova" (AOP), Italy	38	1781	46.87

\*TP=Total publications; TC=Total citations; CPP=Citations per paper

**Table 8: Profile of Top 10 Most Productive and Cited Journals.**

S.No	Name of the Journal	TP	TC	CPP
Top 10 Most Productive Journals				
1	International Journal of Environmental Research and Public Health	961	6119	6.37
2	BMJ	854	9871	11.56
3	PLOS One	781	2629	3.37
4	Journal of Medical Virology	779	17070	21.91
5	BMJ Clinical Ed	684	3106	4.54
6	The Lancet	564	59956	106.30
7	Journal of Infectious Diseases	530	8301	15.66
8	JAMA-Journal of the American Medical Association	482	36234	75.17
9	New England Journal of Medicine	441	54145	122.78
10	Science	427	13873	32.49
Top 10 Most Cited Journals				
1	New England Journal of Medicine	441	54145	122.78
2	The Lancet	564	59956	106.30
3	JAMA-Journal of the American Medical Association	482	36234	75.17
4	Journal of Medical Virology	779	17070	21.91
5	Science	427	13873	32.49
6	Nature	297	16476	55.47
7	BMJ	854	9871	11.56
8	Lancet Infectious Diseases	261	12566	48.15
9	Science of the Total Environment	368	8074	21.94
10	Journal of Infection	380	7724	20.33

\*TP=Total publications; TC=Total citations; CPP=Citations per paper

Hospital, USA (29 papers), Ministry of Education, China (28 papers), University of Milan and National University of Singapore (26 papers each).

Among authors participating in highly-cited papers, L. Liu of Second Affiliated Hospital of Southern University of S&T, China) contributed the largest number of papers (19 papers), followed by Y. Liu (Second Affiliated Hospital of Southern Univ of S&T, China) (10 papers), J.F.W. Chan (University of Hong Kong (10 papers), K.K.W. To (University of Hong Kong (10 papers), G. Lippi (University of Verona, Italy) (10 papers), Z. Zhang (Second Affiliated Hospital of Southern Univ of S&T, China) (9 papers), Y. Ling (Shanghai Public Health Clinical Centre, China) (9 papers), Y.Hu (Tongji Medical College, China) (7 papers), Y. Xiong (Zhongnan Hospital of Wuhan University, China) (7 papers), P.Du (Peking Union Medical College Hospital, China) (7 papers), K.Y.Yuen (University of Hong Kong) (7 papers), J. Zhao (Tongji Medical College, China) (7 papers), J.C. Lagier (The Research Institute for Development, France) (6 papers) and Y.S. Leo, (Tan Tock Seng Hospital, Singapore) (6 papers).

**Table 9: List of Top 10 Highly Cited Papers.**

S.No	Authors	Title	Source	Number of Citations
1	Huang, C.A, et al.	Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China	The Lancet, 2020 395 (10223), pp. 497-506	11832
2	Guan, W. et al.	Clinical characteristics of coronavirus disease 2019 in China,	New England Journal of Medicine, 2020, 382 (18), pp. 1708-1720	7838
3	Wang, D. et al.	Clinical Characteristics of 138 Hospitalized Patients with 2019 Novel Coronavirus-Infected Pneumonia in Wuhan, China	JAMA - Journal of the American Medical Association, 2020, 323 (11), pp. 1061-1069.	6753
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.	The Lancet, 2020, 395 (10229), pp. 1054-1062.	6547
5	Zhu, N. et al.	A novel coronavirus from patients with pneumonia in China, 2019.	New England Journal of Medicine, 2020, 382 (8), pp. 727-733.	6449
6	Chen, N. et al.	Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: A descriptive study.	The Lancet, 2020, 395 (10223), pp. 507-513.	5851
7	Zhou, P. et al.	A pneumonia outbreak associated with a new coronavirus of probable bat origin	Nature, 2020, 579 (7798), pp. 270-273.	4868
8	Wu, Z and McGoogan, J.M.	Characteristics of and Important Lessons from the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72314 Cases from the Chinese Center for Disease Control and Prevention.	JAMA - Journal of the American Medical Association, 2020, 323 (13), pp. 1239-1242	4598
9	Li, Q. et al.	Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia.	New England Journal of Medicine, 2020, 382 (13), pp. 1199-1207	4332
10	Hoffmann, M. et al.	SARS-CoV-2 Cell Entry Depends on ACE2 and TMPRSS2 and Is Blocked by a Clinically Proven Protease Inhibitor.	Cell, 2020, 181 (2), pp. 271-280.	3642



Among the various journals contributing to highly-cited papers, *New England Journal of Medicine* contributed the largest number of papers (71), followed by *The Lancet* (63 papers), *JAMA-Journal of the American Medical Association* (55 papers), *Journal of Medical Virology* (41 papers), *Science* (31 papers), *Nature* (25 papers), *BMJ* (24 papers), *Lancet Infectious Diseases* (22 papers), *Science of the Total Environment* (21 papers), *Journal of Infection* (20 papers), *Journal of Infectious Diseases* (16 papers), *Lancet Respiratory Medicine* (15 papers), *Emerging Infectious Diseases* (12 papers), *Proceedings of The National Academy of Sciences of The United States Of America* (10 papers) and *Asian Journal of Psychiatry* (8 papers), *Diabetes and Metabolic Syndromes Clinical Research and Review* (7 papers) and *BMJ Clinical Ed* (7 papers).

## SUMMARY AND CONCLUSION

The study provides a bibliometric analysis of 103054 publications on COVID-19 disease published during the early stage of the outbreak (January 2020) till February 15, 2021. About 32% of total publications were financially supported by 1000+ funding agencies. The USA, China and U.K published the most share of publications (25.56%, 10.77% and 10.70% share respectively), followed by Italy (9.07%), India (6.95%), etc. Medicine is the top most area of research investigation in COVID-19 disease studies with a 71.44% share of global output, followed by Biochemistry, Genetics and Molecular Biology (10.61%), Social Sciences (9.70%), Immunology and Microbiology (6.71%), etc. Nearly 15% of research output is focused on Adults group affected by COVID-19 disease, followed by Middle Aged (10.59%), Aged (9.86%), Adolescents (3.62%) and Children group studies (1.55%). Treatment studies in COVID-19 research account for a 17.94% share, followed by clinical studies (11.90%), complications (7.06%), epidemiological studies (3.60%) and pathophysiology (3.55%). Under clinical studies, Virological studies accounted for the most publications (9.58% share), followed by respiratory studies (6.97%), molecular studies (3.11%), genetics studies (3.09%), biological studies (2.85%), immunological studies (1.30%), etc. The study also provides a window to key research countries, organizations and authors and their collaborative linkages. It also identified the key source journals. Of the top 50 organizations, 18 were from USA, 7 from Australia, 6 each from China, Italy and U.K., 4 from France, 2 from Canada and 1 each from Brazil, India, Iran, Australia, Singapore, Iran and Hong Kong. Of the top 50 authors, 10 are from U.K., 8 from Italy, 7 from USA, 5 from India, 3 each from France and Hong Kong, 2 each from Belgium and China and 1 each from Columbia, Iran, Malaysia, Switzerland, Canada, Nepal, Saudi Arabia, Indonesia and Singapore. In conclusion it may be stated that COVID-19 disease research is though global in nature but it is the countries like the USA, UK, and China which dominate the field whereas the other participating countries are just distant cousins in COVID-19 research. The results of this study should be of interest to working scientists, clinicians and

policy-makers in improving their understanding of COVID-19 disease and in its management.

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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