

A Scientometric Analysis of Highly Cited Papers of Pakistan in COVID-19 Research 2020-2023

Brij Mohan Gupta¹, Surinder Mohan Dhawan², Yogendra Singh³, Nupur Srivastava³, Raju Vaishya⁴, Mallikarjun Kappi⁵, Ghouse Modin Nabeesab Mamdapur^{6,*}

¹Formerly with CSIR-NISTADS, Pusa, New Delhi, INDIA.

²Formerly with CSIR-NPL, Pusa, New Delhi, INDIA.

³Central Library, Swami Rama Himalayan University, Swami Ram Nagar, Jollygrant, Dehradun, Uttarakhand, INDIA.

⁴Department of Orthopaedics and Joint Replacement Surgery, Senior Consultant Orthopaedics, Indraprastha Apollo Hospitals Sarita Vihar, New Delhi, INDIA.

⁵Department of Library and Information Science, Government First Grade College, Hosapete, Karnataka, INDIA.

⁶Department of Library and Information Science, Yenepoya (Deemed to be University), Deralakatte, Mangalore, Karnataka, INDIA.

ABSTRACT

Highly Cited Papers (HCPs) are influential sources of information that highlight trend-setting areas of research and identify key players within a subject. This study aims to measure the research performance of Pakistan in COVID-19-related research from 2020 to 2023, focusing specifically on HCPs that have received more than 100 citations. A bibliometric approach was employed to analyse COVID-19 research papers from Pakistan, with data sourced from Scopus. The period covered was from 2020 to 2023. The analysis included metrics such as the number of HCPs, citation counts, international collaboration, and funding sources. A total of 7602 COVID-19-related papers were published by Pakistani researchers, of which 164 (1.59%) were classified as HCPs. These HCPs collectively registered 38,244 citations, averaging 233.10 citations per paper. International collaboration was evident in 81.71% of these HCPs, and 32.92% were funded by external agencies. The USA, China, UK, and Saudi Arabia were identified as the leading international collaborating partners. Despite the high collaboration rates, the average productivity per organization in Pakistan was low, with only 6.32 HCPs per organization. Similarly, the average productivity of 31 research authors was 2.48 HCPs per author. International collaboration has positioned Pakistan at the centre stage in COVID-19 research, with external funding significantly enhancing research quality. However, the share of HCPs remains less than 2% of Pakistan's total COVID-19-related publications, indicating a significant gap between the quantity and quality of research output. This suggests that while Pakistan has made notable contributions, there remains substantial potential for addressing the ongoing health challenges posed by COVID-19 through enhanced research efforts.

Keywords: COVID-19, Research, Citation, Collaboration, Pakistan.

Correspondence:

Mr. Ghouse Modin Nabeesab Mamdapur

Department of Library and Information Science, Yenepoya (Deemed to be University), Deralakatte, Mangalore, Karnataka, INDIA.

Email: 20915@yenepoya.edu.in

ORCID: 0000-0003-4155-1987

Received: 14-06-2024;

Revised: 05-07-2024;

Accepted: 24-07-2024.

INTRODUCTION

Virus-driven infectious diseases have been fast spreading across the world raising thereby serious health management concerns across several countries. The latest most infectious disease the world has been facing is COVID-19. It first erupted in China in December 2019 and soon after it started spreading fast across 230 plus countries, With the alarming rise in this novel human coronavirus-infected cases, the World Health Organization (WHO) announced it as the sixth public health emergency in January 2020, and later in March 2020, it was declared as a

COVID-19 pandemic (World Health Organization, 2020). As of 8 November 2023, WHO had reported a total of 771,820,937 cases as confirmed cases of COVID-19, including 6,978,175 deaths (World Health Organization, 2020).

South Asia countries have also been witnessing overwhelming pressure on their national healthcare systems. In Pakistan, COVID-19 cases have also started rising. As per WHO data, by 8 November 2023, the tally of COVID-19 infected cases in Pakistan had reached 1,580,631 with 30,656 confirmed deaths WHO (World Health Organization, 2023). Pakistan responded to the public health crisis by rolling out RandD programmes with project funding from the government and private sectors. Pakistan focused its research pursuits on the COVID-19 disease covering mainly topics such as epidemiology, characteristics, pathophysiology, diagnosis, and prevention of this viral disease (Abid *et al.*, 2020; World Health Organization, 2023).



DOI: 10.5530/jcitation.3.2.15

Copyright Information :

Copyright Author (s) 2024 Distributed under Creative Commons CC-BY 4.0

Publishing Partner : EManuscript Tech. [www.emanuscript.in]

Ever since the outbreak of COVID-19 in December 2019, there has been a significant surge in research publications on the topic of COVID-19. The research publications tally on the subject has since grown to more than 5,500,000 studies (Di Girolamo and Meursing Reynders, 2020).

Bibliometric studies are important to identify the most cited papers, popular topics, prolific authors, and highly productive institutions, and map research institutions, and researchers for identifying their collaborative network relationships (Bornmann *et al.*, 2008). Younger scientists use bibliometric studies to speed up the completion of their projects (Schui and Krampen, 2010). Highly Cited Publications (HCPs) are better known to provide trend-setting information, core journals, and key players in the relevant of their interest. Certainly, assessing the research performance and progress of an entity based on an analysis of HCPs is hailed as a more useful and effective approach (Chuang *et al.*, 2011; Van Raan, 2003).

Currently, bibliometric studies analysing *per se* COVID-19 literature with a special reference to South Asia countries are quite few (Gupta *et al.*, 2021; Naseer *et al.*, 2023). The same is also true of COVID-19-related bibliometric studies on India (Gupta, 2021; Vaishya *et al.*, 2023), Bangladesh (Gupta, Kappi, Walke, *et al.*, 2023) and Nepal (Gupta, Kappi, Bansal, *et al.*, 2023). Currently, most of such studies on COVID-19 topics have since become outdated, due to their limited or incomplete coverage, and also because such studies were mainly restricted to the initial periods of the pandemic outbreak.

This study proposes to analyse highly cited papers by Pakistan on COVID-19 using a bibliometric approach to assess and understand trends and characteristics of COVID-19 research in the country. The study is going to highlight the key researchers, key research organizations, core journals, and major areas of COVID-19 research using quantitative and qualitative indicators of research productivity, citations and performance.

LITERATURE REVIEW

Shah and Shaikh assessed COVID-19 publications by Pakistan as indexed in the Scopus database till 29 May 2020 (Shah and Shaikh, 2020). More recently, Ulah in a bibliometric study assessed 480 publications by Pakistan on COVID-19 research as covered in the PakMediNet database till 11 February 2022 (Ullah, 2023). In another study on South Asia, Gupta and others analyzed 4412 COVID-19 publications in South Asia, but their coverage was limited to 2246 publications by Pakistan from December 2019 to 8 July 2021 (Gupta *et al.*, 2021). Only 12 out of these 2246 publications were rated as highly cited papers. In a more recent study on South Asia, the authors of this paper assessed 100 top HCPs from South Asia covering literature up to October 2022, but such HCPs having a focus on Pakistan were just a few in this study. Pakistan has already published a large number of research papers on the topic of COVID-19, with more than 7600 publications. But

until recently, not a single bibliometric study exists till date that has sought to have attempted to evaluate the research performance of Pakistan in COVID-19 on a comprehensive publications data set of the country for the purpose.

METHODOLOGY

Research publications by Pakistan on COVID-19 research were sourced from the Scopus database. The search strategy included COVID-19-related keywords, co-joined with TITLE-ABS-KEY tag, coupled with affiliation tag (for limiting the country search only to Pakistan), and date range tag limited to the beginning of virus eruption till 19.11.2023. The Scopus database retrieved a total of 7602 publication records related to COVID-19 research by Pakistan. These records were sorted by the citations they received since their publication. Out of 7602 publications by Pakistan, only 164 were found to have received 100 to 1578 citations per paper. These 164 papers are presumed as HCPs for this study. Their meta-data records were organized and all information related to contributing authors, organizations, subject categories, research collaboration, funding and keywords was downloaded. Furthermore, these 164 HCPs were sorted by broad subject areas, document type, source type, affiliating organizations, research authors and their affiliations, source journals for research publication and keywords. No restrictions were applied in downloading records by document type, publication source and language. The data so collected was documented, tabulated, and analyzed using Microsoft Excel. VOSviewer software was utilized for network visualization of participating countries, organizations, authors and keywords used. The study applied select bibliometric indicators for measuring the publication performance of Pakistan in COVID-19 research. The search strategy of our study was as follows:

TITLE-ABS-KEY ("COVID 19" OR "2019 novel coronavirus" OR "coronavirus 2019" OR "SARS-CoV-2" OR "SARS-CoV 2" OR "coronavirus disease 2019" OR "2019-novel CoV" OR "2019 nCoV" OR "COVID 2019" 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 "Novel Coronavirus") AND (LIMIT-TO (AFFILCOUNTRY, "Pakistan"))

RESULTS

Overall Picture

Globally a total of 586,597 publications were found to have been published on COVID-19, as indexed in the Scopus database as of 18.11.2023. Of these, the USA (140,607 and 23.97% share) accounted for the largest number of publications and global share, followed by the UK (546, 96 and 9.32% share), China (53760 and 9.16% share), India (43,232 and 7.37% share), Italy (38854 and 6.62% share), etc., Among South Asia countries, India published the largest number of papers (43,232 and 7.37% share) on COVID-19, followed by Pakistan (7602 and 1.59% share),

Bangladesh (4393 and 0.75% share), Nepal (1315 and 0.22% share), Sri Lanka (905 and 0.15% share), etc.,

Pakistan ranked at 24th position in global COVID-19 output, received a total of 38244 citations from 7602 papers since their publication, and averaged 233.10 Citations Per Paper (CPP). Out of 7602 publications, only 164 HCPs received 100 to 1578 citations per paper.

The distribution of 164 HCPs by select citation range revealed that the bulk of HCPs (105 papers, 64.02% share) received 100-200 citations per paper, 24 HCPs (8.53%) received 202-287 CPP, 10 HCPs (6.10%) received 511-924 CPP and only 2 papers were in the highest citations range (1457-1578 CPP). Their distribution by publication year revealed that most publications (92, 54.88%) were published in 2020, 60 publications (36.58%) in 2021, 10 (6.09%) in 2022 and 2 (1.225%) in 2023.

The distribution of HCPs by funding source revealed that 54 (32.92%) HCPs were funded by foreign and international funding agencies such as National Institute of Health, USA (10 papers), National Natural Science Foundation of China (9 papers), U.S. Department of Health and Human Service (8 papers), National Institutes for Health Research (7 papers), European Commission (6 papers), World Health Organization and National Institute of Allergy and Infectious Diseases, USA (4 papers each), Bill and Melinda Gates Foundation and U.K. Research and Innovation (3 papers each), etc.,

In 60 of the 164 HCPs, two or more organizations per paper were involved in collaborative research at the national level within Pakistan. In 134 HCPs (81.71% share) Pakistan collaborated with 185 countries; these 134 HCPs received 30,728 citations, an average of 229.31 CPP. The USA and China were involved in international collaborative research with Pakistan in most HCPs (50 and 48), followed by the U.K. (39 papers), India and Saudi Arabia (27 papers each), France (24), Canada (23 papers), Australia and Italy (21 papers each), etc. HCPs involving collaboration between Pakistan and Malaysia registered the highest citation impact per paper (386.78), Canada (303.78), U.K. (284.08), Brazil (281.74), Bangladesh (272.29), etc., (Table 1).

In 36 HCPs, involving international collaboration, Pakistan was the lead country, followed by China (15 papers), U.K. (12 papers), USA (11 papers), Saudi Arabia (8 papers), Germany (5 papers), etc., In 29 HCPs Pakistan was also involved in collaboration with South Asia countries, but in 2 HCPs the collaboration was at intra-regional level.

The top seventeen countries with which Pakistan published 17 or more HCPs were mapped for their collaborative linkages using VOSviewer software. It resulted in two major clusters. Cluster One had 12 members led by the USA, followed by the U.K., India, etc., Cluster Two had five members led by China and followed by Saudi Arabia, Malaysia, etc. Details of clusters, Pakistan linkages

with the top seventeen countries, and total linkages with all countries collaborating with Pakistan are presented in Table 1 and the cluster map is presented in Figure 1.

Leading Organizations

A total of 1457 organizations were involved in the publication of 164 HCPs on COVID-19 research by Pakistan. Of these, 126 (8.65%) were based in Pakistan. Such Pakistani organizations which contributed three or more HCPs are listed in Table 2.

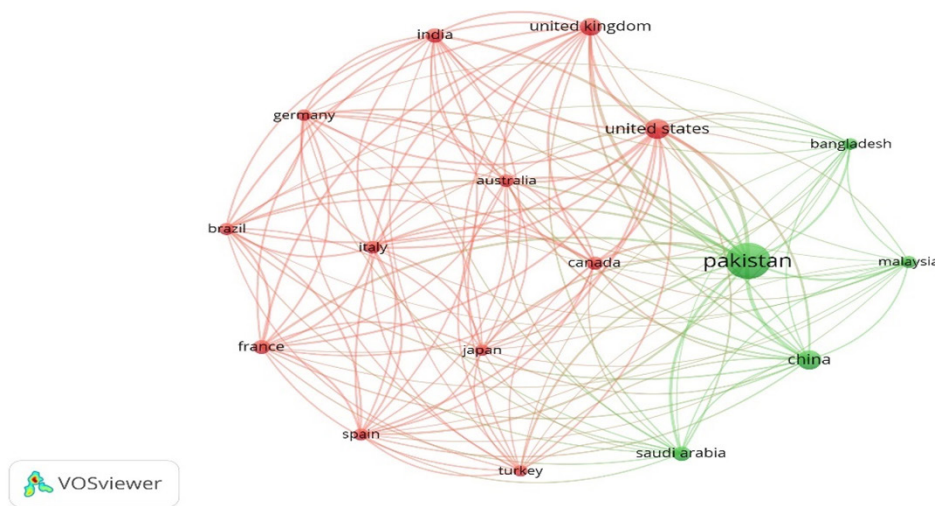
The top 22 organizations individually contributed 3 to 25 HCP papers and together they contributed 139 HCPs (84.76% of 164 HCPs) and accounted for 30301 citations (79.23% share). Of the top 22 Pakistan-based organizations, only 6 contributed their productivity above the group average of 6.32 HCPs per organization. They are The Agha Khan University ($n=25$), University of Management and Technology, Lahore ($N=11$), The Agha Khan University Hospital and Quaid-i-Azam University ($n=9$ each), Dow University of Health Sciences and Lahore University of Management Science ($n=7$ each). The average citation impact, depicted by Citation Per Paper (CPP) and Relative Citation Index (RCI) registered by the top 22 Pakistan organizations was 217.99 and 0.93 respectively. Only 5 organizations registered their impact above the group average impact: National University of Medical University (356.8 and 1.53), Khyber Medical University (308.0 and 1.32), The Agha Khan University (289.76 and 1.24), Lahore University of Management Science (274.86 and 1.18) and University of Veterinary and Animal Sciences, Lahore (252.8 and 1.08).

The collaborative linkages of the top 22 Pakistan organizations were mapped using the VOSviewer software, which grouped them into six clusters on a similarity basis. The first cluster had five members led by Islamic Azad University followed by the University of Management and Tech. Lahore, COMSATS University. University of Malakand and University of Punjab ($n=5$ each). Cluster Two also had five members led by King Edward Medical University, followed by Khyber Medical University, Liaquat National Hospital Mayo Hospital Lahore and Ziauddin University. There were four members in cluster 3, led by The Agha Khan Univ., followed by the Agha Khan Univ. Hospital, National University of Medical Sciences ($n=4$), Univ. of Health Sciences, Lahore ($n=3$). Dow Univ. of Health Sciences led the fourth Cluster followed by Gandhara University Univ. of Karachi and Dow Medical College. The fifth cluster had three members: Quaid-i-Azam University, National Univ. of Science and Technology and Univ. of Veterinary and Animal Sciences. Lahore University of Management Science was the solitary member in cluster 6th. The various statistics of cluster numbers, links among the top 22 institutions and total links within the whole data are presented in Table 2 and Figure 2 presents a collaboration network obtained from VOSviewer.

Table 1: Major Countries in International Collaboration with Pakistan for COVID-19 Research.

Sl. No.	Country	TP	TC	CPP	TLS	Links with top 17	Cluster
1	Pakistan	164	38271	233.36	911	802	2
2	United States	50	12192	243.84	593	272	1
3	China	48	9519	198.31	425	202	2
4	United Kingdom	39	11079	284.08	537	238	1
5	India	27	7270	269.26	370	169	1
6	Saudi Arabia	27	7331	271.52	294	127	2
7	France	24	5587	232.79	462	191	1
8	Canada	23	6987	303.78	423	169	1
9	Australia	21	5148	245.14	399	161	1
10	Italy	21	6097	290.33	467	189	1
11	Brazil	19	5353	281.74	439	178	1
12	Spain	19	4988	262.53	428	172	1
13	Malaysia	18	6962	386.78	200	84	2
14	Bangladesh	17	4629	272.29	209	92	2
15	Germany	17	3463	203.71	410	160	1
16	Japan	16	3840	240.00	324	135	1
17	Turkey	16	3188	199.25	324	125	1

(TP-Total Papers, TC-Total Citations, CPP-Citations per paper, RCI-Relative Citations Index, TLS-Total Collaborative Linkages).

**Figure 1:** Cluster map of countries collaborating with Pakistan (VOSviewer $n \geq 17$).

Leading Authors

A total of 3537 authors contributed to the 164 HCPs on COVID-19 research by Pakistan. Of these, 327 (9.24%) authors were affiliated with organizations within Pakistan. Table 3 lists Pakistan organizations contributing 3 or more papers.

The top 31 authors from Pakistan contributed 2 to 5 papers each and together they contributed 77 papers accounting for 46.95% share and received 17710 citations (46.31 share). Only 9 authors contributed above the group average productivity

of 2.48: Z.A. Bhutta (Aga Khan Univ., Karachi) and I. Ullah (Gandhara Univ., Peshawar) ($n=5$ each), S. Mukhtar (Univ. of Management and Technology, Lahore) and S.A.R. Rizvi. (Lahore Univ. of Management Sciences) ($n=4$ each), J. Akram (Univ. of Health Sciences, Lahore), A.M. Baig (Aga Khan Univ., Karachi), O. Haroon (Lahore Univ. of Management Sciences), S.K. A. Rizvi (Lahore School of Economics, Lahore) and K. Shah (Univ. of Malakand, Chakdara, Pakhtunkhwa) ($n=3$ each).

The average citation impact, depicted by Citations Per Paper (CPP) and Relative Citation Index (RCI) registered by the top 31

Table 2: Leading Organizations with 3 or more HCPs in COVID-19 research by Pakistan.

Sl. No.	Name of the organization	TP	TC	CPP	RCI	TLS	Links with top 22	Cluster
1	The Agha Khan University	25	7244	289.76	1.24	335	3	3
2	University of Management and Technology, Lahore.	11	2075	188.64	0.81	24	1	1
3	The Agha Khan University Hospital.	9	2052	228.00	0.98	109	4	3
4	Quaid-i-Azam University	9	1535	170.56	0.73	96	6	5
5	Dow University of Health Sciences.	7	1513	216.14	0.93	46	8	4
6	Lahore University of Management Science.	7	1924	274.86	1.18	14	0	6
7	The Islamic University of Bawalpur.	6	1162	193.67	0.83	44	4	1
8	University of Malakand, Chakdar.	6	830	138.33	0.59	23	5	1
9	University of the Punjab.	5	856	171.20	0.73	20	2	1
10	National University of Medical University	5	1784	356.80	1.53	56	3	3
11	COMSATS University, Islamabad.	5	655	131.00	0.56	36	1	1
12	University of Veterinary and Animal Sciences, Lahore.	5	1264	252.80	1.08	19	1	5
13	University of Karachi.	5	1076	215.20	0.92	38	1	4
14	Gandhara University.	5	731	146.20	0.63	51	3	4
15	National University of Science and Technology.	4	815	203.75	0.87	46	3	3
16	King Edward Memorial University, Lahore.	4	640	160.00	0.69	30	6	2
17	Liaquat National Hospital.	4	467	116.75	0.50	24	5	2
18	University of Health Sciences, Lahore.	4	811	202.75	0.87	95	1	3
19	Khyber Medical University.	4	1232	308.00	1.32	18	3	2
20	Dow Medical College.	3	540	180.00	0.77	32	6	4
21	Ziauddin University.	3	589	196.33	0.84	14	3	2
22	Mayo Hospital, Lahore.	3	506	168.67	0.72	18	3	2
	A total of 22 organizations.	139	30301	217.99	0.93			
	Pakistan total	164	38244	233.20	1.00			
	Share of top 20 organizations in Pakistan's total publications.	84.76	79.23					

(TP-Total Papers, TC-Total Citations, CPP-Citations per paper, RCI-Relative Citations Index, TLS-Total Link Strength).

Pakistan authors was 230.0 and 0.99 respectively. Only 10 authors registered citation impact above the group average: M. Khan (Aga Khan University, Karachi) (645.5 and 2.77), A.M. Baig (Agha Khan University, Karachi, Pakistan) (594.33 and 2.55), A. Sharif (Eman Inst. of Management and Sciences, Karachi) (473.5 and 2.03), M. Bashir (Government of Punjab, Pakistan) (397.50 and 1.7), I. Ullah (Gandhara University, Peshawar) (336.8 and 1.44), S.A.R Rizvi (Lahore University of Management Sciences) (279.25 and 1.2), W. Aslam (Islamia University of Bahawalpur, Pakistan) (246.5 and 1.06), A. Mehmood (Islamia University of Bahawalpur

(246.5 and 1.06), O. Haroon (Lahore University of Management Sciences) (237.0 and 1.02) and N. Ahmed (Altamash Institute of Dental Medicine, Karachi) (236.5 and 1.01).

The collaborative linkages of the top 31 Pakistan authors were mapped using VOSviewer software, which grouped them into 24 clusters based on their similarity. Of the 31 authors, 14 authors collaborated among themselves and were divided into 7 clusters, with 2 authors in each cluster. The rest of the authors were included in the remaining 17 clusters with 1 author each. The statistics concerning cluster numbers, linkages among the top 31

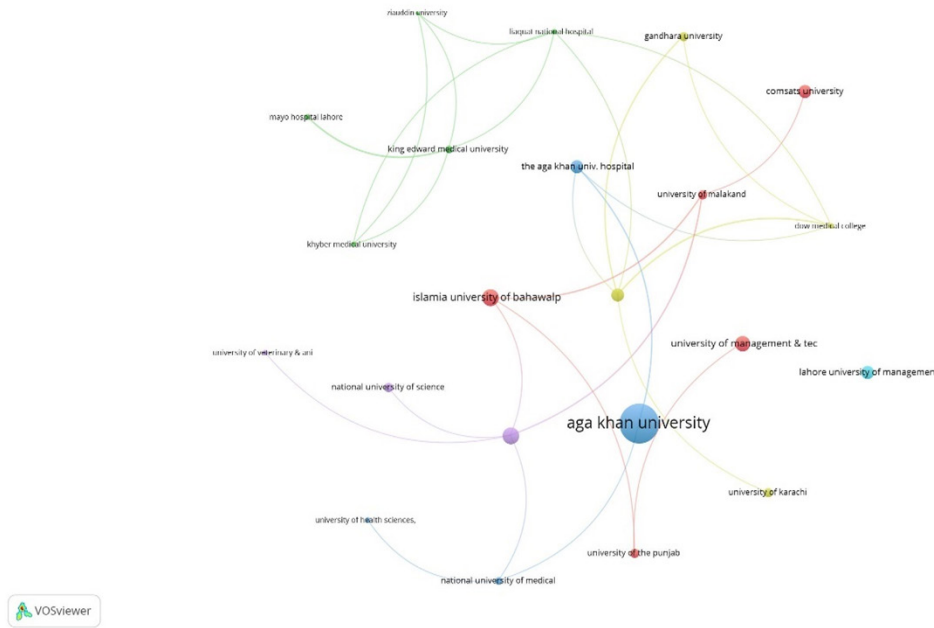


Figure 2: Cluster Map of Top 22 Organizations in Pakistan (VOSviewer, $n=>2$).

authors and total linkages within the whole data are presented in Table 3 and Figure 3.

Leading Journals

The study noted that 164 HCPs in Pakistan are scattered across as many as 113 journals. The bulk of which (84) appeared in 84 journals, 1 paper each. Thirty papers appeared in 15 journals (2 papers each), and another set of 30 papers appeared in 10 journals (3 papers each). Two journals published 4 papers each and the other set of 2 journals published 6 papers each. The top six most productive journals are *Pakistan Journal of Medical Sciences* and *Chaos, Solitons and Fractals* ($n=6$ each), *The Lancet Psychiatry* and *IEEE Access* ($n=4$ each), *Plos One* and *Journal of Medical Virology* ($n=3$ each). The top 6 journals ranked by citations per paper are *The Lancet Psychiatry* (445.25), *IEEE Access* (424.5), *Journal of Behavioral and Experimental Finance* (369.5), *Journal of Infection and Public Health* (357.5), *Science of the Total Environment* (318.0) and *International Journal of Environmental Research and Public Health* (283.0) (Table 4).

Subject-Wise Distribution

As per Scopus database classification, the global output by Pakistan in COVID-19 is organized into eleven broad subject categories (Table 5). Medicine; Biochemistry, Genetics and Molecular Biology; and Immunology and Microbiology accounted for 52.44%, 14.63% and 12.80% share of HCPs respectively. Neuroscience ranks on top for registering the highest (331.8) citations per HCP and Energy accounts for the least (122.25) CPP.

Significant Keywords

In all 2539 keywords were used in Scopus to describe 164 HCPs by Pakistan on COVID-19. The frequency of their occurrence varied from 1 to 140 times. 170 keywords accounted for 4 or more occurrences. The top 10 most significant keywords ranked by the frequency of their occurrence are: “COVID-19” ($n=140$), “Virus Pneumonia” ($n=47$), “Mental Health” ($n=22$), “Virology” ($n=22$), “Psychology” ($n=21$), “Quarantine” ($n=16$), “Prevention and Control” ($n=13$), “Anxiety” ($n=12$), “Antivirus Agents” ($n=11$) and “Mental Stress” ($n=11$).

Of the 170 keywords, 78 were mapped for co-occurrence analysis using VOSviewer software. The keywords appeared in six clusters. The details of clusters and their linkages are presented in Table 6 and the cluster map is presented in Figure 4.

The first cluster had 21 members led by mental health followed by psychology and quarantine with 22, 21 and 18 frequencies respectively. Other members of the group were anxiety, mental stress, social isolation, depression, mental disease, stress etc. mostly related to the psychological aspect of the diseases.

The second cluster was composed of 20 members with virology ($n=22$) on top. It was followed by an antiviral agent and hydroxychloroquine with 11 and 10 occurrences. Other members were mostly antiviral or antibacterial agents or drugs such as remdesivir, azithromycin etc.

The third cluster with 16 members was led by COVID-19 itself with 140 occurrences and followed by prevention and control, and social media ($n=13$, $n=10$ respectively). The members in this

Table 3: Leading Authors with 3 or more Highly Cited Papers in COVID-19 Research by Pakistan.

Sl. No.	Name of the author	Affiliation of the author	TP	TC	CPP	RCI	TLS	Total links among 31 authors	Cluster
1	Z.A. Bhutta	Aga Khan Univ., Karachi.	5	731	146.20	0.63	71	0	13
2	I. Ullah	Gandhara Univ., Peshawar.	5	1684	336.80	1.44	36	2	7
3	S. Mukhtar	Univ. of Management and Technology, Lahore.	4	671	167.75	0.72	1	0	18
4	S.A. R. Rizvi	Lahore Univ. of Management Sciences, Lahore.	4	1117	279.25	1.20	7	3	1
5	J. Akram	Univ. of Health Sciences, Lahore, Pakistan.	3	671	223.67	0.96	99	0	9
6	A.M. Baig	Aga Khan Univ., Karachi, Pakistan.	3	1783	594.33	2.55	3	0	11
7	O. Haroon	Lahore Univ. of Management Sciences.	3	711	237.00	1.02	5	3	1
8	S.K.A. Rizvi	Lahore School of Economics, Lahore.	3	364	121.33	0.52	9	2	6
9	K. Shah	Univ. of Malakand, Chakdara, Pakhtunkhwa.	3	380	126.67	0.54	12	0	20
10	N. Ahmed	Altamash Inst. of Dental Medicine, Karachi.	2	473	236.50	1.01	14	0	8
11	F. Aslam	COMSATs Univ., Islamabad, Pakistan.	2	285	142.50	0.61	8	0	10
12	Aslam w	Islamia Univ. of Bahawalpur.	2	493	246.50	1.06	11	2	
13	M. Bashir	Government of the Punjab, Pakistan.	2	795	397.50	1.70	13	0	12
14	R. Bhatti	Islamia Univ. of Bahawalpur.	2	388	194.00	0.83	3	2	4
15	S. Farid	Univ. of Management and Technology, Lahore.	2	223	111.50	0.48	5	0	14
16	H.A. Habib	Univ. of Karachi	2	456	228.00	0.98	55	2	2
17	S. Hussain	DHQ Hospital, Jhelum.	2	456	228.00	0.98	55	2	2
18	N. Imran	King Edward Medical Univ., Lahore.	2	400	200.00	0.86	6	9	15
19	K. Jabeen	Aga Khan Univ., Karachi.	2	234	117.00	0.50	51	1	5

Sl. No.	Name of the author	Affiliation of the author	TP	TC	CPP	RCI	TLS	Total links among 31 authors	Cluster
20	H.W. Kamran	IQRA Univ., Karachi.	2	267	133.50	0.57	11	0	16
21	K.S. Khan	Dow Univ. of Health Sciences, Karachi.	2	283	141.50	0.61	7	2	7
22	M. Khan	Aaga Khan Univ., Karachi.	2	1291	645.50	2.77	111	0	17
23	A.Mehmood	Islamia Univ. of Bahawalpur.	2	493	246.50	1.06	11	2	3
24	S.B. Naeem	Islamia Univ. of Bahawalpur.	2	388	194.00	0.83	3	2	4
25	B. Naqvi	Lahore Univ. of Management Sciences.	2	262	131.00	0.56	6	2	6
26	N. Nasir	Aga Khan Univ., Karachi	2	288	144.00	0.62	19	1	5
27	F.A. Rathore	Bahria Univ. Medical and Dental College, Karachi.	2	446	223.00	0.96	2	0	19
28	A. Sharif	Eman Inst. of Management and Sciences, Karachi.	2	947	473.50	2.03	6	0	21
29	M. Umair	Univ. Of Lakki Marwat, Pakistan.	2	261	130.50	0.56	4	0	22
30	F. Yasmin	Dow Univ. of Health Sciences, Karachi.	2	228	114.00	0.49	21	0	23
31	G. Zaman	Univ. of Malakand, Chakdara.	2	241	120.50	0.52	6	0	24
		A total of 31 authors.	77	17710	230.00	0.99			
		Pakistan total	164	38244	233.20	1.0			
		Share of top 31 authors in Pakistan's total publications.	46.95	46.31					

(TP-Total Papers, TC-Total Citations, CPP-Citations per paper, RCI-Relative Citations Index, TLS-Total Collaborative Linkages).

group mainly relate to diagnosis, social awareness and treatment aspects of the diseases.

Eleven keywords belonged to the fourth cluster mainly related to the immunological aspects with immunology ($n=10$) on top followed by angiotensin-converting enzyme 2 and genetics ($n=9$ each).

The fifth cluster had five members with virus pneumonia on top with 47 occurrences and pneumonia, viral in second place with 46 occurrences. Molecular docking came third with five occurrences.

Education, social distancing and e-learning with 8, 7 and 4 frequencies respectively made the sixth cluster

The seventh cluster had two members: stock markets and financial markets with five and four occurrences each.

Highly Cited Papers

A study of the top fifteen most cited papers by Pakistan (Supplementary Table 1) reveals that the top ten papers had received high-end (457-1601) CPP. Twelve of 15 top HCPs were funded by external agencies and 13 were International

Table 4: Leading Journals with 2 or more HCPs by Pakistan in COVID-19 Research.

Sl. No.	Source Title	TP	TC	CPP	IF (2022-23)
1	Pakistan Journal of Medical Sciences.	6	1526	254.33	2.2
2	Chaos, Solitons and Fractals.	6	970	161.67	3.741
3	The Lancet Psychiatry.	4	1781	445.25	64.3
4	IEEE Access	4	1698	424.5	3.476
5	PLOS One	3	556	185.33	3.7
6	Journal of Medical Virology.	3	486	162	20.693
7	Journal of Biomolecular Structure and Dynamics.	3	528	176	5.235
8	International Journal of Environmental Research and Public Health.	3	849	283	4.614
9	Health Information and Libraries Journal.	3	499	166.33	3.55
10	Frontiers in Public Health.	3	337	112.33	6.461
11	Finance Research Letters.	3	532	177.33	9.848
12	European Review for Medical and Pharmacological Sciences.	3	822	274	3.784
13	Environmental Research.	3	519	173	8.431
14	BMJ Global Health.	3	662	220.67	8.10
15	The Lancet	2	294	147	168.9
16	Technological Forecasting and Social Change.	2	225	112.5	10.884
17	Science of the Total Environment.	2	636	318	10.754
18	Science Immunology.	2	478	239	30.658
19	Resources Policy	2	261	130.5	8.222
20	Nature Communications.	2	350	175	16.6
21	Molecules	2	372	186	4.927
22	Journal of Infection and Public Health.	2	715	357.5	7.537
23	Journal of Behavioral and Experimental Finance.	2	739	369.5	8.222
24	International Journal of Infectious Diseases.	2	533	266.5	12.073
25	Environmental Science and Pollution Research.	2	280	140	5.19
26	Current research in behavioural sciences.	2	346	173	6.63
27	Brain, Behavior and Immunity.	2	357	178.5	15.1
28	Asian Journal of Psychiatry.	2	339	169.5	13.89
29	American Journal of Tropical Medicine and Hygiene.	2	273	136.5	3.707
		80	17963	224.54	
		164	38244	233.2	
		48.78	46.97		

(TP-Total Papers, TC-Total Citations, CPP-Citations per paper, IF-Impact Factor).

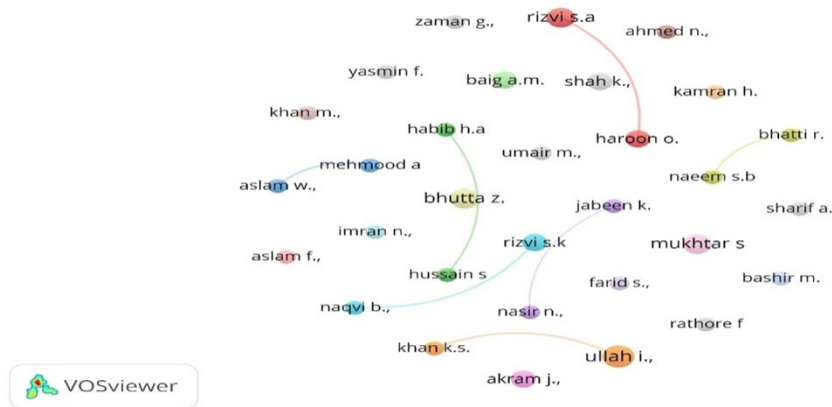
Collaborative Papers (ICPs). Two out of 15 HCPs were involved in collaboration at the national level. Ten out of 15 HCPs appeared as articles, followed by reviews (4) and notes (1). Six HCPs appeared in six high impact factor journals (IF=26.8 to 158.5), five in 5 medium range impact journals (IF=6.698 to 10.754) and 4 appeared in journals having IF from 0.13 to 4.64. The HCP which ranked at the top of the list is entitled “Repurposed antiviral drugs for COVID-19-Interim WHO solidarity trial results.” by Pan, H., Raza, A. et al. published in 2021 in “The New England Journal

of Medicine” had the highest citations ($n=1601$). This paper which ranked second is entitled “Evidence of the COVID-19 Virus Targeting the CNS: Tissue Distribution, Host-Virus Interaction, and Proposed Neurotropic Mechanisms” by Baig, A.M., Khaleeq, A. et al. ACS Chemical Neuroscience in 2020¹ (1469 citations). The HCP at the bottom of the list is entitled “Exploring the Effect of Image Enhancement Techniques on COVID-19 Detection Using Chest X-ray Images” authored by Rahman, T, Khan, M.S. et al. Computers in Biology and Medicine in 2021¹ (457 citations).

Table 5: Subject-wise Distribution of Highly Cited Papers by Pakistan in COVID-19 Research.

Sl. No.	Name of the broad subject	TP	TC	CPP	%TP
1	Medicine	86	20620	239.77	52.44
2	Biochemistry, Genetics and Molecular Biology.	24	6024	251.00	14.63
3	Immunology and Microbiology.	21	3385	161.19	12.80
4	Neuroscience	15	4977	331.80	9.15
5	Environment Science	15	2870	191.33	9.15
6	Computer Science	13	3279	252.23	7.93
7	Engineering	13	2940	226.15	7.93
8	Social Sciences	13	2527	194.38	7.93
9	Psychology	10	1577	157.70	6.10
10	Pharmacology, Toxicology and Pharmaceutics.	6	970	161.67	3.66
11	Energy	4	489	122.25	2.44
	Pakistan's total	164	38244	233.20	100.0

(TP-Total Papers, TC-Total Citations, CPP-Citations per paper).

**Figure 3:** Collaboration Network Map of Top 31 Authors in COVID-19 Research.

DISCUSSION

The HCPs from Pakistan reflect the nation's growing influence in various fields of research and innovation. Since the onset of COVID-19, Pakistan has contributed a total of 7602 publications of which 164 are HCPs (1.59% share) showcasing the depth and breadth of its scientific contributions to the subject under study. Pakistan ranks at 24th position in global output. Overall, it registered an average of 233.10 Citations Per Paper (CPP); HCPs received 100 to 1578 citations per paper since their publication.

Collaborative research at the international level is the driving COVID-19 research activity in Pakistan. Overall, Pakistan collaborated at the international level involving 185 countries, and it published 134 collaborative research HCPs (81.71% share). The USA, China, and the UK were the lead international partners in most HCPs. Pakistan was the lead partner in 36 HCPs. Pakistan was also involved in collaborative research in partnership with South Asia countries.

Of the total 164 HCPs by Pakistan, 92 were published (54.88%) in 2020, 60 (36.58%) in 2021, 10 (6.09%) in 2022 and 2 (1.225%) in 2023. International funding agencies from the USA and the UK had sponsored 32.92% share (54) of the total HCPs in COVID-19 research.

Research publications productivity of the national research organizations from Pakistan is highly skewed. Just 22 out of a total of 126 organizations accounted for a high share of 84.76% of publications. The average productivity of research organizations from Pakistan is however small, just 6.32 HCPs per organization. The top three most productive national organizations in COVID-19 research in Pakistan are (i) The Agha Khan University ($n=25$), (ii) University of Management and Technology, Lahore ($N=11$) and (iii) The Agha Khan University Hospital ($n=9$).

The average research productivity of the top 31 authors is also low, with just 2.48 highly cited publications per author. The top most productive authors of HCPs in Pakistan: (i) Z.A. Bhutta (Aga Khan Univ., Karachi) (ii) I. Ullah (Gandhara Univ.,

Table 6: Cluster Numbers, Unique Occurrences, and Total Links to 39 Significant Keywords.

Rank	Keyword	Cluster	occurrences	Total Co-occurrences	Frequency	Rank	Keyword	Cluster	Unique occurrences	Total Co-occurrences	Frequency
1	COVID-19	3	77	419	113	40	Genetic variability	4	9	16	5
2	Virus pneumonia	5	61	279	47	41	Hypertension	2	15	25	5
3	Pneumonia, viral	5	61	273	46	42	Isolation	1	26	42	5
4	Mental health	1	34	175	22	43	Molecular docking	5	13	23	5
5	Virology	2	42	131	22	44	Molecular docking simulation	5	13	23	5
6	Psychology	1	38	162	21	45	Posttraumatic stress disorder	1	23	50	5
7	Quarantine	1	32	119	16	46	Psychological well-being	1	26	61	5
8	Prevention and control	3	38	72	13	47	Stock market	7	2	5	5
9	Anxiety	1	29	115	12	48	Tuberculosis	3	19	27	5
10	Antivirus agent	2	34	81	11	49	United Kingdom	4	30	37	5
11	Mental stress	1	26	87	11	50	Adult respiratory distress syndrome	2	15	26	4
12	Hydroxychloroquine	2	34	84	10	51	Air pollution	3	7	15	4
13	Immunology	4	30	70	10	52	Angiotensin-converting enzyme 2	4	15	23	4
14	Social media	3	25	41	10	53	Antibodies, viral	4	18	31	4
15	Angiotensin Converting enzyme 2	4	26	42	9	54	Antiviral therapy	2	27	36	4
16	Antiviral agents	2	31	66	9	55	Artificial intelligence	3	12	18	4
17	Deep learning	3	13	27	9	56	Coping behavior	1	27	44	4
18	Genetics	4	34	70	9	57	Coronavirus spike glycoprotein	4	17	25	4

Rank	Keyword	Cluster	occurrences	Total Co-occurrences	Frequency	Rank	Keyword	Cluster	Unique occurrences	Total Co-occurrences	Frequency
19	Remdesivir	2	33	78	9	58	COVID-19 testing	2	19	25	4
20	Social isolation	1	28	83	9	59	Drug therapy	2	24	36	4
21	COVID-19 vaccines	3	32	63	8	60	Dyspnea	2	24	29	4
22	Depression	1	26	82	8	61	E-learning	6	5	8	4
23	Diabetes mellitus	2	25	49	8	62	Fatigue	2	37	45	4
24	Education	6	23	40	8	63	Financial market	7	2	3	4
25	Mental disease	1	27	83	8	64	Learning systems	3	6	10	4
26	Social distance	1	32	70	8	65	Lopinavir	2	18	35	4
27	Stress, psychological	1	23	73	8	66	Misinformation	3	16	22	4
28	Chloroquine	2	29	55	7	67	Oseltamivir	2	17	28	4
29	Fear	1	27	77	7	68	Prediction	5	22	29	4
30	Obesity	2	26	39	7	69	Ritonavir	2	18	35	4
31	Sars-cov-2 vaccine	3	32	56	7	70	Social support	1	20	33	4
32	Social distancing	6	33	45	7	71	Steroid	2	25	37	4
33	Vaccination	3	33	47	7	72	Stigma	1	19	39	4
34	Adverse event	3	20	35	6	73	Stress	1	19	42	4
35	Diagnosis	3	30	43	6	74	Suicide	1	17	28	4
36	Machine learning	3	6	13	6	75	Tozinameran	4	27	36	4
37	Mental health service	1	21	55	6	76	Vaccine hesitancy	3	11	15	4
38	Azithromycin	2	21	37	5	77	Virus antibody	4	18	31	4
39	Distress syndrome	1	21	44	5	78	Virus genome	4	11	21	4

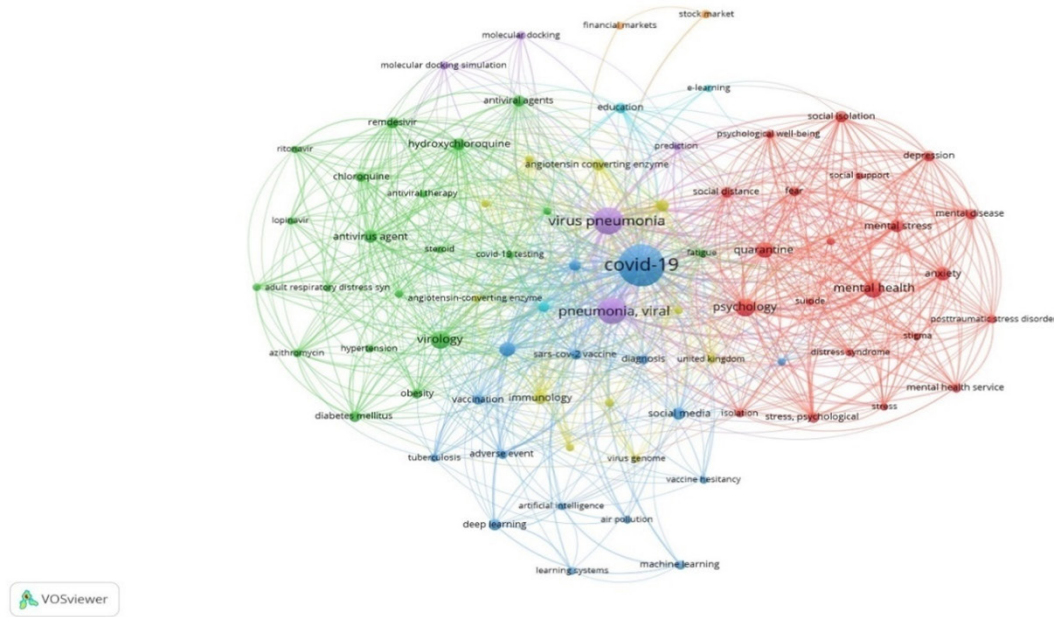


Figure 4: Cluster map of 78 significant Keywords ($n=4$)

Peshawar) ($n=5$ each) and (iii) S. Mukhtar (Univ. of Management and Technology, Lahore) ($n=4$).

LIMITATIONS

The data for this study was sourced from the Scopus database. The limitation is that depending upon a single database we might have missed out on some additional records had the data search been expanded to cover other databases (e.g., PubMed/Medline and Google Scholar).

CONCLUSION

It is the institutional collaboration activity with leading foreign countries that has brought Pakistan to the centre stage in COVID-19 research. The USA, China, and the UK are the leading countries with which Pakistan has undertaken most research collaboration activities. The support that Pakistan received from external funding agencies from the USA and the UK is yet another cornerstone that has been instrumental in driving the quality of its output in COVID-19 research in the country. Overall, the share of quality output of Pakistan at present is still small less than 2% of its total output in COVID-19. research This shows that there exists a wide gap in the quantity and quality of research output in Pakistan in the area of COVID-19 studies. Pakistan will have to work out appropriate policy-based strategies to fill the gap. In 36 international collaborative HCPs, Pakistan was the lead country. This strengthens the view that Pakistan still has great potential to address the challenging health problems in the area of COVID-19.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

- Abid, K., Bari, Y. A., Younas, M., Tahir Javaid, S., and Imran, A. (2020). Progress of COVID-19 Epidemic in Pakistan. *Asia Pacific Journal of Public Health*, 32(4), 154–156. DOI: 10.1177/1010539520927259
- Bormann, L., Mutz, R., Neuhaus, C., and Daniel, H. (2008). Citation counts for research evaluation: standards of good practice for analyzing bibliometric data and presenting and interpreting results. *Ethics in Science and Environmental Politics*, 8, 93–102. DOI: 10.3354/esepp00084
- Chuang, K.-Y., Chuang, Y.-C., Ho, M., and Ho, Y.-S. (2011). Bibliometric analysis of public health research in Africa: The overall trend and regional comparisons. *South African Journal of Science*, 107 (5/6). DOI: 10.4102/sajs.v107i5/6.309
- Di Girolamo, N., and Meursing Reynders, R. (2020). Characteristics of scientific articles on COVID-19 published during the initial 3 months of the pandemic. *Scientometrics*, 125(1), 795–812. DOI: 10.1007/s11192-020-03632-0
- Gupta, B. M. (2021). India's Research on COVID-19: A Scientometric Assessment of Publications 2019-21. *Journal of Young Pharmacists*, 13(3s), s30–s41. DOI: 10.5530/jyp.2021.13s.68
- Gupta, B. M., Dhawan, S. M., and Surulathi, M. (2021). Select South Asian Countries in COVID-19 Research: A Bibliometric Assessment of their Publications during 2019-21. *Journal of Young Pharmacists*, 13(3s), s19–s29. DOI: 10.5530/jyp.2021.13s.67
- Gupta, B. M., Kappi, M., Bansal, J., Walke, R., and Mamdapur, G. M. N. (2023). Scientometric Analysis of Top 100 High Cited Papers on COVID-19 Research in Nepal: A Study. *Indian Journal of Information, Library and Society*, 36 (1–2), 43–56.
- Gupta, B. M., Kappi, M., Walke, R., and Bansal, M. (2023). COVID-19 research in Bangladesh: A scientometric analysis during 2020-23. *Iberoamerican Journal of Science Measurement and Communication*, 3(1). DOI: 10.47909/ijsmc.445
- Naseer, B., Ali, M., and Azhar, N. (2023). COVID-19 research in South Asia: a bibliometric analysis of the 100 most-cited articles. DOI: 10.3205/DGKH000448
- Schui, G., and Krampen, G. (2010). Bibliometric Analyses on the Emergence and Present Growth of Positive Psychology. *Applied Psychology: Health and Well-Being*, 2(1), 52–64. DOI: 10.1111/j.1758-0854.2009.01022.x
- Shah, S. A. H., and Shaikh, M. A. (2020). COVID-19 (SARS-CoV-2) and Bibliometrics of Pakistani Research: COVID-19 and Pakistan. LAP LAMBERT Academic Publishing.
- Ullah, M. (2023). Bibliometric Analysis of Pakistani Medical Journals Evidenced Exponential Growth of Coronavirus Disease–Related Publications. *Journal of Electronic Resources in Medical Libraries*, 20(1), 1–14. DOI: 10.1080/15424065.2023.2180125
- Vaishya, R., Gupta, B. M., Misra, A., Mamdapur, G. M. N., Walke, R., and Vaish, A. (2023). Top 100 highly cited papers from India on COVID-19 research: A bibliometric analysis of

- the core literature. *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, 17(11), 102898. DOI: 10.1016/j.dsx.2023.102898
- World Health Organization. (2020, April 9). Coronavirus disease 2019 (COVID-19) pandemic: Overview. <https://www.who.int/europe/emergencies/situations/covid-19>
- World Health Organization. (2023). WHO Coronavirus (COVID-19) Dashboard. <https://COVID19.who.int>
- Van Raan, A. (2003). The use of bibliometric analysis in research performance assessment and monitoring of interdisciplinary scientific developments. *TATuP-Zeitschrift Für Technikfolgenabschätzung in Theorie Und Praxis*, 12(1), 20–29. DOI: 10.14512/tatup.12.1.20

Cite this article: Gupta BM, Dhawan SM, Singh Y, Srivastava N, Vaishya R, Kappi M, *et al.* A Scientometric Analysis of Highly Cited Papers of Pakistan in COVID-19 Research 2020-2023. *Journal of Data Science, Informetrics, and Citation Studies*. 2024;3(2):123-37.

Supplementary Table 1: List of Top 15 HCPs in COVID-19 by Pakistan.

Sl. No.	Name of the authors	Title	Source	No. of citations
1	Pan, H, Raza, A <i>et al.</i>	Repurposed antiviral drugs for COVID-19- InteriM WHO solidarity trial results. (2021).	New England Journal of Medicine, 2021, 384 (6), pp. 497-511.	1601
2	Baig, A.M, Khaleeq, A. <i>et al.</i>	Evidence of the COVID-19 Virus Targeting the CNS: Tissue Distribution, Host-Virus Interaction, and Proposed Neurotropic Mechanisms. <i>ACS Chemical Neuroscience</i> , 2020, 11 (7), pp. 995-998. Cited 1468 times.	<i>ACS Chemical Neuroscience</i> , 2020, 11 (7), pp. 995-8.	1468
3	Peeri, N.C., Shrestha, N. <i>et al.</i>	. The SARS, MERS and novel coronavirus (COVID-19) epidemics, the newest and biggest global health threats: what lessons have we learned?	<i>International Journal of Epidemiology</i> , 2021, 49 (3), pp. 717-26.	936
4	Gunnell, D, Khan, M. <i>et al.</i>	Suicide risk and prevention during the COVID-19 pandemic.	<i>The Lancet Psychiatry</i> , 2020, 7 (6), pp. 468-71.	921
5	Chowdhury, M.E.H., Rahman, T. <i>et al.</i>	Can AI Help in Screening Viral and COVID-19 Pneumonia?	<i>IEEE Access</i> , 2020, 8, art. no. 9144185, pp. 132665-76.	872
6	Sharif, A. <i>et al.</i>	COVID-19 pandemic, oil prices, stock market, geopolitical risk and policy uncertainty nexus in the US economy: Fresh evidence from the wavelet-based approach.	<i>International Review of Financial Analysis</i> , 2020, 70, art. no. 101496	852
7	Villar, J, Ariff, S. <i>et al.</i>	Maternal and Neonatal Morbidity and Mortality among Pregnant Women with and without COVID-19 Infection: The INTERCOVID Multinational Cohort Study.	<i>JAMA Pediatrics</i> , 2021, 175 (8), pp. 817-26.	755
8	Cameroni, E, Iqbal, N.T. <i>et al.</i>	Broadly neutralizing antibodies overcome SARS-CoV-2 Omicron antigenic shift.	<i>Nature</i> , 2022, 602 (7898), pp. 664-70.	625
9	Mukhtar, K., Javed, K. <i>et al.</i>	Advantages, limitations and recommendations for online learning during COVID-19 pandemic era.	<i>Pakistan Journal of Medical Sciences</i> , 2020, 36 (COVID19-S4), pp. S27-S31.	595
10	Solís Arce, J.S, Asad, S. <i>et al.</i>	COVID-19 vaccine acceptance and hesitancy in low- and middle-income countries.	<i>Nature Medicine</i> , 2021, 27 (8), pp. 1385-1394	563
11	Khailany, R.A., Safdar, M., <i>et al.</i>	Genomic characterization of a novel SARS-CoV-2.	<i>Gene Reports</i> , 2020, 19, art. no. 100682.	563

Sl. No.	Name of the authors	Title	Source	No. of citations
12	Jiang, L., Bhutta, Z.A. <i>et al.</i>	COVID-19 and multisystem inflammatory syndrome in children and adolescents.	The Lancet Infectious Diseases, 2020, 20 (11), pp. e276-e288.	
13	Bashir, M.F., Bashir, M. <i>et al.</i>	Correlation between climate indicators and COVID-19 pandemic in New York, USA.	Science of the Total Environment, 2020, 728, art. no. 138835.	488
14	Ejaz, H., Alsrhani, A. <i>et al.</i>	COVID-19 and comorbidities: Deleterious impact on infected patients.	Journal of Infection and Public Health, 2020, 13 (12), pp. 1833-9.	466
15	Rahman, T., Khan, M.S. <i>et al.</i>	Exploring the effect of image enhancement techniques on COVID-19 detection using chest X-ray images.	Computers in Biology and Medicine, 2021, 132, art. no. 104319.	457