DSX 17 (2023) 102898

Contents lists available at ScienceDirect

Diabetes & Metabolic Syndrome: Clinical Research & Reviews

journal homepage: www.elsevier.com/locate/dsx

Top 100 highly cited papers from India on COVID-19 research: A bibliometric analysis of the core literature

Raju Vaishya [a,*], Brij Mohan Gupta [b], Anoop Misra [c,d], Ghouse Modin N. Mamdapur [e], Rajpal Walke [f], Abhishek Vaish [a]

[a] Indraprastha Apollo Hospitals, New Delhi, India
[b] Formerly with CSIR-NISTADS, New Delhi, 110012, India
[c] Fortis C-DOC Center of Excellence for Diabetes, Metabolic Diseases, and Endocrinology, B-16, Chirag Enclave, New Delhi, India
[d] National Diabetes, Obesity and Cholesterol Foundation (N-DOC), Diabetes Foundation (India) (DFI), India
[e] Yenepoya (Deemed to be University), Mangalore, 575018, India
[f] CSIR-NPL, New Delhi, 110012, India

ARTICLE INFO

Keywords:
COVID-19
Pandemics
SARS-CoV-2
Bibliometrics
Publications
Data management
Top-cited articles

ABSTRACT

Background and aims: This study aimed to assess the current status of India's COVID-19 research from the top 100 most cited papers, using bibliometrics methods and indicators and suggest strengths and weaknesses.
Methodology: Publications on COVID-19 research from India between December 2019 and 22 August 2023 were retrieved from the Scopus database. From 37101 studies retrieved, the first top 100 Highly Cited Papers (HCPs) having received 270 to 2931 citations, were identified.
Results: The top 100 most cited Indian papers were published from 2020 to 2023, with the majority (75) in the year 2021, followed by 24 in 2022. They were cited a total of 56661 times (average - 566.61 times). The 242 authors of these HCPs were from 159 Indian organizations, and the articles were published in 60 journals. 29 % and 59 % of these HCPs received external funding support and were involved in international collaborations, respectively. There was poor collaboration among Indian research institutions and a dearth of funding from India. None of the Indian HCPs figured in the global 100 HCPs.
Conclusions: Although citations of research papers published from India increased during COVID-19, limited collaboration, inadequate funding, and subpar publications hindered Indian scientists. To enhance India's research landscape, we propose dismantling barriers, nurturing collaboration, and encouraging knowledge exchange among domestic institutions.

1. Introduction

The World Health Organization (WHO) declared the outbreak of coronavirus infections a pandemic on 11 March 2020 [1,2] and the pandemic was declared as no longer a "global health emergency" on 5th May 2023 b y the WHO [3]. COVID-19 cases are still prevalent in. According to the WHO, COVID-19 dashboard, as of 9 August 2023, there have been global 769, 369, 823 confirmed cases of COVID-19, including 6,954,336 deaths in more than 200 countries. In India, from 3rd January 2020 to 9th August 2023, there have been 44, 996, 059 confirmed cases of COVID-19 with 531,918 reported deaths [4,5].

The global scientific community has made substantial contributions through collective research related to COVID-19, which helped to enhance our understanding of the disease, tackle challenges in its prevention, elucidate its consequences, propose effective solutions, and illuminate potential pitfalls encountered in the implementation of prevention and treatment strategies [6]. The quantum of published literature from the scientific community on this theme has increased resulting in a better understanding of the disease's various factors [7,8].

Bibliometric assessments are quantitative analyses and evaluations of scientific publications, typically used to measure the impact and influence of research outputs, authors, journals, or institutions within a specific field of study. The primary aim of bibliometric assessments is to provide insights into the visibility, relevance, and quality of scholarly

* Corresponding author. Department of Orthopaedics Indraprastha, Apollo Hospitals Sarita Vihar, New Delhi, 110076, India.
E-mail addresses: raju.vaishya@gmail.com (R. Vaishya), bmgupta@gmail.com (B.M. Gupta), anoopmisra@gmail.com (A. Misra), ghouse@synthite.com (G.M.N. Mamdapur), rajpalw@gmail.com (R. Walke), drabhishekvaish@gmail.com (A. Vaish).

https://doi.org/10.1016/j.dsx.2023.102898
Received 11 September 2023; Received in revised form 15 October 2023; Accepted 19 October 2023
Available online 7 November 2023

work [9]. It uses bibliometric and visual mapping techniques to evince connections between the main publications, authors, institutions, themes, and other characteristics of the field [10]. The highly cited papers (HCP) are central to mainstream research and offer a greater chance of visibility. The HCP evaluation provides evidence and information about research trends and scientific progress in a specific field [11–13].

Many bibliometric studies have been performed concerning overall global COVID-19 research [14], but the specific subject of COVID-19 research from India remained comparatively less explored. There are some bibliometric studies on COVID-19 research from India [15–20], but their coverage was restricted to literature published up to 2020–2021. Currently, in 2022, India stood at 3rd rank in the global output of publications in all subject areas and 5th in Medicine [21]. Since India's publications have substantially increased, it would be useful to analyze only HCPs, which will throw light on the quality of research in the country.

We aimed to evaluate qualitatively and quantitatively the top 100 HCPs in the field of COVID-19 research from India to study the overall trends, analyze the funding and collaboration characteristics, identify the major players (organizations, authors and journals), explore major themes being pursued using significant keywords, besides analyzing and constructing visualization network of co-authorship of organizations and authors, co-occurrence of keywords and co-citation of sources to provide a reference for future research in this field.

2. Methodology

2.1. Search strategy

For identification, retrieval and downloading of relevant papers on COVID-19 search from India, covering literature till July 22, 2023, a comprehensive search strategy was developed and applied in the "Advanced Research Section" in the Scopus database. The search strategy used various keywords related to "Covid-19" in "TITLE-ABS-KEY" tag and restricted the search to India in "Affilcountry" Tag.

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 (PUBYEAR, 2023) OR LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020)) AND (LIMIT-TO (AFFILCOUNTRY, "India"))

The search yielded 37101 records, which were subsequently rearranged in the decreasing order of citations to identify the first top 100 HCPs. These papers were further analyzed using analytical provisions provided in the Scopus database for refining the retried records by broad subject area, document type, source type, organizations, author, journal, and keywords.

2.2. Data collection

We collected the following bibliometric information: year of publication; country of origin; article type, published journal; citation count; and authorship for each record identified, among the top 100 HCPs, information related to citation counts, authors and organizations and their affiliations, year of publication, source journal, geographical origin, subject, article type, funding details, etc. were retrieved for further analysis.

2.3. Data analysis

The publication data of the first 100 HCPs were exported as Comma Separated Values (CSV) files and imported by VOSviewer software (https://www.vosviewer.com/), which provides a network visualization of the publications, including bibliographic coupling, co-authorship, co-citation, and co-occurrence analysis of publications, countries, organizations, authors, journals, and keywords. Labels represent items in the network visualization using circles. The weight of an item determines the size of the label and the circle around it. An item's colour is determined by the cluster to which it belongs. The lines between items represent links [8].

The top 100 HCPs, with the highest number of citations, were included in this study as per their number of citations chronologically (from higher to the lower). The most productive authors and institutions were defined as those with the maximum number of publications. Whereas the most impactful authors and institutions were considered those with the highest Citations Per Paper (CPP) and Relative Citation Index (RCI). The CPP means the number of citations received by each paper, whereas the RCI weighs the number of citations that a paper receives to a comparison group within the same field. The International Collaborative Papers (ICP) are those where Indian authors and institutions have collaborated with an international author or institution. Total link strength (TLS) indicates the number of links of an item with other items and the total strength of the links of an item with other items.

3. Results

3.1. Highly cited papers (HCPs)

From the 37,101 papers on COVID-19 research from India, the top 100 received 270 to 2931 citations and are assumed as HCPs). Among these, 75 % were published in 2020, followed by 24 % in 2021 and 1 % in 2022. Together, the first 100 HCPs registered 56,661 citations, averaging 566.61 citations per paper (CPP). These HCPs showed an uneven distribution of citations received: 66 fell in the citation range 270–487, 24 in 596–986 and 10 in 1020–2931. Among the document types, research articles (61.0 %) constitute the largest output among the top 100 HCPs, followed by reviews (28.0 %), editorials and letters (7.0 % each).

Only 29 % of the top 100 HCPs received extramural funding from more than 100 national and international foreign funding agencies and together, have received 18933 citations, averaging 652.86 CPP. Among external funding agencies supporting India's research in this area (along with their output), the most significant were: the National Institute of Health (NIH), USA (n = 8), National Institute of Allergy & Infectious Diseases, USA (n = 7), Bill & Melinda Gates Foundation, USA, the Welcome Trust, U.K., European Commission and Medical Research Council (n = 5 each), National Health & Medical Research Council, U.K, Research & Innovation, India, Indian Council of Medical Research (n = 4 each), India, National Institute of Mental Health, USA (n = 3), Pfizer, USA, European Regional Development Fund, Belgium and the WHO (n = 2 each), etc. (Supplementary Table 1).

Among 100 HCPs, clinical studies account for the most studies (28 %) followed by epidemiology, pathophysiology, and risk factors (15 % each), genetics (13 %), complications (12 %), diagnosis (8 %), prognosis (5 %), treatment outcome (3 %) and adverse events (1 %). Among publication design, original research accounted for the most (16 %), followed by clinical trials (10 %), randomized clinical trials (RCTs) (5 %), cross-sectional studies and others (3 %).

Of the first 100 HCPs from India, 16 were involved in single organization participation (no collaboration), while 84 were involved in the collaborative participation of 2 or more organizations: 25 national and 59 internationals. Amongst the top 100 HCPs, 59 % were ICPs and these together receive 34650 citations, averaging 587.29 CPP, with the largest foreign participation coming from the USA (32.0 %), followed by U.K. (26.0 %), China (16.0 %), Australia (15.0 %), and Brazil (14.0 %) (Fig. 1). The Highest citation impact made by these ICPs were from Israel (1213.7 CPP), Norway (1007.5 CPP), Columbia (957.63 CPP), France

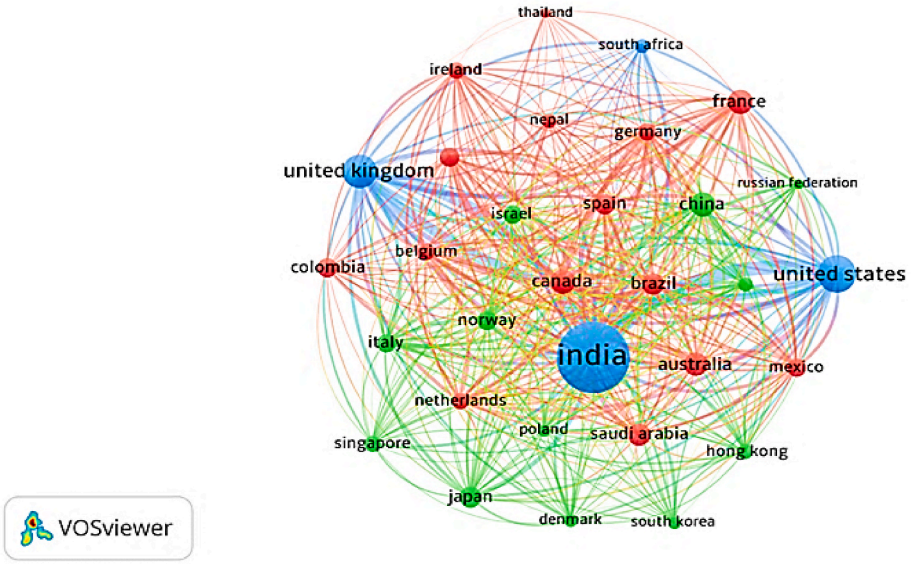

Fig. 1. Co-authorship Map of the Most Productive Countries Producing Highly Cited Papers published During the COVID-19 Pandemic.
(The largest set of connected countries consists of 15 countries in 1 cluster (red colour). These 31 countries have been divided into 3 clusters with 450 links and a total link strength (TLS) of 2164. Each node represents a country, and its size indicates its productivity. The lines connecting the nodes depict their collaboration, and the thickness of the links represents the level of collaboration).

(926.92 CPP), and Hong Kong (914.67 CPP). Indian authors were the first authors in 18 papers, followed by the authors from the U.K. (n = 9), USA (n = 7), Singapore (n = 4), and Australia and Canada (n = 3 each) (Fig. 1).

A list of the top 10 HCPs on COVID-19 research by the Indian authors is provided in Supplementary Table 2.

3.2. Most productive and impactful organizations

In all, 159 Indian organizations participated in the top 100 HCPs. The top 26 organizations contributed 2 to 7 papers and these together contributed 72 papers which received 38041 citations, accounting for more than 72.0 % and 67.14 % share each in India's top 100 HCPs and citations (Supplementary Table 3). On further analysis, it was observed that 11 organizations (7 government and 4 privately funded) were the most active and productive, as they contributed more than the average publication productivity (2.77) of all 26 organizations: The 13 organizations were more influential as they registered CPP and Relative Citation Index (RCI) of more than their group average (528.35 and 0.93) of top 26 organizations. Table 1 presents the bibliometric profile of the top 8 most productive and 8 most impactful organizations.

The TLS of the top 26 participating organizations varied from 1 to 573, with the Highest (573 TLS) depicted by Bai Jerbai Wadia Hospital For Children, Mumbai, followed by Indraprastha Apollo Hospital, New Delhi (n = 160), and Institute of Genomics & Integrated Biology, New Delhi (n = 87).

3.3. Most productive and impactful authors

In all, 242 Indian authors participated in the top 100 HCPs. The top 32 authors contributed 2 to 5 papers and these together contributed 79 papers which received 38882 citations, accounting for 79.0 % and 68.62 % share in India's top 100 HCPs and citations (Supplementary Table 4). On further analysis, it was observed that 8 authors among the top 32 were the most active and productive as they contributed more than the average group productivity (2.47) of all 32 authors. They were K. Dhama and A.K. Singh (n = 5 each), Y.S. Malik, R. Tiwari and A. Misra (n = 4 each), R. Vaishya, A. Haleem and M. Javaid (n = 3 each). Table 2 presents the profile of the 8 most productive and 8 most impactful authors.

Table 1
Bibliometric profile of the top eight most productive and impactful organizations.

S. No.	Name of the Organization	TP	TC	CPP	RCI	TLS
Top Eight Most Productive Organizations						
1	Postgraduate Institute of Medical Education and Research, Chandigarh, Union Territory	7	2490	355.71	0.63	38
2	Indian Veterinary Research Institute, Bareilly, Uttar Pradesh	5	3266	653.20	1.15	56
3	Jamia Milia Islamia, New Delhi, Delhi	5	2919	583.80	1.03	16
4	G. D. Hospital and Diabetes Institute, Kolkata, West Bengal	4	1466	366.50	0.65	14
5	National Institute of Mental Health and Neuroscience, Bangalore, Karnataka	4	1848	462.00	0.82	57
6	Indraprastha Apollo Hospital, New Delhi, Delhi	3	1841	613.67	1.08	65
7	Apollo Specialty Hospital, Chennai, Tamil Nadu	3	2009	669.67	1.18	160
8	Mizoram University, Mizoram	3	1620	540.00	0.95	7
Top Eight Most Impactful Organizations						
1	Bai Jerbai Wadia Hospital For Children, Mumbai, Maharashtra	2	2793	1396.50	2.46	573
2	King George's Medical University, Lucknow, Uttar Pradesh	2	1813	906.50	1.60	1
3	National Centre for Disease Control, Delhi	2	1358	679.00	1.20	41
4	Apollo Specialty Hospital, Chennai, Tamil Nadu	3	2009	669.67	1.18	160
5	Indian Veterinary Research Institute, Bareilly, Uttar Pradesh	5	3266	653.20	1.15	56
6	Behrampore Mental Hospital, Berhampore, Orissa	2	1269	634.50	1.12	10
7	Burdwan Medical College and Hospital, Burdwan, West Bengal	2	1269	634.50	1.12	10
8	Rajendra Institute of Medical Sciences, Ranchi, Jharkhand	2	1269	634.50	1.12	10

TP = Total papers; TC = Total citations; CPP=Citations per paper; RCI=Relative citation index; TLS = Total link strength.

Table 2
Bibliometric profile of the top eight most productive and impactful authors.

S. No.	Name of authors	Affiliation of authors	TP	TC	CPP	RCI	TLS
Eight Most Productive Authors							
1	K. Dhama	Indian Veterinary Research Institute, Bareilly, Uttar Pradesh	5	3266	653.2	1.15	1
2	A.K. Singh	GD Hospital and Diabetes Institute, Kolkata, West Bengal	5	1920	384	0.68	2
3	Y.S. Malik	Indian Veterinary Research Institute, Bareilly, Uttar Pradesh	4	1716	429	0.76	3
4	R. Tiwari	Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan, Mathura, Uttar Pradesh	4	1716	429	0.76	4
5	A. Misra	Fortis CDOC Hospital for Diabetes and Allied Sciences, New Delhi, Delhi	4	1584	396	0.70	5
6	R. Vaishya	Indraprastha Apollo Hospital, New Delhi, Delhi	3	1841	613.67	1.08	6
7	A. Haleem	Jamia Millia Islamia, New Delhi, Delhi	3	1591	530.33	0.94	7
8	M. Javaid	Jamia Millia Islamia, New Delhi, Delhi	3	1591	530.33	0.94	8
Eight Most Impactful Authors							
1	M. Desai	Bai Jerbai Wadia Hospital for Children, Mumbai, Maharashtra	2	2793	1396.5	2.46	803
2	D. Roy	King George's Medical University, Lucknow, Uttar Pradesh	2	1813	906.5	1.60	2
3	K. Dhama	Indian Veterinary Research Institute, Bareilly, Uttar Pradesh	5	3266	653.2	1.15	27
4	M.J. Dubey	Behrampore Mental Hospital, Behrampore, Orissa	2	1269	634.5	1.12	6
5	S. Dubey	Institute of Post Graduate Medical Education and Research & SSKM Hospital, Kolkata, West Bengal	2	1269	634.5	1.12	10
6	R. Ghosh	Burdwan Medical College and Hospital, Burdwan, West Bengal	2	1269	634.5	1.12	10
7	R. Vaishya	Indraprastha Apollo Hospital, New Delhi, Delhi	3	1841	613.67	1.08	68
8	A. Haleem	Jamia Millia Islamia, New Delhi, Delhi	3	1591	530.33	0.94	11

TP = Total papers; TC = Total citations; CPP=Citations per paper; RCI=Relative citation index; TLS = Total link strength.

Fig. 2 presents a co-authorship map of the top 32 authors, each with at least 2 publications. Among these 32 authors, connections exist between some of them, and they have been divided into 9 clusters with 58 links and a TLS of 111. The co-citation analysis presents nine clusters of authors and their respective link strengths, providing insights into their contributions to the field of top 100 HCPs in COVID-19.

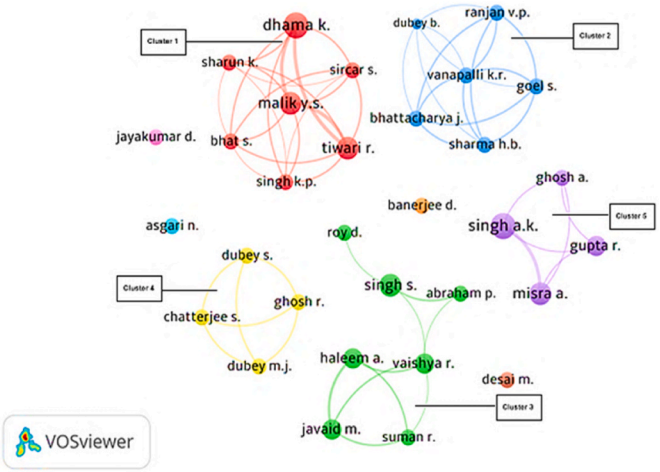

Fig. 2. Co-authorship Network Map of 32 Authors
(Each node in the map represents an author, and the size of the node corresponds to the author's productivity (i.e., the number of publications). The lines connecting the nodes illustrate the collaboration between the authors, with the thickness of the links indicating the level of collaboration between them).

3.4. Most productive and impactful journals

The 100 HCPs were published in 60 journals (Supplementary Table 5). *Diabetes and Metabolic Syndrome: Clinical Research & Reviews* was among the top 60 contributing journals and had the most publications (n = 11), followed by *Science of the Total Environment* (n = 7), *Asian Journal of Psychiatry*, *The BMJ* (n = 5 each) and *Nature* (n = 3). However, the most cited journal was the *Indian Journal of Pediatrics (2010.0 CPP)*, followed by *Travel Medicine & Infectious Disease (1550.0 CPP), Science*

Table 3
Profile of the top six journals by publication productivity, citations per paper and journal impact factor.

S. No.	Name of the journal	TP	TC	CPP	JIF (2022)
Top Six Journals by Number of Papers					
1	Diabetes and Metabolic Syndrome: Clinical Research & Reviews, India	11	5388	489.82	10.00
2	Science of the Total Environment, Netherlands	8	4243	530.38	10.94
3	Asian Journal of Psychiatry, Netherlands	6	5148	858.00	13.89
4	The BMJ, UK	5	1938	387.60	105.7
5	The Lancet, UK	3	3661	1220.33	168.9
6	New England Journal of Medicine, USA	3	2486	828.67	158.5
Top Six Journals by Citations per Paper					
1	Indian Journal of Pediatrics, India	1	2010	2010.00	4.3
2	Travel Medicine & Infectious Disease, Multinational	1	1550	1550.00	20.44
3	Science, USA	2	2793	1396.50	14.9
4	The Lancet Neurology, UK	1	1231	1231.00	48
5	The Lancet, UK	3	3661	1220.33	168.9
6	Brain, Behavior & Immunity, USA	1	975	975.00	15.1
Top Six Journals by Journal Impact Factor					
1	The Lancet, UK	3	3661	1220.33	168.9
2	New England Journal of Medicine, USA	3	2486	828.67	158.5
3	JAMA - Journal of the American Medical Association, USA	2	1393	696.50	157.37
4	The BMJ, UK	5	1938	387.60	105.7
5	The Lancet Respiratory Medicine, UK	1	959	959.00	76.2
6	The Lancet Infectious Disease, UK	1	435	435.00	71.421

TP = Total papers; TC = Total citations; CPP=Citations per paper; JIF = Journal Impact Factor.

(1396.5 CPP), The Lancet Neurology (1231.0 CPP), and The Lancet (1220.33 CPP). Table 3 lists the top six journals by publication productivity, CPP and Journal Impact Factor (JIF).

3.5. Distribution by subject and Co-occurrence of keywords

3.5.1. Subject-wise distribution of highly cited papers

Amongst the top 100 HCPs on COVID-19 research from India, the subject category of General Medicine contributed the largest share (64.0 %), followed by Environment Science (15.0 %), and Immunology & Microbiology (9.0 %). In terms of CPP, Psychology registered the Highest (731.57 CPP) and Veterinary Science the lowest (308.0 CPP) (Table 4).

3.5.2. Significant keywords

A total of 1980 author keywords were identified from the first top 100 HCPs on COVID-19 research from India. The frequency of occurrence of keywords indicates their importance in this area. Of the 1980 keywords, the 106 significant keywords were selected with a frequency of 1–79 and presented in Supplementary Table 6, and Supplementary Fig. 1.

4. Discussion

The HCPs often demonstrate the novelty of research and may provide comprehensive guidance to a field of research on real-world applications. These also help to lay the groundwork for new or emerging aspects and fields within the area of research. The bibliometric assessments that are considered superior to the traditional peer-review methods remain a matter of debate. The citations reflect the research aspects related to scientific impact and relevance, but there is no evidence to confirm that citations alone may reflect the research quality [22].

The conduct of research may entail expenses and hence funding is required to meet these expenses and smooth execution of research projects. High-end research like multi-centric studies, randomized controlled trials, experimental studies or observational studies with large sample sizes may not be possible without external funding. Many local, national, and international funding agencies can provide necessary research grants, and the researchers must be aware of their details and requirements [23]. We found that for India's top 100 HCPs on COVID-19 research, the major funding support came from the USA, while there was only a small contribution from Indian funding agencies. Hence, Indian funding agencies allocate more money to support the research activities of the Indian authors in such pandemic situations.

There has been an unprecedented surge in publications on COVID-19 since the disease started, especially in the early phase of the pandemic. The substantial quantum of publications on COVID-19 points towards the seriousness of this disease and the quest to find appropriate solutions to combat it. Ioannidis et al. [24] found that more than 700,000 scientists published COVID-19-related articles from January 2020 up to September 2021. Khambampati et al. [25] found a rate of COVID-19 publications 59 per day at the beginning of the pandemic in 2020. Another study reported ~137 papers being published daily between February to June 2020 [26]. Such a rate of publications is perhaps the highest for any disease so far [27]. Many authors have published COVID-19-related articles beyond their specialties, and this testifies to the attractiveness of COVID-19 as a field of research, which has been able to bring in specialists with expertise in diverse fields together, fostering interdisciplinarity research.

A bibliometric study in the early phase (between 3rd March to 8th May 2020) of the COVID-19 pandemic in India, showed eighty-nine publications by Indian authors. Of these, only 13 (14.60 %) articles were single-authored publications, whereas the remaining articles were authored collaboratively. Except for one (A. Misra), all the prolific authors (with more than 3 publications) were from government institutions, and the maximum contributions came from Delhi State [18]. In the present study, we also observed that four out of the top eight prolific authors were from Delhi, but not necessarily from Government funded organizations (Table 1). It is encouraging to note that the authors from privately funded Indian institutions have contributed to the high-impact COVID-19 research and we suggest it should be encouraged by providing access and opportunities for them to research funding by both the government and private funding agencies.

In our study, a low density of institutional collaboration networks was observed among Indian institutions. Few Indian organizations had strong TLS, but their collaborative linkages were mainly with foreign research organizations. The collaborative inter-institutional linkages of tertiary care academic organizations, such as All India Institute of Medical Sciences (AIIMS), New Delhi and Post Graduate Institute of Medical Education and Research (PGIMER), Chandigarh were comparatively weak. This could be due to a lack of inter-personal dialogue and collaborative relationship of the researchers between the institutions, and unawareness about the research activities in different institutes. We noticed many collaborative linkages among Indian authors within the same organizations, but their collaborative linkages from other organizations were weak (Fig. 2).

Interestingly, only one Indian journal i.e., *Diabetes and Metabolic Syndrome: Clinical Research & Reviews* had published the HCPs of Indian authors and the remaining HCPs were published by international journals (Table 3). It is therefore necessary that more Indian journals publish the Highly-quality research of the Indian authors, to address their local issues and research work.

Across all science branches, 98 of the 100 HCPs that were published in 2020–2021, were related to COVID-19. And 110 global scientists received ≥10,000 citations for their cumulative COVID-19 work, during this period. Interestingly, none of them received such a huge number of citations for non–COVID–19 work published in 2020–2021, pointing towards a strong tilt towards COVID-19-related research citations [28]. Hence, it can be derived that all the global authors who published on COVID-19-related issues, especially in the early course of the pandemic, received a high number of citations rapidly and these helped them to increase their publication metrics [28]. Ganesh et al. [29] found that the top 100 COVID-19 articles published globally in one year of COVID-19 research (i.e., in 2020) received citations ranging from 1147 to 20,440 per paper. The median (interquartile range [IQR]) number of citations was 1970 (1456–2939). The majority of the first authors of these global top 100 COVID-19 articles were from China (58 %), followed by the USA (16 %) and the UK (7 %). Most of the globally top-cited COVID-19

Table 4
Subject-wise distribution of highly cited papers by scopus subject categories.

S. No.	Name of the Subject*	TP	TC	CPP	S. No.	Name of the subject	TP	TC	CPP
1	General Medicine	64	38164	596.31	7	Business, Management & Accounting	6	2207	367.83
2	Environment Science	15	7151	476.73	8	Engineering	5	2203	440.60
3	Immunology & Microbiology	9	4099	455.44	9	Neuroscience	5	2709	541.80
4	Biochemistry, Genetics & Molecular Biology	8	3892	486.50	10	Pharmacology, Toxicology & Pharmaceutics	3	1005	335.00
5	Psychology	7	5121	731.57	11	Veterinary Science	2	616	308.00
6	Social Sciences	6	2169	361.50		India's total	100		

N.B.: There is an overlapping of literature under the various subjects.
TP = Total papers; TC = Total citations; CPP=Citations per paper.

literature were descriptive studies focusing on epidemiology (48 %) and clinical course (60 %). Brandt et al. [30] used the Web of Science (WOS)—Science Citation Index Expanded (SCIE) database to identify COVID-19 papers published in 24 major scientific journals over 24 months from 1st January 2020 to 31st December 2021. They found that these papers published in the past two years had a median citation rate of 120.79 compared to 21.63 for non-COVID-19 papers and demonstrated that there was more than 80 % increase in citations of COVID-19 papers compared to non-COVID-19 papers. Malekpour et al. [31] in a bibliometric study found that the majority of COVID-19 publications (70.8 %) were related to health sciences, followed by life sciences (23.1 %), social sciences (17.3 %), and physical sciences (12.9 %).

Further, the Journal Impact Factor (JIF) was positively affected by COVID-19 too. He et al. [32] studied 20 global health journals that published papers after the COVID-19 outbreak in February 2020. The total number of non-COVID-19 publications significantly decreased by 14.2 %, compared with the previous month, and since then, on average, the publications have decreased by 0.6 % per month until June 2022. The authors concluded that although the journals publishing on COVID-19-related research may benefit from increased JIFs, global health journals should avoid relying on such a single metric. Delardas et al. [33] observed a significant percentage increase in the JIF of following journal publishing on COVID-19, from 2019 to 2020 e.g., *Annals of Internal Medicine (Annals)*: 283 %; *British Medical Journal (BMJ)*: 199 %; *Journal of American Medical Association (JAMA)*: 208 %; *The Lancet*: 392 %; *Nature Medicine (NatMed)*: 111 %; and *New England Journal of Medicine (NEJM)*: 196 %. In addition, the citation rate for COVID-19 publications peaked in the second quarter of 2020. The inflated JIFs of these journals due to COVID-19-related publications create ambiguity as benchmark tools for assessing scholarly impact [33].

It is interesting to note that the 100 most influential/cited COVID-19 articles worldwide were mainly from China (n = 54), followed by the USA (n = 21) and the UK (n = 8), and none from India. All these articles were published in highly ranked, peer-reviewed journals, with research focusing on the diagnosis, transmission, and therapy of COVID-19. However, it is to be noted that the level of evidence of the 100 most cited COVID-19 articles on average was low [34]. Viswanathan et al. [35] studied the top 100 cited papers on T2D and COVID-19 globally and found that these were written by the first authors affiliated with institutes in the USA, the publication from China was the most influential.

4.1. Strengths and limitations of the study

Unlike previous bibliometric analyses, this bibliometric study has focused on the analysis of the most comprehensive literature on India's COVID-19 research to date and has Highlighted the HCPs. We acknowledge some limitations. Here, we used Scopus as the only database used for identification of major amassing publications, hence some publications included in other databases (e.g., WOS, PubMed and Google Scholar) might have been missed. We, however, believe that the use of the Scopus database for analysis provides a robust insight for understanding research performance focusing on COVID-19 research in India, as it covers all PubMed/Medline publications. Furthermore, mixing the information and data derived from the other sources would have been heterogeneous making the bibliometric analysis complex and inaccurate.

4.2. Study relevance and future directions

Our findings provide the global status, research hotspots and potential trends in the field of India's COVID-19 research, which may assist researchers in exploring the knowledge structure and understanding the future trends in India's COVID-19 research. Such bibliometric studies are helpful to clinicians, researchers, and policymakers in evaluating and understanding the knowledge structure and guiding the future development trends of global COVID-19 research. Practicing scholars may use such studies to identify potential collaborative partners and identify landmark studies and research topics within their domains of interest. The funding agencies may also use this study to assess ongoing research and future research trends in India's COVID-19 research.

5. Conclusion

In a study of COVID-19 research in India, we identified the top 100 most cited papers out of 37,101 records. These papers involved 242 Indian authors from 159 organizations and were published in 60 journals. Unfortunately, there was limited collaboration among Indian scientists, insufficient funding support, and a lack of high-quality publications, and none of the Indian papers made it to the top 100 globally. To improve research progress in India, we recommend breaking down barriers, fostering cooperation, and promoting exchange among Indian organizations. Notably, COVID-19 papers received significantly more citations than non-COVID-19 articles, leading to improved research and journal metrics for the authors and journals involved.

Funding

None.

Use of AI tool

None.

Ethical approval

Not required.

Data availability

The raw data is available with the corresponding author and can be provided if required.

Author's contribution

-RV: Conceptualization, Literature Search, Manuscript writing, editing and final approval -BMG: Conceptualization, Literature Search, Manuscript writing, editing and final approval-AM: Conceptualization, Literature Search, Manuscript writing, editing and final approval -GMNM: Data collection, Literature Search, Manuscript writing, editing and final approval -RW: Data collection, Literature Search, Manuscript writing, editing and final approval -AV: Literature Search, Manuscript writing, editing and final approval.

Declaration of competing interest

All the authors hereby declare that there is conflict of interest regarding this manuscript & no funding was received from any source.

We declare that this manuscript has been solely submitted to this journal and is not under consideration by any other journal.

All the research presented in this paper is original.

Acknowledgement

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dsx.2023.102898.

References

[1] WHO. Regulation and Prequalification. https://www.who.int/teams/regulation-prequalification/eul/covid-19 (Accessed on 16.August.2023).

[2] Mohan BS, Nambiar V. COVID-19: an insight into SARS-CoV-2 pandemic originated at wuhan city in hubei province of China. J Infect Dis Epidemiol 2020;6:146. https://doi.org/10.23937/2474-3658/1510146.

[3] World Health Organization. http://www.who.int/news/item/05-05-2023-statement-on-the-fifteenth-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-coronavirus-disease-(covid-19)-pandemic. [Accessed 31 August 2023].

[4] WHO Coronavirus (COVID-19) Dashboard. Global situation. https://covid19.who.int/. [Accessed 16 August 2023].

[5] WHO. Indian situation, https://covid19.who.int/region/searo/country/in. [Accessed 16 August 2023].

[6] Ghosh TK. "Bibliometric landscape of Indian publications on COVID-19 in 2020". 2021. Library Philosophy and Practice (e-journal). 5814, https://digitalcommons.unl.edu/libphilprac/5814.

[7] Ahmad T, Murad MA, Baig M, Hui J. Research trends in COVID-19 vaccine: a bibliometric analysis. Hum Vaccines Immunother 2021;17(8):2367–72. https://doi.org/10.1080/21645515.2021.1886806.

[8] Xu Z, Qu H, Ren Y, et al. Update on the COVID-19 vaccine research trends: a bibliometric analysis. Infect Drug Resist 2021;14:4237–47. https://doi.org/10.2147/IDR.S335745. Published 2021 Oct 14.

[9] Chen C. Searching for intellectual turning points: progressive knowledge domain visualization. Proc Natl Acad Sci USA 2004;101:5303–10.

[10] Tchuente D, Nyawa S, Wamba SF. COVID-19 vaccine global information management through bibliometrics. J Global Inf Manag 2021;29(6):1–22. https://doi.org/10.4018/JGIM.

[11] Shah SM, Ahmad T, Chen S, Yuting G, Liu X, Yuan YA, et al. Bibliometric analysis of the one hundred most cited studies in psychosomatic research. Psychother Psychosom 2021;90:425–30.

[12] Wohlin C. An Analysis of the most cited articles in software engineering journals – 1999. Inf Software Technol 2005;47(15):957–64.

[13] Fardi A. Top-cited articles in endodontic journals. J Endocrinol 2011;37(9):1183–90.

[14] Gupta BM, Dhawan SM, Mueen Ahmed KK, Mamdapur GN. Global research on COVID-19 disease: a scientific assessment of publications during 2020-21. Int J Med Publ Health 2021;11(2):76–84.

[15] Gupta BM. India's research on covid-19: a scientometric assessment of publications 2019-21. J Young Pharm 2021;13(3):s30–41. Suppl.

[16] Kaur H, Kaur M, Bhattacharyya A, et al. Indian contribution toward biomedical research and development in COVID-19: a systematic review. Indian J Pharmacol 2021;53(1):63–72. https://doi.org/10.4103/ijp.ijp_168_21.

[17] Pathak M. Covid-19 research in India: a quantitative analysis. Indian J Biochem Biophys. June 2020;57(3):351–5.

[18] Vr N, Patil SB. Indian Publications on SARS-CoV-2: a bibliometric study of WHO COVID-19 database. Diabetes Metabol Syndr 2020;14(5):1171–8. https://doi.org/10.1016/j.dsx.2020.07.007.

[19] Prajapati AR, Kanadia P. India's contribution to Covid-19 research: a bibliometric study. BiblioMed JCR 2020;7(15):5883–97. https://doi.org/10.31838/jcr.07.15.761.

[20] Raman R, Vinuesa R, Nedungadi P. Bibliometric Analysis of SARS, MERS, and Covid-19 Studies from India and connection to sustainable development goals. Sustainability 2021;13(14):7555. https://doi.org/10.3390/su13147555.

[21] SCImago country rankings. SJR – International Science Ranking (scimagojr.com); 2022. . [Accessed 2 September 2023].

[22] Aksnes DW, Langfeldt L, Wouters P. Citations, citation indicators, and research quality: an overview of basic concepts and theories. Sage Open 2019;9(1). https://doi.org/10.1177/2158244019829575.

[23] Neema S, Chandrashekar L. Research funding-why, when, and how? Indian Dermatol Online J 2021 Jan 16;12(1):134–8. https://doi.org/10.4103/idoj.IDOJ_684_20. PMID: 33768035; PMCID: PMC7982031.

[24] Ioannidis JPA, Salholz-Hillel M, Boyack KW, Baas J. The rapid, massive growth of COVID-19 authors in the scientific literature. R Soc Open Sci 2021 Sep 7;8(9):210389. https://doi.org/10.1098/rsos.210389. PMID: 34527271; PMCID: PMC8422596.

[25] Kambhampati SBS, Vaishya R, Vaish A. Unprecedented surge in publications related to COVID-19 in the first three months of pandemic: a bibliometric analytic report. J Clin Orthop Trauma 2020;11(Suppl 3):S304–6. https://doi.org/10.1016/j.jcot.2020.04.030.

[26] Yeo-Teh NSL, Tang BL. An alarming retraction rate for scientific publications on Coronavirus Disease 2019 (COVID-19). Account Res 2021;28(1):47–53. https://doi.org/10.1080/08989621.2020.1782203.

[27] Kambhampati SBS, Vasudeva N, Vaishya R, Patralekh MK. Top 50 cited articles on Covid-19 after the first year of the pandemic: a bibliometric analysis. Diabetes Metabol Syndr 2021;15(4):102140. https://doi.org/10.1016/j.dsx.2021.05.013.

[28] Ioannidis JPA, Bendavid E, Salholz-Hillel M, Boyack KW, Baas J. Massive covidization of research citations and the citation elite. Proc Natl Acad Sci U S A 2022;119(28):e2204074119. https://doi.org/10.1073/pnas.2204074119.

[29] Ganesh R, Mahalingam K, Kandaswamy N, Shanmugam C, Vishnu VY, Subbiah A. Top 100 cited articles in one year of COVID-19 research - a bibliometric analysis. Indian J Publ Health 2021;65(4):375–9. https://doi.org/10.4103/ijph.ijph_1133_21.

[30] Brandt MD, Ghozy SA, Kallmes DF, McDonald RJ, Kadirvel RD. Comparison of citation rates between Covid-19 and non-COVID-19 articles across 24 major scientific journals. PLoS One 2022;17(7):e0271071. https://doi.org/10.1371/journal.pone.0271071.

[31] Malekpour M-R, Abbasi-Kangevari M, Azadnajafabad S, Ghamari S-H, Rezaei N, Rezazadeh-Khadem S, et al. How the scientific community responded to the COVID-19 pandemic: a subject-level time-trend bibliometric analysis. PLoS One 2021;16(9):e0258064. https://doi.org/10.1371/journal.pone.0258064.

[32] He J, Liu X, Lu X, et al. The impact of COVID-19 on global health journals: an analysis of impact factor and publication trends. BMJ Glob Health 2023;8:e011514.

[33] Delardas O, Giannos P. How COVID-19 affected the journal impact factor of highly impact medical journals: bibliometric analysis. J Med Internet Res 2022 Dec 21;24(12):e43089. https://doi.org/10.2196/43089. PMID: 36454727; PMCID: PMC9778719.

[34] Ahmad SJ, Degiannis K, Borucki J, et al. The most influential COVID-19 articles: a systematic review. New Microbes New Infect 2023;52:101094. https://doi.org/10.1016/j.nmni.2023.101094.

[35] Vishwanathan K, Kambhampati SBS, Vaishya R. Top 100 cited articles on diabetes mellitus and Covid-19: a bibliometric analysis. Diabetes Metabol Syndr 2021;15(4):102160. https://doi.org/10.1016/j.dsx.2021.05.033.