Research Article

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An Updated Bibliometric Analysis of Tuberculosis Research in ASEAN Countries: 2000–2024

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Abstract: Tuberculosis (TB) continues to be a significant public health challenge in ASEAN countries, particularly in settings with limited diagnostic and treatment facilities. This study presented a comprehensive bibliometric analysis of TB research published from January 1, 2000, to April 1, 2024, employing a search of the Scopus database. Our analysis of 3,666 documents revealed a growth rate of 9.98% in TB research within the region, with Indonesia, Thailand, Malaysia, and Vietnam as the leading contributors. Indonesia's and Thailand's publications accounted for 910 documents (24.82%) and 855 documents (23.32%), respectively. Malaysia constituted 12.06%, and Vietnam 11.29%. Key findings included an upward trend in publications on multidrug-resistant TB and TB-human immunodeficiency virus coinfection, indicating an evolving focus of regional research efforts. We also identified a marked increase in intercountry collaboration, highlighting the growing importance of cooperative approaches to TB management. This study not only mapped the scientific landscape of TB research in the ASEAN countries but also highlighted important areas for future investigations and policy development aimed at mitigating the impact of TB. The findings suggest that enhancing regional collaboration and focusing on emerging TB challenges could be pivotal for advancing TB control strategies in these countries.

Keywords: ASEAN countries, Bibliometric analysis, Multidrug-resistant tuberculosis, Regional collaboration, Tuberculosis

INTRODUCTION

Tuberculosis (TB) is an infectious disease caused by the bacterium *Mycobacterium tuberculosis*. It is a preventable and often curable disease (1). TB is spread through the air by people with the disease who cough or sneeze and release bacteria into the air (2). According to the World Health Organization (WHO) 2023 edition, one quarter of the global population is reported to have TB. In 2023, the WHO reported that TB is the second cause of concern due to its deaths after single transferrable infection and after coronavirus disease 2019 (COVID-19).

TB affects twice as many people as acquired immunodeficiency syndrome (AIDS), with more than 10 million people becoming sick and ill each year. The number of TB patients diagnosed in the year 2022 was 7.5 million worldwide, and 55% were males, 33% were females, and fewer than 14% were children. The WHO estimates that 410,000 people (95% UI: 370,000–450,000) are newly sick with TB and are resistant to many drugs or rifampicin. Eighty-five percent of the worldwide TB cases were diagnosed in 30 countries with a high TB burden: India (27%), Indonesia (10%),

China (7.1%), the Philippines (7.0%), Pakistan (5.7%), Nigeria (4.5%), Bangladesh (3.6%), and the Democratic Republic of the Congo (3.3%). These 8 countries account for more than 87% of the most infections (3).

Therefore, the information provided above indicates that TB remains a battleground for the global population. Its prevalence is high in a variety of resource-poor settings, identical to low- and middle-income countries and multiple member countries in Southeast Asia (4). This region has unique geographical and demographic characteristics, as well as interesting TB research and control history, mainly because of its territorial diversity and the extremely different financial characteristics and healthcare systems of its members. Although the prevalence of TB in this region has significantly improved over the past few years, specific epidemiological parameters for this disease need to be considered in the ASEAN region because of the increased incidence of TB and the increased incidence of multidrug resistance-TB (MDR-TB) and TB-human immunodeficiency virus (TB-HIV) coinfections in these countries (5). In addition, high inequalities in socioeconomic indicators, intense territorial mobility, and limited access to health services increase TB problems in this region, making it reasonable to consider research and intervention in terms of TB in the region (6).

Despite numerous studies on TB, comprehensive data analyzing the breadth of research conducted in the ASEAN region, which is critical for understanding regional dynamics and developing targeted interventions, are lacking. The literature review identified three relevant studies similar to the current study. First, Abdullah et al. (7) conducted a bibliometric analysis of the global research performance of TB research from 2011--2020. Second, Zhen et al. (8) presented a bibliometric analysis of TB molecular epidemiology via CiteSpace software. The other study, conducted by Cahyadin et al. (9) in 2017, was a bibliometric analysis specific to ASEAN countries that produced 2,630 TB publications. In later publications, Thailand, Singapore, and Malaysia produced 55.66% of TB research publications in ASEAN countries (9). Despite the studies reviewed summarizing individual countries' or associations' research output over several years, there is no recent and all-inclusive bibliometric analysis of the research output in the ASEAN context. A comprehensive and up-to-date bibliometric analysis of TB research publications within ASEAN countries will provide an overview of the progress, volume, focus, and scope of the topic. It will also help to understand how published studies reveal collaboration within ASEAN member states and between the association and the global research partnership. Like other fields of research (10), a bibliometric review will also identify whether the TB topic aligns with the prevailing TB disease challenges in the ASEAN region. The study also highlights the robustness and unidentified areas of adequate and insufficient knowledge. The rise of MDR-TB and the TB-HIV coinfection epidemic calls for specialized knowledge gaps and new research strategies and innovations. Therefore, a comprehensive bibliometric analysis is essential for determining TB research trends in the ASEAN region and guiding stakeholders in decision making.

Bibliometric analysis, as a quantitative method, evaluates the impact and tendencies of a particular body of literature. With this approach, it is possible to apply a variety of statistical tools to the stored data to understand the trends and statistics of publications. Thus, bibliometric analysis examines the metadata from the publication's perspective and interprets the statistics of the number of publications, time, citations, coauthorship between many authors, frequency of keywords, and many other factors linking those phenomena into a coherent network. In other words, bibliometric analysis is useful when mapping the intellectual world of a subject; highlighting the works of leading authors, institutions, and countries; and discovering how topics and collaboration have evolved. This tool is helpful, particularly in medical research, for understanding tendencies and changes across designated periods (10).

In this context, this study aims to answer several questions underpinning the trends, gaps,

and focal points of TB research within ASEAN countries throughout the designated period. Therefore, the authors aim to determine the following:

- Evolution of the volume of TB research in ASEAN countries from 2000–2024. It is important to understand the degree of increase or decrease in research output and identify any periods characterized by particularly sharp or prolonged changes.

- The thematic evolution of TB research trends and topics within the ASEAN region during this time. It is necessary to determine core thematic clusters, such as drug resistance, epidemiology, or public health interventions, and describe how their prominence has evolved.

- The league table of TB research by country in ASEAN countries and worldwide. Ranking of countries by output and determination of how their performance stacks up against the global average.

- The "who is who" scorecard of researchers and top-ranked institutions leading TB research in the ASEAN countries. Identifying institutions and researchers can help determine centers of excellence and track potential areas of cooperation.

- Coauthorship network types across ASEAN countries and their contributions to international partners. Analyzing coauthorship networks can help determine the types of collaboration, both among ASEAN countries and with international partners.

- The impact of TB research originating from ASEAN countries on citation metrics. At the same time, this may help determine the quality of the research on the basis of impact indicators such as citation counts and the H-index.

- Identification of the future trends and methods of TB research in ASEAN countries in the latest articles. Finally, this will help forecast the future emphasis on thematic areas using the most recent literature highlighting the latest issues.

The research questions above sought to fill a gap in TB research in ASEAN countries. This article was, therefore, a comprehensive examination of TB research currently in the field. The aim of this study was to analyze TB research in ASEAN countries from January 1, 2000, to April 1, 2024, for two reasons. First, we aimed to gain an overall understanding of the scientific output, quality, collaboration, thematic areas of TB research in the region, and any changes over time. Second, we were looking for existing areas of research capability and potential research desiderata. Finally, the conclusions of this article have implications for healthcare students and researchers, practitioners and policymakers, public health professionals, and others. They should inform data and strategic decisions and collaboration for the ASEAN and internationally, regionally.

MATERIALS AND METHODS

Data source and search strategy

This bibliometric study focused only on the Scopus database to identify publications related to TB in the ASEAN region from 1 January 2000 to 1 April 2024. A systematic search was conducted using specific keywords and Boolean operators to capture the breadth of TB research in the ASEAN region. The search query was structured as follows: TITLE-ABS-KEY ("tuberculosis" OR "TB") AND AFFILCOUNTRY ("Brunei Darussalam" OR "Cambodia" OR "Indonesia" OR "Laos" OR "Malaysia" OR "Myanmar" OR "Philippines" OR "Singapore" OR "Thailand" OR "Vietnam"). This targeted approach was aimed at extracting documents that not only mentioned TB in the title, abstract, or keywords but were also affiliated with any of the ASEAN countries, thus ensuring the relevance and regional focus of the data collected. The search was limited to articles published in English to maintain consistency in language for analysis purposes.

Inclusion and exclusion criteria

Only original research articles related to TB in ASEAN countries were included. Non-ASEAN-

specific works not related to TB and nonoriginal works such as conference papers, reviews, commentaries, editorials, or letters to the editor were excluded. Additionally, non-English articles were excluded to ensure a uniform dataset for accurate analysis and comparison.

Data extraction and analysis

Two reviewers independently screened the titles and abstracts of the retrieved articles for eligibility. The full texts of potentially suitable studies were subsequently carefully reviewed for inclusion/exclusion. Disagreements were resolved by discussion or consensus with a third reviewer. The key data that were extracted included author(s), year of publication, countries of focus, type of studies, main findings, and main keywords used. All data management and preliminary summarization tasks were performed via Microsoft Excel, which facilitated the organization and preliminary analysis of the data.

Bibliometric and statistical analysis

Bibliometric analysis was performed with VOSviewer 1.6.20, a software tool for visual data analysis (https://www.vosviewer.com/). This analysis facilitated the identification of temporal trends in publications, distributions by country, prominent authors and institutions, and research hotspots through keyword cocitation. Furthermore, influential studies were identified through citation analysis. In addition, the authors included descriptive statistics to summarize the datasets more comprehensively. This included measures such as the mean number of publications per year, the average number of citations per article, and the distribution of publications across different ASEAN countries. The authors also calculated the standard deviation to provide insights into the variability of publications and citations among the researchers studied. The geographic distribution of research in this study was primarily based on the country of affiliation of the first author of each publication. This approach is commonly used in bibliometric analyses to approximate the primary location of research activities, as it typically represents the main contributing institution. However, for research articles that included relevant studies globally, we assigned the country on the basis of the majority of the data sources used in the studies, if discernible, or otherwise by the corresponding author's country to ensure relevance to the ASEAN context. Specifically, the number of publications, the level of citations, and the Scopus H-index values were thoroughly reviewed for each researcher (author) selected. Overall, this assessment helps to define the impact, scholarly productivity, and collaborative patterns of scientific publication in the ASEAN field of TB research.

RESULTS

Overview of TB publications in ASEAN countries

A PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram (Figure 1) outlines the process we employed to identify relevant and reliable studies on TB research in ASEAN countries. The initial search conducted in the Scopus database yielded a total of 4,665 records, encompassing a diverse range of document types. From the initial search, we identified 3,753 research articles, 281 reviews, and 251 conference proceedings. Additional documents included letters, notes, editorials, book chapters, errata, short surveys, data papers, conference reviews, and books. Among these, one retracted article and six duplicates were excluded. To maintain uniformity in the dataset, 72 non-English papers were also excluded. This filtering left 3,675 records. After a detailed assessment of titles and abstracts, 3,666 articles remained, which were thoroughly reviewed to ensure that they specifically addressed TB research within the ASEAN context. Articles that did not fit this criterion or made insignificant contributions to the field were excluded. Ultimately, 3,666 records were deemed eligible and formed the basis of our

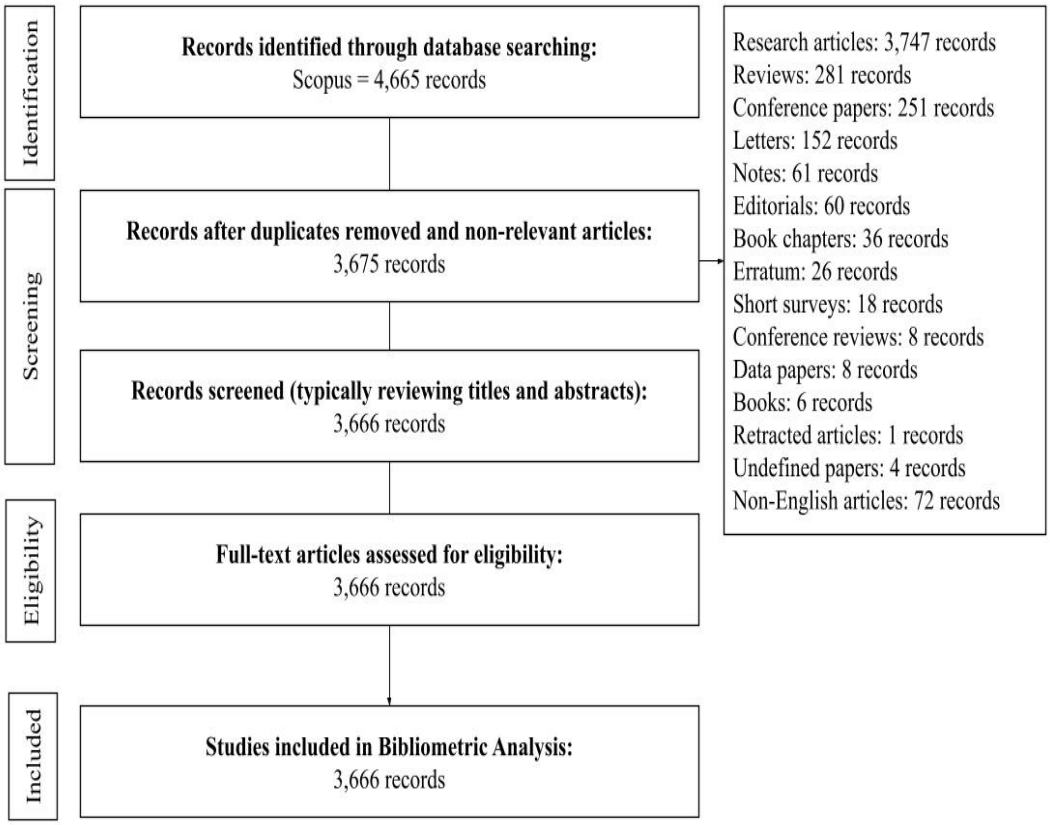

Figure 1. PRISMA flow diagram for the selection of tuberculosis research studies in ASEAN countries from the Scopus database.

bibliometric analysis. This analysis focused on publication trends, geographic distribution, citation patterns, and the identification of research hotspots within the region on the basis of the selected articles.

Publication trend analysis

Over the course of 24 years (Figure 2), 3,666 research articles were published. The initial year (2000) had a modest output of 40 documents, followed by a relatively stable period with minor fluctuations averaging approximately 60 publications per year until 2006. Throughout the years, there was a visible overall increase in the number of publications from 83 documents in 2007. The numbers continue to fluctuate and grow, reaching more than 200 by 2018 and more than 300 between 2021 and 2022, with a peak of 329 in 2021. There is a slight decline in 2023 when the number of publications reaches 302, whereas the number for 2024 is low because of the lack of updated information for the whole year, with the data accounting for only April 1, 224, publications. These interim data did not necessarily reflect a decrease in research activity for the entire year. The typical delay in academic publication and indexing may lead to an underestimation of the total number of publications for 2024. The overall trend over the span of two decades demonstrates a robust and expanding body of literature. This reflects a calculated growth rate of 9.98% in TB research within the region over the study period.

Geographic distribution of research

The ASEAN region, as indexed by the Scopus database, has demonstrated significant contributions from member countries, underlining active research landscapes and international collaborations. The classification of countries was based on the majority of the data sources used in

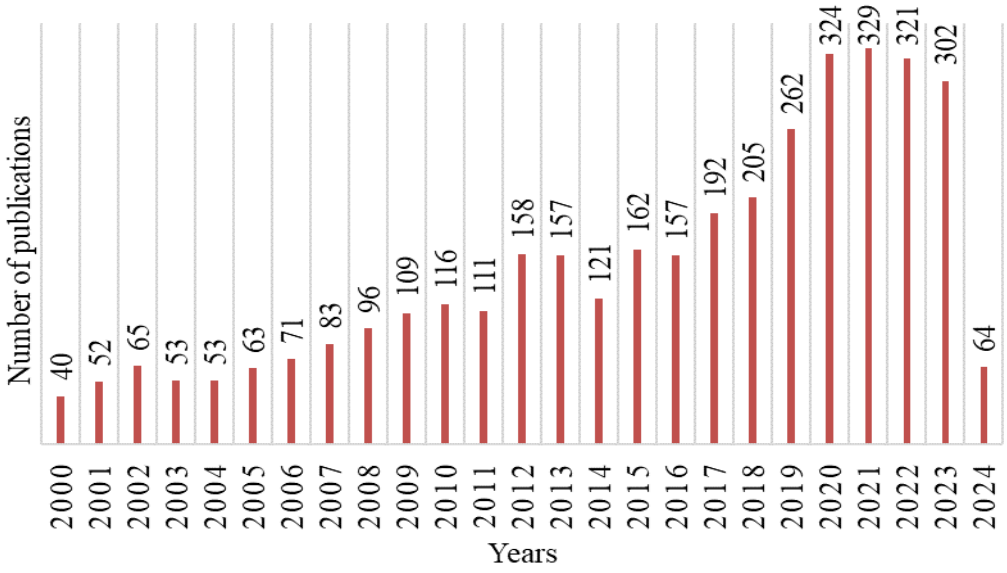

Figure 2. Analysis of publication trends in tuberculosis research in ASEAN countries (1 January 2000 - 1 April 2024).

the review, if discernible, or otherwise by the corresponding author's country to ensure relevance to the ASEAN context. As depicted in Figure 3, Indonesia leads with 910 publications, reflecting its robust national research initiatives. This prominence is likely influenced by its status as the most populous country in the region (with a current population of 279,418,243 as of May 1, 2024, according to Worldometer (https://www.worldometers.info/)), which may correlate with a higher TB incidence and more intensive research activity. Thailand follows closely with 855 documents, indicating its strong research infrastructure and government support for TB research. Malaysia and Vietnam also show substantial efforts, with 442 and 414 records, respectively, aligned with their national health priorities and research capabilities. The Philippines, with 246 records, and Singapore, with 230 publications, demonstrate significant research outputs, with Singapore also serving as a regional hub for medical research and innovation. Cambodia (148 records) and Myanmar (125 records) are emerging as active research environments, likely driven by increasing TB burdens and the need for evidence-based interventions. Brunei Darussalam and Laos, with smaller outputs of 19 and 36 records, respectively, reflect their relative population sizes and economies but still indicate engagement in scientific efforts to understand and combat TB. The collective research output from all ASEAN countries, as depicted by their publication records, underscores a regionally concerted effort to advance TB research.

Authorship analysis

The analysis of authorship in TB research across ASEAN countries demonstrated notable contributions by experts, primarily from Indonesia and Thailand. As shown in Table 1, Bachti Alisjahbana from the Research Center for Care and Control of Infectious Disease, Universitas Padjadjaran, Indonesia, had the greatest number of publications, with 90 written publications. Rovia Ruslami, from the Faculty of Medicine, Universitas Padjadjaran, Indonesia, closely follows with 56 publications. Angkana K. Chaiprasert from Siriraj Hospital, Thailand, holds the third position, contributing 52 papers to the field. Van Crevel, who is based at Radboud University Medical Center, Netherlands, and collaborates with researchers in Indonesia, holds the fourth position, with a total of

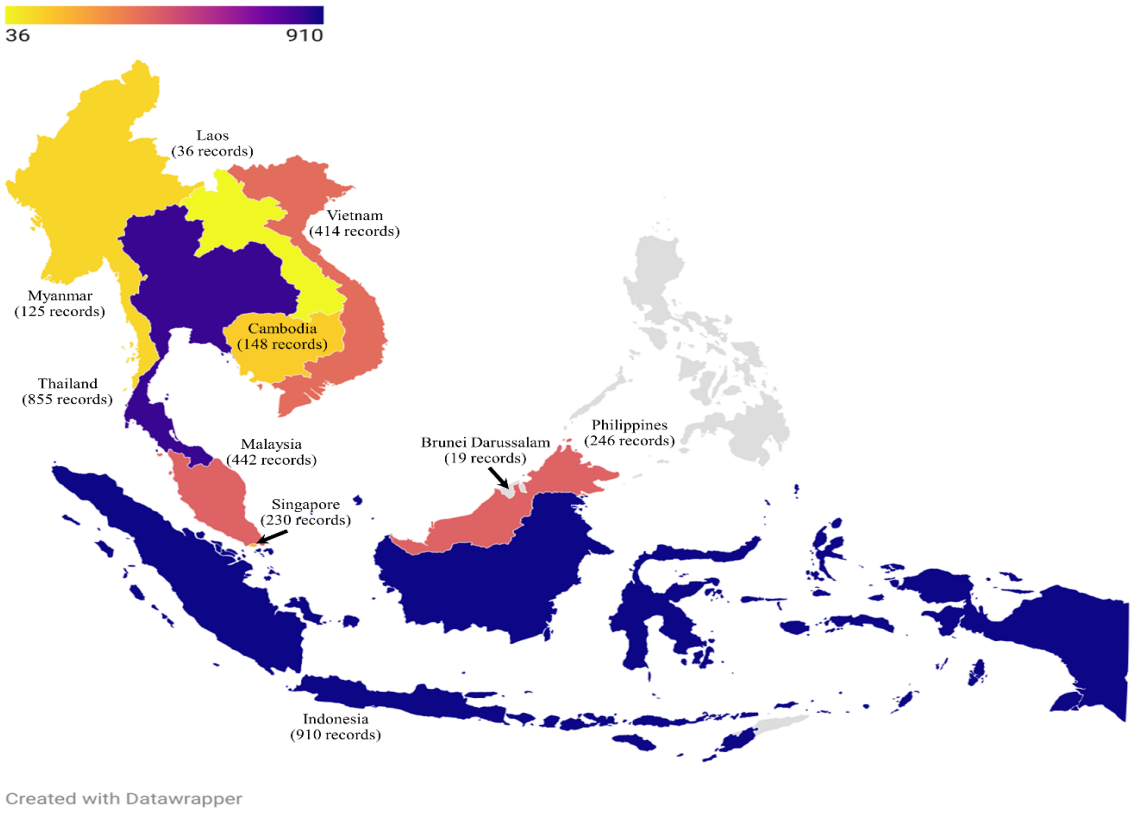

Figure 3. Ten ASEAN countries with numbers of publications (1 January 2000 - 1 April 2024). (The map was created using Data wrapper, a free software, https://www.datawrapper.de/basemaps/south-east-asia.)

49 publications. Nguyen Thi Ngoc Lan, from Pham Ngoc Thach Hospital in Vietnam, closely follows with 48 publications. Additional noteworthy contributions were made by Jay K. Varma from Weill Cornell Medicine, United States, who collaborated with researchers in Thailand and published 47 papers; Virasakdi Chongsuvivatwong from the Faculty of Medicine, Prince of Songkhla University, Thailand, who published 44 papers; and Cynthia Bin Eng Chee from Tan Tock Seng Hospital, Singapore, who published 42 papers. Moreover, Maxine Caws from the Birat Nepal Medical Trust, Nepal, who collaborated with researchers in ASEAN countries, and Yee Tang Wang from Tan Tock Seng Hospital, Singapore, have made significant contributions, with 40 and 38 publications, respectively.

Citation analysis and impactful publications

The data analysis of the dataset and the most cited articles revealed that the most impactful articles were related to epidemiological studies and clinical trials on drug-resistant TB. As illustrated in Table 2, the citation analysis of impactful publications in TB research supports the statement that the most impactful articles were focused on epidemiological studies and clinical trials. More recent articles frequently cite earlier works, particularly those discussing comprehensive themes such as the global disease burden. This pattern underscores the influence of foundational research and its enduring relevance within the field. Such citations signify the developmental nature of scholarly discourse, where newer studies build upon and reference the findings of preceding studies. For example, the most impactful source that collected 8,276 citations was an article written by James et al. and published in The Lancet in 2018, which was related to the analysis of the global disease burden, including TB (11). A close review follows: the article by Naghavi et al., published earlier in the same journal in 2015, covers various causes of

Table 1. The top 10 authors with the greatest number of publications.

Rank	Authors	Scopus H-index	Number of Publications	Country
1	Bachti Alisjahbana	39	90	Indonesia
2	Rovia Ruslami	32	56	Indonesia
3	Angkana K. Chaiprasert	27	52	Thailand
4	Reinout Van Crevel	74	49	Netherlands*
5	Nguyen Thi Ngoc Lan	37	48	Thailand
6	Jay K. Varma	37	47	United States
7	Virasakdi Chongsuvivatwong	41	44	Thailand
8	Cynthia Bin Eng Chee	25	42	Singapore
9	Maxine Caws	37	40	Nepal*
10	Yee Tang Wang	27	38	Singapore

*Collaboration with researchers in some Asian countries.

mortality, including TB, resulting in 5,888 citations. This article is essential for health policies regarding TB (12). The article by Hay et al. is also significant for epidemiological studies and has been cited 1,552 times. This article provides new data on global disability-adjusted life-years for diseases, including TB (13). Boehme et al.'s article on the Xpert MTB/RIF test for the diagnosis of TB as well as drug resistance, which had 826 citations (14), and Thwaites et al.'s 2004 article on dexamethasone treatment for tuberculous meningitis, which had 822 citations, highlight the importance of the development of new diagnostic tools and treatment strategies (15). Helb et al.'s 2010 study on rapid detection technologies for TB and rifampin resistance, which was cited 695 times (16), along with Caws et al.'s 2008 study on the effects of host and bacterial genotypes on the development of disseminated disease with TB, with 403 citations (17). Glynn et al.'s 2002 systematic review on the Beijing/W strains of *Mycobacterium tuberculosis*, which is crucial for understanding global epidemiology, has 532 citations (18). Chakaya et al.'s 2021 overview of global TB efforts in the International Journal of Infectious Diseases and O'Brien et al.'s 2019 Lancet study on severe pneumonia in children both contribute to a broader understanding of infectious diseases, with 492 and 481 citations (19, 20), respectively. Collectively, these publications illustrate the extensive and multifaceted research efforts aimed at comprehending and controlling TB on an ASEAN scale.

Research focus and hotspots

The analysis of TB research in the ASEAN countries revealed major areas of focus and emerging scientific hotspots. The analysis was based on a pool of 17,832 research publications, from which 2,948 keywords were extracted, five of which were included in the keyword list of relevance, occurring at least five times (Figure 4). The one thousand keywords were then introduced into five clusters that represented major fields of TB research. The red cluster includes TB and HIV coinfection themes, which include keywords such as TB with human immunodeficiency virus, CD4 lymphocyte count, and clinical outcomes related to coinfection. The blue cluster targets drug-resistant TB, including keywords such as *Mycobacterium tuberculosis*, multidrug resistance, and socioeconomic factors affecting treatment. The green cluster covers epidemiology and public health and includes keywords such as risk factor, cross-sectional study, and prevalence. The yellow cluster focuses on the diagnosis of TB with keywords related to pulmonary assessment, sputum analysis, and radiographic technique. Finally, the purple cluster targets specific demographic issues and treatments, including keywords related to aged adults, diabetes complications, and treatment outcomes in high-risk and very elderly patients.

Table 2. The top 10 publications with the greatest number of citations.

Rank	Document title	Authors	Source	Year	Citations
1	Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: A systematic analysis for the global burden of disease study 2017.	James, S.L., Abate, D., Abate, K.H., ...Vos, T., Murray, C.J.L.	The Lancet, 392 (10159), pp. 1789-1858	2018	8,276
2	Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 cases of death, 1990-2013: A systematic analysis for the global burden of disease study 2013	Naghavi, M., Wang, H., Lazano, R., …Sabin, N., Temesgen, A.M.	The Lancet, 385(9963), pp. 117-171	2015	5,888
3	Global, regional, and national disability-adjusted life-years (DALYs) for 333 diseases and injuries and health life expectancy (HALE) for 195 countries and territories, 1990-2016: A systematic analysis for the global burden of disease study 2016	Hay, S.I., Abajobir, A.A., Abat, K.H., … Murdoch, M.E., Bryane, C.E.G.	The Lancet, 390 (10100), pp. 126-1344	2017	1,552
4	Feasibility, diagnostic accuracy, and effectiveness of decentralized use of the Xpert MTB/RIF test for diagnosis of tuberculosis and multidrug resistance: A multicenter implementation study	Boehme, C.C., Nico, M.P., Nabeta, P., … Alland, D., Perkins, M.D.	The Lancet, 377 (9776), pp. 1495-1505	2011	826
5	Dexamethasone for the treatment of tuberculous meningitis in adolescents and adults	Thwaites, G.E., Bang, N.D., Dung, N.H., …Hien, T.T., Farrar, J.J.	New England Journal of Medicine, 351 (17)	2004	822
6	Rapid detection of *Mycobacterium tuberculosis* and rifampin resistance by use of on-demand, near-patient technology	Helb, D., Jones, M., Story, E., …Persing, D.H., Alland, D.	Journal of Clinical Microbiology, 48(1), pp. 229-237	2010	695
7	Worldwide occurrence of Beijing/W strains of *Mycobacterium tuberculosis*: A systematic review	Glynn, J.R., Whiteley, J., Bifani, P.J., Kremer, K., Van Soolingen, D.	Emerging Infectious Diseases, 8(8), pp. 843-849	2002	532
8	Global tuberculosis report 2020-reflections on the global TB burden, treatment, and prevention efforts	Chakaya, J., Khan, M., Ntoumi, F., …Abubakar, I., Zumla, A.	International Journal of Infectious Diseases, 113, pp. S7-S12	2021	492

Table 2. The top 10 publications with the greatest number of citations. (continued)

Rank	Document title	Authors	Source	Year	Citations
9	Causes of severe pneumonia requiring hospital admission in children without HIV infection from Africa and Asia: the PERCH multicountry case–control study	O'Brien, K.L., Baggett, H.C., Brooks, W.A., ...Zaman, K., Zaman, S.M.A.	The Lancet, 394 (10200), pp. 757-779	2019	481
10	The influence of host and bacterial genotype on the development of disseminated disease with *Mycobacterium tuberculosis*	Caws, M., Thwites, G., Dunstan, S., Chau, N.V.V., Farrar, J.	PLoS Pathogens, 4(3), e1000034	2008	403

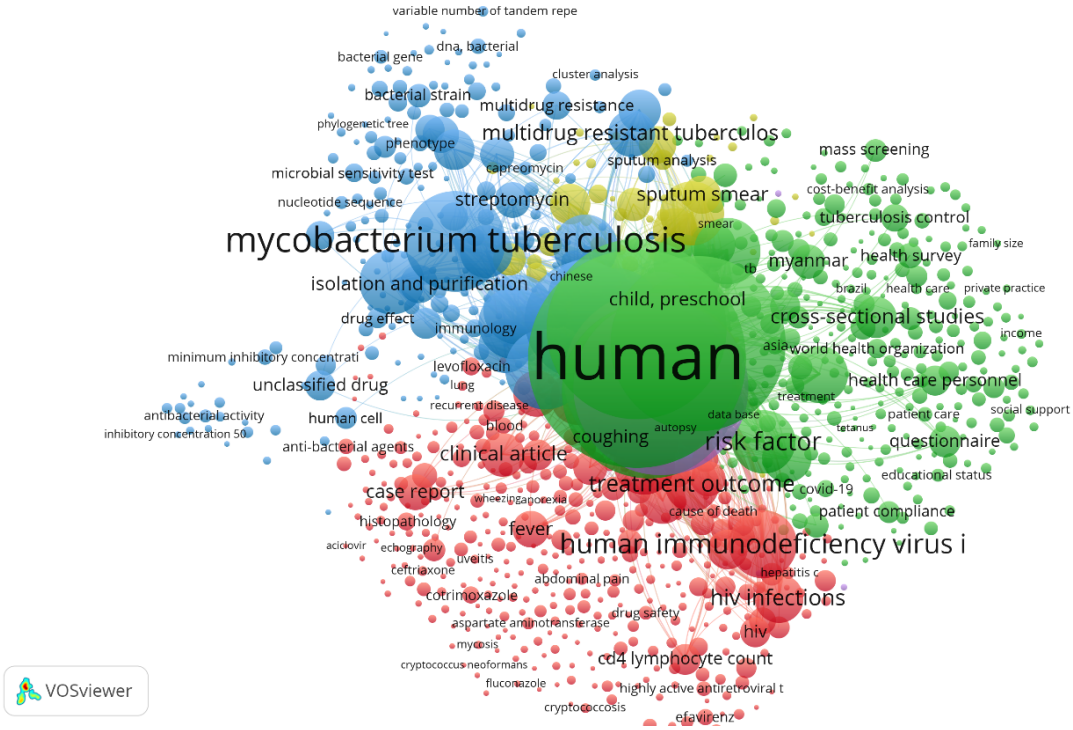

Figure 4. Clustering of research themes in tuberculosis research studies in ASEAN countries from the Scopus database. Source: Data were compiled from the Scopus database and visualized using VOS viewer version 1.6.20 (January 1, 2000 - April 1, 2024).

Collaboration networks

In the analysis of collaboration networks within TB research, among 176 countries surveyed, 72 met the established thresholds by having at least five documented contributions each. The strength of the coauthorship links between these countries was assessed, highlighting the most interconnected nations. All 72 selected countries exhibited strong collaboration patterns, and their relationships are depicted in Figure 5, which identified six distinct clusters of collaboration. Notably, intraregional collaboration among ASEAN countries was particularly strong. Vietnam, Thailand, and Indonesia emerged as key contributors and central nodes within the regional

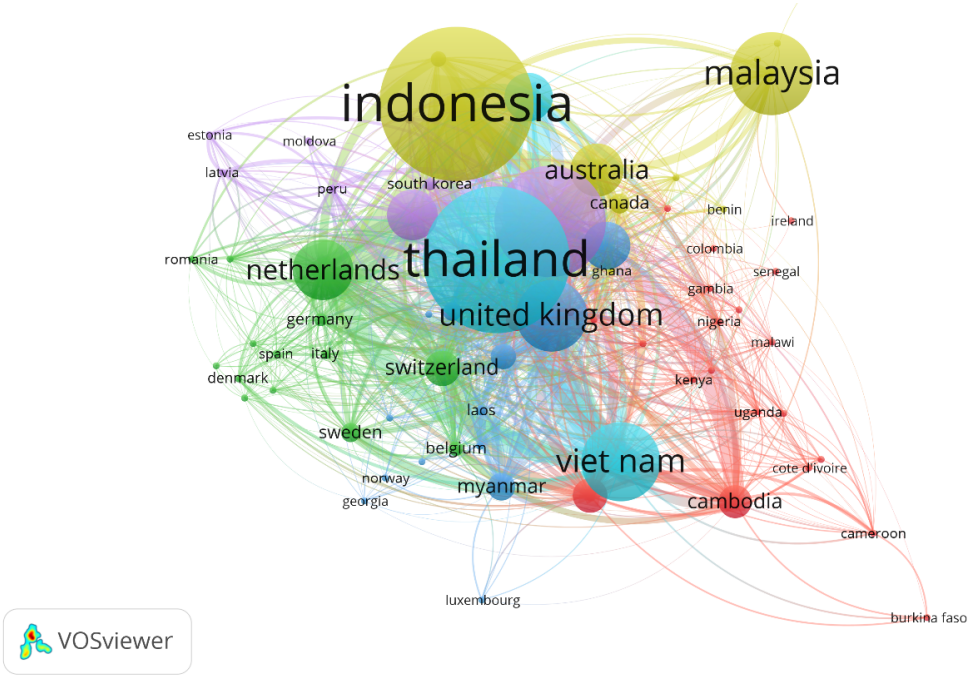

Figure 5. ASEAN and Global Collaboration Networks in Tuberculosis Research. Source: Data were compiled from the Scopus database and visualized using VOS viewer version 1.6.20 (January 1, 2000 - April 1, 2024).

research network, with Vietnam presenting 414 documents, 12,182 citations, and a total link strength of 828; Thailand with 855 documents, 16,920 citations, and a link strength of 786; and Indonesia contributing 910 documents, 9,988 citations, and a link strength of 707. The clusters illustrated varied international collaborations: Cluster 1 included Singapore, Laos, Myanmar, and several non-ASEAN countries, such as Austria and the United Kingdom; Cluster 2 included Malaysia, Brunei Darussalam, Indonesia, and countries such as Australia and Canada; Cluster 3 included the Philippines, the United States, and South Korea; and Cluster 4 included Thailand, Vietnam, and Japan.

In addition, the analysis of collaboration networks among research institutes involved in TB studies revealed a dynamic and extensive collaborative environment (Figure 6). Among the 12,258 organizations examined, 191 met the established criteria, each having contributed at least five documents. This analysis underscored strong intraregional collaboration within ASEAN countries, particularly highlighting Thailand, Indonesia, and Vietnam not only as the largest contributors but also as central nodes in the regional research network. These countries demonstrated a robust framework for collaboration, significantly enhancing the collective research output on TB. Additionally, there were significant international collaborations, primarily with institutions from the United States, the United Kingdom, and Australia, showcasing the global integration of ASEAN TB research. Over time, the density of these collaboration networks has markedly increased, reflecting the growing number of partnerships in effectively addressing the challenges posed by TB.

Research trends

Figure 7 shows the trend-based clustering of the ASEAN TB research studies. The TB has undergone significant evolution in the field of research within the ASEAN region. Global health priorities and technological advancements have significantly influenced TB research since 2000. Initially, research focused on the epidemiology and control of TB, with many studies concentrating on the basic mechanisms of TB transmission and infection rates across various populations. Around

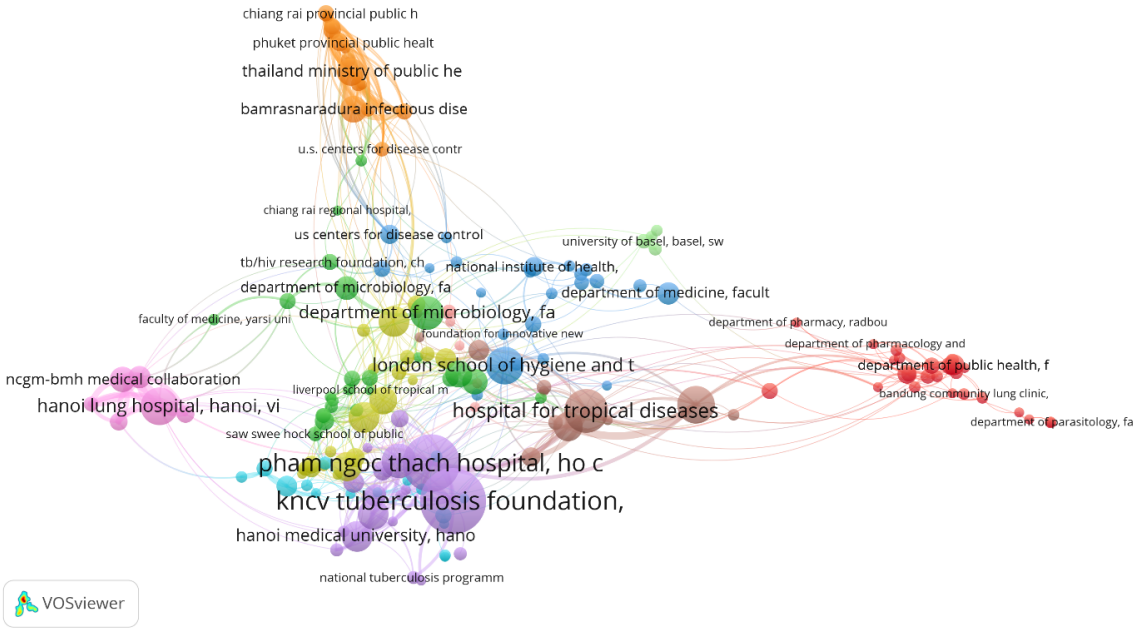

Figure 6. Map of collaboration networks among research institutes in tuberculosis (TB) studies across ASEAN countries and globally. Source: Data were compiled from the Scopus database and visualized using VOS viewer version 1.6.20 (January 1, 2000 - April 1, 2024).

the mid-2000s, there was a noticeable shift to drug-resistant TB research, prompted by the emergence of multidrug-resistant and extensively drug-resistant TB. There was a substantial increase in research funding for the development and testing of new drug therapies and diagnostic technologies, including the invention of the Xpert MTB/RIF assay, which enables faster diagnosis of antibiotic resistance (21). In recent years, research has broadened to integrate issues such as social determinants of health that influence TB outcomes, encompassing studies on poverty, urbanization, and healthcare access. The integration of genomic data and bioinformatics has also become a significant trend, enabling scientists to track TB strains more easily and understand their genetic diversity in ASEAN countries. Additionally, there is an emerging trend for more collaborative regional efforts in TB research, harmonizing TB control strategies, and data sharing due to high internal and external population volatility and similar epidemiological problems facing ASEAN countries. These trends reflect a scientific evolution aimed at controlling and eliminating TB from the region.

Research gaps in TB research within the ASEAN region

Bibliometric analysis, which focuses on identifying gaps in TB research within the ASEAN region, highlights several underexplored areas that could benefit from increased scholarly attention. Despite the substantial body of research conducted, significant gaps persist, particularly in the integration of socioeconomic determinants into TB management strategies. Research on the effects of poverty, migration issues, or urbanization patterns on the prevalence of the disease and the results of treatment are notably infrequent. The intersection of TB with noncommunicable diseases is also underresearched. Given that diabetes and cardiovascular conditions are increasing across the region, it is important to assess the existing connections. New therapeutic techniques and the development of vaccines have not been sufficiently investigated. In light of the current struggles with drug-resistant strains of the disease, this is a serious shortcoming. Despite the existence of

multiple control projects, communities, and hospitals, few of them are subject to operational research. Therefore, the potential for developing cultural context solutions within well-established policy frameworks cannot be trusted. The prioritization of these areas of study will help develop more useful and outcome-oriented recommendations for regional and international efforts to eradicate the disease.

Synthesis of findings

An extensive bibliometric analysis of TB research in Southeast Asian countries was conducted, covering documents authored between January 1, 2000, and April 1, 2024. A total of 3,666 documents in the Scopus database were included in the analysis. The results revealed a steady increase in research productivity, indicating increasing regional and global efforts to fight TB. Indonesia, Thailand, Malaysia, and Vietnam were significant contributors to research publications, serving as crucial hubs for TB research in Southeast Asia. Indonesia and Thailand had the greatest contributions, suggesting their critical role in the region's efforts. Fundamental research was a common source of publication, with an increase in publications related to MDR-TB and TB-HIV coinfection, reflecting the region's response to managing drug resistance and coinfections. The analysis also revealed robust ASEAN collaboration and international cooperation, demonstrating strong intellectual and material exchanges. As lower- and middle-income countries, Indonesia, Malaysia, and Thailand publish high-quality international research and apply their knowledge to TB control. These countries work together under national collaboration and with high-income countries, effectively influencing and managing TB. Additionally, the collaborative ASEAN analysis portrays an integrated effort to enhance and promote TB research, informing policy development strategies aimed at controlling the health impact of TB in the region.

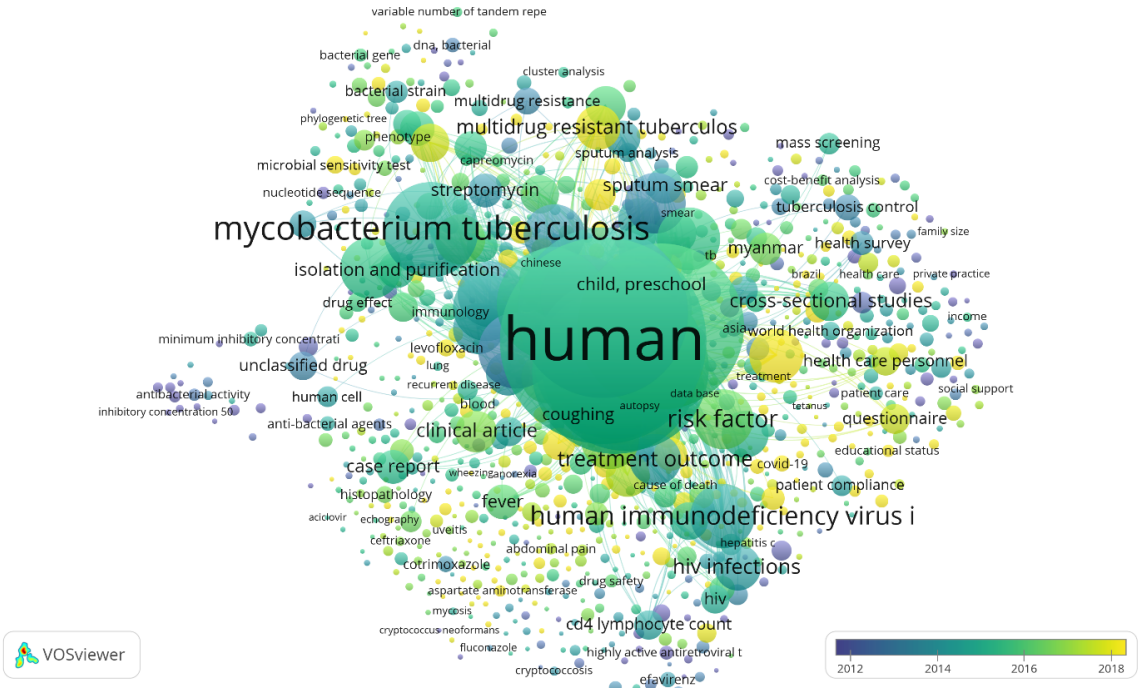

Figure 7. Trend-based clustering of ASEAN tuberculosis research studies from Scopus, January 1, 2000, to April 1, 2024. Source: Data were compiled from the Scopus database and visualized using VOS viewer version 1.6.20 (January 1, 2000 - April 1, 2024).

DISCUSSION

This study offers a distinctive perspective compared with previous studies by providing an updated and comprehensive review of TB research from 2000--2024, specifically within the ASEAN region. This unique regional focus allows for an in-depth understanding of the contributions and trends specific to Southeast Asian countries, a dimension not fully explored in global studies that often does not disaggregate data by region. Unlike earlier reports that concluded in 2017, our extended timeline to early 2024 captures nearly 24 years of research evolution, highlighting significant shifts and trends specific to the ASEAN context (7-9, 22, 23). Importantly, this study's extended timeframe and up-to-date data inclusion make it a valuable longitudinal observation. We noted an increasing prevalence of MDR-TB and TB-HIV coinfections within the region, topics that are critical in understanding the changing landscape of TB challenges. The recent publications included in our analysis offer insights into emerging trends and responses to these challenges, which may differ substantially from earlier periods (24). Furthermore, the depth of our analysis extends beyond mere publication counts. We critically examined collaborative networks and the impact of research through citation analysis, which provides a more nuanced understanding of the scientific community's engagement with TB research. Studies such as those by Cahyadin et al. (9) have suggested that the strength of research networks and funding sources significantly influences the impact and quality of research outputs in a region.

In addressing the quality of publications, our study not only counted the number of publications but also assessed their impact and relevance through citation metrics and the involvement of high-impact journals. This approach aligns with current bibliometric practices that emphasize the quality and influence of research rather than just quantity. As supported by Netthong et al. (10), high citation counts and prestigious publication venues are indicative of significant contributions to the field, reflecting both the scientific community's acknowledgment of the work's relevance and its applicability to real-world challenges. The increasing trend in TB research publications from ASEAN countries underscores a growing regional commitment to addressing TB. This increase likely reflects an intensified recognition of TB as a critical public health issue, driven by increasing disease burdens. Notably, Indonesia and Thailand have emerged as leaders in this effort, reflecting strong national research capabilities and focused strategies to combat TB. These findings align with recent studies, such as those by Cahyadin et al. (9), which highlight the pivotal role of national policy and investment in research infrastructure in enhancing regional health outcomes. Regarding the quality of publications, our methodology included an assessment of citation impacts and the involvement of high-impact journals, which serve as proxies for research quality. Studies such as those by Netthong et al. (10) validate the use of such metrics, suggesting that high citation rates and publications in prestigious journals are indicative of significant scholarly impact and community recognition.

The analysis of TB research in the ASEAN region reveals key focus areas and emerging hotspots, highlighting the multidimensional nature of the field. The identification of 2,948 keywords clustered into five main categories—TB and HIV coinfection, drug-resistant TB, epidemiology and public health, diagnosis, and demographic-specific issues—demonstrates the breadth and complexity of TB research. The emphasis of the red cluster on TB and HIV coinfection reflects the critical need for integrated treatment strategies for managing dual infections. The blue cluster underscores the significant challenges posed by drug-resistant TB, linking it with socioeconomic factors that affect treatment efficacy. The green cluster on epidemiology and public health highlights ongoing efforts to understand TB risk factors and prevalence, which are crucial for effective public health interventions. The yellow cluster focuses on improving diagnostic methods, which are essential for timely and accurate TB management. Finally, the purple cluster addresses the needs of specific demographics, emphasizing the importance of tailored treatments for high-risk and elderly patients. This approach underscores the necessity

of integrating social determinants of health into TB research. Factors such as poverty, migration, and healthcare access are critical for developing culturally appropriate and effective TB interventions. By combining biomedical and social science perspectives, this research promotes comprehensive TB control strategies tailored to the ASEAN context. This analysis not only maps the current research landscape but also sets the stage for future studies to build on these insights, advancing integrated and holistic approaches to TB in the region.

This analysis underscores the importance of extensive regional and international collaboration in TB research within the ASEAN region and reveals both a quantitative increase and a qualitative improvement in research outputs. Such collaborative networks are vital for tackling global health challenges such as tuberculosis, a disease that does not respect national borders and requires coordinated international efforts for effective management. The increased quality and increased quantity of research stemming from these collaborations reflect a more integrated approach to understanding and combating TB, leveraging diverse expertise and resources across countries. The importance of these collaborations extends beyond mere data sharing; they foster innovation and accelerate the dissemination of knowledge across the public health sector, which is critical in the context of TB owing to the complex nature of the disease and its treatment, especially with the rise of multidrug-resistant strains and the disease's intersection with other health issues such as HIV. Collaborative efforts enable a synergistic approach to research, where findings from one country can inform and refine strategies in others, thereby optimizing the overall response to the disease. Research from sources such as Islam et al. (22) has documented the profound impact of international cooperation on public health outcomes, highlighting how collaborative research networks can lead to breakthroughs in treatment and prevention strategies that may not be possible through isolated efforts. For example, multicountry epidemiological studies are crucial for capturing diversity, especially those trying to understand the genetic basis of drug resistance, which might vary greatly across regions. Furthermore, joint efforts across nations can promote the creation of standardized methodologies and protocols for generating data, which increases the validity of studies. Additionally, these collaborative efforts often draw on more substantial monies and resources that are necessary to carry out the types of large-scale studies needed for definitive public health questions. They also support the training and development of researchers in their region, helping to build the capacity for TB research. In short, the consolidation of research networks in regional and international partnerships not only increases the quality and extent of TB research performed but also makes a major contribution to global efforts toward TB control and elimination.

Our bibliometric analysis of TB research within the ASEAN region revealed a significant shift toward addressing more complex and emergent aspects of tuberculosis, such as multidrug-resistant tuberculosis (MDR-TB) and TB-HIV coinfection, reflecting broader global trends driven by evolving epidemiological patterns. This shift is critical because MDR-TB and TB-HIV coinfections present unique public health challenges characterized by complex treatment regimes, higher treatment failure rates, and greater transmission risks—issues exacerbated by socioeconomic and systemic healthcare deficiencies prevalent across the region. The focus on these conditions globally has grown, as they complicate standard TB treatments because MDR-TB requires prolonged use of less effective, more toxic, and costly second-line drugs and TB-HIV coinfection, demanding integrated treatment approaches to manage the dual burden effectively and reduce mortality. Research, such as that by Spies et al. (5), highlights the necessity of robust healthcare strategies that can adapt to the dynamic nature of TB, particularly in the context of antibiotic resistance and HIV-related immune challenges. As the intersection of TB and HIV becomes increasingly central to research owing to its complexities and implications for public health policy, ASEAN countries are aligning their research priorities with global health challenges and directives from bodies such as the World Health

Organization, which has prioritized action against these conditions. This alignment suggests a growing awareness within the ASEAN research community of the need to address these critical issues, which is essential not only for meeting global health goals but also for developing localized, culturally appropriate, and resource-sensitive strategies that enhance the efficacy and reach of health interventions across the region.

Our analysis of TB research trends in the ASEAN region highlights significant shifts over time, influenced by global health priorities and technological advancements. Initially, with a focus on epidemiology and TB control, research pivoted in the mid-2000s to address drug-resistant TB, spurred by the emergence of MDR and XDR TB and advancements such as the Xpert MTB/RIF assay. In recent years, there has been a broader integration of social determinants of health, such as poverty, urbanization, and healthcare access, alongside the incorporation of genomic data and bioinformatics for tracking TB strains. Additionally, there is an emerging trend toward regional collaboration, harmonizing TB control strategies, and enhancing data sharing. These trends differ from the static focus areas—such as TB and HIV coinfection, drug-resistant TB, epidemiology, diagnosis, and demographic-specific issues—by illustrating the evolving research priorities and adaptive strategies aimed not only at controlling but also at eliminating TB from the region.

Despite the growing body of TB research in the ASEAN region, our bibliometric analysis reveals significant and persistent gaps that need to be addressed to enhance both the scope and impact of future studies. One notable deficiency is the insufficient integration of socioeconomic factors into TB management strategies. Research on how poverty, migration, and urbanization influence TB incidence and treatment outcomes is scarce, despite the critical role these factors play in disease spread and management effectiveness. Similarly, the interplay between TB and noncommunicable diseases such as diabetes and cardiovascular conditions, which are increasingly prevalent in the region, remains underexplored. This oversight is concerning given the known complications these conditions can introduce in TB treatment and management. Additionally, there is a stark inadequacy in research on new therapeutic approaches and vaccine development, which are crucial for combating the emerging challenges of drug-resistant TB strains. Operational research on existing TB control projects within communities and hospitals is also lacking, which limits the understanding of their efficacy and the development of culturally contextual solutions within established policy frameworks. Addressing these gaps is essential for forming robust, outcome-oriented strategies that align regional efforts with the global goal of eradicating TB. Prioritizing these underexplored areas could significantly increase the effectiveness of public health interventions and policy adaptations in the ASEAN context. Overall, our bibliometric analysis provides a critical, updated, and region-specific review of TB research in ASEAN countries. By focusing on the quality and impact of research, this report contributes to a deeper understanding of how TB research has evolved in response to regional needs and global health challenges, thereby offering a valuable resource for policymakers, researchers, and public health officials engaged in TB control and prevention efforts.

Regarding the limitations and recommendations for future research, this study was based only on publications obtained from the Scopus database. As a result, one of the limitations was identified, as this review did not encompass other databases that could contain publications on the topic of this analysis. For example, the use of Web of Science, PubMed, MSAS (Microsoft Academic Search), Dimensions, or Google Scholar significantly expanded the scope of publications considered in this review. Thus, this limitation means that gaps are potentially identified in the publications included in this review, as the databases were also accessible for analysis. In addition, the limitation of this review was the exclusion of non-English publications, which might have reduced the extent of the analysis, as this region has many non-English publications from local sources. Therefore, the recommendation for additional research should be the inclusion of

multiple databases for reviewing publications to enclose all relevant publications on the selected topic.

CONCLUSION

The bibliometric analysis of TB research in ASEAN countries between 1 January 2000 and 1 April 2024 provides an illuminating perspective on the changing landscape of scientific inquiry and collaboration in an increasingly connected region with the heavy burden of the disease. The present study highlights a substantial increase in TB research output, particularly in Thailand, Indonesia, and Vietnam—countries with a high disease burden and strong research capacities. Despite these advancements, a disparity remains among ASEAN nations, underscoring the need for more unified regional efforts to tackle TB. The key research areas identified include drug resistance, HIV coinfection, and vaccine development, reflecting a responsive research community to the dynamic challenges of TB control. However, the limited global visibility of ASEAN TB research indicates a crucial gap that must be addressed to increase the region's contribution to the global TB discourse. Our findings advocate enhancing investment in research infrastructure and policy development informed by scientific evidence, particularly in underrepresented ASEAN countries. Looking forward, fostering an environment that supports innovation, collaboration, and equitable funding will be essential for closing existing gaps and advancing toward the global goal of ending TB. Future research should expand to include non-English publications and utilize a broader range of databases to enrich the comprehensiveness of data, focusing on translational research that connects scientific findings with public health implementations and considers the broader social determinants of health. ASEAN nations continue to address the complexities of TB control, and research on this topic will be crucial for shaping effective strategies and contributing significantly to global efforts.

CONFLICTS OF INTEREST

None.

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REFERENCES

1. Rees CED, Swift BMC, Haldar P. State-of-the-art detection of Mycobacterium tuberculosis in blood during tuberculosis infection using phage technology. Int J Infect Dis. 2024;141:106991. https://doi.org/10.1016/j.ijid.2024.106991
2. Denholm JT, Behr MA, de Vries G, Anthony R, Robinson E, Backx M, et al. Developing best practice public health standards for whole genome sequencing of Mycobacterium tuberculosis. Lancet Reg Health West Pac. 2024:101014. https://doi.org/10.1016/j.lanwpc.2024.101014
3. World Health Organization. Global Tuberculosis Report 2023. World Heath Organization; 7 November 2023. [31 May 2024]. Available from: https://iris.who.int/bitstream/handle/10665/373828/ 9789240083851-eng.pdf?sequence=1
4. Enane LA, Duda SN, Chanyachukul T, Bolton-Moore C, Navuluri N, Messou E, et al. The Tuberculosis Sentinel Research Network (TB-SRN) of the International epidemiology Databases to Evaluate AIDS (IeDEA): Protocol for a prospective cohort study in Africa, Southeast Asia and Latin America. BMJ Open. 2024;14(1):e079138. https://doi.org/10.1136/bmjopen-2023-079138
5. Spies R, Hong HN, Trieu PP, Lan LK, Lan K, Hue NN, et al. Spatial analysis of drug-susceptible and multidrug-resistant cases of tuberculosis, Ho Chi Minh City, Vietnam, 2020-2023. Emerg Infect Dis. 2024;30(3):499-509. https://doi.org/10.3201/eid3003. 231309
6. Davis RA, Leavitt HB, Singh A, Fanouraki E, Yen RW, Bratches RW. Examining interventions that aim to enhance TB treatment adherence in Southeast Asia: A systematic review and meta-analysis. Indian J Tuberc. 2024;71(1):48-63. https://doi.org/10.1016/j.ijtb.2023.03.001

7. Abdullah M, Humayun A, Imran M, Bashir MA, Malik AA. A bibliometric analysis of global research performance on tuberculosis (2011-2020): Time for a global approach to support high-burden countries. J Family Community Med. 2022;29(2):117-24. https://doi.org/10.4103/jfcm.jfcm_112_22
8. Zheng MQ, Li XX, Xu R, Liu S, Rui ZY, Guo ZY, et al. Bibliometric analysis of tuberculosis molecular epidemiology based on CiteSpace. Front Public Health. 2022;10:1040176. https://doi.org/10.3389/fpubh.2022.1040176
9. Cahyadin C, Sebba AK, Fitriana V. Tuberculosis research in ASEAN countries: A bibliometric analysis. Berita Kedokteran Masyarakat. 2017;33(11):1. https://doi.org/10.22146/bkm.37611
10. Netthong R, Khumsikiew J, Donsamak S, Navabhatra A, Yingngam K, Yingngam B. Bibliometric Analysis of Antibacterial Drug Resistance: An Overview. In: Grewal AS, Dhingra AK, Nepali K, Deswal G, Srivastav AL, editors. Frontiers in Combating Antibacterial Resistance: Current Perspectives and Future Horizons. Hershey, PA, USA: IGI Global; 2024. p. 196-245. https://doi.org/10.4018/979-8-3693-4139-1.ch009
11. James SL, Abate D, Abate KH, Abay SM, Abbafati C, Abbasi N, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 354 Diseases and Injuries for 195 countries and territories, 1990-2017: A systematic analysis for the global burden of disease study 2017. Lancet. 2018;392(10159):1789-858. https://doi.org/10.1016/S0140-6736(18)32279-7
12. Naghavi M, Wang H, Lozano R, Davis A, Liang X, Zhou M, et al. Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013: A systematic analysis for the global burden of disease study 2013. Lancet. 2015;385(9963):117-71. https://doi.org/10.1016/S0140-6736(14)61682-2
13. Hay SI, Abajobir AA, Abate KH, Abbafati C, Abbas KM, Abd-Allah F, et al. Global, regional, and national disability-adjusted life-years (DALYs) for 333 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990-2016: A systematic analysis for the global burden of disease study 2016. Lancet. 2017;390(10100):1260-344. https://doi.org/10.1016/S0140-6736(17)32130-X
14. Boehme CC, Nicol MP, Nabeta P, Michael JS, Gotuzzo E, Tahirli R, et al. Feasibility, diagnostic accuracy, and effectiveness of decentralized use of the Xpert MTB/RIF test for diagnosis of tuberculosis and multidrug resistance: A multicenter implementation study. Lancet. 2011;377(9776):1495-505. https://doi.org/10.1016/S0140-6736(11)60438-8
15. Thwaites GE, Bang ND, Dung NH, Quy HT, Oanh DTT, Thoa NTC, et al. Dexamethasone for the treatment of tuberculous meningitis in adolescents and adults. N Engl J Med. 2004;351(17):1741-51. https://doi.org/10.1056/NEJMoa040573
16. Helb D, Jones M, Story E, Boehme C, Wallace E, Ho K, et al. Rapid detection of Mycobacterium tuberculosis and rifampin resistance by use of on-demand, near-patient technology. J Clin Microbiol. 2010;48(1):229-37. https://doi.org/10.1128/JCM.01463-09
17. Caws M, Thwites G, Dunstan S, Hawn TR, Lan NTN, et al. The influence of host and bacterial genotype on the development of disseminated disease with Mycobacterium tuberculosis. PloS Pathog. 2008;4(3):e1000034. https://doi.org/10.1371/journal.ppat.1000034
18. Glynn JR, Whiteley J, Bifani PJ, Kremer K, Van Soolingen D. Worldwide occurrence of Beijing/W strains of Mycobacterium tuberculosis: A systematic review. Emerg Infect Dis. 2002;8(8):843-9. https://doi.org/10.3201/eid0805.020002
19. Chakaya J, Khan M, Ntoumi F, Aklillu E, Fatima R, Mwaba P, et al. Global Tuberculosis Report 2020 – Reflections on the global TB burden, treatment and prevention efforts. Int J Infect Dis. 2021;113:S7-S12. https://doi.org/10.1016/j.ijid.2021.02.107
20. O'Brien KL, Baggett HC, Brooks WA, Feikin DR, Hammitt LL, Higdon MM, et al. Causes of severe pneumonia requiring hospital admission in children without HIV infection from Africa and Asia: the PERCH multicountry case–control study. Lancet. 2019;394(10200):757-79. https://doi.org/10.1016/S0140-6736(19)30721-4
21. Biset S, Teferi M, Alamirew H, Birhanu B, Dessie A, Aschale A, et al. Trends of Mycobacterium tuberculosis and rifampicin resistance in northwest Ethiopia: Xpert® MTB/RIF assay results from 2015 to 2021. BMC Infect Dis. 2024;24(1):238. https://doi.org/10.1186/s12879-024-09135-0

22. Morishita F, Yamanaka T, Islam T. Intensified research on tuberculosis in the Western Pacific Region: a bibliometric analysis, 2000-2019. Western Pac Surveill Response J. 2020;11(4):24-31. https://doi.org/10.5365/wpsar.2020.11.3.003
23. Islam MA, Kundu S, Hanis TM, Hajissa K, Musa KI. A global bibliometric analysis on antibiotic-resistant active pulmonary tuberculosis over the last 25 years (1996–2020). Antibiotics. 2022; 11(8):1012. https://doi.org/10.3390/antibiotics11081012
24. Lestari BW, Nijman G, Larasmanah A, Soeroto AY, Santoso P, et al. Management of drug-resistant tuberculosis in Indonesia: A four-year cascade of care analysis. Lancet Reg Health Southeast Asia. 2024; 22:100294. https://doi.org/10.1016/j.lansea.2023.100294