Int J Med. Public Health. 2021; 11(3):133-138.
A Multifaceted Peer Reviewed Journal in the field of Medicine and Public Health
www.ijmedph.org

Review Article

Black Fungus (Mucormycosis) Research in India during 1998-2021: A Scopus-based Scientometric Analysis

Brij Mohan Gupta[1], Ghouse Modin Mamdapur[2], Devi Dayal[3,*]

ABSTRACT

Introduction: Mucormycosis is a well-researched infection worldwide. The Indian contribution to global Mucormycosis research remains unevaluated. **Materials and Methods:** Elsevier's Scopus database was used to retrieve Indian publications on mucormycosis during 1998-2021. The extracted data were analyzed in terms of the number of publications, citation metrics, top productive organizations and authors, research collaborations, and active journals, using appropriate bibliometric tools. **Results:** India produced 799 publications on mucormycosis during 1998-2021. The publications grew at 8.5% annually and 175.1% cumulatively and received on average 9.6 citations per paper (CPP). Only 8.7% of publications involved international collaboration. The most researched types of mucormycosis were pulmonary and gastrointestinal, while diabetes mellitus and diabetic ketoacidosis were the top risk factors studied. Most of the research focused on clinical studies and treatment, while genetics was the least researched aspect of mucormycosis. The top 20 of the 294 organizations and 384 authors that participated in research contributed 59.7% and 29.4% to the total national output, and 97.3% and 76.2% to total citations, respectively. The most productive organizations were PGIMER-Chandigarh, AIIMS-New Delhi, and CMC-Vellore, and the most prolific authors were A. Chakrabarti, M.R. Shivprakash, and J. Chander. Indian Journal of Otolaryngology and Head and Neck Surgery, Mycosis, and BMJ Case Reports were the high-yielding journals, whereas Medical Mycology, Mycosis, and Journal of Postgraduate Medicine were the most impactful. **Conclusion:** Indian research in mucormycosis has shown consistent growth during 1998-2021. There is, however, a need to improve on collaborative research and focus on emerging areas such as the genetics of mucormycosis.

Key words: Mycormycosis, Invasive fungal infection, Indian publications, Bibliometrics, Scientometrics.

Brij Mohan Gupta[1], Ghouse Modin Mamdapur[2], Devi Dayal[3,*]

[1]Formerly with CSIR-NISTADS, New Delhi, INDIA.
[2]Synthite Industries (Pvt.) Ltd., Kolenchery, Kerala, INDIA.
[3]Department of Pediatrics, Advanced Pediatrics Center, Postgraduate Institute of Medical Education and Research, Chandigarh, INDIA.

Correspondence
Prof. Devi Dayal
Endocrinology and Diabetes Unit, Department of Pediatrics, Advanced Pediatrics Center, Postgraduate Institute of Medical Education and Research, Chandigarh-160012, INDIA.
Phone no: +91-172-2755657
Email: drdevidayal@gmail.com

History
- Submission Date: 28-04-2021
- Revised Date: 01-06-2021
- Accepted Date: 16-07-2021

DOI : 10.5530/ijmedph.2021.3.24

Article Available online
http://www.ijmedph.org/v11/i3

INTRODUCTION

Mucormycosis is an invasive filamentous fungal infection characterized by a rapid invasion of blood vessels and neighboring structures. The morbidity and mortality due to mucormycosis remain high throughout the world.[1] Individuals who have diabetes, chronic renal failure, iron overload, neutropenia, hematological malignancies, and induced immunosuppression or immunodeficient conditions are particularly vulnerable to mucormycosis.[1,2] The infection may involve any organ system in the body, but rhinocerebral, pulmonary, cutaneous, and gastrointestinal forms are the most common.[2-5] The infection may sometimes involve multiple organs even though the spread usually occurs in a contiguous manner.[2] The prognosis for survival is generally poor, and the outcome depends on an aggressive management strategy involving extensive surgical resection of the affected tissues, the use of antifungal drugs, and control of the underlying condition.[6-8]

Several new challenges have been experienced over the past decades by clinicians and researchers dealing with invasive fungi, particularly mucormycosis. Some of these are an overall increase in the incidence of mucormycosis, its expansion into new hosts, and the development of multidrug resistance.[1] On a global level, the European Confederation of Medical Mycology (ECMM), representing 25 affiliated National Medical Mycology Societies, has initiated several measures to improve the outcome of affected patients.[9] The onset of the COVID-19 pandemic has also renewed focus on mucormycosis in view of a significant surge in the rates of mucormycosis infections that have been noted in patients with COVID-19.[10-12] A worrying aspect of COVID-19-associated Mucormycosis is its disproportionate occurrence in Indian patients; almost three-fourth of all global cases were reported from India.[11,12] Although underlying diabetes and indiscriminate steroid use could partially explain the excessive occurrence, diligent research by Indian researchers may reveal additional factors that could be contributory.[13] The need to address the research gaps is even more in the context of the need for treatment guidelines for a possible third COVID-19 wave which is expected to affect children disproportionately, particularly those with comorbidities.[14,15] Thus, there is a need

Cite this article : Gupta BM, Mamdapur GM, Dayal D. Black Fungus (Mucormycosis) Research in India during 1998-2021: A Scopus-based Scientometric Analysis. Int J Med Public Health. 2021;11(3):133-8.

to address the new challenges posed by mucormycosis through further organized research. In this context, a bibliometric assessment of the mucormycosis research conducted so far is essential to guide future research in this field.

Bibliometric studies evaluate trends in research activity over time, help compare the contributions of researchers, institutes, and countries, and dictate future policy.[16] Bibliometrics also help researchers identify the research gaps and hotspots, thus assisting them in working on fewer interest areas. However, a comprehensive bibliometric analysis of the Indian research on mucormycosis is unavailable. The two previous bibliometric studies on mucormycosis were focused on global publications.[17,18] We, therefore, planned to conduct a qualitative and quantitative assessment of Indian publications on mucormycosis from 1998 to 2021.

Objectives

The study aimed to provide a quantitative and qualitative evaluation of Indian research on mucormycosis based on publications indexed in Elsevier's Scopus database during 1998-2021. The analysis included India's publications growth, international collaboration, funding support, citation impact, top organizations, authors, and journals, and characteristics of highly-cited papers (HCPs).

MATERIALS AND METHODS

India's publications on mucormycosis were identified and downloaded from the Scopus database (http://www.scopus.com) using a defined search strategy, similar to previous bibliometric analyses.[19-21] The keywords mucormycosis* or zygomycosis* or phycomycosis*were searched in "TITLE" or "KEY" tags, and the search output was confined to the period '1998-21' using "date range tag" and 'India' in the country tag. The following search string was used:

(KEY(mucormycosis* or zygomycosis* or phycomycosis*) or TITLE (mucormycosis* or zygomycosis* or phycomycosis*)) AND PUBYEAR > 1997 AND PUBYEAR < 2022 AND (LIMIT-TO (AFFILCOUNTRY,"India"))

The analytical provisions of the Scopus database were used to identify publications by broad subjects, collaborating countries, author-wise, organization-wise, and journal-wise, etc. We used complete counting for authors or organizations covered in multiple authorship publications and used other specific fields such as affiliations to resolve the issue of synonyms or homonyms in authors' names. Several indicators of quality of publications, such as citations per paper (CPP), relative citation index (RCI), and Hirsch index (HI), were used. The CPP was obtained by dividing the number of citations by the number of publications. For RCI, the number of citations was divided by the average citations received by an article in the same field and then benchmarking the number obtained against the median RCI for all publications funded by the National Institute of Health.[22] HI was calculated by counting the number of publications for which an author has been cited by others at least that same number of times. Publications with more than 50 citations were considered HCPs. The activity index was used to understand changes in research activity over time. The study period of 1998-2021 was divided into two 12-year halves to understand the long-term changes in publication growth and metrics. Citations to publications were counted from the date of their publication till May 16, 2021.

Ethical considerations

The use of secondary data does not require approval from the ethics committee for research on humans. However, we followed all the ethical principles recommended for analysis of this nature by respecting ideas and citations and appropriately referencing authors and their publications.

RESULTS

India's research yield on mucormycosis was 799 publications over 24 years. The annual publications increased from 11 in the year 1998 to 39 in 2021, registering an 8.5% average growth rate. The 12-years cumulative publications increased from 213 during 1998-2009 to 586 during 2010-2021, registering 175.1% absolute growth. India contributed 14.1% to the global output over 24 years, increasing from 10.6% during 1998-2009 to 16.0% during 2010-2021. The average CPP was 9.6, which decreased from 19.4 to 6.1 over the two timespans (Table 1). The publication types were original articles (76.9%), reviews (9.5%), letters (8.6%), notes (2.7%), and conference papers, book chapters, editorials, and short surveys (0.2% to 0.8%).

International collaboration

Only 70 (8.7%) were international collaborative publications (ICPs) which increased marginally from 6.5% to 9.5% during 1998-2009 to 2010-2021. The USA, Spain, France, Netherlands, and Austria were the top collaborating countries with 47.1%, 21.4%, 20.0%, 14.3%, and 11.4% share, respectively.

Table 1: India's publication yield, citation metrics, and share in global research in mucormycosis during 1998-2021.

Year	Global	Indian					
	TP	TP	%TP	Citations	CPP	ICP	%ICP
1998	104	11	10.5	148	13.4	0	0.0
1999	121	12	9.9	175	14.5	1	8.3
2000	99	7	7.0	54	7.7	2	28.5
2001	121	10	8.2	193	19.3	0	0.0
2002	115	10	8.7	80	8.0	0	0.0
2003	119	13	10.9	373	28.7	0	0.0
2004	161	15	9.3	261	17.4	1	6.6
2005	191	19	0.9	682	35.9	2	10.5
2006	219	27	12.3	592	21.9	2	7.4
2007	223	33	14.8	527	15.9	0	0.0
2008	252	24	9.5	316	13.1	1	4.1
2009	277	32	11.5	737	23.0	5	15.6
2010	276	38	13.7	453	11.9	5	13.1
2011	273	38	13.9	374	9.8	4	10.5
2012	317	47	14.8	299	6.3	7	14.9
2013	296	48	16.2	239	4.9	3	6.2
2014	347	52	14.9	662	12.7	2	3.8
2015	305	57	18.7	326	5.7	6	10.5
2016	300	52	17.3	506	9.7	6	11.5
2017	304	40	13.1	152	3.8	2	5.0
2018	326	49	15.0	160	3.2	6	12.2
2019	392	66	16.8	333	5.0	5	7.5
2020	355	60	16.9	57	0.9	6	10.0
2021	165	39	23.6	12	0.3	4	10.2
1998-2009	2002	213	10.6	4138	19.4	14	6.5
2010-2021	3656	586	16.0	3573	6.1	56	9.5
1998-2021	5658	799	14.1	7711	9.6	70	8.7

Abbreviations: TP, total publications; CPP, citations per publication; ICP, international collaborative publications

Distribution of publications by the age of the studied population

Almost half (394, 49.3%) of the publications involved adults, followed by middle-aged (209, 26.1%), children (126, 15.7%), elderly (105, 13.1%), and adolescents (89, 11.1%). The publications in the adolescent age group were the most impactful, with an average CPP of 23.3.

Research topics

The most common subject of research was the treatment of mucormycosis with a 53.7% share, followed by clinical studies, diagnostics and imaging, pathophysiology, complications, etc. Genetics was the least researched subject. Epidemiology registered the highest and pathophysiology the least impact (Table 2).

Types of mucormycosis

Publications on zygomycosis accounted for the largest share (22.5%), followed by pulmonary (8.1%), gastrointestinal (8.0%), cutaneous (6.1%), rhinocerebral (3.5%), renal (1.7%), and disseminated forms (1.4%). The rest were uncommon types. The highest and the least cited publications belonged to cutaneous and rhinocerebral forms, respectively.

Risk factors

Diabetes mellitus was the most studied underlying risk factor for mucormycosis, accounting for 296 (37.0%) publications followed by diabetic ketoacidosis (47, 5.8%), immunocompromised host (38, 4.7%), neutropenia (30, 3.7%), renal failure (28, 3.5%), etc. Hematological malignancy, trauma, autoimmune disease, bone marrow and solid organ transplantation, deferoxamine therapy, HIV infection, and corticosteroid therapy were the other risk factors. Publications with solid organ transplantation and autoimmune disease registered the highest and the lowest CPP of 92.2 and 0.0, respectively.

Table 2: Distribution of India's literature on mucormycosis by research topics during 1998-2021.

Research topic	Number (%) of publications			Cited	CPP*
	1998-2009	2010-2021	1998-2021		
Clinical Studies	85 (39.9)	192 (32.7)	277 (34.6)	4061	14.6
Epidemiology	13 (6.1)	36 (6.1)	49 (6.1)	1390	28.3
Pathophysiology	25 (11.7)	88 (15.0)	113 (14.1)	857	7.5
Genetics	0 (0.0)	12 (2.0)	12 (1.5)	186	15.5
Complications	22 (10.3)	70 (11.9)	92 (11.5)	878	9.5
Diagnostic and Imaging	28 (13.1)	105 (17.9)	133 (16.6)	1776	13.3
Risk Factors	13 (6.1)	34 (5.8)	47 (5.8)	1181	25.1
Treatment	117 (54.9)	315 (53.7)	432 (54.0)	5202	12.0
Drug Therapy	0 (0.0)	43 (7.3)	43 (5.3)	289	6.7
Anti-Fungal Therapy	13 (6.1)	30 (5.1)	43 (5.3)	359	8.3
Antibiotic Therapy	16 (7.5)	20 (3.4)	36 (4.5)	465	12.9
Immunosuppressives	11 (5.1)	23 (3.9)	34 (4.2)	502	14.7
Steroids	52 (24.4)	88 (15.0)	140 (17.5)	2361	16.8
Treatment Outcome	85 (39.9)	192 (32.7)	277 (34.6)	4061	14.6
Total	213 (100.0)	586 (100.0)	799 (100.0)	7711	9.6

*Citations per publication

High-yield organizations

Two hundred ninety-four organizations unevenly participated in India's mucormycosis research during 1998-21: 254 organizations published 1-5 papers each, 26 organizations 6-10 papers each, 12 organizations 11-50 papers each, and two organizations 66-149 papers each. The productivity of the top 20 most productive organizations varied from 7 to 150 publications per organization; together, they contributed 477 (59.7%) publications and 7506 (97.3%) citations during 1998-2021. Five organizations registered their publication output above the group average of 23.8, whereas six registered their CPP and RCI above the group average of 15.7 and 1.6, respectively (Table 3).

Research collaborations between organizations

All except two of the top 20 organizations had one-to-one collaborative linkages; the number of associations varied from 0-28. The top three organizations with the largest collaborations (28, 19, and 17) were PGIMER-Chandigarh, AIIMS-New Delhi, and CMC-Vellore. The organization pairs with the highest partnerships were the University of Delhi and VPCI-Delhi, with eight linkages, JIPMER-Pondicherry and MAHE-Manipal (4 linkages) and KMC-Manipal and MAHE-Manipal (4 linkages), and the University of Delhi and UCMC-Delhi (3 links).

Most prolific authors

Of the 384 authors who participated in mucormycosis research, 347 published 1-5 papers each, 30 published 6-10 articles each, and seven published 11-47 papers each. The research productivity of the 20 most productive authors varied from 7-47 publications; their combined contribution was 29.4% (235) publications and 76.2% (5882) citations. The publication output of five authors was above the group average of 11.7, whereas six authors had their CPP and RCI above the group average of 25.0 and 2.5, respectively (Table 4).

Research partnerships between authors

All the top 20 authors had extensive collaborations between them; the number of linkages varied from 2 to 53. A. Chakrabarti, M.R. Shivprakash, and K.L.Gupta collaborated 53, 34, and 22 times with 2-4 other authors. On author to author basis, A. Chakrabarti and M.R. Shivprakash registered the highest number of collaborative linkages (16 each), followed by J. Chander and R.S. Punia, V. Sakhuja and K.L. Gupta, V. Sakhuja and V. Jha, K.L. Gupta and V. Muthu (6 linkages each), etc.

Medium of research communication

Of the 799 publications, 794 (99.3%) appeared in journals, 3 (0.3%) as books, and 2 (0.2%) as book series. The journal articles were published in 312 journals. The top 20 most productive journals are shown in Table 5.

Highly-cited publications

Only 28 papers (3.5%) were HCPs; their total citations were 3559, averaging 127.1 CPP (range 58-381). The participating organizations in HCPs were PGIMER, Chandigarh, CMC, Vellore, Vallabhai Patel Chest Institute, Delhi, Nizam's Institute of Medical Sciences, Hyderabad, NIHMANS, Bangalore, AIIMS, New Delhi, and Seth GS Medical College and KEM Hospital, Mumbai. The most number of HCPs were contributed by A. Chakraborty, followed by A. Das, M.R. Shivprakash, V. Sakhuja, and K.L. Gupta. Journal of Postgraduate Medicine and Mycoses published three HCPs each, while Clinical Microbiology and Infection, The Lancet Infectious Disease, and Histopathology published two HCPs each. Sixteen other journals published one HCP each.

Table 3: Top 10 most productive and most impactful organizations in Indian mucormycosis research during 1998-2021.

S.no.	Organization	TP	TC	CPP	HI	ICP	ICP (%)	RCI
	Most productive organizations							
1.	Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh	150	2946	19.6	29	22	14.6	2.0
2.	All India Institute of Medical Sciences, New Delhi	66	524	7.9	12	2	3.0	0.8
3.	Christian Medical College, Vellore	29	446	15.3	11	3	10.3	1.6
4.	Government Medical College and Hospital (GMCH), Chandigarh	26	347	13.3	11	10	38.4	1.3
5.	Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow	25	200	8.0	9	1	4.0	0.8
6.	Nizam's Institute of Medical Sciences, Hyderabad	18	356	19.7	9	1	5.5	2.0
7.	Seth G S Medical College and KEM Hospital, Mumbai	18	246	13.6	7	2	11.1	1.4
8.	Maulana Azad Medical College, Delhi	17	81	4.7	6	0	0.0	0.5
9.	Jawaharlal Institute of Postgraduate Medical Education and Research, Pondicherry	16	94	5.8	6	2	12.5	0.6
10.	Kasturba Medical College, Manipal	14	61	4.3	4	0	0.0	0.4
	Most impactful organizations							
1.	Vallabbhai Patel Chest Institute, Delhi	8	646	80.7	8	6	75.0	8.3
2.	University of Delhi	13	672	51.7	9	6	46.1	5.3
3.	National Institute of Mental Health and Allied Sciences, Bangalore	7	261	37.3	5	1	14.3	3.8
4.	Nizam's Institute of Medical Sciences, Hyderabad	18	356	19.7	9	1	5.5	2.0
5.	Postgraduate Institute of Medical Education and Research, Chandigarh	150	2946	19.6	29	22	14.6	2.0
6.	Sri Ramchandra Institute of Higher Education and Research, Chennai	13	216	16.6	6	3	23.0	1.7
7.	Christian Medical College, Vellore	29	446	15.3	11	3	10.3	1.6
8.	Seth G S Medical College and KEM Hospital, Mumbai	18	246	13.6	7	2	11.1	1.4
9.	Government Medical College and Hospital, Chandigarh	26	347	13.3	11	10	38.4	1.3
10.	VMMC and Safdarjang Hospital, New Delhi	8	101	12.6	4	3	37.5	1.3

Abbreviations: TP, total publications; TC, total citations; CPP, citations per paper; HI, Hirsch-index; ICP, international collaborative papers; RCI, relative citation index.

Table 4: The most prolific and the most influential authors in India's mucormycosis research during 1998-2021.

S.no	Author	Affiliation	TP	TC	CPP	HI	ICP	ICP (%)	RCI
		Most productive authors							
1.	A. Chakrabarti	PGIMER, Chandigarh	47	1831	38.9	21	14	29.8	4.0
2.	M.R. Shivprakash	PGIMER, Chandigarh	22	536	24.3	10	4	8.5	2.5
3.	J. Chander	GMCH, Chandigarh	18	325	18.0	10	9	19.1	1.8
4.	V. Sakhuja	PGIMER, Chandigarh	13	475	36.5	8	1	2.1	3.8
5.	K.L. Gupta	PGIMER, Chandigarh	12	361	30.0	7	4	8.5	3.1
6.	R. Agarwal	PGIMER, Chandigarh	11	100	9.0	6	1	2.1	0.9
7.	V. Jha	PGIMER, Chandigarh	11	170	15.4	5	1	2.1	1.6
8.	A. Das	PGIMER, Chandigarh	9	570	63.3	7	0	0.0	6.5
9.	H. Kaur	PGIMER, Chandigarh	9	65	7.2	5	1	2.1	0.7
10.	G. Singh	PGIMER, Chandigarh	9	19	2.1	2	0	0.0	0.2
		Most impactful authors							
1.	A. Chowdhary	University of Delhi	7	564	80.5	7	6	12.7	8.3
2.	A. Das	PGIMER, Chandigarh	9	570	63.3	7	0	0.0	6.5
3.	A. Chakrabarti	PGIMER, Chandigarh	47	1831	38.9	21	14	29.8	4.0
4.	A. Bhansali	PGIMER, Chandigarh	7	266	38.0	5	0	0.0	3.9
5.	V. Sakhuja	PGIMER, Chandigarh	13	475	36.5	8	1	2.1	3.8
6.	K.L. Gupta	PGIMER, Chandigarh	12	361	30.0	7	4	8.5	3.1
7.	M.R. Shivprakash	PGIMER, Chandigarh	22	536	24.3	10	4	8.5	2.5
8.	A. Bal	PGIMER, Chandigarh	7	144	20.5	5	0	0.0	2.1
9.	K. Joshi	PGIMER, Chandigarh	8	164	20.5	5	0	0.0	2.1
10.	J. Chander	GMCH, Chandigarh	18	325	18.0	10	9	19.1	1.8

Table 5: Top 20 most productive journals in Indian mucormycosis research during 1998-2021.

S.no.	Journal	Number of publications			Citations	CPP*
		1998-09	2010-21	1998-2021		
1.	Indian Journal of Otolaryngology and Head and Neck Surgery	11	17	28	91	3.2
2.	Mycoses	13	11	24	519	21.6
3.	BMJ Case Reports	0	22	22	30	1.3
4.	Indian Journal of Medical Microbiology	9	13	22	172	7.8
5.	Indian Journal of Pathology and Microbiology	7	14	21	128	6.1
6.	Journal of the Association of Physicians of India	7	13	20	52	2.6
7.	Journal of Clinical and Diagnostic Research	0	18	18	34	1.9
8.	Mycopathology	4	11	15	107	7.1
9.	Journal of Postgraduate Medicine	11	3	14	254	18.1
10.	Indian Journal of Ophthalmology	5	7	12	141	11.7
11.	Medical Mycology	3	9	12	366	30.5
12.	Clinical Rhinology	0	11	11	6	0.5
13.	Indian Journal of Dermatology Venereology and Leprology	6	5	11	82	7.4
14.	Indian Journal of Pediatrics	3	7	10	59	5.9
15.	Tropical Doctor	0	10	10	14	1.4
16.	Indian Journal of Nephrology	1	8	9	17	1.9
17.	Lung India	0	9	9	38	4.2
18.	Diagnostic Cytopathology	2	6	8	50	6.2
19.	Indian Journal of Critical Care Medicine	0	8	8	10	1.2
20.	Indian Pediatrics	6	2	8	49	6.1

*Citations per publication

DISCUSSION

Our study reveals that Indian research in mucormycosis grew steadily since 1998, and its contribution to global mucormycosis research was quite significant at 14.1%. However, the quality of research as indicated by the CPP fell dramatically during the second half of the study period to about one-third of its previous value. One important reason for the fall in the quality of research could be the lack of significant collaboration, specifically international, throughout the timespan of the study, which stood at meagerly 8.7%. Collaboration promotes high research quality as it enables the delivery of results of high external validity and the development and implementation of standards.[23] In addition, the robustness of the research increases when results are obtained through combining different approaches, experiences, and expertise of all partners.[23] Another cause for suboptimal research quality is poor financial support, although this aspect was not analyzed separately in our study. Funding of research is generally insufficient in low-income countries, often reflected in the poor quality of publications.[24] The difference between the CPP of funded and non-funded publications (77.2 versus 18.6) was significant in a recent Indian study.[25] In contrast, the availability of infrastructure and funding and the commitment by the national organizations and governments to quality research that is a highly organized activity often show up in the high quality of publications from high-income countries.[26] Lastly, a general decrease in the quality of medical research has been observed over the past few decades due to growth in the number of researchers and the emphasis on quantity and not quality in hiring or promotions in jobs.[27]

A particular research gap identified in the current analysis was the lack of studies on genetic aspects of mucormycosis. Genetic studies are a vital approach to understanding some of the possible mechanisms of azole resistance and may help find out how to overcome resistance and improve the efficacy of antifungal drugs.[28] In addition, such studies also help to understand the virulence of mucormycosis.[29] India occupies the second position after the USA in terms of contribution to global mucormycosis research, the reason why Indian researchers need to shoulder more responsibility in futuristic mucormycosis research such as genetics.[18]

The current bibliometric analysis has some limitations. The study is based on the use of a single database and may have missed some publications or citations. However, most of the bibliometric studies use a single database.[30,31] We chose the Scopus database for its better content coverage, search analysis tools, and better citation accuracy as compared to PubMed or Web of Science.[30,31] Also because, for bibliometric studies, the Scopus is the most widely-used medical database.[32] Even a simultaneous search in Scopus, PubMed, and WoS may still miss some data.[30,31] Despite this limitation, we were able to identify the trends and gaps in the Indian mucormycosis research. The study thus provides the landscape of Indian mucormycosis research and a framework for authors and organizations to develop focus and partnerships on future research in this field.

CONCLUSION

The quantity of Indian research in mucormycosis has increased steadily during 1998-2021. The quality, however, has dipped. There is a need to foster collaborative research and focus on emerging areas such as the genetics of Mucormycosis.

CONTRIBUTORS' LIST

BMG, Concept, and design of the study, and acquisition, analysis, and interpretation of data; GMM, Data analysis, and intellectual inputs

during the revision of the manuscript; DD, Manuscript preparation and critical revision for important intellectual content. All authors approved the final version of the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ABBREVIATIONS

COVID 19: The Coronavirus Disease of 2019.

REFERENCES

1. Prakash H, Chakrabarti A. Global epidemiology of mucormycosis. J Fungi (Basel). 2019;5(1):26. doi: 10.3390/jof5010026, PMID 30901907.
2. Dayal D, Jain P, Kumar R, Bakshi J, Menon P, Das A, Singhi S, Singh M. Clinical spectrum and outcome of invasive filamentous fungal infections in children with Type 1 diabetes: North Indian experience. Clin Pediatr Endocrinol. 2015;24(2):51-7. doi: 10.1297/cpe.24.51, PMID 26019401.
3. Devidayal, Menon P, Vaiphei K, Singh M, Rao K, Singhi S. Pleuropulmonary Zygomycosis in a diabetic child. Clin Pediatr Endocrinol. 2009;18(1):35-40. doi: 10.1297/cpe.18.35, PMID 24790378.
4. Dayal D, Bakshi J, Jain P, Shivaprakash MR, Singhi S. Outcome of rhino-sinus mucormycosis in children with Type 1 diabetes. Indian J Pediatr. 2015;82(7):651-2. doi: 10.1007/s12098-014-1680-4, PMID 25589195.
5. Dayal D, Saini A, Sodhi K, Rao KLN, Gupta N, Dogra S. Thymic Zygomycosis in a girl with poorly controlled diabetes. Acta Endo (Buc). 2011;7(3):379-83. doi: 10.4183/aeb.2011.379.
6. Dayal D. A multimodal approach is necessary to manage mucormycosis in patients with diabetes. J Clin Diagn Res. 2016;10(9):SL01. doi: 10.7860/JCDR/2016/21349.8477, PMID 27790541.
7. Dayal D, Bakshi J. Early diagnosis and surgery is crucial to survival outcome in rhinocerebral mucormycosis. Indian J Otolaryngol Head Neck Surg. 2016;68(2):261-2. doi: 10.1007/s12070-015-0953-1, PMID 27340648.
8. Vaughan C, Bartolo A, Vallabh N, Leong SC. A meta-analysis of survival factors in rhino-orbital-cerebral mucormycosis-has anything changed in the past 20 years? Clin Otolaryngol. 2018;43(6):1454-64. doi: 10.1111/coa.13175, PMID 29947167.
9. Hoenigl M, Gangneux JP, Segal E, Alanio A, Chakrabarti A, Chen SC, Govender N, Hagen F, Klimko N, Meis JF, Pasqualotto AC, Seidel D, Walsh TJ, Lagrou K, Lass-Flörl C, Cornely OA, European Confederation of Medical Mycology (ECMM). Global guidelines and initiatives from the European Confederation of Medical Mycology to improve patient care and research worldwide: new leadership is about working together. Mycoses. 2018;61(11):885-94. doi: 10.1111/myc.12836, PMID 30086186.
10. Gupta BM, Pal R, Rohilla L, Dayal D. Bibliometric analysis of diabetes research in relation to the COVID-19 pandemic. J Diabetol. 2021;12(3): doi:10.4103/jod.jod_30_21. (in press).
11. Pal R, Singh B, Bhadada SK, Banerjee M, Bhogal RS, Hage N, Kumar A. COVID-19-associated mucormycosis: an updated systematic review of literature. Mycoses. 2021 Jun 16. doi: 10.1111/myc.13338 [Epub ahead of print]. PMID 34133798.
12. Singh AK, Singh R, Joshi SR, Misra A. Mucormycosis in COVID-19: A systematic review of cases reported worldwide and in India. Diabetes Metab Syndr. 2021;15(4):102146. doi: 10.1016/j.dsx.2021.05.019.
13. Sen M, Honavar SG, Bansal R, Sengupta S, Rao R, Kim U, *et al*. Epidemiology, clinical profile, management, and outcome of COVID-19-associated rhino-orbital-cerebral mucormycosis in 2826 patients in India - Collaborative OPAI-IJO Study on Mucormycosis in COVID-19 (COSMIC), Report 1, Report 1. Indian J Ophthalmol. 2021;69(7):1670-92. doi: 10.4103/ijo.IJO_1565_21, PMID 34156034.
14. Dayal D. We urgently need guidelines for managing COVID-19 in children with comorbidities. Acta Paediatr. 2020;109(7):1497-8. doi: 10.1111/apa.15304, PMID 32279351.
15. Dayal D, Yadav A. COVID-19: considerations for children and adolescents with diabetes. J Diabetol. 2020;11(3):126-30. doi: 10.4103/JOD.JOD_40_20.
16. Cooper ID. Bibliometrics basics. J Med Libr Assoc. 2015;103(4):217-8. doi: 10.3163/1536-5050.103.4.013, PMID 26512226.
17. Sivankalai S, Sivasekaran K. Mucormycosis (Black Fungus) Maiming Covid Patients: scientometrics analysis through prism of Biblioshiny. Libr Philos Pract. 2021;5546.
18. Gupta BM, Mamdapur GM, Gupta S, Rohilla L, Dayal D. Global mucormycosis research: A bibliometric assessment based on Scopus database (1998-2021). J Scientometr Res. 2021.
19. Gupta BM, Dayal D. Pediatric type 1 diabetes research in the 21st century: a scientometric review. Pediatr Endocrinol Diabetes Metab. 2020;26(3):132-9. doi: 10.5114/pedm.2020.98165, PMID 32901470.
20. Dayal D, Gupta BM, Gupta S. Quantitative and qualitative assessment of Indian research yield in type 1 diabetes during 1996-2019. J Diabetol. 2021;12:28-35.
21. Dayal D, Gupta BM, Gupta A. Thyroid disorders in children and adolescents: systematic mapping of global research over the last three decades. Thyroid Res Pract. 2021;18 (1): doi:10.4103/trp.trp_5_21. (in press).
22. Surkis A, Spore S. The relative citation ratio: what is it and why should medical librarians care? J Med Libr Assoc. 2018;106(4):508-13. doi: 10.5195/jmla.2018.499, PMID 30271298.
23. Vaudano E. Research collaborations and quality in research: foes or friends? Handb Exp Pharmacol. 2020;257:383-98. doi: 10.1007/164_2019_293, PMID 31628602.
24. Lakhotia SC. Research fund crunch, real or created, is hitting India's Academia on the Wrong Side. Proc Indian Natl Sci Acad. 2018;98:545-7. doi: 10.16943/ptinsa/2018/49475.
25. Gupta BM, Sikka P, Gupta S, Dayal D. Indian research in gestational diabetes mellitus during the past three decades: A scientometric analysis. J Obstet Gynecol India. 2021;71(3):254-61. doi: 10.1007/s13224-021-01444-7.
26. Fradkin JE, Wallace JA, Akolkar B, Rodgers GP. Type 1 diabetes--reaping the rewards of a targeted research investment. Diabetes. 2016;65(2):307-13. doi: 10.2337/db15-1030, PMID 26798117.
27. Sandström U, van den Besselaar P. Quantity and/or Quality? The Importance of publishing Many Papers. PLOS ONE. 2016;11(11):e0166149. doi: 10.1371/journal.pone.0166149, PMID 27870854.
28. Nagy G, Kiss S, Varghese R, Bauer K, Szebenyi C, Kocsubé S, Homa M, Bodai L, Zsindely N, Nagy G, Vágvölgyi C, Papp T. Characterization of three Pleiotropic Drug Resistance Transporter Genes and Their Participation in the Azole Resistance of *Mucor circinelloides*. Front Cell Infect Microbiol. 2021;11:660347. doi: 10.3389/fcimb.2021.660347.
29. Pérez-Arques C, Navarro-Mendoza MI, Murcia L, Navarro E, Garre V, Nicolás FE. The RNAi mechanism regulates a new exonuclease gene involved in the virulence of Mucorales. Int J Mol Sci. 2021;22(5):2282. doi: 10.3390/ijms22052282, PMID 33668930.
30. Kokol P, Vošner HB. Discrepancies among Scopus, Web of Science, and PubMed coverage of funding information in medical journal articles. J Med Libr Assoc. 2018;106(1):81-6. doi: 10.5195/jmla.2018.181, PMID 29339937.
31. AlRyalat SAS, Malkawi LW, Momani SM. Comparing bibliometric analysis using PubMed, Scopus, and Web of Science databases. J Vis Exp. 2019;152(152). doi: 10.3791/58494, PMID 31710021.
32. Baas J, Schotten M, Plume A, Côté G, Karimi R. Scopus as a curated, high-quality bibliometric data source for academic research in quantitative science studies. Quant Sci Stud. 2020;1(1):377-86. doi: 10.1162/qss_a_00019.

Cite this article : Gupta BM, Mamdapur GM, Dayal D. Black Fungus (Mucormycosis) Research in India during 1998-2021: A Scopus-based Scientometric Analysis. Int J Med Public Health. 2021;11(3):133-8.