Optimizing Tuberculosis Treatment through Health Management: Addressing Environmental and Socioeconomic Determinants

Siska Hidayani[1*]

[1]*Department of Medicine, Faculty of Medicine, Universitas Riau; Pekanbaru, Indonesia*

*Corresponding Author E-Mail: siskahidayani.unri@gmail.com

Submitted:
December 29, 2025

Revised:
March 3, 2026

Accepted:
March 28, 2026

Published Online:
March 31, 2026

ABSTRACT

Tuberculosis remains a major public health challenge, with treatment outcomes influenced by the complex interplay of environmental, socioeconomic, and health system factors. This study aims to analyze the key determinants affecting tuberculosis treatment success from a health management perspective, focusing on how contextual conditions shape patient adherence and program effectiveness. A systematic literature-based approach was employed, reviewing empirical and review articles published in peer-reviewed journals over the past decade. The analysis centered on three main aspects: environmental determinants, socioeconomic conditions, and healthcare system factors related to tuberculosis treatment outcomes. Findings indicate that poor housing conditions, air pollution, and low environmental quality increase the risk of adverse treatment outcomes. Moreover, low socioeconomic status, financial constraints, and social stigma significantly undermine patient adherence, while barriers to healthcare access, including long travel distances, inadequate infrastructure, and limited human resource capacity, exacerbate treatment failure and patient loss to follow-up. These results highlight the importance of integrated tuberculosis control strategies that extend beyond clinical interventions, encompassing strengthened service delivery, enhanced patient support mechanisms, and the integration of socioeconomic and environmental considerations. A multisectoral, patient-centered approach is essential to improve tuberculosis treatment outcomes and reduce the overall disease burden.

Keywords*: Environmental Factors, Healthcare Access, Health Management, Socioeconomic Determinants, Tuberculosis Treatment.*

INTRODUCTION

Tuberculosis remains one of the most persistent global public health challenges, particularly in low- and middle-income countries where environmental and socioeconomic vulnerabilities intersect. Despite the availability of effective pharmacological treatments, tuberculosis continues to cause substantial morbidity and mortality, largely due to problems related to treatment adherence, delayed care-seeking, and adverse treatment outcomes. In recent years, growing attention has been directed toward understanding how environmental determinants shape tuberculosis transmission dynamics and influence treatment success, beyond individual clinical and behavioral factors. This shift reflects an increasing recognition that tuberculosis is not merely a biomedical disease but also a condition deeply embedded in the physical, social, and environmental contexts in which patients live (Jethani et al., 2012; Nidoi et al., 2021).

Environmental conditions critically determine exposure to *Mycobacterium tuberculosis*, disease progression, and patients' capacity to adhere to prolonged treatment regimens. Poor housing quality, overcrowding, and inadequate sanitation facilitate tuberculosis transmission and reinfection while undermining patients' physical resilience. Empirical evidence indicates that households lacking access to basic sanitation and clean water exhibit higher rates of treatment non-adherence, as daily survival priorities often

JIMKES

Jurnal Ilmiah Manajemen Kesatuan
Vol. 14 No. 2, 2026
pp. 1991-2002
IBI Kesatuan
ISSN 2337 – 7860
E-ISSN 2721 – 169X
DOI: 10.37641/jimkes.v14i2.5044

supersede engagement with healthcare services (Djochie & Opare-Addo, 2025; Rahman & Shiddik, 2025). Air quality similarly influences treatment outcomes, with both outdoor and indoor pollution exacerbating respiratory inflammation and suppressing immune function. Exposure to particulate matter, nitrogen dioxide, sulfur dioxide, carbon monoxide, and tobacco smoke has been linked to increased mortality and diminished treatment efficacy (Moreira et al., 2020; Zhao et al., 2023; Hammouri et al., 2025).

Geographical and spatial factors critically influence tuberculosis burden and treatment outcomes. Differences between rural and urban areas often reflect disparities in living conditions, environmental quality, and access to healthcare services. Rural regions frequently exhibit higher tuberculosis prevalence and poorer treatment outcomes due to limited healthcare infrastructure, longer travel distances, and lower environmental standards (Liu et al., 2023). Seasonal variations in tuberculosis incidence further suggest that environmental conditions, such as temperature and humidity, interact with human behavior and residential settings to shape disease dynamics, highlighting the need for context-sensitive interventions.

Beyond immediate living conditions, long-term environmental contamination has been linked to elevated tuberculosis incidence. Historical exposure to industrial pollutants correlates with increased tuberculosis rates, indicating lasting effects of environmental degradation on population susceptibility to respiratory diseases (Peptenatu et al., 2025). Conversely, positive environmental features, including exposure to green spaces measured via Normalized Difference Vegetation Index (NDVI), have been associated with reduced mortality among newly treated tuberculosis patients, emphasizing the protective role of healthier environments (Zhao et al., 2023). Environmental determinants intersect with socioeconomic and structural factors, as economic hardship, lack of health insurance, and unstable employment undermine treatment adherence, while limited transportation and weak tuberculosis surveillance exacerbate these challenges (Bonilla-Asalde et al., 2020; Rahman & Willott, 2025). Social stigma further isolates patients, whereas strong family and community support promotes sustained engagement with care (Wingfield et al., 2016).

Taken together, these findings demonstrate that tuberculosis treatment outcomes are profoundly shaped by environmental contexts that extend far beyond healthcare facilities. Understanding how housing, pollution, geography, and environmental quality interact with socioeconomic vulnerabilities is essential for developing integrated tuberculosis control strategies. Addressing environmental determinants alongside medical treatment is therefore not optional but necessary to reduce the global tuberculosis burden and improve treatment success rates (Najafizada et al., 2021; Hammouri et al., 2025; Giovenco et al., 2025).

This study is guided by two main research questions. It aims to identify the key environmental factors that affect tuberculosis treatment adherence and outcomes across different settings, including housing, sanitation, air quality, and geographical conditions. It examines how these environmental factors interact with socioeconomic and structural conditions, such as financial stability, healthcare access, and social support, to influence overall treatment effectiveness. Understanding these interactions can provide insights for developing integrated strategies to improve tuberculosis treatment outcomes.

LITERATURE REVIEW

Environmental and Tuberculosis

Environmental conditions play a critical role in influencing the transmission and treatment outcomes of tuberculosis. Physical factors such as housing quality, population density, sanitation, and access to clean water directly affect the risk of infection and patients' ability to adhere to long-term treatment regimens (Maciel et al., 2018). Overcrowded homes and inadequate sanitation create environments conducive to *Mycobacterium tuberculosis* transmission, increasing the likelihood of reinfection among patients undergoing therapy. Furthermore, air quality, both indoors and outdoors, significantly impacts respiratory health and treatment efficacy. Exposure to air pollutants,

including particulate matter, nitrogen dioxide, sulfur dioxide, carbon monoxide, and tobacco smoke, exacerbates respiratory inflammation and weakens immune responses, thereby reducing the effectiveness of tuberculosis treatment (Mundra et al., 2018; Zhao et al., 2023; Hammouri et al., 2025). These findings highlight that tuberculosis control efforts cannot focus solely on medical interventions but must also consider the physical environment in which patients live.

In addition to direct environmental factors, geographical and spatial conditions contribute substantially to variations in tuberculosis treatment outcomes. Differences between rural and urban areas, for example, influence patients' access to healthcare services, travel distances, and the quality of their living environments. Rural areas generally report higher tuberculosis prevalence and poorer treatment outcomes due to limited healthcare infrastructure and lower environmental standards (Boualam et al., 2025). Conversely, exposure to healthier environments, such as green spaces, has demonstrated protective effects, including reduced mortality among tuberculosis patients during treatment (Yousaf et al., 2025). Seasonal variations and climatic conditions further interact with human behavior and living conditions, affecting disease dynamics and highlighting the need for context-specific interventions. Therefore, environmental factors create both opportunities and barriers for tuberculosis patients in completing their treatment, emphasizing the necessity of an integrated approach that combines medical care with environmental considerations.

Socioeconomic Factors and Support

Socioeconomic factors and social support significantly influence tuberculosis treatment adherence and outcomes. Patients experiencing financial hardship, unstable employment, or lack of health insurance often face difficulties maintaining long-term treatment regimens, increasing the risk of delayed care-seeking or treatment discontinuation (Meghji et al., 2021). Structural barriers, including limited transportation options, weak tuberculosis monitoring systems, and inadequate healthcare facilities in certain areas, further hinder patients' ability to access services. These socioeconomic and structural determinants frequently interact with environmental conditions, as low-income individuals often reside in crowded, poorly sanitized, and polluted areas, increasing the risk of complications and reducing treatment effectiveness (Anugwom & Anugwom, 2023).

Beyond economic and structural factors, social support plays a crucial role in enhancing tuberculosis treatment outcomes. Stigma and discrimination associated with tuberculosis can isolate patients from their communities, negatively affecting psychological well-being and treatment adherence. In contrast, strong family and community support facilitates patients' engagement with healthcare services, promotes adherence, and improves treatment outcomes (Wingfield et al., 2017; World Health Organization, 2025). Multidimensional interventions that integrate environmental improvements, social support, and medical care are more effective than singular approaches. Therefore, tuberculosis control strategies must address the interconnections between socioeconomic status, community support, and physical environment to ensure patients can complete treatment successfully and to reduce the overall burden of the disease.

Environmental and Socioeconomic Determinants in Tuberculosis Outcomes

The interaction between environmental and socioeconomic determinants plays a crucial role in shaping Tuberculosis (TB) treatment outcomes. Environmental risks such as overcrowded housing, poor sanitation, and air pollution are disproportionately experienced by populations with low socioeconomic status, indicating a strong structural link between living conditions and economic disadvantage. Poverty and social deprivation are key drivers that increase both exposure to *Mycobacterium tuberculosis* and delays in seeking or completing treatment, as individuals in vulnerable economic conditions often face competing survival priorities that limit healthcare access. This

demonstrates that TB outcomes are shaped by the interaction of environmental exposure and socioeconomic inequality rather than by isolated determinants (Cintron et al., 2025; Singh et al., 2025).

Furthermore, the interaction between environmental and socioeconomic factors highlights the importance of integrated, multisectoral interventions in tuberculosis control. Financial insecurity, limited transportation, weak health systems, and inadequate housing conditions collectively reduce patients' ability to maintain long-term treatment adherence and increase the risk of treatment interruption. Studies emphasize that addressing TB effectively requires simultaneous improvements in social protection, healthcare access, and environmental conditions, as isolated interventions are insufficient to reduce disease burden (Todd et al., 2023). Therefore, a comprehensive approach that targets both structural inequality and environmental risk factors is essential to improve treatment outcomes and reduce TB incidence globally (Költringer et al., 2023).

RESEARCH METHODS

This study employed a systematic literature-based analytical approach to examine the determinants of tuberculosis treatment outcomes from a health management perspective, with particular attention to environmental, socioeconomic, and health system factors. This design was selected due to its suitability for synthesizing heterogeneous evidence and generating comprehensive insights across multiple study contexts, which is particularly important for complex public health issues such as tuberculosis treatment outcomes. The research design was aligned with the study's research questions, which focus on identifying key determinants and understanding their implications for health service management and policy.

Data were collected through a structured literature search of peer-reviewed international journals indexed in Scopus. Scopus was chosen due to its extensive coverage of high-quality, peer-reviewed journals and its strong indexing of health and social science literature. The search strategy employed combinations of keywords, including tuberculosis, treatment outcomes, environmental determinants, socioeconomic status, healthcare access, adherence, and health system management. Only articles published in English within the last ten years were included to ensure methodological comparability, contemporary relevance, and alignment with recent developments in global health policy and tuberculosis control strategies.

Study selection followed three stages: title screening, abstract review, and full-text assessment. Inclusion criteria covered empirical quantitative studies, qualitative research, and systematic or scoping reviews that explicitly examined tuberculosis treatment outcomes in relation to environmental, socioeconomic, cultural, or healthcare system factors. The inclusion of multiple study designs was justified by the need to capture both measurable associations and contextual/experiential dimensions of treatment outcomes. Studies focusing solely on clinical or pharmacological aspects without managerial or system-level implications were excluded to maintain focus on health service management relevance.

Data extraction was conducted using a standardized matrix capturing study context, methodology, key variables, and reported outcomes. The extracted data were then analyzed using thematic synthesis, which was selected for its ability to systematically integrate findings across diverse methodologies and identify recurring patterns within complex evidence bases. This method enabled the mapping of determinants across studies while preserving contextual meaning, making it appropriate for policy-oriented synthesis.

To enhance analytical rigor, findings were interpreted through a health systems and management lens, emphasizing access to care, service delivery efficiency, patient support mechanisms, and cross-sectoral coordination. This interpretive framework was adopted because tuberculosis treatment outcomes are strongly influenced not only by clinical factors but also by structural and managerial dimensions of health systems. The synthesis provides evidence-based insights to inform health management strategies aimed at improving tuberculosis treatment adherence and outcomes in diverse settings.

RESULTS

Environmental Determinants Influencing Tuberculosis Treatment Outcomes

The findings demonstrate that tuberculosis treatment outcomes are strongly shaped by a complex set of environmental determinants that interact with patients' daily living conditions. Across the reviewed studies, environmental factors consistently emerged as key drivers of treatment adherence, disease progression, and mortality risk, indicating that biomedical interventions alone are insufficient to ensure successful tuberculosis control. Housing conditions and sanitation were among the most consistently reported environmental determinants affecting tuberculosis treatment. Studies conducted in diverse geographical contexts showed that overcrowded housing, poor ventilation, and inadequate access to sanitation facilities significantly increased the likelihood of treatment non-adherence and ongoing transmission. Households lacking basic infrastructure such as clean water and proper waste disposal were associated with higher rates of treatment interruption, as patients often faced competing priorities related to survival and household responsibilities (Herrero et al., 2015; Maciel et al., 2018). In addition to affecting adherence, inadequate housing environments were strongly linked to the emergence and spread of Multidrug-Resistant Tuberculosis (MDR-TB), suggesting that prolonged exposure to poor physical environments may contribute to treatment failure and resistance development (Pavinati et al., 2025).

Air pollution was another major environmental determinant influencing tuberculosis treatment outcomes. Multiple studies reported that exposure to ambient air pollutants, including particulate matter (PM2.5 and PM10) and gaseous pollutants such as nitrogen dioxide, sulfur dioxide, and carbon monoxide, was associated with increased mortality during tuberculosis treatment. These pollutants contribute to chronic lung inflammation and impaired immune responses, thereby reducing patients' capacity to recover during treatment (Hammouri et al., 2025). Quantitative evidence indicated that even modest increases in particulate matter concentration substantially elevated the risk of death among patients undergoing tuberculosis therapy (Zhao et al., 2024). Indoor air pollution further exacerbated these risks, particularly in households where smoking or the use of solid fuels for cooking was common, highlighting the importance of indoor environmental quality in treatment success (Mundra et al., 2018).

Geographical and spatial patterns also played a significant role in shaping tuberculosis treatment outcomes. The reviewed evidence showed marked disparities between rural and urban settings. Rural areas often experience higher tuberculosis prevalence and poorer treatment outcomes due to substandard housing, environmental deprivation, and limited access to healthcare services (Boualam et al., 2025). Patients in rural contexts frequently faced long travel distances and unreliable transportation, increasing the likelihood of missed appointments and treatment discontinuation. Seasonal variations in tuberculosis incidence further underscored the role of environmental conditions, as fluctuations in climate and living patterns appeared to influence transmission dynamics and treatment continuity.

Environmental contamination, particularly from historical industrial pollution, was also identified as a significant determinant of tuberculosis burden. Evidence from environmentally degraded regions demonstrated a clear association between long-term exposure to environmental pollutants and higher tuberculosis incidence. In Romania, areas with a legacy of industrial contamination exhibited elevated tuberculosis rates, suggesting that environmental degradation may increase population susceptibility to respiratory infections and undermine treatment effectiveness over time (Peptenatu et al., 2025). These findings indicate that environmental risks extend beyond immediate exposure and may reflect cumulative health impacts that persist across generations.

In contrast to harmful environmental exposures, positive environmental features such as greenness were associated with improved tuberculosis treatment outcomes. Studies measuring environmental quality using the Normalized Difference Vegetation Index (NDVI) found that greater exposure to green spaces was linked to reduced mortality among newly treated tuberculosis patients (Zhao et al., 2023). Greenness appeared to

mitigate some of the adverse effects of air pollution by improving air quality, reducing stress, and supporting overall respiratory health. These findings suggest that environmental quality is not only a risk factor but also a potential protective determinant in tuberculosis treatment outcomes.

Socioeconomic and structural conditions were closely intertwined with environmental determinants and further shaped treatment outcomes. Economic hardship consistently emerged as a barrier to treatment adherence, as patients with limited financial resources often delayed care-seeking or discontinued treatment due to indirect costs such as transportation, food insecurity, and loss of income (Herrero et al., 2015; Abaynew et al., 2025). Lower income and educational attainment were associated with higher tuberculosis prevalence and poorer treatment outcomes, reinforcing the role of multidimensional poverty in sustaining tuberculosis vulnerability (Choi et al., 2023).

Healthcare access functioned as both an environmental and structural determinant. The need to use multiple modes of transportation, long travel times, and inadequate healthcare infrastructure were consistently linked to poorer treatment outcomes, particularly in rural settings (Egede et al., 2024). Weak infection control measures within healthcare facilities further increased the risk of transmission and compromised treatment success (Vigenschow et al., 2021). These findings highlight that environmental conditions extend into healthcare settings and directly influence treatment effectiveness.

Social environments also played a critical role in shaping tuberculosis treatment outcomes. Strong family and community support facilitated treatment adherence by providing emotional encouragement and practical assistance. Conversely, tuberculosis-related stigma and discrimination were frequently reported as barriers to adherence, leading to social isolation, psychological distress, and treatment discontinuation (Cintron et al., 2025; Vieira et al., 2025). Cultural beliefs surrounding tuberculosis further influenced patients' perceptions of illness and treatment, underscoring the importance of socially informed and culturally sensitive interventions.

Socioeconomic and Structural Factors Shaping Tuberculosis Treatment Outcomes

The findings indicate that socioeconomic and structural factors play a decisive role in shaping tuberculosis treatment outcomes, often mediating or amplifying the effects of environmental determinants. According to the reviewed studies, treatment adherence, continuity of care, and clinical success were strongly influenced by patients' economic capacity, access to healthcare services, and the social contexts in which treatment was undertaken. Economic conditions consistently emerged as a primary determinant of tuberculosis treatment outcomes. Multiple studies demonstrated that patients experiencing financial hardship were significantly more likely to delay treatment initiation, interrupt therapy, or default entirely. Direct costs, such as transportation and medication-related expenses, as well as indirect costs, including income loss due to illness, were identified as critical barriers to sustained treatment adherence (Solovič et al., 2019). In low-income settings, tuberculosis patients often face competing economic priorities, forcing them to choose between attending healthcare appointments and meeting basic household needs. Giovenco et al. (2025) showed that lack of medical insurance and unstable employment status were associated with higher rates of treatment interruption and poorer clinical outcomes.

Poverty-related vulnerabilities were also closely linked to educational attainment and health literacy. Patients with lower levels of education were more likely to misunderstand treatment regimens, underestimate the importance of treatment completion, or rely on informal sources of health information. Several studies reported that limited health literacy contributed to delayed care-seeking behavior and inconsistent medication use, thereby increasing the risk of treatment failure and drug resistance (Nidoi et al., 2021; Choi et al., 2023). These findings suggest that socioeconomic disadvantage influences tuberculosis outcomes not only through material deprivation but also through reduced capacity to navigate health systems effectively.

Healthcare access constituted a central structural determinant affecting tuberculosis treatment outcomes. Geographic distance to healthcare facilities, limited availability of tuberculosis services, and inadequate transportation infrastructure were repeatedly identified as barriers to treatment adherence. Patients who were required to use multiple modes of transport or travel long distances to reach treatment centers were significantly more likely to miss appointments or discontinue therapy altogether (Maciel et al., 2018; Appiah et al., 2023). This challenge was particularly pronounced in rural areas, where healthcare facilities were sparse and logistical constraints were more severe.

Table 1. SES and Tuberculosis Treatment Outcomes

Aspect	Impact of Low Socioeconomic Status
Treatment Success	Higher risk of unsuccessful outcomes, higher default rates.
Barriers to Treatment	Inadequate food, stigma, lack of social protection, drug stock-outs, and transport issues.
Health Services Access	Delays in diagnosis and treatment, poor healthcare access.
Interventions and Support	Socioeconomic support improves adherence and outcomes.
Long-term Economic Impact	Persistent financial strain, limited recovery in income and employment.

Table 1 indicates that low Socioeconomic Status (SES) substantially affects tuberculosis treatment outcomes. Patients with low SES are at higher risk of treatment failure and default due to barriers such as food insecurity, stigma, limited social protection, medication stock-outs, and transportation challenges. Restricted access to healthcare services and delayed diagnosis further undermine treatment adherence. Socioeconomic support can enhance adherence and improve outcomes. However, patients often continue to face long-term financial burdens that impede recovery of income and employment. The quality and organization of healthcare systems further shaped treatment outcomes. Weak tuberculosis control programs, insufficient follow-up mechanisms, and inadequate surveillance systems were associated with higher rates of treatment default and relapse. Studies by Shah et al. (2022) highlighted that fragmented healthcare delivery, poor coordination between diagnostic and treatment services, and limited patient monitoring reduced the effectiveness of tuberculosis treatment programs. In addition, inadequate infection prevention and control measures within healthcare facilities increased the risk of nosocomial transmission, undermining both patient safety and treatment success (Vigenschow et al., 2021).

Social support systems were identified as critical facilitators of successful tuberculosis treatment. Strong family involvement and community-based support mechanisms were consistently associated with higher treatment adherence and better outcomes. Patients who received emotional encouragement, practical assistance, and supervision from family members were more likely to complete treatment and attend follow-up visits (Bustos et al., 2022). Community health workers and peer-support initiatives also played an important role in reinforcing adherence, particularly in resource-limited settings where formal healthcare capacity was constrained. Tuberculosis-related stigma and discrimination emerged as major social barriers to effective treatment. Evidence from multiple contexts showed that fear of social exclusion, loss of employment, and negative community perceptions discouraged patients from disclosing their diagnosis and seeking timely care (Vieira et al., 2025). Stigma often resulted in treatment being undertaken in secrecy, increasing the likelihood of missed doses and incomplete therapy. Psychological distress associated with stigma further undermined patients' motivation to adhere to lengthy treatment regimens, highlighting the interplay between social and mental health factors in tuberculosis outcomes.

Structural inequalities related to gender and social status also influenced treatment trajectories. In some settings, women faced additional barriers to accessing tuberculosis services due to caregiving responsibilities, restricted mobility, or limited decision-making autonomy within households. Men, on the other hand, were more likely to delay care-seeking due to work-related constraints or social norms discouraging health service

utilization. These gendered patterns contributed to differential treatment outcomes and underscored the importance of context-specific analyses (Choi et al., 2023; Abaynew et al., 2025).

The interaction between socioeconomic conditions and environmental determinants was evident across the reviewed studies. Poor households were more likely to reside in environmentally disadvantaged areas characterized by overcrowded housing, air pollution, and inadequate sanitation, compounding their vulnerability to poor treatment outcomes. Economic constraints limited patients' ability to modify their living environments or reduce exposure to environmental risks, thereby reinforcing cycles of illness and treatment failure (Najafizada et al., 2021). The results demonstrate that socioeconomic and structural factors are central to understanding disparities in tuberculosis treatment outcomes. Economic hardship, limited healthcare access, weak health system capacity, and adverse social environments collectively shape patients' ability to initiate, adhere to, and complete tuberculosis treatment. These findings indicate that tuberculosis treatment outcomes cannot be fully explained by clinical or environmental factors alone, but rather emerge from the interaction of social, economic, and structural conditions that frame patients' everyday lives.

DISCUSSION

The findings of this study reaffirm that tuberculosis treatment outcomes are shaped by a complex interplay of environmental, socioeconomic, and health system factors rather than by clinical interventions alone. Consistent with previous research, poor housing conditions, including overcrowding, inadequate sanitation, and limited access to clean water, significantly undermine treatment adherence and facilitate ongoing transmission (Maciel et al., 2018; Okesanya et al., 2024; Boualam et al., 2025). Such living environments not only delay recovery but also increase the risk of Multidrug-Resistant Tuberculosis (MDR-TB), highlighting housing quality as a critical concern for tuberculosis program management (Najafizada et al., 2021). Patients residing in these environments often face competing survival priorities, such as food security and income generation, which further limit their sustained engagement with healthcare services.

Environmental exposures, particularly air pollution, also emerged as key determinants of treatment outcomes. Exposure to particulate matter (PM2.5 and PM10) and gaseous pollutants such as nitrogen dioxide, sulfur dioxide, and carbon monoxide exacerbate pulmonary inflammation and impair immune function, contributing to higher mortality among tuberculosis patients during treatment (Jakubowiak et al., 2008; Zhao et al., 2023; Hammouri et al., 2025). Indoor air pollution, including tobacco smoke and solid fuel use, further compromises lung function and treatment efficacy (Mundra et al., 2018). These findings underscore the need for tuberculosis control strategies to integrate environmental health interventions, including air quality improvement and pollution mitigation, alongside clinical care.

Socioeconomic factors play a central role in mediating these environmental risks. Individuals with low income and limited education are more likely to experience delayed diagnosis, poor adherence, and treatment default due to financial constraints and competing livelihood demands (Choi et al., 2023; Reddy et al., 2025). Multidimensional poverty further limits access to nutrition, transportation, and social support, which are essential for sustained treatment adherence (Najafizada et al., 2021). Healthcare system capacity and accessibility also significantly influence outcomes, as long travel distances, inadequate infrastructure, and weak surveillance compromise continuity of care, particularly in rural settings (Batool & Lopez, 2023; Tuty et al., 2025).

Social support emerges as a critical facilitator of adherence. Strong family and community support improves treatment completion and follow-up attendance (Abaynew et al., 2025). Conversely, tuberculosis-related stigma and discrimination can result in social isolation, psychological distress, and treatment discontinuation (Vieira et al., 2025; Abaynew et al., 2025). Gender and structural inequalities further influence treatment trajectories, with women facing additional barriers due to caregiving responsibilities and

limited autonomy, while men may delay care due to work obligations and social norms (Choi et al., 2023; Abaynew et al., 2025).

These findings indicate that successful tuberculosis treatment depends on addressing environmental, socioeconomic, and structural determinants alongside clinical interventions. Multisectoral strategies that improve housing quality, mitigate pollution, enhance healthcare access, and provide social support are essential for reducing treatment failure, preventing drug resistance, and improving overall tuberculosis treatment outcomes (Najafizada et al., 2021; Akhtar et al., 2023; Hammouri et al., 2025).

CONCLUSION

The findings of this study indicate that tuberculosis treatment outcomes are shaped by a complex interplay of environmental, socioeconomic, and structural factors. Poor housing quality, overcrowding, inadequate sanitation, air pollution, and long-term environmental contamination significantly reduce treatment adherence and increase mortality risk. Socioeconomic constraints, including financial hardship, low health literacy, and unstable employment, further hinder timely care-seeking and sustained treatment. Structural barriers such as limited healthcare access, long travel distances, and fragmented service delivery exacerbate these challenges, particularly in rural and underserved areas. Social dynamics, including family and community support, facilitate adherence, whereas stigma, discrimination, and gender inequalities impede treatment completion. These findings underscore that tuberculosis control programs must extend beyond biomedical interventions to integrate environmental management, social support, and community engagement to enhance treatment success.

However, this study has limitations. Reliance on literature synthesis may overlook unpublished data or context-specific factors, and heterogeneity among included studies limits generalizability. Future research is recommended to employ mixed methods designs that combine quantitative and qualitative insights into patient experiences and behavioral determinants. Longitudinal studies examining the combined effects of environmental interventions, social support mechanisms, and healthcare system strengthening on tuberculosis treatment adherence are also warranted. Policymakers and health managers should develop multisectoral, patient-centered strategies that address environmental exposures, healthcare infrastructure, and socioeconomic support to ensure effective, context-sensitive, and sustainable tuberculosis interventions across diverse populations.

FUNDING STATEMENT: This research did not receive any specific grant from funding agencies in the public, commercial, or not - for - profit sectors.

CONFLICTS OF INTEREST: The author declares no conflict of interest.

DECLARATION OF GENERATIVE AI STATEMENT: During the preparation of this work, the author used Turnitin, Grammarly, and ChatGPT to improve sentence structure and overall clarity. All content was then reviewed, edited, and refined by the author, who takes full responsibility for the accuracy, integrity, and originality of the final publication.

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