



## Trend Analysis of Pulmonary TB Cases and Environmental Risk Factors Over the Past Five Years

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### Abstrak

*Pulmonary tuberculosis (TB) remains a major global public health problem influenced by complex environmental, social, and demographic factors. The growing volume of research on pulmonary TB highlights the need for a systematic mapping of research trends, thematic structures, and contributions from countries and journals. This study aims to analyze global research trends on pulmonary tuberculosis and environmental risk factors over the past five years based on international scientific publications. A bibliometric approach with a descriptive-analytical design was employed. Bibliographic data were retrieved from the Scopus database using relevant keywords and analyzed using various bibliometric techniques, including three-field plots, country contribution analysis, geographic distribution mapping, word cloud analysis, keyword co-occurrence networks, and thematic mapping. The results indicate that epidemiology, risk factors, and human population characteristics dominate pulmonary TB research. China, the United States, and India emerge as the leading contributors, with varying levels of international collaboration. Publications are predominantly disseminated through high-impact journals in infectious diseases and public health. The thematic analysis reveals well-established core themes alongside niche topics and emerging or declining themes, reflecting the dynamic evolution of pulmonary TB research. In conclusion, global research on pulmonary tuberculosis has developed within a structured and interconnected scientific network. However, stronger international collaboration and deeper exploration of environmental risk factors are required to support evidence-based TB control strategies.*

## 1. Introduction

Tuberculosis (TB) remains one of the most persistent global public health challenges, particularly in low- and middle-income countries. According to the World

Health Organization, pulmonary tuberculosis accounts for the majority of TB cases and continues to contribute significantly to morbidity and mortality worldwide (WHO, 2023). Environmental conditions such as poor housing quality, inadequate ventilation, overcrowding, air pollution, and sanitation deficiencies have long been recognized as critical determinants influencing TB transmission and disease progression (Lönnroth et al., 2010; Prüss-Ustün et al., 2019). In recent years, rapid urbanization, population density growth, and environmental degradation have further intensified the vulnerability of communities to pulmonary tuberculosis, making trend-based analysis essential for evidence-based public health interventions.

Previous studies have extensively examined the epidemiological patterns of pulmonary tuberculosis using temporal and spatial approaches. For instance, studies by Tadesse et al. (2018) and Onozaki et al. (2015) revealed fluctuating TB incidence trends influenced by demographic shifts and public health policy changes. Research in several developing countries demonstrated that TB case trends often reflect disparities in healthcare access, socio-economic conditions, and environmental exposure (Hargreaves et al., 2011; Suryani et al., 2020). These studies emphasize that trend analysis is a valuable tool for understanding disease dynamics and evaluating the effectiveness of TB control programs. In addition, a growing body of literature has highlighted the role of environmental risk factors in shaping TB trends. Studies by Lin et al. (2019) and Melsew et al. (2021) found strong associations between pulmonary tuberculosis incidence and factors such as indoor air pollution, humidity, temperature variation, and housing density. Meanwhile, Baker et al. (2018) demonstrated that environmental vulnerability often interacts with socio-economic determinants, creating complex transmission patterns. Despite these contributions, many studies focus on either epidemiological trends or environmental factors separately, limiting a comprehensive understanding of their combined influence over time.

There remains a notable research gap in studies that simultaneously examine long-term trends of pulmonary tuberculosis cases together with environmental risk factors within a unified analytical framework. Many existing investigations rely on cross-sectional designs or short observation periods, which limit their capacity to capture temporal dynamics, evolving risk patterns, and the cumulative influence of environmental exposures. Such methodological constraints hinder a comprehensive understanding of how changes in environmental conditions interact with tuberculosis incidence over time. Limited availability of localized evidence, particularly at regional or municipal levels, further constrains the practical relevance of current findings. National-level analyses often mask contextual variations related to environmental quality, population density, and socio-spatial conditions that shape tuberculosis transmission. The lack of fine-grained, location-specific studies reduces the effectiveness of evidence-based policy formulation and the design of targeted public health interventions aimed at controlling pulmonary tuberculosis.

One of the key problems in tuberculosis control is the persistent increase or stagnation of pulmonary TB cases despite the implementation of standardized treatment and prevention programs. Environmental risk factors often remain inadequately addressed in public health strategies, as TB control efforts tend to focus primarily on clinical and pharmaceutical interventions. This imbalance may undermine the effectiveness of TB elimination targets, especially in settings where environmental exposure continues to facilitate disease transmission. Additionally,

significant gaps persist in data integration and analytical capacity, particularly in linking surveillance data with environmental indicators. Challenges such as incomplete reporting, inconsistent environmental monitoring, and limited intersectoral collaboration hinder comprehensive trend analysis. Addressing these challenges is crucial to strengthen TB control policies, improve early detection strategies, and design environmentally responsive public health interventions that align with sustainable disease prevention goals.

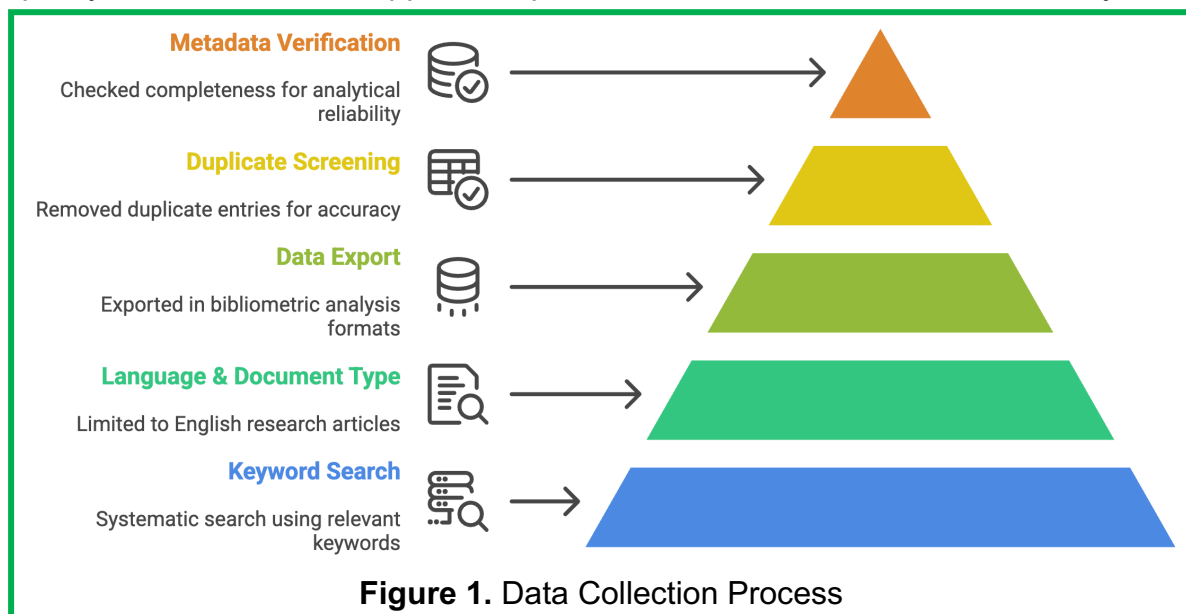
This study provides evidence-based solutions through an integrated trend analysis of pulmonary tuberculosis cases and environmental risk factors over the past five years. By combining tuberculosis surveillance data with environmental indicators, the study generates a more comprehensive mapping of case dynamics, enabling the identification of periods of increased incidence and environmental conditions that contribute most significantly to disease transmission. These findings serve as a foundation for developing more context-sensitive TB control strategies, including the strengthening of environment-based interventions, improvements in housing quality and ventilation, regulation of residential density, and the integration of TB programs with environmental health policies. Furthermore, the results can support policymakers in enhancing early warning systems and designing more effective, targeted, and sustainable prevention programs.

This research is compelling because it addresses the urgent need for tuberculosis control approaches that extend beyond clinical and pharmaceutical interventions to incorporate environmental determinants that are often overlooked. In the context of rapid urbanization, environmental change, and persistent social inequalities, a comprehensive trend analysis offers valuable insights for the development of adaptive, data-driven public health policies. In addition to contributing to the scientific literature on epidemiology and environmental health, this study holds strong practical relevance, as it can inform tuberculosis control planning at local and regional levels and support the achievement of sustainable tuberculosis elimination targets.

## 2. Methods

This study employs a bibliometric approach with a descriptive–analytical design to identify, map, and analyze the development of research on *pulmonary tuberculosis* (TB) and environmental risk factors over the past five years. The bibliometric approach was selected because it provides a systematic and quantitative overview of the dynamics of scientific publications, including research trend patterns, country contributions, scientific collaboration, conceptual structures, and dominant themes emerging in the international literature (Aria & Cuccurullo, 2017; Donthu et al., 2021). The research process began with topic determination and the formulation of core keywords relevant to pulmonary TB and environmental risk factors, followed by the retrieval and downloading of bibliographic data from the Scopus database. The subsequent stage involved data screening and cleaning to ensure temporal consistency and document relevance. The validated data were then analyzed using multiple bibliometric techniques to generate visualizations, including three-field plots, country contribution analysis, geographic distribution maps, word cloud analysis, keyword co-occurrence networks, and thematic maps. The analytical results were interpreted descriptively to explain research trends, patterns of scientific collaboration, and the global direction of pulmonary TB research development (Zupic & Čater, 2015).

The research data were obtained from Scopus (www.scopus.com), one of the largest and most reputable international scientific databases. The dataset consisted of journal articles published over the past five years, with a specific focus on *pulmonary tuberculosis* and environmental risk factors. The extracted bibliographic information included article titles, authors' names, institutional affiliations and countries, publication years, keywords, abstracts, and source journals. Scopus was selected due to its broad multidisciplinary coverage and high-quality metadata, which support comprehensive and reliable bibliometric analysis.



**Figure 1.** Data Collection Process

The figure illustrates a systematic and sequential data collection process applied in the bibliometric analysis to ensure data quality and analytical reliability. The process begins with a structured keyword search related to *pulmonary tuberculosis* and environmental risk factors within a scientific database. The retrieved records are then limited to English-language research articles to maintain consistency and academic validity. The selected data are subsequently exported in formats compatible with bibliometric analysis tools, followed by duplicate screening to eliminate redundant entries. The final stage involves metadata verification to ensure the completeness, accuracy, and consistency of bibliographic information, thereby ensuring that the dataset used for analysis is robust and reliable.

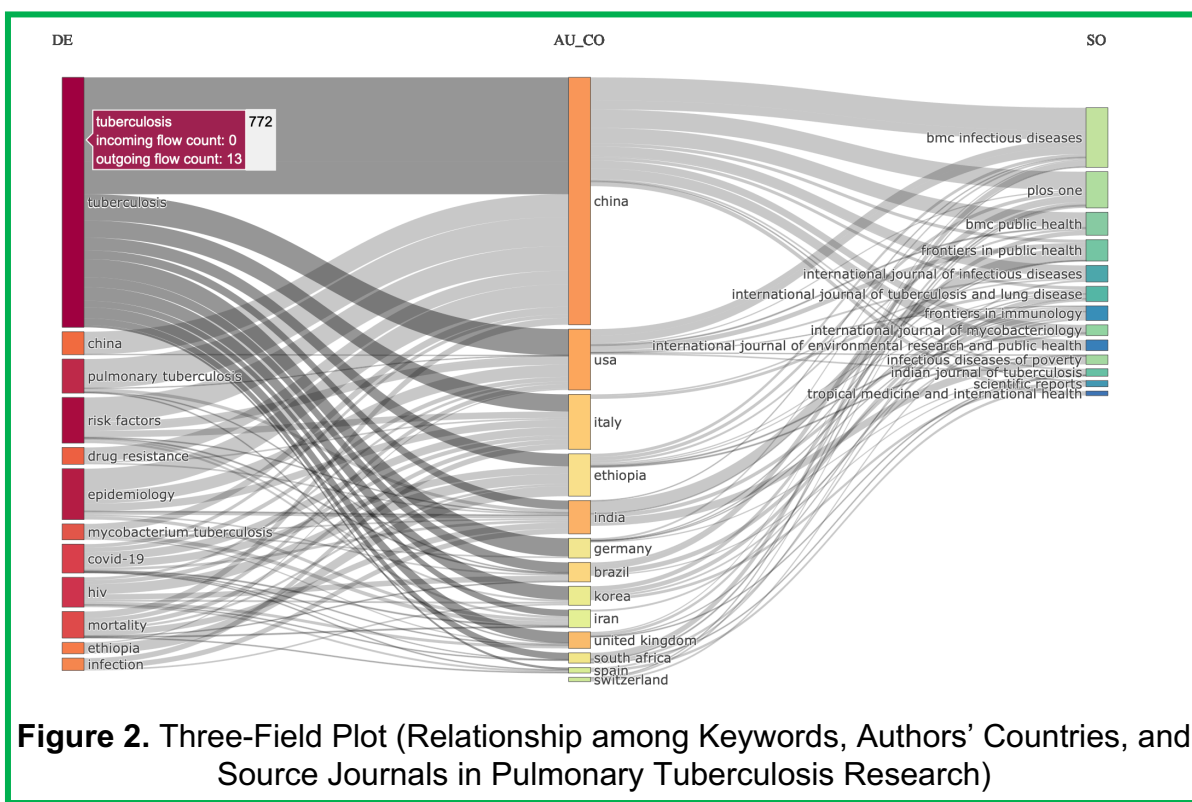
Data analysis was conducted using a quantitative bibliometric approach combined with scientific visualization techniques. The analysis included mapping the relationships among keywords, authors' countries, and source journals using three-field plots; examining country contributions and collaboration patterns through the indicators of *Single Country Publications* (SCP) and *Multiple Country Publications* (MCP); and performing spatial analysis to illustrate the global distribution of publications. In addition, *word cloud* analysis was applied to identify dominant keywords, while *keyword co-occurrence* network analysis was used to map the conceptual structure of the research field. Thematic mapping based on *centrality* and *density* was further employed to classify research themes into *basic themes*, *motor themes*, *niche themes*, and *emerging or declining themes*. All analytical results were interpreted descriptively to explain the dynamics and developmental directions of research on pulmonary tuberculosis and environmental risk factors.

### 3. Findings and Discussions

#### 3.1 Findings

##### Relationship between Keywords, Authors' Countries, and Source Journals

Understanding the development of research on *pulmonary tuberculosis* (TB) and its association with environmental risk factors over the past five years requires a mapping approach that reveals the interconnections among research themes, country contributions, and scientific publication outlets. Bibliometric visualization serves as a relevant approach because it can comprehensively illustrate patterns of knowledge flow, ranging from dominant keyword focuses and contributing authors' countries to target journals for publication. This approach facilitates the identification of global research trends, key contributing actors, and the most influential dissemination channels in studies of pulmonary TB and environmental risk factors.



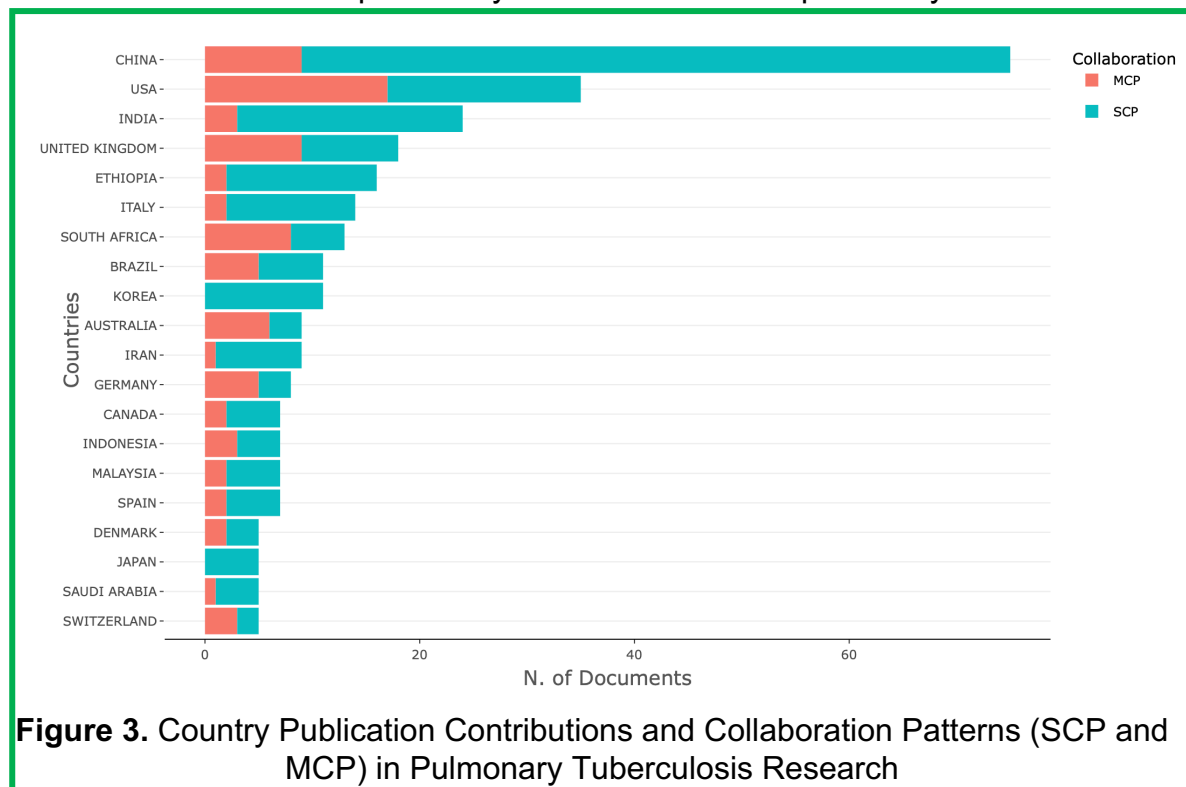
**Figure 2.** Three-Field Plot (Relationship among Keywords, Authors' Countries, and Source Journals in Pulmonary Tuberculosis Research)

The figure presents a three-field plot in the form of a Sankey diagram that visualizes the relationships among three main elements: *Descriptors/Keywords* (DE) on the left, *Authors' Countries* (AU\_CO) in the center, and *Sources/Journals* (SO) on the right. The thickness of the flows represents the strength of the relationships or the frequency of co-occurrence among these elements. The keywords “tuberculosis” and “pulmonary tuberculosis” appear as the most dominant terms, indicating that research primarily focuses on epidemiological aspects, risk factors, drug resistance, and their associations with environmental issues and comorbidities such as HIV and COVID-19. This pattern reflects the complexity of pulmonary TB as a public health problem influenced by multiple environmental and social determinants. In terms of authors' countries, China and the United States emerge as the leading contributors, followed by other countries such as Italy, India, Ethiopia, and Germany. The subsequent flows show that research outputs are predominantly published in reputable journals in the fields of public health and infectious diseases,

including *BMC Infectious Diseases*, *PLOS ONE*, *BMC Public Health*, and the *International Journal of Tuberculosis and Lung Disease*. This pattern indicates that research on pulmonary TB and environmental risk factors is not only advancing rapidly in countries with a high TB burden but has also become a major concern of the global scientific community. Overall, the figure highlights the concentration of research themes, cross-country collaboration, and journal preferences in disseminating findings related to pulmonary TB trends over the past five years.

### Country Contributions

An analysis of country contributions and patterns of scientific collaboration provides deeper insight into the global dynamics of research on *pulmonary tuberculosis* (TB) and environmental risk factors. This mapping highlights the countries that play dominant roles in the production of scientific publications and illustrates whether research activities are conducted primarily at the national level or through international collaboration. Such information is essential for assessing the strength of global research networks and understanding the direction and intensity of collaborative efforts in pulmonary TB studies over the past five years.

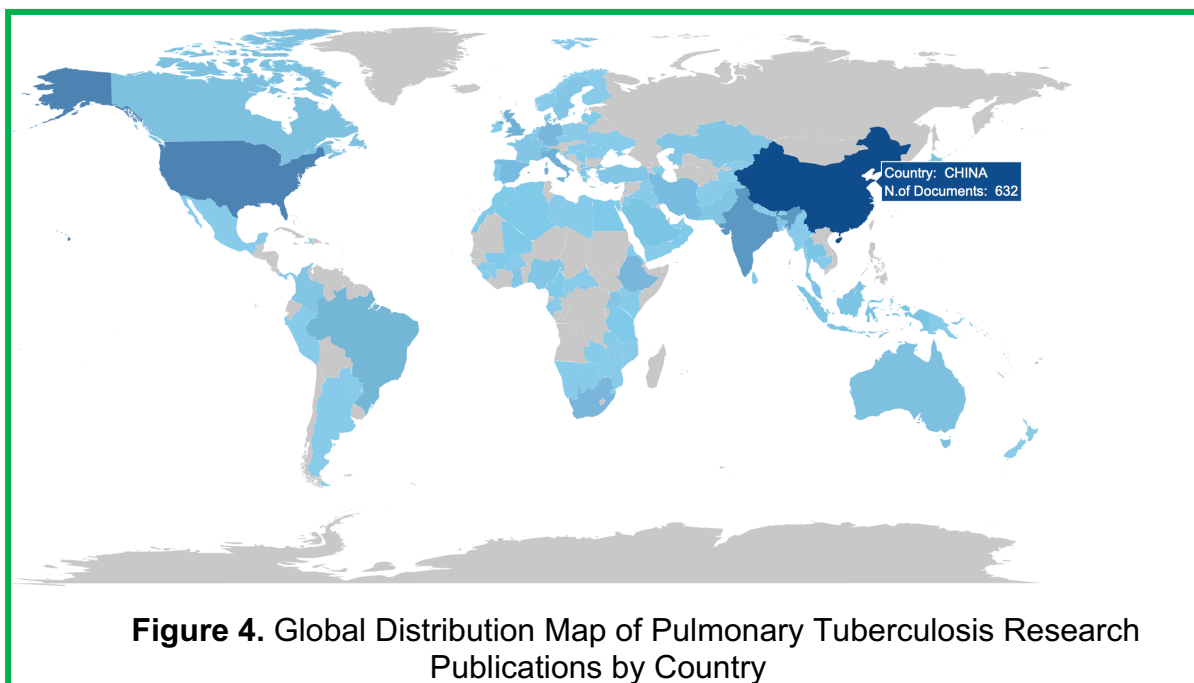


**Figure 3.** Country Publication Contributions and Collaboration Patterns (SCP and MCP) in Pulmonary Tuberculosis Research

The figure illustrates the number of scientific publications by authors' countries, classified into *Single Country Publications* (SCP) and *Multiple Country Publications* (MCP). China records the highest number of publications, predominantly represented by SCP, reflecting strong domestic research capacity in pulmonary tuberculosis studies. The United States and India also demonstrate substantial contributions, with relatively balanced proportions of SCP and MCP, indicating their ability to conduct national research while actively engaging in international scientific collaboration. Countries such as the United Kingdom, Italy, Ethiopia, Brazil, and South Africa exhibit a higher proportion of MCP than SCP, highlighting the intensity of cross-national collaboration in their scientific outputs. This pattern suggests that international collaboration serves as a key strategy for

enhancing research quality and global visibility, particularly for countries with a high tuberculosis burden or limited research resources. The presence of Indonesia, Malaysia, and several other Asian countries reflects the involvement of developing regions in global pulmonary TB research, although their contributions remain comparatively limited. Overall, the figure emphasizes the critical role of international collaboration in advancing knowledge production and evidence-based solutions related to pulmonary tuberculosis and environmental risk factors.

The geographic distribution of scientific publications provides an important overview of how country-level contributions to pulmonary tuberculosis research are spatially distributed worldwide. This region-based mapping enables the identification of major centers of knowledge production, disparities in research contributions across countries, and the relationship between disease burden and research intensity. Such spatial visualization helps clarify the global research landscape of pulmonary tuberculosis over the past five years.

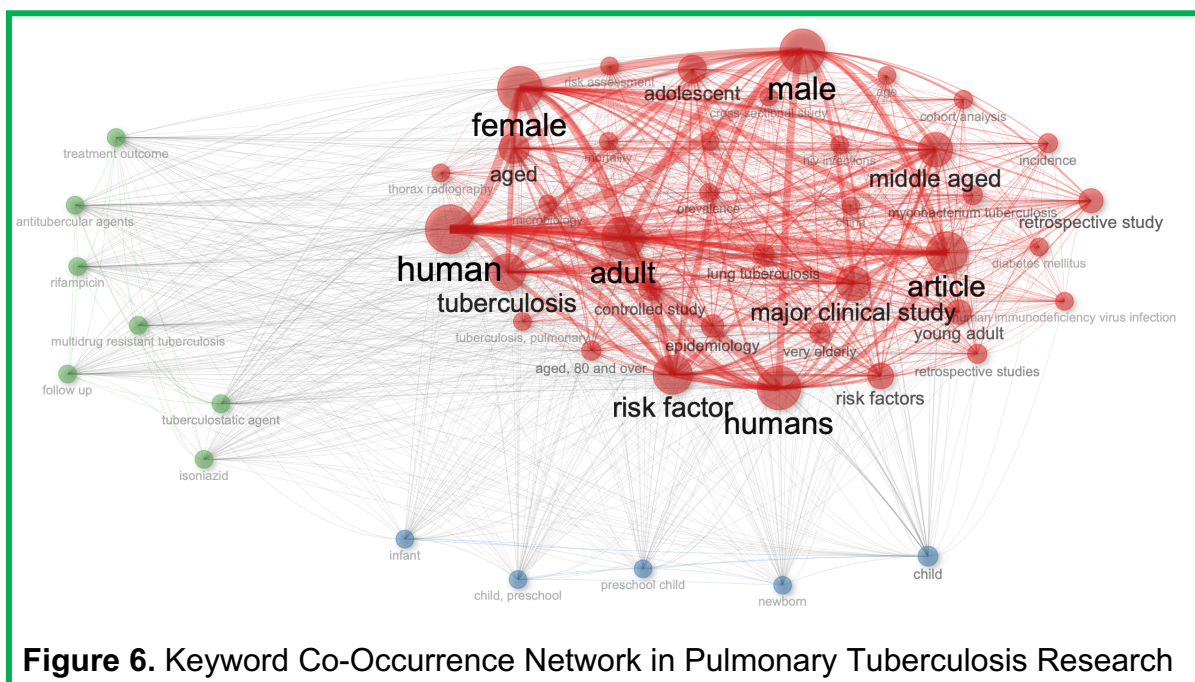


The figure presents a world map with color gradients representing the number of research publications produced by each country. Darker colors indicate higher publication contributions. China emerges as the leading contributor with 632 publications, highlighting its dominant role in global pulmonary tuberculosis research. The United States, India, and several European countries also display relatively high color intensities, reflecting consistent research productivity in the fields of infectious diseases and environmental health. Countries in Africa, Southeast Asia, and Latin America show varying levels of publication output, with most falling into the medium to low contribution categories. This pattern illustrates a disparity between regions with a high tuberculosis burden and those with limited scientific publication capacity. The inclusion of developing countries on the map indicates ongoing global participation in pulmonary tuberculosis research, although contributions remain uneven. Overall, this visualization underscores the need to strengthen research capacity and international collaboration to achieve a more geographically balanced production of knowledge on pulmonary tuberculosis and environmental risk factors.



treatment and drug resistance, including “antitubercular agents,” “rifampicin,” and “multidrug resistant tuberculosis,” further emphasize ongoing concerns regarding TB therapy challenges. Overall, this visualization illustrates the multidimensional development of pulmonary TB research, encompassing demographic, epidemiological, methodological, and disease control perspectives.

The analysis of keyword interrelationships provides deeper insight into the conceptual structure and thematic patterns of pulmonary tuberculosis research. Keyword network mapping enables the identification of core topics, interconnected subthemes, and emerging research clusters based on conceptual proximity. This visualization plays a critical role in illustrating the direction and complexity of scientific discourse on pulmonary TB over the past five years.

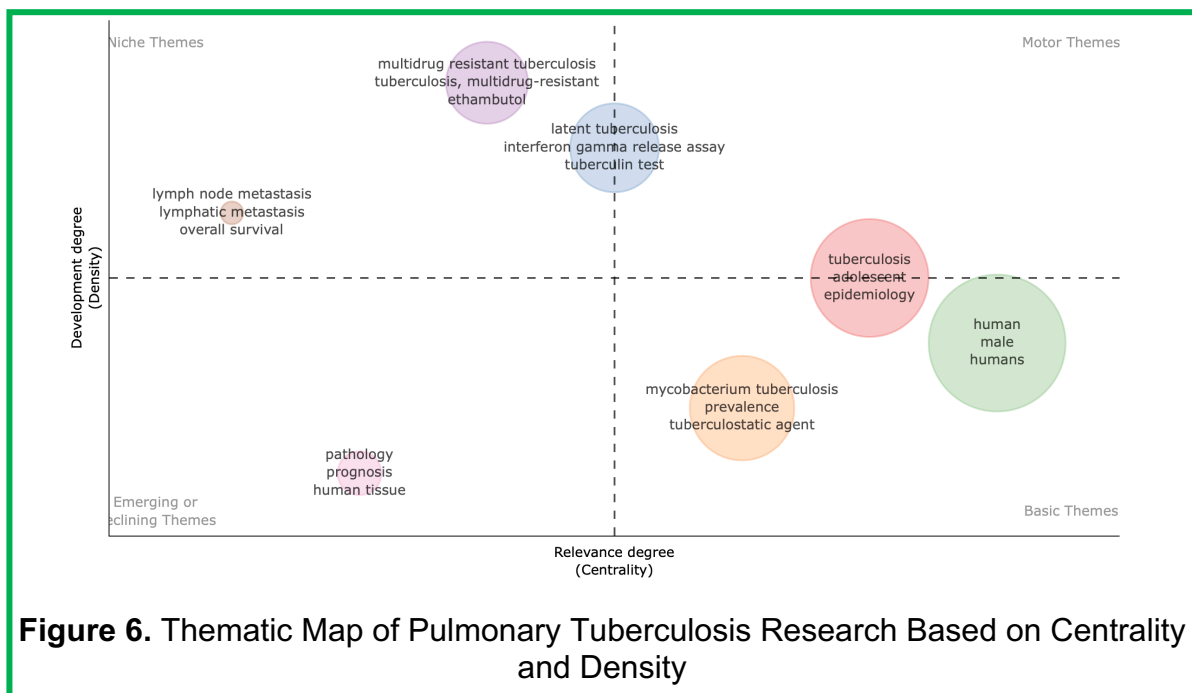


**Figure 6.** Keyword Co-Occurrence Network in Pulmonary Tuberculosis Research

The figure presents a keyword co-occurrence network map, where each node represents a specific term and the size of the node indicates its frequency of occurrence in the analyzed publications. The links between nodes reflect the strength of relationships or the frequency of co-occurrence among keywords within the scientific literature. Keywords such as “tuberculosis,” “human,” “humans,” “adult,” and “risk factor” occupy central positions with larger node sizes, highlighting their roles as core concepts in pulmonary tuberculosis research. Different node colors indicate distinct thematic clusters that represent variations in research focus. The red cluster is dominated by demographic and clinical terms such as “male,” “female,” “middle aged,” “major clinical study,” and “retrospective study,” indicating a strong emphasis on clinical and epidemiological approaches. Other smaller clusters include terms related to therapy, treatment follow-up, and pediatric age groups. This pattern illustrates that pulmonary tuberculosis research is organized into several interconnected thematic clusters, with dominant attention given to risk factors, population characteristics, and clinical research approaches.

## Research Thematic Map

Thematic analysis is essential for understanding the structure and positioning of research themes in *pulmonary tuberculosis* (TB) studies based on their levels of relevance and developmental maturity. This approach enables the classification of themes into core themes, motor themes, niche themes, as well as emerging or declining themes. Thematic mapping provides a strategic overview of dominant research focuses and potential directions for the future development of pulmonary tuberculosis research.



The figure presents a thematic map that classifies pulmonary tuberculosis research themes into four quadrants according to their level of relevance (*centrality*) on the horizontal axis and their degree of development (*density*) on the vertical axis. The *Basic Themes* quadrant in the lower-right area is dominated by themes such as “human,” “male,” and “humans,” indicating foundational topics with high relevance but moderate levels of thematic development. These themes serve as the main conceptual foundations of pulmonary TB research, as they are directly related to the characteristics of human populations under study. The *Motor Themes* quadrant in the upper-right area includes themes such as “tuberculosis,” “adolescent,” and “epidemiology,” which reflect topics with both high relevance and strong developmental maturity. These themes function as key drivers of pulmonary TB research due to their strong connections with other themes and their intensive scholarly exploration. The *Niche Themes* quadrant in the upper-left area encompasses specialized topics such as “multidrug resistant tuberculosis” and latent diagnostic testing, indicating well-developed but conceptually isolated themes. The *Emerging or Declining Themes* quadrant in the lower-left area features themes such as “pathology” and “prognosis,” suggesting topics that are either still emerging or gradually receiving less research attention. Overall, this thematic mapping illustrates a balance between core and specialized themes in the evolution of pulmonary tuberculosis research.

### 3.2 Discussions

The results of the three-field plot analysis reveal a strong interconnection among the main keywords (*Descriptors/Keywords*), authors' countries (*Authors' Countries*), and source journals (*Sources*), reflecting the global knowledge production structure in pulmonary tuberculosis (TB) research. The dominance of keywords such as *tuberculosis*, *pulmonary tuberculosis*, *risk factors*, and *epidemiology* indicates that research continues to focus primarily on epidemiological aspects, risk factors, and disease control challenges. The linkage of these keywords with major contributing countries such as China and the United States suggests that pulmonary TB research agendas are strongly shaped by countries with robust research capacity as well as significant disease burdens. This pattern confirms that research themes do not evolve randomly but are aligned with global health priorities and evidence-based policy needs. From the perspective of source journals, the findings show that publications related to pulmonary TB and environmental risk factors are concentrated in reputable journals in the fields of infectious diseases and public health, including *BMC Infectious Diseases*, *PLOS ONE*, *BMC Public Health*, and the *International Journal of Tuberculosis and Lung Disease*. This concentration indicates a clear preference among researchers for journals with multidisciplinary scopes and broad international reach. The consistent linkage between authors' countries and these journals also highlights the role of such outlets as key nodes in the global dissemination of scientific knowledge. Overall, these findings confirm that pulmonary TB research is inherently cross-national and interdisciplinary, supported by a relatively established publication ecosystem centered on specific high-impact scientific outlets.

The findings of this study are consistent with previous research indicating that relationship visualizations such as three-field plots or Sankey-based analyses are effective for mapping the connections among thematic research focuses, the geographic distribution of authors, and major publication outlets within a given discipline (Cobo et al., 2011). Other bibliometric studies have also demonstrated that countries with strong research infrastructures and stable research funding tend to dominate publication output and play a significant role in shaping global research agendas and thematic directions, particularly in the fields of public health and infectious diseases (Moral-Muñoz et al., 2020). In addition, Waltman et al. (2014) showed that the concentration of publications in internationally reputable journals reflects the level of consolidation and maturity of a field's scientific structure. Therefore, the results of this study reinforce prior evidence that pulmonary tuberculosis research has developed within a structured global scientific network, characterized by systematic linkages among dominant themes, key contributing countries, and core source journals.

The results of the country contribution analysis indicate that research publication output on *pulmonary tuberculosis* (TB) and environmental risk factors is still dominated by a limited number of countries, particularly China, the United States, and India. China ranks first with the highest number of publications, most of which are classified as *Single Country Publications* (SCP), reflecting strong domestic research capacity and a solid national commitment to TB control. The dominance of SCP suggests that pulmonary TB research agendas in China are largely driven by well-established internal research systems and national policies. The United States and India also demonstrate substantial contributions, with relatively balanced

proportions of SCP and *Multiple Country Publications* (MCP), indicating their capacity to conduct nationally driven research while actively engaging in international collaboration. Other countries, such as the United Kingdom, Italy, Ethiopia, Brazil, and South Africa, exhibit higher proportions of MCP than SCP, reflecting a greater reliance on cross-national collaboration in producing scientific publications. This pattern is commonly observed in countries with a high TB burden or limited research resources, where international collaboration becomes a key strategy for enhancing research quality and global visibility. The presence of developing countries, including Indonesia and Malaysia, indicates participation in global pulmonary TB research, although their contributions remain relatively limited. This pattern highlights disparities in research capacity across countries, which may influence the distribution of knowledge and innovation in TB control.

The findings of this study are consistent with bibliometric evidence showing that global scientific publication output is largely dominated by countries with strong research capacity, robust funding support, and well-developed scientific infrastructure, resulting in unequal knowledge contributions across regions (Bornmann & Leydesdorff, 2014). Other studies emphasize that international collaboration plays a crucial role in advancing global health research, particularly in infectious disease studies, by facilitating the exchange of resources, data, and expertise across countries (Katz & Martin, 1997). In addition, Glänzel and Schubert (2004) note that country-based collaboration indicators are effective in identifying cooperation patterns, levels of research internationalization, and disparities in scientific productivity. Therefore, the results of this study reinforce the understanding that pulmonary TB research develops within an uneven global scientific network, underscoring the importance of strengthening research capacity and expanding international collaboration in developing countries.

The results of the *word cloud* analysis show that keywords such as *tuberculosis*, *human*, and *humans* have the highest frequencies, confirming that pulmonary tuberculosis (TB) research over the past five years has strongly focused on TB as a human health problem. The dominance of demographic terms such as *male*, *female*, *adult*, *middle aged*, and *adolescent* reflects substantial scholarly attention to population heterogeneity in pulmonary TB studies. The emphasis on productive-age groups and sex-specific categories indicates a systematic effort to understand differences in risk, vulnerability, and disease response across demographic groups, which has direct implications for TB prevention and control strategies. The frequent appearance of keywords such as *risk factor*, *epidemiology*, *incidence*, and *prevalence* further indicates the dominance of an epidemiological approach in pulmonary TB research, with strong attention to disease distribution patterns and the identification of environmental and social determinants influencing TB transmission. In addition, the presence of methodological and clinical terms such as *cohort analysis*, *retrospective study*, and *major clinical study* suggests a preference for observational study designs to examine causal relationships and disease outcomes. Keywords related to treatment and drug resistance, including *antitubercular agents*, *rifampicin*, and *multidrug resistant tuberculosis*, underscore that therapeutic challenges and drug resistance remain central concerns in global pulmonary TB research.

These findings are consistent with previous studies indicating that keyword frequency analysis and *word cloud*-based visualization are effective tools for

identifying dominant thematic focuses and developmental trends within a research field (Heimerl et al., 2014). Other studies have shown that the prevalence of epidemiological and demographic terminology in public health literature reflects a strong research orientation toward risk factors, disease distribution, and affected population characteristics (Callaghan et al., 2019). Furthermore, Noyons et al. (1999) demonstrated that the repeated occurrence of methodological and clinical terms in bibliometric analyses serves as an indicator of sustained scientific responses to complex and persistent health challenges. Therefore, the *word cloud* results of this study reinforce evidence that pulmonary TB research has developed in a multidimensional manner, with strong emphasis on epidemiology, demography, and disease control.

The thematic map results indicate that research themes on *pulmonary tuberculosis* (TB) are distributed across four main quadrants based on their levels of *centrality* and *density*. The *Basic Themes* quadrant is dominated by themes such as *human*, *male*, and *humans*, which exhibit high relevance but relatively moderate levels of thematic development. The presence of these themes suggests that human population characteristics remain a fundamental foundation of pulmonary TB research. These basic themes function as conceptual linkages across various research topics and serve as starting points for more specific investigations, including studies on environmental risk factors and social determinants of health. The *Motor Themes* quadrant includes themes such as *tuberculosis*, *adolescent*, and *epidemiology*, which demonstrate both high relevance and strong developmental maturity. These themes act as the main driving forces of pulmonary TB research due to their strong interconnections with other themes and their intensive scholarly exploration. The *Niche Themes* quadrant highlights specialized topics such as *multidrug resistant tuberculosis* and latent diagnostic issues, indicating themes with high internal development but limited connections to other research areas. The *Emerging or Declining Themes* quadrant contains themes such as *pathology* and *prognosis*, suggesting topics that are either still developing or gradually receiving reduced research attention. This distribution reflects the dynamic nature of pulmonary TB research, which balances the consolidation of core themes with the exploration of specialized issues.

These findings are consistent with previous studies indicating that thematic mapping based on *centrality* and *density* is effective for identifying the evolution of conceptual structures and the strategic positioning of themes within a research field (Leydesdorff & Welbers, 2011). Other research has shown that themes with high *centrality* serve as key connectors across research domains and reflect agendas with broad scientific impact, whereas themes with high *density* but low *centrality* tend to represent more focused and specialized knowledge development (Small, 2006). In addition, Börner et al. (2003) emphasized that the emergence of themes with low connectivity and limited density may signal the early development of new research areas or shifts in scholarly focus. Therefore, the thematic map results of this study confirm that pulmonary TB research is evolving dynamically, characterized by continuous interaction among established core themes, deeply developed specialized themes, and emerging topics with future research potential.

#### 4. Conclusion

This study demonstrates that the development of research on *pulmonary tuberculosis* (TB) and environmental risk factors over the past five years has formed a relatively mature and globally integrated scientific structure. Bibliometric analysis reveals the dominance of epidemiological and demographic themes as the main foundations of research, supported by strong contributions from leading countries and internationally reputable journals. Mapping of keyword relationships, country contributions, and the geographic distribution of publications confirms that pulmonary TB research has evolved within cross-national collaborative networks, although disparities in research capacity between developed and developing countries persist. The findings from the *word cloud*, keyword *co-occurrence* network, and *thematic map* indicate that core themes such as epidemiology, risk factors, and human population characteristics function as the main drivers of pulmonary TB research, while specific issues such as drug resistance and latent diagnostics have developed as specialized themes with strong potential for further investigation. The presence of emerging or declining themes suggests opportunities for innovation and the exploration of new approaches, particularly in relation to environmental risk factors and locally contextualized control strategies. Overall, these results provide a comprehensive overview of the direction of pulmonary TB research and may serve as a valuable reference for researchers and policymakers in formulating more targeted research agendas and evidence-based public health interventions.

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