Bibliometric Analysis of Nontuberculous Mycobacteria Research in South Korea

Geunin Lee, M.D.[1] (iD), Young Ae Kang, M.D., Ph D.[1,2] and Youngmok Park, M.D., Ph.D.[1,3] (iD)

[1]Division of Pulmonary and Critical Care Medicine, Department of Internal Medicine, Severance Hospital, Yonsei University College of Medicine, Seoul, [2]Institute for Immunology and Immunological Diseases, Yonsei University College of Medicine, Seoul, [3]Institute for Innovation in Digital Healthcare, Yonsei University, Seoul, Republic of Korea

Check for updates

Address for correspondence
Youngmok Park, M.D., Ph.D.
Division of Pulmonary and Critical Care Medicine, Department of Internal Medicine, Severance Hospital, Yonsei University College of Medicine, 50-1 Yonsei-ro, Seodaemun-gu, Seoul 03722, Republic of Korea
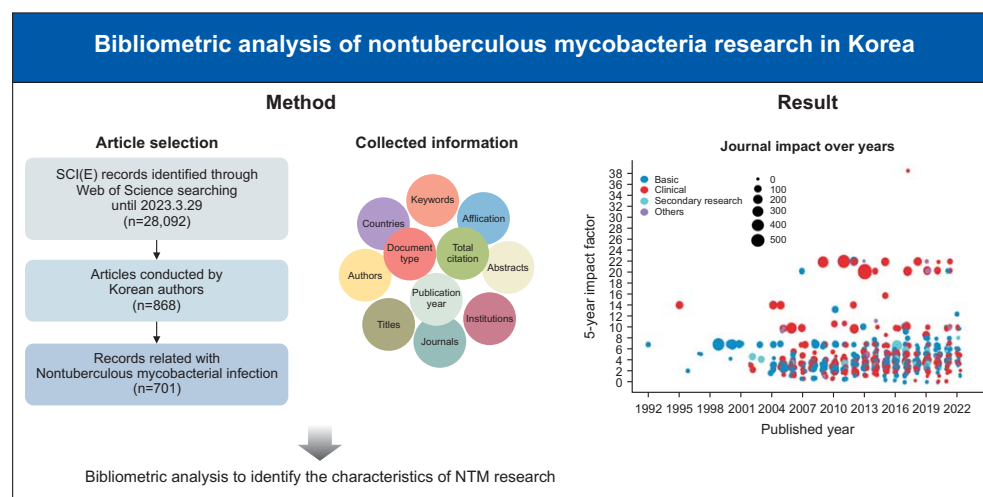**Phone** 82-2-2228-1952
Fax 82-2-393-6884
E-mail 0mokfv@yuhs.ac
Received Oct. 15, 2024
Revised Dec. 13, 2024
Accepted Jan. 13, 2025
Published online Jan. 14, 2025

Bibliometric analysis of nontuberculous mycobacteria research in Korea

Method

Article selection

SCI(E) records identified through Web of Science searching until 2023.3.29 (n=28,092)

↓

Articles conducted by Korean authors (n=868)

↓

Records related with Nontuberculous mycobacterial infection (n=701)

Collected information

Keywords, Affilation, Countries, Document type, Total citation, Abstracts, Authors, Publication year, Institutions, Titles, Journals

Result

Journal impact over years

↓

Bibliometric analysis to identify the characteristics of NTM research

Conclusion NTM research in South Korea has advanced in both quality and quantity, with an increasing number of high-impact and highly cited papers.

Abstract

Background: Current research on nontuberculous mycobacteria (NTM) is multidisciplinary, necessitating proper organization to obtain comprehensive insight. Therefore, a bibliometric analysis was performed to identify NTM research characteristics in South Korea.

Methods: The Web of Science was searched for NTM articles authored by Koreans at Korean institutions until March 2023. We collected data on authors, publication year, article type, study design, research area, citations, research institutes, and funding sources.

Results: Of the 28,092 articles on NTM, Koreans authored 868. After excluding 167 unrelated studies, 701 relevant articles were analyzed. The first study was from 1992, with publication rates markedly increasing from 2004 onward. Basic research constituted 41.3% (n=290) of the papers, whereas clinical research represented 44.7% (n=313). Basic research consisted mostly of biochemistry studies (n=73, 10.4%), whereas clinical research primarily involved retrospective studies (n=118, 16.8%). Fifty-four institutions participated in NTM research, with the top five contributing to 71% (n=498) of the publications. The National Research Foundation of Korea was the most significant funding source, supporting 181 studies (32.5% of funded articles). Citation analysis revealed a median citation count of 10 (interquartile range, 3 to 13), with clinical research dominating the top-cited articles and a rise in publications in high-impact journals over time.

Conclusion: The quality and quantity of NTM research in South Korea has improved. However, it is concentrated in a few institutions and is largely funded by a few sources. Future research should use more diverse funding sources, be conducted in more institutions, and prioritize prospective study designs to enhance the understanding and treatment of NTM.

Keywords: Bibliometrics; Nontuberculous Mycobacteria; Research Trends

Introduction

Nontuberculous mycobacteria (NTM) are ubiquitous, encompassing over 200 species of mycobacteria[1]. NTM can cause infections and diseases in various body parts, including the lungs, lymphatic system, skin, and soft tissues, and can cause disseminated disease[2,3]. Species causing NTM diseases vary with climate and environmental factors, leading to research efforts across different countries and regions[4,5]. Personal behavior can also affect the risk of NTM disease; the clinical characteristics of patients differ with age and sex[6,7]. Therefore, research regarding NTM is conducted across various fields, warranting an organized approach to gain comprehensive insight.

Bibliometric analysis is a valuable tool that uses published articles to obtain quantitative insight into the characteristics of diseases[8]. This method has been used often in various research fields, such as in cardiology and in the management of infectious diseases, such as tuberculosis (TB)[9-11]. While some studies have analyzed the trends in NTM research[12], none have focused specifically on South Korea. Since diseases caused by NTM vary by region, collecting relevant country-specific information can help identify the hotspots and gaps in current research. This information could guide future efforts to improve the management of diseases caused by NTM in South Korea. Therefore, we aimed to conduct a bibliometric analysis to identify the characteristics of NTM research in South Korea, providing a detailed overview and highlighting key trends and contributions in this area.

Materials and Methods

1. Collected information

We searched the Web of Science database for articles related to NTM authored by Koreans up to March 2023. The search was performed using the following search terms: 'nontuberculous mycobacteri,*' 'non-tuberculous,' 'avium,' 'intracellulare,' 'abscessus,' 'kansasii,' and 'fortuitum.' Articles were included if they had at least one Korean author affiliated with a Korean institution, regardless of the author's position.

For each article, we gathered details on the first and corresponding authors, journal name, year of publication, 5-year impact factor (2022), type of article, study design, research area, total number of citations, citations per year, affiliated research institute, and funding sources.

2. Article classification and analysis

The articles were categorized using an existing classification method[13,14]. They were broadly classified into one of the following categories: (1) basic research, including biochemistry, cell studies, genetic engineering and gene sequencing, genetic studies, animal studies, and material development. The ambiguity in the classification of biochemistry, was addressed by defining this term as the study of biological processes at the molecular level, including the chemical processes within and related to living organisms; (2) clinical research, encompassing case reports, case series, cross-sectional studies, non-comparative studies, before-and-after studies, case-control studies, retrospective or prospective cohort studies, and randomized controlled trials. A non-comparative study was defined as an observational study focused on a single group without comparison to another group; and (3) secondary research, which included reviews and systematic reviews with meta-analyses. Articles that could not be classified were grouped under 'others.'

Additionally, the articles were further classified based on their research areas using the International Roadmap for TB Research[15] since no specific classification system is available for NTM. These areas included fundamental research, epidemiology, diagnostics, treatment, operational and public health research, and vaccines. Unclassifiable articles were categorized as 'others.'

The abstracts were read and classified, and in cases of ambiguity, the full text was examined for classifica-

tion by two researchers (Geunin Lee and Youngmok Park). Data were analyzed using the Cochran-Armitage trend test. A p<0.05 indicated statistical significance. All statistical analyses were performed using R version 4.2.3 computing software (R Core Team, Vienna, Austria). Ethical approval and consent to participate were not required because this study was a bibliographic analysis of published articles.

## Results

1. Article selection
We searched Science Citation Index (Expanded) jour-

nals using defined terms and initially identified 28,092 articles, of which 868 were published with the participation of Korean authors. We excluded 167 articles due to duplication or association with conditions such as TB, bronchiectasis, hepatitis, and *Enterococcus avium*. Finally, we analyzed and categorized 701 articles (Figure 1).

2. Number of publications, study types, and design
The first study of NTM in Korea emerged in 1992, with the number of studies increasing slowly over the next decade until there was a substantial increase in the number of annual publications noted from 2004.

Figure 1. Flowchart of article selection for bibliometric analysis.
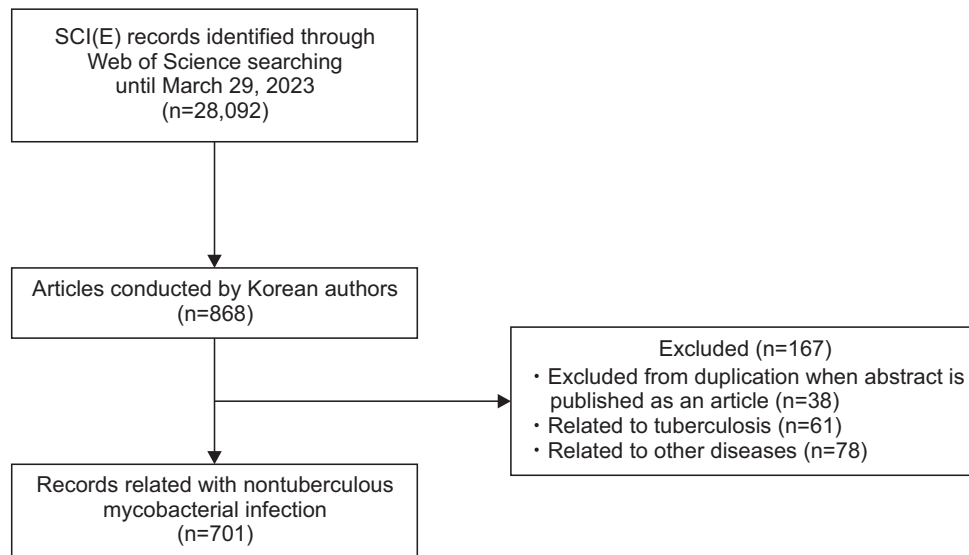
Figure 2. Research areas of articles related to nontuberculous mycobacteria published annually between 1992 and 2022 in South Korea: p for trend (fundamental 0.0205, epidemiology 0.0157, diagnosis 0.0279, treatment 0.0073, vaccines 0.0550, others 0.0196).
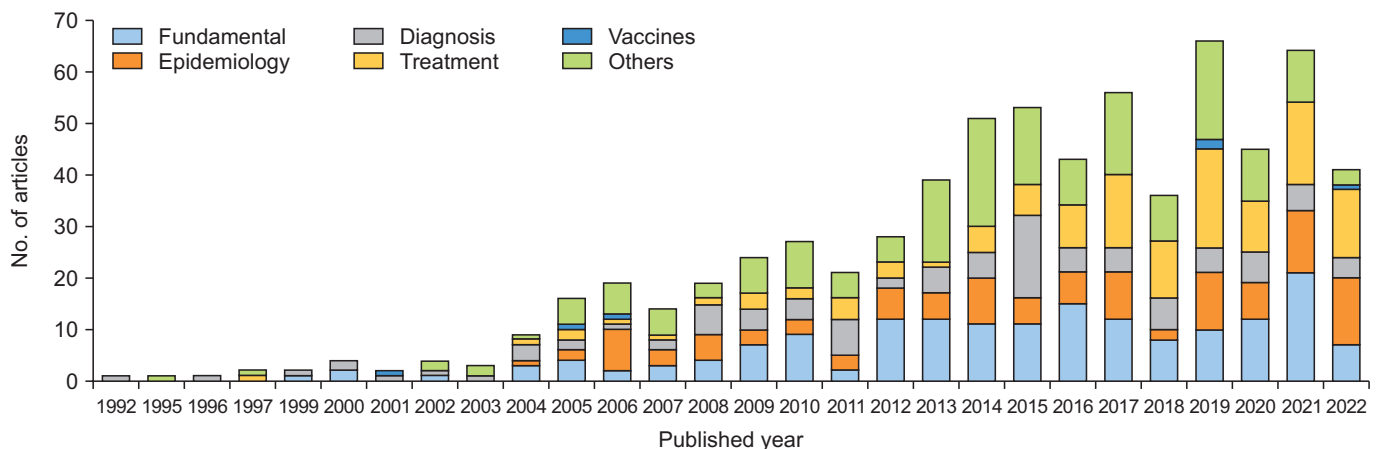
In 2019, the number of articles published annually reached a peak of 66 (Figure 2). Except for those concerning vaccines, the p-values for these trends were all below 0.05. When categorized based on publication type[15], the number of articles in the 'treatment' category showed the largest increase in 2019, with a growth rate of 1,200%. Basic research constituted 41.3% (n=290) of the published articles, while clinical research represented 44.7% (n=313) (Table 1). Within basic research, biochemistry studies were the most common (n=73, 10.4%), whereas in clinical research, retrospective cohort studies were the most prominent (n=118, 16.8%). When categorized based on the research topic, 'fundamental research' constituted the majority of the studies (23.5%), followed by 'epidemiology' (17.4%) and 'treatment' (17.1%) (Table 2).

3. Research institutes and funding

A total of 54 institutions participated in the research. Table 2 presents the top 10 publishing institutes by research area. The combined number of articles from the top five institutions totaled 498, representing 71% of the overall articles.

There were 557 funding sources, with some articles having multiple funders (Table 3). Excluding duplicates, funding information was available for 371 articles (52.9%). A total of 221 articles (76.2%) reporting basic research and 136 articles (43.6%) reporting clinical research received funding. The National Research Foundation of Korea was the primary funder for NTM research, supporting 181 studies (32.5%). Fundamental research received the most support, accounting for 198 articles (35.5%).

4. Impact of published articles

Excluding meeting abstracts, there were 653 articles, with a median citation count of 10 (interquartile range [IQR], 3 to 13). Of the top 20 cited articles, 12 were regarding clinical research, half of which focused on treatment (Supplementary Table S1). The most-cited article, with 523 citations, pertains to the epidemiology of clinical research, explicitly addressing the geographic diversity of NTM[4]. As the number of published articles increased, the number of articles published in journals with a 5-year impact factor of ≥20 also increased (Figure 3 and Supplementary Table S2).

Table 1. Number of articles on nontuberculous mycobacteria by article type and study design (1992–2023) in South Korea

| Article type	Study design	No. of articles (%)	No. of total citations, median (range)
Basic research (n=290, 41.3%)	Biochemistry	73 (10.4)	9 (0–75)
	Animal	63 (9.0)	10 (0–100)
	Material development	61 (8.7)	9 (0–188)
	Genetic study	57 (8.1)	11 (0–155)
	Cell study	27 (3.85)	13 (1–69)
	Genetic engineering/gene sequencing	9 (1.28)	21 (2–332)
Clinical research (n=313, 44.7%)	Retrospective cohort study	118 (16.8)	14(0–374)
	Case report	71 (10.1)	5 (0–22)
	Non-comparative study	61 (8.7)	18 (0–110)
	Case-control study	23 (3.3)	7 (0–87)
	Cross-sectional study	20 (2.9)	5.5 (0–523)
	Prospective cohort study	7 (1.0)	18 (1–126)
	Case series	7 (1.0)	13 (0–40)
	Before-and-after study	4 (0.6)	10.5 (0–61)
	Randomized controlled trial	1 (0.1)	109 (109–109)
Secondary research (n=34, 4.9%)	Review	31 (4.4)	9 (0–220)
	Systematic review with meta-analysis	4 (0.6)	58 (15–94)
Others (n=64, 9.1%)	Letter	16 (2.3)	2.5 (0–10)
	Meeting abstract	48 (6.8)	0 (0–1)

Table 2. Research institutes that published articles on nontuberculous mycobacteria (1992–2023) in South Korea

Research institution	Fundamental	Epidemiology	Diagnosis	Treatment	Vaccines	Others	Total no. (%)
Sungkyunkwan University	33	32	14	47	1	53	180 (25.6)
Seoul National University	47	32	29	15	0	25	148 (21.1)
University of Ulsan	9	13	9	15	0	19	65 (9.3)
Yonsei University	16	12	11	11	1	8	59 (8.4)
Chungnam National University	30	1	8	6	0	1	46 (6.6)
Chonnam National University	7	1	2	2	1	7	20 (2.9)
Pusan National University	2	3	7	2	0	3	17 (2.4)
Gyeongsang National University	2	2	2	9	0	1	16 (2.3)
Catholic University	0	4	3	0	0	7	14 (2.0)
Inje University	4	1	2	0	1	4	12 (1.7)
Others	15	21	19	13	2	54	124 (17.7)
Total no. (%)	165 (23.5)	122 (17.4)	106 (15.1)	120 (17.1)	6 (0.9)	182 (26.0)	701 (100)

Table 3. Research funds that contributed to published articles on nontuberculous mycobacteria (1992–2023) in South Korea

Research fund	Fundamental	Epidemiology	Diagnosis	Treatment	Vaccines	Others	Total no. (%)
National Research of Foundation of Korea	73	23	24	45	2	14	181 (32.5)
Ministry of Health and Welfare	33	11	21	24	1	16	106 (19.0)
Seoul National University	14	6	11	4	0	2	37 (6.6)
Ministry of Science & Technology	6	4	11	5	1	5	32 (5.7)
Samsung Medical Center	4	1	1	10	0	2	18 (3.2)
Korea Health Promotion Institute	5	2	3	2	0	3	15 (2.7)
Rural Development Administration	9	3	1	1	0	0	14 (2.5)
Agriculture Science & Technology Development	8	2	2	1	0	0	13 (2.3)
Chonnam National University	7	0	2	0	0	2	11 (2.0)
Chungnam University	5	0	1	3	0	0	9 (1.6)
Others	34	22	24	23	1	17	75 (21.6)
Total no. (%)	198 (35.5)	74 (13.2)	101 (18.1)	118 (21.2)	5 (0.9)	61 (11.0)	557 (100)

Figure 3. Five-year impact factors of journals in which articles on nontuberculous mycobacteria and by researchers based in South Korea were published between 1992 and 2022.

Discussion
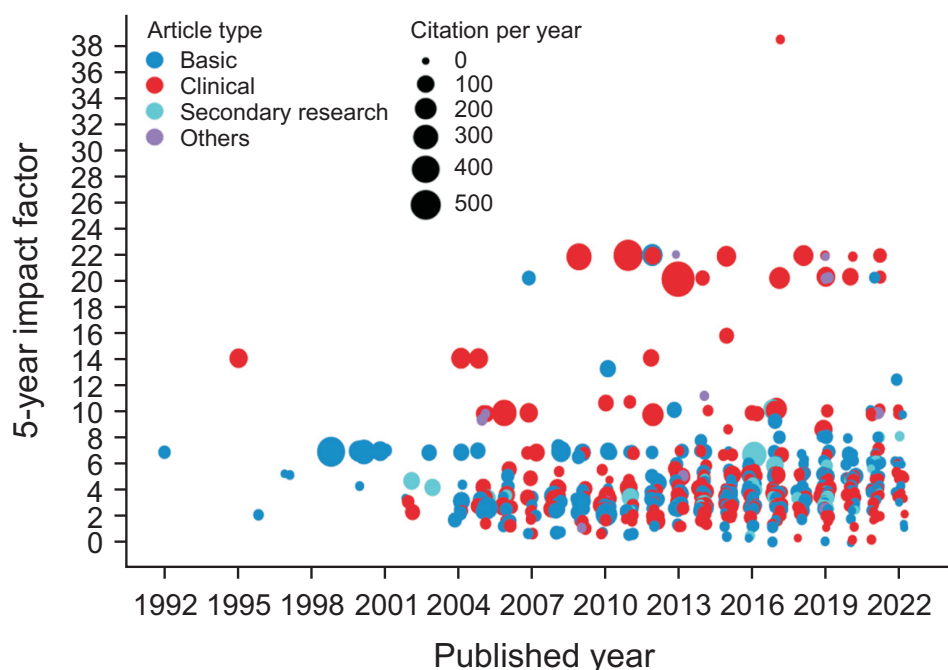
In basic research, the study design with the highest number of total citations was genetic engineering and gene sequencing (median, 21 [IQR, 17 to 40]). In clinical research, the study design with the highest total citations was randomized controlled trials (median, 109) (Table 1).

We analyzed NTM-related publications authored by researchers based in Korea. Over time, there have been continuous improvements in both the quality and quantity of publications, with study topics closely reflecting the characteristics of NTM. However, there is a need for greater diversification in study design, research institutions, and funding sources.

The incidence and prevalence of pulmonary diseases caused by NTM have steadily increased worldwide in recent decades[16]. In South Korea, the annual prevalence surged from 11.4 to 56.7 cases per 100,000 population between 2010 and 2021, respectively[17]. As interest in NTM grows and scientific demand intensifies, research on NTM has correspondingly expanded in Korea. Notably, interest in treatment has also grown significantly. This study showed that in 2019, the highest proportion of publications focused on treatment, which has also shown the largest increase in the number of articles. Over the past two decades, the focus of research has evolved, transitioning from the establishment of basic treatment protocols and the evaluation of outcomes (2004 to 2013) to the development of personalized strategies and the topic of drug resistance (2014 to 2023). This reflects a growing emphasis on optimizing regimens and improving patients' quality of life.

Notably, the characteristics of diseases caused by NTM are reflected in the focus of research regarding NTM. These diseases are not considered a notifiable condition in many countries, including South Korea[5]. Due to the absence of a central reporting system, numerous epidemiological studies have been published to deepen our understanding of the basic characteristics and clinical presentations of the affected population[7]. In our findings, 17.4% of articles were dedicated to epidemiology, a higher percentage than that of TB research (10.0%) in Korea.[10] Retrospective cohort studies comprised the plurality of clinical research (16.8%), and prospective cohort studies (1.0%) and randomized controlled trials (0.1%) were less common. Conducting prospective studies on NTM diseases presents several challenges. First, these diseases are caused by a variety of mycobacterial species, each with distinct clinical manifestations and treatment responses, necessitating species-specific considerations in diagnosis and management[18,19]. Second, because of the slow progression and prolonged treatment durations associated

with NTM diseases, extended follow-ups of the study participants are required to detect significant clinical changes[20,21]. Third, continuous environmental exposure complicates the evaluation of treatment responses[22]. Despite these challenges, future research should prioritize prospective and longitudinal studies over retrospective or single-snapshot studies to improve our understanding of the nature of the diseases and optimize treatment regimens.

The funding landscape revealed that the National Research Foundation of Korea and the Ministry of Health and Welfare play a crucial role in supporting NTM research, together sponsoring over half of the funded studies (51.5%). This underscores the critical importance of national funding bodies in driving scientific inquiry and innovation in the medical field. However, there is a need to diversify funding sources and research institutions, as a small group of entities contributes to a considerable portion of the funding and publications. When funding sources are limited, there is a greater likelihood that only certain types of research will receive support, leading to potential bias in research. Basic research receives 32.6% more funding than clinical research. Thus, it is important to allocate additional funding to clinical research to ensure balanced development between foundational knowledge and practical application.

Several limitations should be considered when interpreting the results of our study. First, our research was conducted using only one electronic medical database; this may limit the comprehensiveness of our findings. However, it covers interdisciplinary scientific fields. Therefore, previous bibliometric analyses have often used the same database[10-12]. Second, the ranking of the research institute was based solely on the number of publications, without accounting for their quality[23]. Third, we only measured the frequency of funding but could not assess the amount. Fourth, neither impact factors nor citation counts can fully capture the scientific impact of research[24]. Moreover, recent publications may have fewer citations simply due to their newer release dates.

In conclusion, this bibliometric analysis showed that both the quality and quantity of research regarding NTM in South Korea have advanced, with research topics closely reflecting the characteristics of NTM. However, research regarding NTM remains concentrated in a limited number of institutions and funding bodies. The scope and impact of future studies should be broadened through greater diversification across institutions and funding sources. Prioritizing prospective study designs over retrospective approaches is crucial for deepening our understanding of diseases caused by NTM and improving treatment strategies. These steps will be vital for advancing research regarding these pathogens and achieving more comprehensive and robust findings.

Authors' Contributions

Conceptualization: Kang YA, Park Y. Methodology: Kang YA, Park Y. Formal analysis: all authors. Data curation: Lee G, Park Y. Funding acquisition: Project administration: Visualization: Software: Validation: all authors. Investigation: all authors. Writing - original draft preparation: Lee G. Writing - review and editing: all authors. Approval of final manuscript: all authors.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

Acknowledgments

Funding

Supplementary Material

Supplementary material can be found in the journal homepage (http://www.e-trd.org).

Supplementary Table S1. The top 20 most-cited articles on nontuberculous mycobacteria by researchers based in Korea.

Supplementary Table S2. The top 20 articles on nontuberculous mycobacteria with the highest impact factors by researchers based in Korea.

References

1. Jeon D. Infection source and epidemiology of nontuberculous mycobacterial lung disease. Tuberc Respir Dis (Seoul) 2019;82:94-101.
2. Kumar K, Loebinger MR. Nontuberculous mycobacterial pulmonary disease: clinical epidemiologic features, risk factors, and diagnosis: the nontuberculous mycobacterial series. Chest 2022;161:637-46.

3. Park H, Kang YA, Park Y. Disseminated nontuberculous mycobacterial infection in a tertiary referral hospital in South Korea: a retrospective observational study. Yonsei Med J 2023;64:612-7.

4. Hoefsloot W, van Ingen J, Andrejak C, Angeby K, Bauriaud R, Bemer P, et al. The geographic diversity of nontuberculous mycobacteria isolated from pulmonary samples: an NTM-NET collaborative study. Eur Respir J 2013;42:1604-13.

5. Prevots DR, Marshall JE, Wagner D, Morimoto K. Global epidemiology of nontuberculous mycobacterial pulmonary disease: a review. Clin Chest Med 2023;44:675-721.

6. Park Y, Kwak SH, Yong SH, Lee SH, Leem AY, Kim SY, et al. The association between behavioral risk factors and nontuberculous mycobacterial pulmonary disease. Yonsei Med J 2021;62:702-7.

7. Lee G, Kim S, Chang S, Sohn H, Kang YA, Park Y. Epidemiological characteristics of nontuberculous mycobacterial pulmonary disease in South Korea: a meta-analysis of individual participant data. Tuberc Respir Dis (Seoul) 2024;87:386-97.

8. Ellegaard O, Wallin JA. The bibliometric analysis of scholarly production: How great is the impact? Scientometrics 2015;105:1809-31.

9. Shuaib W, Khan MS, Shahid H, Valdes EA, Alweis R. Bibliometric analysis of the top 100 cited cardiovascular articles. Am J Cardiol 2015;115:972-81.

10. Lee HW, Yim JJ. A bibliometric analysis on tuberculosis research of Korea from 1979 to 2017. J Korean Med Sci 2019;34:e95.

11. Nafade V, Nash M, Huddart S, Pande T, Gebreselassie N, Lienhardt C, et al. A bibliometric analysis of tuberculosis research, 2007-2016. PLoS One 2018;13:e0199706.

12. Jhun BW, Kim SY, Kong JH, Park JR, Park SY, Shim MA, et al. The 100 most-cited articles on non-tuberculous mycobacterial infection from 1995 to 2015. Int J Tuberc Lung Dis 2017;21:100-6.

13. Seo HJ, Kim SY, Lee YJ, Jang BH, Park JE, Sheen SS, et al. A newly developed tool for classifying study designs in systematic reviews of interventions and exposures showed substantial reliability and validity. J Clin Epidemiol 2016;70:200-5.

14. Rohrig B, du Prel JB, Wachtlin D, Blettner M. Types of study in medical research: part 3 of a series on evaluation of scientific publications. Dtsch Arztebl Int 2009;106:262-8.

15. World Health Organization and Stop TB Partnership. An international roadmap for tuberculosis research: towards a world free of tuberculosis. Geneva: WHO; 2011.

16. Dahl VN, Molhave M, Floe A, van Ingen J, Schon T, Lillebaek T, et al. Global trends of pulmonary infections with nontuberculous mycobacteria: a systematic review. Int J Infect Dis 2022;125:120-31.

17. Kim JY, Kwak N, Yim JJ. The rise in prevalence and related costs of nontuberculous mycobacterial diseases in South Korea, 2010-2021. Open Forum Infect Dis 2022;9:ofac649.

18. Kwon YS, Koh WJ. Diagnosis and treatment of nontuberculous mycobacterial lung disease. J Korean Med Sci 2016;31:649-59.

19. van der Laan R, Snabilie A, Obradovic M. Meeting the challenges of NTM-PD from the perspective of the organism and the disease process: innovations in drug development and delivery. Respir Res 2022;23:376.

20. Hwang JA, Kim S, Jo KW, Shim TS. Natural history of Mycobacterium avium complex lung disease in untreated patients with stable course. Eur Respir J 2017;49:1600537.

21. Hwang H, Lee JK, Heo EY, Kim DK, Lee HW. The factors associated with mortality and progressive disease of nontuberculous mycobacterial lung disease: a systematic review and meta-analysis. Sci Rep 2023;13:7348.

22. Honda JR. Environmental sources and transmission of nontuberculous mycobacteria. Clin Chest Med 2023;44:661-74.

23. van Raan AF. Fatal attraction: conceptual and methodological problems in the ranking of universities by bibliometric methods. Scientometrics 2005;62:133-43.

24. Garfield E. The history and meaning of the journal impact factor. JAMA 2006;295:90-3.