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Research Article

Global Research Trends and Collaboration Patterns in Mycetoma (Madura Foot): A Bibliometric Analysis

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Abstract

Objectives: Mycetoma (Madura foot) is a neglected tropical disease associated with significant morbidity, particularly in endemic regions. Although scientific interest in mycetoma has increased in recent years, the overall structure, global distribution, and collaborative patterns of research in this field have not been systematically evaluated. This study aimed to perform a comprehensive bibliometric analysis of mycetoma-related research.

Methods: A retrospective bibliometric analysis was conducted using the Web of Science Core Collection. English-language original research articles published up to September 30, 2023, were included. Bibliographic data were extracted and analyzed using VOSviewer software to evaluate publication trends, contributing countries and institutions, journals, citation metrics, collaboration networks, and keyword co-occurrence patterns.

Results: A total of 506 articles were identified, accumulating 7,452 citations, with an overall H-index of 39. Research output demonstrated a steadily increasing trend, particularly over the past decade, with peak publication activity observed in 2021. Sudan emerged as the leading contributor, followed by the United States and several European countries. The University of Khartoum was the most productive institution, and research findings were primarily published in journals focusing on tropical medicine, infectious diseases, dermatology, and mycology. Network analyses revealed strong international collaboration and thematic emphasis on disease classification, causative organisms, and treatment strategies.

Conclusion: Global research activity on mycetoma has increased substantially, reflecting growing awareness of its clinical and public health importance. This bibliometric analysis provides a comprehensive overview of research trends and key contributors and may support future research planning and policy development aimed at improving the prevention, diagnosis, and management of mycetoma.

Keywords: Bibliometric analysis, Global collaboration, Madura foot, Mycetoma, Research trends

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Mycetoma, also known as Madura foot, is a chronic granulomatous infection of the skin and subcutaneous tissues and is classified as a neglected tropical disease by the World Health Organization (WHO).[1,2] It is caused by bacterial (actinomycetoma) or fungal (eumycetoma) pathogens and primarily affects populations living in tropical and subtropical regions.[1–3] Common causative agents include *Streptomyces*, *Actinomadura*, and *Nocardia* species in actinomycetoma, and *Madurella mycetomatis* and related fungi in eumycetoma.[2] The disease is strongly associated with low socioeconomic conditions and predominantly affects agricultural workers who frequently walk barefoot in endemic areas.[1,4] Adult males between 20 and 50 years of age are most commonly affected, although younger individuals may also be involved in underdeveloped regions.[5] Mycetoma is endemic within the so-called "mycetoma belt," extending across parts of Africa, Asia, and Latin America, with Sudan and Mexico reporting the highest number of documented cases worldwide.[5] Clinically, mycetoma is characterized by a classic triad of painless subcutaneous swelling, sinus tract formation, and discharge of colored grains.[1,6,7] If left untreated, the infection may progress to deeper tissues, including bone, resulting in osteomyelitis, severe deformity, and permanent disability.[1,2,7] Diagnosis relies on clinical assessment supported by imaging, histopathology, microbiological culture, and molecular techniques.[1] Treatment strategies vary according to the causative organism, with actinomycetoma generally responding to prolonged antibiotic therapy, whereas eumycetoma often requires combined antifungal treatment and surgical intervention.[1,2] In recent years, global attention to mycetoma has increased through international training programs, collaborative research initiatives, and the development of novel therapeutic approaches.[5] Nevertheless, despite the growing number of publications, the global research landscape, publication trends, and collaboration patterns in mycetoma research have not been systematically evaluated. Bibliometric analysis is a quantitative approach widely used to assess research productivity, identify influential contributors, and map collaboration networks and thematic trends.[8–10] Therefore, the aim of this study was to perform a comprehensive bibliometric analysis of mycetoma research, focusing on global publication trends, leading countries and institutions, and international collaboration patterns.

Methods

Study Design and Data Source

This study was designed as a retrospective bibliometric analysis conducted in accordance with established bibliometric analysis guidelines.[11] A comprehensive literature search was performed using the Web of Science Core Collection (WoSCC), an electronic database maintained by Clarivate Analytics (Philadelphia, PA, USA). The WoSCC was selected due to its standardized citation indexing, robust export capabilities, and widespread use in bibliometric research.[12–15] Data were retrieved from the Science Citation Index Expanded (SCI-EXPANDED) and Emerging Sources Citation Index (ESCI) databases within WoSCC. To minimize potential bias related to database updates, all data were collected on a single day, October 1, 2023. Only articles published in English were included in the analysis.

Search Strategy

The literature search was conducted using a predefined Boolean query applied to article titles to ensure specificity. The following search strategy was used:

TI = ("mycetoma" OR "Madura foot" OR "Madurella mycetomatis")

No restrictions were applied regarding publication year. Document type was limited to original research articles.

Study Selection Criteria

The initial search yielded 922 records. After limiting the results to original research articles, 594 records remained. Subsequently, non-English publications were excluded, resulting in a final dataset of 506 articles included in the bibliometric analysis.

Data Extraction

Bibliographic information, including authors, institutional affiliations, countries/regions, journals, publication year, citation counts, keywords, references, and H-index values, was extracted from WoSCC and exported to Microsoft Excel 2019 for preliminary organization. Two authors independently reviewed and verified the extracted data to ensure accuracy. Discrepancies were resolved by consensus. The finalized dataset was subsequently imported into VOSviewer software version 1.6.19 (Leiden University, Leiden, the Netherlands) for further analysis.[16]

Bibliometric Analysis

Quantitative bibliometric indicators, including the number of publications, total citations, and citations per year, were used to assess research productivity and impact. Network analyses were conducted to evaluate collaborations among authors, institutions, and countries, as well as keyword co-occurrence patterns. The H-index, originally proposed by Hirsch, was used to evaluate the scientific impact and productivity of countries with the highest publication output.[17] In addition,

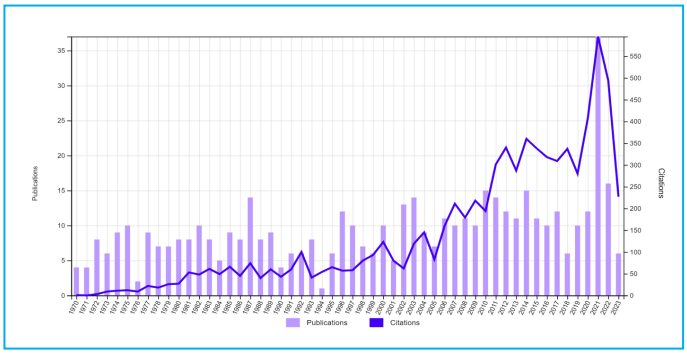

Figure 1. Annual publication output and citation trends in mycetoma research.

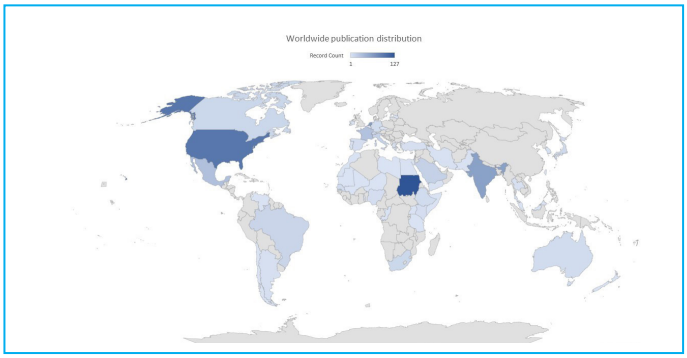

Figure 2. Global distribution of mycetoma-related publications.

Total Link Strength (TLS), as calculated by VOSviewer, was used to quantify the strength of relationships between items within bibliometric networks, including authors, institutions, countries, and keywords.[16] Visualization maps generated by VOSviewer illustrated clusters, link strengths, and node sizes, with larger nodes representing greater influence or productivity within the network. Clusters were distinguished by color to facilitate interpretation of thematic groupings and collaboration patterns.[16] Journal quality and impact were assessed using Impact Factor (IF) values obtained from the most recent edition of the Journal Citation Reports (JCR).[18]

Results

General Information and Publication Trends

A total of 506 mycetoma-related research articles were identified in the Web of Science Core Collection, accumulating 7,452 citations with a mean of 14.73 citations per article. The overall H-index of the dataset was 39. Publication output showed a progressive increase over time, with a marked rise during the last decade. The year 2021 was the most productive, accounting for 37 publications (7.3% of all records), indicating growing global research interest (Fig. 1). The publications spanned multiple disciplines, predominantly tropical medicine, dermatology, and mycology, with additional contributions from infectious diseases, microbiology, public and occupational health, and other medical specialties, reflecting the interdisciplinary nature of mycetoma research.

Global Distribution of Publications

The included articles originated from 60 countries or regions. Sudan was the leading contributor, followed by the United States, the Netherlands, India, and England. At the continental level, Africa accounted for the largest share of publications, largely driven by Sudan, followed by North America and Europe. Asia, South America, and Oceania contributed smaller but notable proportions. The global distribution of publications is shown in Figure 2.

Top Publishing Institutions and Journals

The University of Khartoum emerged as the most productive institution, contributing nearly one-quarter of all publications. Institutions in the Netherlands, particularly Erasmus MC and Erasmus University Rotterdam, also demonstrated substantial research output (Fig. 3). Mycetoma research was primarily published in journals focusing on tropical medicine, infectious diseases, dermatology, and mycology. *Transactions of the Royal Society of Tropical Medicine and Hygiene* was the most prolific journal, followed by *PLOS Neglected Tropical Diseases* and *Journal of Clinical Microbiology*. Additional key journals are summarized in Table 1.

Bibliographic Coupling and Keyword Analysis

Bibliographic coupling analysis identified 22 countries with at least five publications, with Sudan, the United States, and the Netherlands demonstrating the strongest collaboration networks (Fig. 4; Table 2). Keyword analysis revealed 505 distinct keywords, with "mycetoma" showing the highest frequency and Total Link

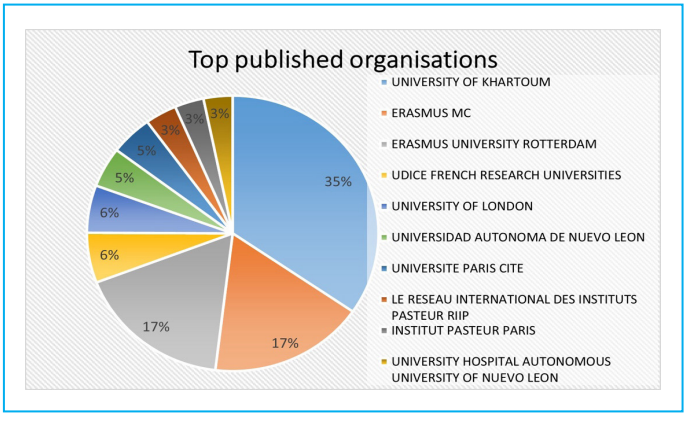

Figure 3. Top contributing institutions in mycetoma research.

Table 1. Top publishing journals on Madura foot

Journal name	n (%)	Journal Impact Factor (IF) ™ Five Year	Journal Citation Reports (JCR) 2022
Transactions of the Royal Society of Tropical Medicine and Hygiene	43 (8.498)	2.1	0.66
Plos Neglected Tropical Diseases	34 (6.719)	4.1	1.08
Journal of Clinical Microbiology	20 (3.953)	6.9	1.76
Mycopathologia	19 (3.755)	3.6	0.86
International Journal of Dermatology	18 (3.557)	2.9	0.67
Sabouraudia Journal of Medical and Veterinary Mycology	14 (2.767)	No information	No information
Medical Mycology	12 (2.372)	3.3	1.06
American Journal of Tropical Medicine and Hygiene	10 (1.976)	2.8	1
Journal De Mycologie Medicale	10 (1.976)	2.7	0.73
Mycoses	10 (1.976)	4.2	1.59

Strength. Other commonly occurring keywords included "eumycetoma," "Madurella mycetomatis," and "actinomycetoma," indicating a research focus on disease classification, causative organisms, and treatment-related themes (Fig. 5).

Discussion

The present bibliometric analysis provides a comprehensive overview of the global research landscape on mycetoma, based on 506 publications indexed in the Web of Science Core Collection. The findings demonstrate a steadily increasing research output over time, with a marked acceleration during the last decade. The peak in publication activity observed in 2021 reflects growing scientific awareness and international interest in this neglected tropical disease. In addition, the wide range of subject categories, led by tropical medicine, dermatology, and mycology, highlights the inherently interdisciplinary nature of mycetoma research. Mycetoma predominantly affects populations in tropical and subtropical regions and disproportionately impacts individuals of low socioeconomic status, particularly manual laborers who frequently work barefoot.[5] Although first described in Madurai, India, the disease has a broad global distribution and remains endemic within the so-called "mycetoma belt," encompassing large parts of Africa, Asia, and Latin America.[5] The prominent contribution of African countries, particularly Sudan, observed in this study likely reflects both the high disease burden in endemic regions and the presence of specialized research centers dedicated to mycetoma. The substantial output from the United States and several European countries further emphasizes the global and collaborative nature of research efforts addressing this condition. Citation-based indicators, including total citations, citations per article, and H-index values, serve as important measures of research impact and scientific influence.[19,20] In the present analysis, Sudan emerged as the leading contributor across multiple bibliometric indicators, underscoring its cen-

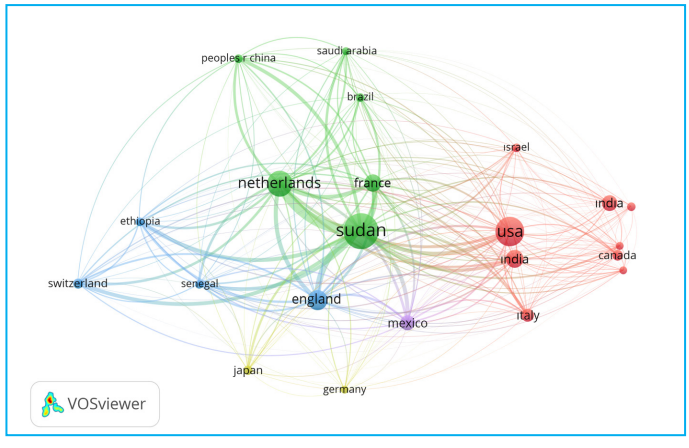

Figure 4. Bibliographic coupling network of countries involved in mycetoma research.

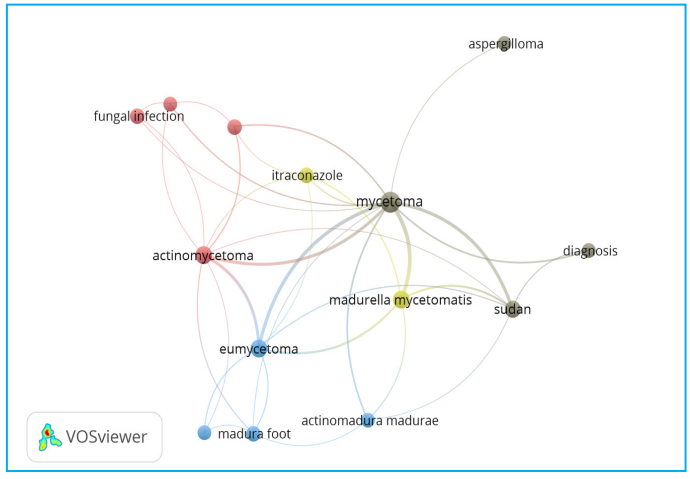

Figure 5. Keyword co-occurrence network in mycetoma research.

Table 2. Top publishing countries, number of citations, number of documents and total link strength and H indexes

Country	Number of documents	Number of citations	Total link strength	H index
Sudan	126	2588	36624	31
The USA	84	1061	5696	22
Netherlands	63	1400	23945	26
England	40	501	11841	15
India	31	370	3382	14
France	29	606	9004	13
Mexico	22	380	5542	12
Italy	16	188	1923	8
Canada	11	140	766	7
Switzerland	10	63	3985	4

tral role in mycetoma research networks. The United States and the Netherlands also demonstrated high research impact, despite differences in publication volume, suggesting strong international collaboration and citation visibility. The bibliographic coupling analysis further supported these findings by identifying dense collaboration networks centered around key countries and institutions, highlighting the interconnected nature of global mycetoma research. Institutional analysis revealed that the University of Khartoum was the most productive affiliation, contributing nearly one-quarter of all publications. This finding underscores the critical role of specialized centers located in endemic regions in advancing scientific knowledge and clinical expertise. In addition, substantial contributions from institutions in the Netherlands, particularly Erasmus MC and Erasmus University Rotterdam, reflect successful international partnerships and sustained academic engagement in mycetoma research. Previous bibliometric studies have similarly demonstrated that strong institutional collaboration is a key determinant of research productivity and impact.[21,22] The diversity of funding sources identified in this study further highlights the multidisciplinary and international commitment to advancing mycetoma research. Support from major public funding bodies, such as the National Institutes of Health and the Wellcome Trust, alongside contributions from national agencies and industry partners, reflects recognition of mycetoma as a significant global health challenge. Bibliometric evidence suggests that publication-based metrics remain valuable indicators for evaluating the short- and medium-term outcomes of funded research, particularly in fields where translational outputs may require extended timeframes.[23,24] Analysis of publishing journals demonstrated that mycetoma research is primarily disseminated through journals focused on tropical medicine, infectious diseases, dermatology, and mycology. High-impact journals such as *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *PLOS Neglected Tropical Diseases*, and *Journal of Clinical Microbiology* played a central role in shaping the scientific discourse. This distribution reflects both the clinical relevance of mycetoma and the continued need for interdisciplinary platforms to address its complex diagnostic and therapeutic challenges. Keyword analysis further emphasized a strong research focus on disease classification, causative organisms, and treatment strategies. The predominance of keywords such as "mycetoma," "eumycetoma," and "Madurella mycetomatis" underscores sustained interest in pathogen-specific research, while the frequent appearance of treatment-related terms highlights ongoing efforts to improve therapeutic outcomes. Consistent with previous bibliometric studies, keyword co-occurrence analysis proved valuable in identifying research priorities and thematic trends within the field.[8,9,22]

Limitations

Several limitations of this study should be acknowledged. First, the analysis was restricted to publications indexed in the Web of Science Core Collection, which may not fully capture relevant studies indexed in other databases. Second, only English-language articles were included, potentially introducing language bias and excluding important contributions from non-English-speaking regions. Third, data were collected on a single day, which may result in minor temporal bias due to ongoing database updates. Additionally, reliance on citation-based metrics and journal impact factors may not fully reflect the qualitative significance of individual studies, and the interpretation of bibliometric clusters remains partially subjective. These limitations should be considered when interpreting the findings and generalizing the results.

Conclusion

This bibliometric analysis demonstrates a steadily increasing global research interest in mycetoma, reflecting growing awareness of its clinical, epidemiological, and public health significance. The findings highlight the interdisciplinary and international nature of mycetoma research, with strong contributions from endemic regions and collaborative networks involving high-income countries. By mapping publication trends, key contributors, and research hotspots, this study provides a comprehensive overview of the current research landscape and may serve as a valuable reference for researchers, clinicians, and policymakers aiming to advance prevention, diagnosis, and management strategies for mycetoma.

Disclosures

Ethics Committee Approval: Ethics committee approval was not required for this study.

Peer-review: Externally peer-reviewed.

Conflict of Interest: The authors declared no conflict of interest.

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