Social Determinants of Tuberculosis: Unpacking the Triad of Poverty, Stigma, and Social Exclusion

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***Abstract*—Tuberculosis (TB) persists as a global health crisis, disproportionately affecting marginalised populations. This review argues that TB is a biosocial disease, driven not merely by a pathogen but by a syndemic of social determinants. We analyse the synergistic interaction of a triad poverty, stigma, and social exclusion that creates a vicious cycle of vulnerability. Poverty fosters malnutrition and overcrowded housing, increasing biological susceptibility and transmission. Stigma acts as a social toxin, delaying diagnosis and undermining treatment adherence. Social exclusion, rooted in structural inequities, concentrates these risks in populations like Indigenous communities and migrants. This triad disrupts the entire TB care cascade, rendering purely biomedical interventions insufficient. We conclude that ending TB requires a paradigm shift towards integrated "social prescriptions," including social protection, stigma reduction, and structural reforms, to dismantle this interconnected web of disadvantage and achieve health equity.**

***Index Terms*—Health Equity; Malnutrition and TB; Social Determinants of Health; Stigma to TB; Tuberculosis burden; Vulnerable Populations to TB.**

I. INTRODUCTION

Tuberculosis as a Health Burden

Tuberculosis (TB), caused by the pathogen Mycobacterium tuberculosis, remains a leading cause of infectious disease mortality worldwide, with an estimated 10.8 million new cases and 1.25 million deaths in 2023 (World Health Organisation, 2024). For decades, the global response has been anchored in a biomedical paradigm, focusing on the critical tasks of developing effective drug regimens, improving diagnostic tools, and promoting preventive therapy. While these efforts have saved countless lives, their ultimate success is consistently undermined by a persistent and troubling paradox: TB is not randomly distributed across populations. Instead, its burden falls disproportionately and relentlessly upon the most disadvantaged and marginalised groups in society (Carter et al., 2018; Siroka et al., 2016). This stark disparity reveals that the bacillus is a necessary but insufficient cause of TB disease; its trajectory is profoundly shaped by the social and economic conditions into which it is transmitted.

A robust body of evidence now positions TB as a disease of inequality, a biological manifestation of social injustice. Key social determinants act as powerful drivers of the epidemic. Poverty is the foundational determinant, creating a risk-laden environment through mechanisms such as food insecurity and malnutrition a condition that compromises cell-mediated immunity and significantly increases the risk of progression from TB infection to active disease (Chandrasekaran et al., 2017; Sinha et al., 2019). Furthermore, poverty dictates living circumstances, with inadequate and overcrowded housing directly facilitating TB transmission (Lee et al., 2022). Beyond these material deprivations, a potent psychosocial determinant stigma serves as a critical barrier to effective TB control. TB-related stigma, rooted in historical fear and misconceptions, deters health-seeking behaviour, delays diagnosis, and disrupts treatment adherence, effectively perpetuating community transmission (Craig et al., 2017; Datiko et al., 2020; Yan et al., 2018). These determinants converge with intense force in socially excluded populations, such as Indigenous communities, tribal groups, and migrants, who experience a syndemic of disadvantage. Social exclusion, rooted in historical and structural inequities, acts as a multiplier, concentrating poverty and intensifying stigma, resulting in TB incidence rates that are often several times higher than in the general population (Cormier et al., 2019; Debnath et al., 2024; Menzies et al., 2018).

II. RESEARCH ARGUMENT AND RATIONALE

While the individual contributions of poverty, stigma, and social exclusion to TB are increasingly documented (e.g., Alene et al., 2020 on delay; Baskaran et al., 2023 on stigma; Feyisa et al., 2024 on malnutrition as a pathway of poverty), a critical gap remains in understanding their synergistic interactions. The prevailing literature often examines these factors in isolation, failing to capture the lived reality where they operate as an interlocking "triad of vulnerability." For instance, the experience of stigma is not uniform; it is intensified by poverty and compounded by pre-existing social exclusion (e.g., Miller et al., 2017 on gender; Rourke et al., 2025 on Indigenous peoples).

This study argues that TB persists not merely because of biological or technical challenges, but because poverty, stigma, and social exclusion create a self-reinforcing cycle that health systems, focused on biomedical interventions, are ill-equipped to break. The rationale for this study is, therefore, to move beyond a siloed view of social determinants and provide a nuanced, integrated analysis that can inform more holistic and effective public health interventions. While the critical roles of stigma (e.g., Craig et al., 2017), malnutrition (e.g., Feyisa et al., 2024), and poverty (e.g., Carter et al., 2018) in the tuberculosis epidemic have been individually established in prior scholarship, existing reviews often analyse these determinants in isolation. For instance, seminal reviews have meticulously detailed the consequences of patient delay (Alene et al., 2020) or the global burden of malnutrition (Feyisa et al., 2024) but have not explicitly modelled their synergistic interactions.

This review moves beyond these siloed analyses by employing a novel integration of the Social Determinants of Health (SDH) and Syndemic Frameworks. This integrated lens allows us to conceptualise and evidence a 'Triad of Vulnerability' in which stigma, poverty, and social exclusion are not merely co-occurring risk factors but are mutually reinforcing, creating a syndemic that exacerbates adverse outcomes across the entire TB care cascade. Unlike prior work that catalogues independent determinants, this synthesis explicitly maps the pathways of interaction for example, how stigma leads to social isolation and economic hardship, worsening material deprivation (poverty), which in turn increases biological susceptibility to TB and the risk of catastrophic costs, thereby intensifying stigma. The novel contribution of this review, which synthesises evidence through an integrated SDH and syndemic lens, is further clarified by contrasting it with key existing systematic reviews in the field. Table 1 positions this review against other influential works, highlighting how its focus on the *synergistic interaction* of the triad moves beyond the more siloed or linear analyses that currently dominate the literature. This comparative positioning underscores the unique conceptual framework and added value of the present analysis.

Table 1. Gap Statement: Positioning this Review's Novel Contribution

Review Focus & Citation	Focus & Approach	Key Novelty of This Review
his Review: The Social Determinants of Tuberculosis	Multi-Determinant & Synergistic. Integrates SDH and Syndemic Frameworks to analyse the interactions between stigma, poverty, and social exclusion as a "Triad of Vulnerability."	Explicitly models the syndemic interactions between these determinants, moving beyond a siloed listing of risks to demonstrate how they form a self-reinforcing cycle that worsens outcomes across the entire TB care cascade.
Stigma-Centred Review Craig et al. (2017)	Single Determinant. A systematic mapping of TB stigma research, primarily in low-incidence countries.	Integrates stigma as one core component of a synergistic model, contextualising it within a broader structural and material framework rather than examining it in isolation.
Malnutrition-Centred Review Feyisa et al. (2024)	Single Determinant. A meta-analysis on the magnitude of undernutrition among TB patients in Ethiopia.	Analyses malnutrition as a dynamic outcome influenced by social factors like stigma and poverty, and as a driver of transmission, positioning it within a causal web.
Delay in Diagnosis & Treatment Alene et al. (2020)	Multi-determinant, but linear. Identifies various factors (e.g., stigma, poverty) contributing to patient delay.	Adopts a syndemic perspective, arguing these factors interact synergistically to create a "vulnerability trap" that explains persistent delays, rather than merely being associated.

Review Focus & Citation	Focus & Approach	Key Novelty of This Review
Structural Determinants / Poverty Carter et al. (2018)	Macro-structural. Focused on the population-level impact of poverty elimination on TB incidence.	Complements this macro view by "unpacking the black box" of poverty, showing how it manifests via synergistic pathways with stigma and exclusion to impact the individual care cascade.
TB in Vulnerable Populations Cormier et al. (2019)	Population-specific. Systematic review of proximate determinants in Indigenous peoples.	Expands to a global triad framework, incorporating intersectional synergies (e.g., exclusion amplifying stigma in migrants and tribals) for multi-level interventions.

III. Research Questions and Objectives

To unpack this triad of vulnerability, this article will address the following research questions (RQs) and corresponding research objectives (ROs):

RQ1: How do poverty, stigma, and social exclusion interact synergistically to increase vulnerability to TB infection and disease progression?

RQ2: What is the impact of this synergistic interaction on key TB care cascade outcomes, including diagnostic delay, treatment adherence, and ultimate treatment success?

RQ3: What are the implications of this triad for designing effective, multi-level TB control interventions?

RO1: To analyse the pathways through which these three determinants potentiate each other to create a heightened risk profile.

RO2: To synthesise evidence on how the triad influences patient experiences and outcomes across the care continuum.

RO3: To propose a framework for integrated interventions that simultaneously address the material, psychosocial, and structural dimensions of TB vulnerability.

By answering these questions, this article aims to contribute a critical social science perspective to TB research, arguing that the path to ending the TB epidemic lies as much in confronting social inequalities as it does in developing new biomedical tools.

IV. THEORETICAL PERSPECTIVE

To comprehensively analyse the interconnected roles of poverty, stigma, and social exclusion in tuberculosis, this study is guided by an integrated theoretical framework that combines the Syndemic Framework with the Social Determinants of Health (SDH) model. This combination provides a powerful lens for moving beyond a simple listing of risk factors to understanding their dynamic and synergistic interactions.

The Social Determinants of Health (SDH) Model: Mapping the Terrain of Vulnerability

The WHO's SDH model offers a foundational structure for understanding the "causes of the causes" of disease. It posits that health outcomes are primarily shaped by the conditions in which people are born, grow, live, work, and age, including the distribution of power, money, and resources. In the context of this study, the SDH model allows us to systematically categorise and map the determinants at play:

- Structural Determinants: This includes the socioeconomic and political context (e.g., policies leading to poverty and inequality) that creates stratification and social hierarchies (Carter et al., 2018; Siroka et al., 2016).
- Intermediate Determinants: These are the material circumstances (e.g., malnutrition, poor housing), psychosocial factors (e.g., stigma, stress), and behavioural and biological factors that more directly influence health (Feleke et al., 2019; Lee et al., 2022; Craig et al., 2017).

The SDH model is instrumental in identifying what the key determinants are and how they are structurally positioned. However, it is less adept at explaining the nature of the interactions between these determinants. For this, we turn to the Syndemic Framework.

The Syndemic Framework: Understanding Synergistic Interaction

A syndemic refers to the concentration of two or more afflictions, health-related conditions, or psychosocial problems in a population, where their interaction exacerbates the negative health effects of each (Singer et al., 2017). This framework moves beyond the concept of comorbidity by emphasising the synergistic interaction that occurs within a specific, adverse socio-environmental context.

In this study, we posit that TB is not a singular epidemic but is part of a syndemic of suffering. The biological pathogen (Mycobacterium tuberculosis) interacts synergistically with a cluster of adverse social conditions:

- Poverty and Malnutrition: Poverty creates material deprivation (malnutrition, poor housing) that biologically compromises the host's immune response (Chandrasekaran et al., 2017), making the body more susceptible to the bacillus and severe disease (Hoyt et al., 2019; Sinha et al., 2023).
- Stigma: Stigma acts as a psychosocial toxin that impairs the social and healthcare-seeking environment. It delays diagnosis and hinders treatment adherence (Yan et al., 2018; Teo et al., 2021), thereby prolonging infectiousness and increasing community transmission.
- The Syndemic Interaction: Crucially, these elements do not merely co-occur; they fuel one another. For example, poverty increases the risk of TB and the associated stigma (e.g., the "disease of the poor" narrative). In turn, the experience of stigma can lead to job loss and social isolation, deepening poverty. This creates a vicious, self-reinforcing cycle where the sum of the adverse effects is greater than their individual parts. This syndemic is particularly acute among socially excluded populations (e.g., Indigenous communities, migrants), who experience a concentration of these adverse conditions (Cormier et al., 2019; Debnath et al., 2024).

Theoretical Integration: A Cohesive Analytical Lens

By integrating the SDH model with the Syndemic Framework, this study achieves a comprehensive analytical perspective:

- The SDH model provides the structural and hierarchical map, identifying poverty and social exclusion as the upstream drivers.
- The Syndemic Framework explains the dynamic, biological-social processes that occur downstream, showing how poverty, stigma, and the TB bacillus interact synergistically to worsen disease burden and perpetuate health inequities.

This integrated theoretical perspective justifies the study's focus on the "triad of poverty, stigma, and social exclusion." It allows us to argue that interventions targeting only one element of this syndemic (e.g., providing drugs without addressing stigma or poverty) are likely to have limited long-term success. Instead, it calls for holistic, multi-level approaches that simultaneously address the intertwined material, psychosocial, and biological dimensions of the TB epidemic, as reflected in the research objectives.

V. RESEARCH DESIGN AND METHODS

Review Design:

This study employed a systematic scoping review methodology, designed to map the breadth of existing evidence and synthesise findings on the complex, multi-faceted topic of social determinants and tuberculosis. This approach was selected to incorporate and synthesise evidence from a wide range of study designs, including quantitative, qualitative, and mixed-methods research.

Search Strategy:

A comprehensive search of the literature was conducted using the electronic databases PubMed/MEDLINE, Scopus, Web of Science, and Cochrane Library. The search strategy combined keywords and controlled vocabulary terms (e.g., MeSH) related to three core concepts:

- "Tuberculosis" OR "TB"
- "Social Determinants of Health" OR "Social Stigma" OR "Malnutrition" OR "Poverty" OR "Vulnerable Populations"
- "Epidemiology" OR "Treatment Outcome" OR "Transmission" Searches were limited to publications from January 2010 to December 2024 to ensure contemporary relevance. The

reference lists of included articles were also screened for additional relevant studies.

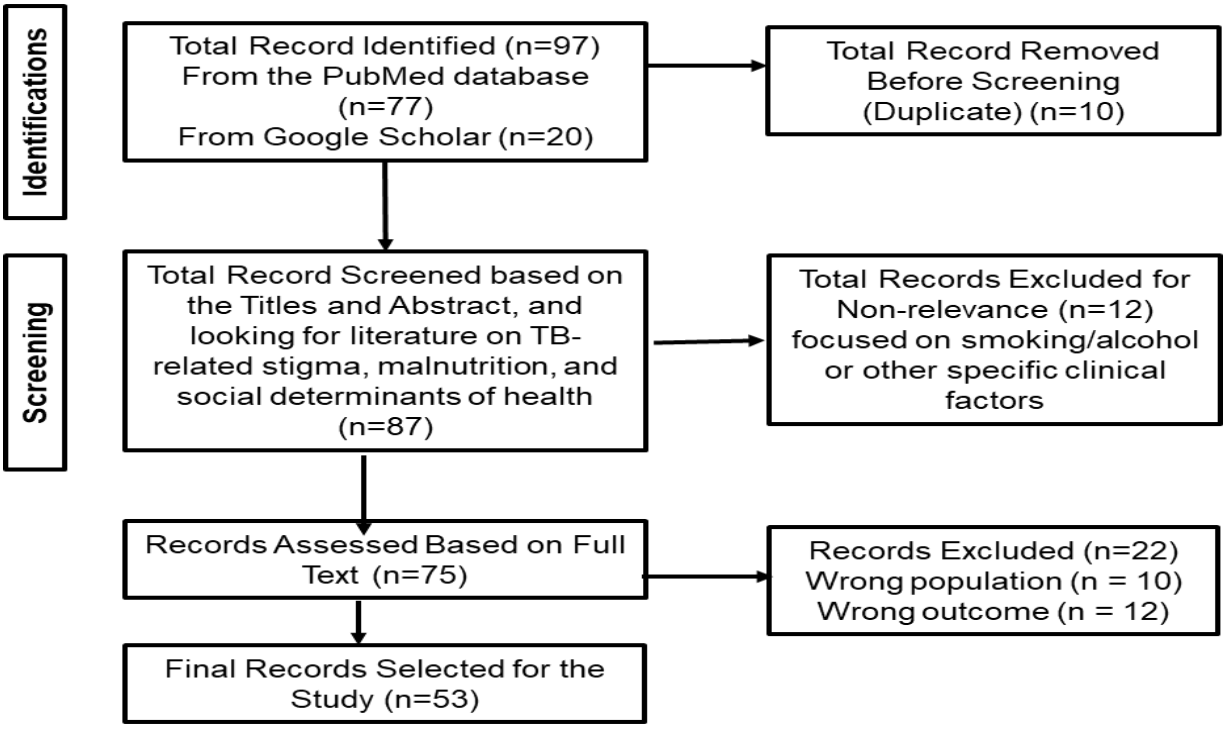
Selection Process:

Study selection was guided by pre-defined eligibility criteria based on the PICOS framework:

- Population: Human populations affected by tuberculosis.
- Exposure: Social and structural determinants of health (e.g., stigma, malnutrition, poverty).
- Outcomes: TB incidence, prevalence, diagnostic delay, treatment adherence, or treatment outcomes.

Study Designs: Systematic reviews, meta-analyses, observational studies, qualitative studies, and modelling studies. Studies focusing primarily on other risk factors (e.g., smoking, alcohol use, HIV) without a direct link to core social determinants were excluded. The selection process was documented using a PRISMA flow diagram, as shown in Figure 1.

Figure 1: PRISMA flow diagram of the literature selection process



Data Extraction and Synthesis:

Data from included studies were extracted using a standardised form. Given the heterogeneity in methodologies and measures, a narrative and thematic synthesis was performed. Where possible, quantitative findings from the source literature were aggregated to provide a summative overview. For instance, when a sufficient number of studies within a thematic area (e.g., stigma and delay) reported a consistent directional association, a descriptive tally was performed to indicate the proportion of evidence supporting a given pathway. The extracted evidence was organised and synthesised into key thematic areas aligned with the research objectives.

Limitations of the Review:

It is important to acknowledge potential limitations in the synthesis. As with any review, there is a risk of publication bias, where studies with statistically significant or strong positive findings are more likely to be published. Furthermore, the search was restricted to English-language publications, which may have led to the omission of relevant research in other languages, potentially skewing the geographical representation of findings. The review may also have an

overrepresentation of studies from Low- and Middle-Income Countries (LMICs), as these bear the highest burden of TB. While this reflects the reality of the epidemic, it may limit the generalizability of specific findings to high-income, low-incidence settings. Lastly, the reliance on a narrative synthesis, while necessary for diverse study designs, precludes formal statistical testing for bias or the calculation of pooled effect sizes.

VI. FINDINGS

The Interconnected Web of Social Determinants: Conceptualising the Triad

The concept of "social determinants of health" extends far beyond a mere catalogue of risk factors; it represents a complex and dynamic system wherein socioeconomic, psychosocial, and structural conditions interact to create a gradient of health vulnerability (Wu et al., 2023; Pedrazzoli et al., 2017). In the context of tuberculosis, this study identifies Poverty, Stigma, and Social Exclusion not as discrete variables but as the central, interlocking nodes of a web that entraps individuals and communities, thereby perpetuating the TB epidemic. This findings section synthesises the evidence to demonstrate that the potency of this "triad of vulnerability" lies not in the individual strength of each component, but in their synergistic interaction, creating a whole that is far more devastating than the sum of its parts (Coussens et al., 2024). Guided by the syndemic framework, the following results reveal how these determinants cluster and interact, directly shaping every stage of the TB care cascade from initial susceptibility and diagnostic delay to treatment adherence and ultimate outcomes (Craig et al., 2017; Teo et al., 2021). The ensuing analysis is structured to first dissect the unique pathways of each determinant before synthesising the evidence of their profound interconnection.

VII. POVERTY AND MATERIAL DEPRIVATION

Poverty as the Foundational Pathogen: Biological and Social Pathways

In the topography of tuberculosis, poverty is not merely a coordinate but the very landscape upon which the epidemic is built. To frame it as a simple risk factor is to misunderstand its role; a deeper exploration reveals poverty as a foundational pathogen, a causative agent that operates through both biological and social pathways to cultivate susceptibility and dictate outcomes. It creates a syndemic environment where material lack and biological vulnerability are inextricably fused. This section explores how poverty manifests as a critical force in the TB epidemic through the key mechanisms of malnutrition, hazardous living conditions, and catastrophic economic burden.

Malnutrition and Immunological Vulnerability: The Body's Compromised Defence

A primary and devastating manifestation of poverty is malnutrition, which we explore not as a simple lack of food, but as a critical biological disabler of the human immune response. The relationship is one of a vicious, self-reinforcing cycle: undernutrition creates a susceptible host for TB, and the catabolic nature of active TB disease, in turn, worsens nutritional status.

The existing evidence suggests specific physiological mechanisms. Protein-energy malnutrition and profound micronutrient deficiencies (notably in vitamin D, zinc, and iron) disrupt the complex cell-mediated immune response, crippling the function of macrophages and T-lymphocytes, which are the very cells responsible for containing and destroying Mycobacterium tuberculosis (Chandrasekaran et al., 2017; Téllez-Navarrete et al., 2021). This is not a theoretical risk; it translates directly into clinical reality. Studies have shown that undernourished patients present with a higher mycobacterial burden and more extensive damage visible on chest radiographs, indicating a failure of the body's initial containment efforts (Hoyt et al., 2019).

The scale of this issue is immense and quantifiable. A meta-analysis in Ethiopia by Feyisa et al. (2024) pooled data from 17 studies to find a prevalence of undernutrition at 46.2% among TB patients, while a global systematic review by Li et al. (2023) reported a prevalence ranging from 35% to 69%, firmly establishing this biological vulnerability as a pandemic challenge intertwined with poverty. The consequences are dire for treatment, as evidenced by a prospective cohort analysis in India, which found that undernutrition at diagnosis was a strong predictor of unfavourable treatment outcomes, including mortality and treatment failure (Sinha et al., 2023). This exploration leads to an inescapable conclusion:

providing effective nutritional support is not an ancillary welfare activity but a core component of biomedical TB care, acting as an essential co-therapy to antibiotics.

The Ecology of Transmission: Housing and Overcrowding

From an SDH perspective, poverty operates here as an *intermediate determinant*, directly shaping the material circumstances of housing. This creates environments that function as efficient hubs for TB transmission, demonstrating the syndemic interaction between a social condition and biological transmission. Inadequate housing characterized by severe overcrowding and poor ventilation is not a passive setting but an active participant in the disease's spread.

The evidence illustrates a clear dose response relationship. A systematic review by Lee et al. (2022) established a consistent positive association between inadequate housing and the incidence of pulmonary TB, where the risk escalates with the degree of overcrowding. This is because the airborne bacillus thrives in confined, unventilated spaces where inhabitants have little means of avoiding prolonged exposure. This dynamic is particularly potent within households. A meta-analysis by Martinez et al. (2017) quantified this, revealing that a substantial proportion of community transmission occurs within households, with the risk being profoundly amplified in congested living conditions.

This ecological risk extends beyond family homes to other poverty linked congregate settings. Prisons, homeless shelters, and refugee camps, often marked by extreme overcrowding, become epicentres of transmission, demonstrating how the disease follows the fault lines of social disadvantage (Segal-Maurer, 2017). For example, a study might find a TB incidence rate in a prison system that is many times higher than in the general population. This exploration suggests that the control of TB is intrinsically linked to structural interventions. Improving housing quality, regulating occupancy, and addressing urban inequality are not separate social goals but are fundamental public health strategies for disrupting the chains of TB transmission.

The Economic Burden of TB Illness: The Vicious Cycle of Debt and Disease

The relationship between poverty and TB culminates in a devastating feedback loop, where the disease both springs from and actively deepens economic precarity. The onset of TB triggers a cascade of financial shocks that can cripple families for generations, effectively recreating the conditions of vulnerability.

This process, often termed the 'medical poverty trap', operates through two parallel channels: catastrophic out-of-pocket expenditures and a dramatic loss of income. Families must pay for diagnostics, drugs not covered by programmes, transportation to clinics, and improved nutrition, while the primary breadwinner(s) often lose their ability to work. This dual shock is a powerful driver of the epidemic at a macro level. Research by Siroka et al. (2016) demonstrated this clearly, showing that household poverty was a robust predictor of TB prevalence across multiple countries.

The fear of this financial catastrophe can itself be a barrier to care, causing individuals to delay seeking a diagnosis until the disease is advanced and more difficult to treat. This exploration of the economic pathway argues that financial protection is a cornerstone of TB control. Analyses, such as that by Carter et al. (2018), have modelled that poverty elimination and social protection could potentially avert a significant proportion of incident TB cases globally. Therefore, interventions like cash transfers, food baskets, and transport subsidies are not merely social support but are strategic investments that break the vicious cycle of poverty and TB, making it feasible for individuals to seek and complete treatment without facing ruin.

The Poverty-Malnutrition Loop: The Core Biological Social Feedback

The interaction between poverty and malnutrition represents a classic, yet potent, synergistic cycle at the heart of the triad. It is not a linear pathway but a feedback cycle where poverty and malnutrition continuously amplify each other. Material deprivation, a consequence of poverty, causes food insecurity and malnutrition. This malnutrition, in turn, biologically compromises the host by weakening cell-mediated immunity, significantly increasing the risk of progression from TB infection to active disease and severe clinical presentation (Chandrasekaran et al., 2017; Hoyt et al., 2019; Sinha et al., 2019). Once TB

is established, the catabolic nature of the disease worsens nutritional status, while the associated healthcare costs and loss of income further deepen poverty, creating a vicious cycle where disease and deprivation continuously fuel one another (Siroka et al., 2016; Sinha et al., 2023). The power of this loop is starkly evidenced by data showing significantly higher rates of malnutrition among TB patients in high-poverty settings (Feyisa et al., 2024; Li et al., 2023; Kannayan et al., 2024). This loop ensures that TB is not just a consequence of poverty but a potent cause of its perpetuation, biologically embodying the social injustice at the heart of the epidemic.

VIII. STIGMA AS A SOCIAL TOXIN

The Anatomy of a Social Toxin: Manifestations and Drivers of Stigma

The evidence from the assessed literature unequivocally positions stigma not merely as a consequence of tuberculosis, but as a parallel social pathology that actively drives the epidemic. Its influence is so profound that it functions as a "social toxin," contaminating social relationships, healthcare seeking environments, and the individual's internal psychological world. Understanding its anatomy how it is formed and how it manifests is critical to diagnosing its pervasiveness.

Stigma manifests through two primary, interconnected dimensions: enacted stigma (the experience of actual discrimination) and felt stigma (the internalised shame and constant fear of discrimination). The evidence shows that enacted stigma frequently materialises as social ostracisation. For example, studies in Ethiopia and Zambia detail how patients are excluded from social gatherings, face verbal abuse, and are even forced to eat and sleep separately from their families, effectively being quarantined by their communities long before any official medical isolation is considered (Cremers et al., 2015; Duko et al., 2019; Datiko et al., 2020). This is often compounded by structural stigma, where systems themselves perpetuate discrimination, such as the fear of using occupational health units for TB services among South African miners due to concerns about confidentiality and job loss (Sommerland et al., 2017).

The drivers of this stigma are deeply rooted in a triad of fear, misinformation, and moral judgment. The historical fear of TB as a deadly, incurable "white plague" persists, now fused with anxieties about its infectious nature. This is powerfully exacerbated by a lack of accurate knowledge, where studies from Nigeria and Malaysia found that misconceptions about transmission such as believing TB can be spread through shared food or casual contact are significant predictors of stigmatising attitudes (Junaid et al., 2021; Loh et al., 2023). Furthermore, TB is often incorrectly moralised as a disease of poverty, poor lifestyle, or even a divine punishment. This "blame-the-victim" narrative is a potent driver, as explored in the Indian context by Thomas & Stephen (2021), who note that such moral attributions create a significant "roadblock" to ending TB.

Crucially, the experience of stigma is not monolithic; it intersects with and is intensified by other social identities. Gendered analyses reveal that women, particularly in contexts like Tanzania and India, fear abandonment by spouses and bring "shame" to their families, impacting their marriageability and social standing (Miller et al., 2017; Mukerji & Turan, 2018). Similarly, the stigma is compounded for already marginalised groups, such as First Nations, Inuit, and Métis peoples in Canada, or tribal populations in India, who experience a form of "double stigma" where prejudice against their ethnicity converges with fear of their disease (Rourke et al., 2025; Gupta et al., 2023).

The Corrosive Impact: How Stigma Sabotages the TB Care Cascade

Viewed through the syndemic lens, stigma acts as a *psychosocial determinant* that synergistically interacts with the biological pathogen. Its true lethality lies in its capacity to systematically sabotage the TB care cascade, demonstrating how a social affliction worsens a biomedical one. The literature provides compelling evidence of its corrosive impact, creating a vicious cycle of avoidance, delay, and failure.

Diagnostic Delay and Concealment: The fear of stigma creates a powerful initial barrier. Individuals experiencing TB symptoms often consciously ignore them or engage in self-treatment, prioritising social survival over physical health. A mixed-methods systematic review by Teo et al. (2021) identified stigma as a paramount factor in causing prolonged delays, with over 80% of the qualitative and survey-based studies included in their synthesis reporting stigma as a primary or significant barrier to timely diagnosis and treatment initiation across high burden

countries. This is not just a statistic; qualitative studies from Thailand illustrate how the desire to avoid the "TB label" leads patients to conceal their symptoms until they are critically ill, by which time they have likely infected many others in their household and community (Ngamvithayapong Yanai et al., 2019).

Treatment Non-Adherence and Default: For those who commence treatment, the ordeal of stigma continues, directly threatening adherence. The very acts required for a cure collecting medication from a known TB clinic, taking pills in public, dealing with side effects can expose an individual to discrimination. Quantitative research from China demonstrated a direct dose-response relationship: higher levels of perceived stigma were a significant predictor of nonadherence to anti-tuberculosis medications (Yan et al., 2018). This is further complicated by the fact that stigma often leads to job loss, creating a catastrophic feedback loop where economic pressure makes it harder to afford transport to clinics, thereby increasing the likelihood of default (Zegeye et al., 2019).

Mental Health Comorbidities: The psychological burden of carrying a stigmatised disease is immense. The constant fear of rejection and experience of isolation frequently culminate in major depressive disorder. A systematic review and meta-analysis by Ruiz-Grosso et al. (2020) established a robust association between TB and depression, and critically, found that this comorbidity significantly increases the risk of negative treatment outcomes, including death and loss to follow-up. This creates a devastating syndemic: stigma fuels depression, which in turn impairs the motivation and cognitive function needed to complete treatment, thereby reinforcing the physical and social suffering of the individual (Nasir et al., 2024).

Undermining Public Health Measures: The impact of stigma extends beyond the individual to cripple core public health interventions. Stigma hinders contact investigation, as index patients, fearing the repercussions for their friends and family, may deliberately withhold contact information. This protective instinct, born from stigma, allows transmission chains to remain hidden and active (Ngamvithayapong Yanai et al., 2019). The Ethiopian national stigma survey aptly summarised this pervasive effect, concluding that stigma negatively impacts care-seeking, adherence, and patient well-being, making its reduction essential for any successful TB elimination strategy (Datiko et al., 2020).

In conclusion, the collective evidence paints a clear picture: stigma is not a peripheral social issue but a central epidemiological determinant. It acts as a primary barrier that discourages timely diagnosis, a sustained disruptor that compromises treatment adherence, and a profound stressor that exacerbates mental health crises. Addressing this "social toxin" with targeted, evidence-based interventions is therefore not a secondary consideration but a fundamental prerequisite for breaking the back of the tuberculosis epidemic.

IX. SOCIAL EXCLUSION AS STRUCTURAL VIOLENCE

Beyond Marginalisation: The Embodiment of Historical and Structural Inequity

The concept of social exclusion in the context of tuberculosis transcends simple marginalisation; it represents a form of structural violence, where social and economic systems systematically disadvantage certain groups, leading to embodied health disparities. This analysis posits that for populations like Indigenous peoples, tribal communities, and migrants, TB is not a random occurrence but a pathological manifestation of long-standing historical injustices and contemporary systemic failures. The syndemic framework becomes critically illuminating here, revealing how social exclusion acts as the conduit through which poverty and stigma are concentrated and amplified, creating landscapes of hyperendemic TB.

The deep roots of this exclusion are often found in colonial histories and ongoing political neglect. The systematic review by Cormier et al. (2019) on Indigenous peoples globally is pivotal, as it moves beyond listing risk factors to identifying them as "proximate determinants" directly stemming from distal structural causes. These include the intergenerational trauma of land dispossession, forced assimilation, and the destruction of traditional food systems, which manifest today as the overcrowded housing and malnutrition that fuel TB transmission and progression. This is not a passive outcome but an active process; a scoping review on Canadian Arctic

Indigenous communities explicitly frames the social determinants of health for TB within the context of "colonialism and racism," arguing that these are fundamental causes that shape all downstream risks, from food insecurity to inadequate housing (Kolahdooz et al., 2025).

This structural analysis is equally potent when examining tribal populations in India. The excessively high TB burden among these groups, as systematically reviewed by Debnath et al. (2024), is a direct result of their geopolitical and economic isolation. A poignant example is the Saharia tribe, studied by Gupta et al. (2023), whose TB vulnerability is a direct consequence of their historical location on the margins of society, resulting in "multidimensional poverty," reliance on forest produce with declining yields, and a lack of political voice to demand functional health services. The severity of this marginalisation is biologically inscribed, as evidenced by a systematic review confirming that tribal TB patients in India suffer from significantly higher rates of malnutrition, a direct metric of their systemic deprivation (Kannayan et al., 2024). This aligns with the *structural determinants* of the SDH model, where socioeconomic and political contexts create the hierarchies that concentrate risk in these populations.

Pathways of Exclusion: Specific Populations and Their Syndemic Realities

The mechanism of social exclusion operates through distinct yet equally devastating pathways for different populations, creating a perfect storm where the triad of vulnerability converges with maximum force.

- Indigenous and Tribal Populations: The Geography of Abandonment. For these groups, exclusion is often geographical, cultural, and political. Their residence in remote or hard-to-reach areas is not a neutral fact but a legacy of displacement. This geographical isolation translates into a public health abandonment, where health infrastructure is dilapidated or non-existent, and health workers are scarce. The high prevalence of TB in these populations, confirmed by Gilmour et al. (2022) across South-East Asia and the Pacific, is a direct outcome. This is compounded by cultural exclusion, where Western biomedical models of care clash with traditional beliefs and healing practices, fostering mistrust and deterring care-seeking behavior. The mixed-methods study in a Kenyan pastoralist community by Mbuthia et al. (2020) effectively captures this, demonstrating how their nomadic identity and cultural distance from formal health systems, combined with intense stigma, create a formidable barrier to TB care that purely biomedical programs cannot overcome.
- Migrants and Refugees: The Pathology of Liminality. For migrants, social exclusion is characterised by liminality existing in a precarious state between legal statuses and national identities. An integrative review by Seyedmehdi et al. (2024) meticulously details how this liminality creates a unique set of barriers: the ever-present fear of deportation deters any interaction with state authorities, including health services; exploitative working conditions in informal sectors prevent taking time off for clinic visits; and xenophobia in host countries enacts a powerful social stigma. This creates a "triple exclusion" legal, economic, and social. The modelling study by Menzies et al. (2018) in the U.S. quantifies the impact of this pathway, showing how migration from high-burden countries sustains TB incidence, effectively demonstrating how global health inequities are literally imported and localised through the exclusionary structures of host nations. A rapid qualitative review by Smith et al. (2021) further confirms that TB stigma is profoundly shaped by racism, colonialism, and migration, creating a "double stigma" for these populations.

The Syndemic Amplification: When Exclusion Multiplies Risk

Within the proposed triad, social exclusion is the non-linear amplifier. It ensures that the effects of poverty and stigma are not additive but multiplicative. Consider a tribal woman from the Saharia community: her poverty is absolute, defined by food insecurity (Gupta et al., 2023). Her gender and tribal identity make her a target for intense, layered stigma (Miller et al., 2017; Mukerji & Turan, 2018). Her social exclusion, due to her remote location and lack of education, means that when she develops TB, the nearest quality health facility is hours away, and she may not be able to navigate the bureaucratic healthcare system effectively.

This is the syndemic in its most devastating form. The pathogen exploits the immunological weakness wrought by poverty (malnutrition), the diagnostic and treatment delays caused by stigma, and the sheer logistical impossibility imposed by social exclusion. The literature confirms that these populations are not just at higher risk of TB, but also of its most severe consequences, including drug-resistant forms (Alibrahim et al., 2024; Salari et al., 2023) and treatment failure, as they are often missed by standard, centrally planned TB programmes.

In conclusion, tackling TB in the 21st century requires a reckoning with these structural pathologies. It demands a move from a biomedical paradigm to a bio-social-political one. This involves:

- Truth and Reconciliation: Acknowledging the historical and ongoing role of colonialism and structural racism in creating TB hotspots.
- Decolonising Public Health: Co-designing TB programs with Indigenous, tribal, and migrant communities to ensure they are culturally safe and accessible.
- Intersectoral Action: Implementing "social prescriptions" that address the root causes land reform, secure housing, legal protections for migrants, and poverty elimination as outlined in the modelling work of Carter et al. (2018).

Ultimately, the fight against TB in these populations is inseparable from the fight for social justice, land rights, and human dignity. To treat their TB without addressing the structural violence that caused it is merely to apply a bandage to a deep, systemic wound.

X. UNPACKING THE TRIAD ANALYSIS OF SYNERGISTIC INTERACTIONS

Having dissected the individual components of poverty, stigma, and social exclusion, this core analytical section synthesises the evidence to demonstrate their synergistic interaction. The triad forms a self-reinforcing system where social exclusion acts as the structural amplifier, concentrating the effects of poverty and stigma to create landscapes of hyperendemic TB. This synergy explains why interventions targeting single determinants often fail. Figure 2 visually models the syndemic interactions proposed by our theoretical framework, illustrating the self-reinforcing cycles between the determinants.

Figure 2: The Triad of Vulnerability - Synergistic Interactions in TB

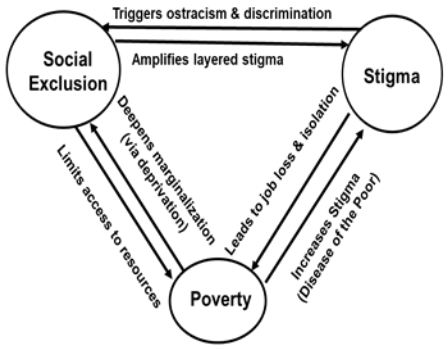


Figure 2. The Triad of Vulnerability: Synergistic Interactions Among Poverty, Stigma, and Social Exclusion in Tuberculosis. This diagram illustrates the self-reinforcing loops within the syndemic framework. Bidirectional arrows represent dynamic pathways, such as poverty intensifying stigma through the "disease of the poor" narrative, and stigma exacerbating exclusion via ostracism. Adapted from integrated SDH and Syndemic models (Singer et al., 2017; Carter et al., 2018).

The Downward Spiral: Poverty and Stigma Fuelling Exclusion

The pathway often begins with the material reality of poverty and the fear associated with stigma, which together trigger processes of social exclusion. Tuberculosis is powerfully framed as a "disease of the poor," a narrative that morally blames individuals for their condition (Thomas & Stephen, 2021). This economically derived stigma accelerates social rupture. Once labelled both "poor" and "sick," individuals face overt ostracisation, eviction, job loss, and even abandonment by family. This enacted stigma is a direct mechanism of social exclusion, severing the kinship and community ties essential for survival (Miller et al., 2017; Cremers et al., 2015). The sequence is clear: Poverty (material lack) + Stigma (moral blame) Social Exclusion (structural marginalisation).

The Cycle of Disadvantage: Exclusion, Deepening Poverty, and Entrenching Stigma

Conversely, pre-existing social exclusion ensures that the impacts of poverty and stigma are not just additive, but multiplicative. For populations like Indigenous communities and migrants, exclusion is geographical, legal, and cultural, confining them to impoverished, overcrowded households and limiting their access to health services and economic opportunities (Cormier et al., 2019; Seyedmehdi et al., 2024). Within this context, a TB diagnosis has catastrophic effects. The fear of stigma, intensified by exclusion, causes diagnostic delays, which in turn lead to more advanced

disease, higher treatment costs, and prolonged income loss (Teo et al., 2021). This newly deepened poverty, a direct result of exclusionary barriers, then constrains individuals' ability to seek care, increasing the risk of poor adherence and default (Zegeye et al., 2019). The sequence here is: Social Exclusion (structural barrier) Worsened Poverty (via delayed care & costs) Reinforced Stigma (via disease severity & marginalisation).

The Stigma Malnutrition Loop

A critical synergistic relationship exists between the social and biological dimensions of the triad. Stigma leads to job loss and social isolation, reducing household income and thereby directly worsening food security and nutritional status. Concurrently, the visible wasting and cachexia of advanced TB and malnutrition can act as a public marker of the disease, intensifying stigma and leading to further social avoidance and discrimination (Baskaran et al., 2023; Thomas & Stephen, 2021). This creates a situation where the social consequence of TB (stigma) actively worsens the biological vulnerability to it (malnutrition), and vice versa. The psychological burden of this cycle is severe. The systematic review by Ruiz-Grosso et al. (2020) meta-analyzed data to show that the pooled prevalence of depression among TB patients was 45.2%, and critically, found that this comorbidity significantly increases the risk of negative treatment outcomes by 1.5 times, creating a devastating feedback loop that impairs both mental well-being and physical recovery by reducing appetite, compromising nutritional intake, and sapping the motivation required to adhere to treatment (Nasir et al., 2024).

The Poverty Malnutrition Loop: The Biological-Core of the Syndemic

This loop, detailed in earlier findings, serves as the biological engine of the triad. It is not a linear pathway but a feedback cycle where poverty and malnutrition continuously amplify each other. Material deprivation associated with poverty causes malnutrition, which biologically compromises the individual, thereby dramatically increasing their vulnerability to TB (Chandrasekaran et al., 2017; Hoyt et al., 2019; Sinha et al., 2019). The onset of active TB then acts as a "disease of poverty," triggering catastrophic costs and income loss that plunge households deeper into economic precarity (Siroka et al., 2016; Sinha et al., 2023), thereby worsening food insecurity and completing the vicious cycle. This loop ensures that TB is not just a consequence of poverty but a potent cause of its perpetuation, biologically embodying the social injustice at the heart of the epidemic, as starkly evidenced by the high prevalence of undernutrition among TB patients in high-poverty settings (Feyisa et al., 2024; Li et al., 2023; Kannayan et al., 2024).

Case Studies of Intersectionality: The Convergence of the Triad

The most devastating impacts occur when all three determinants converge simultaneously on an individual, a phenomenon best understood through the lens of intersectionality. The experiences of specific groups provide powerful case studies of this synergy.

- Case Study 1: The Impoverished Indigenous Woman. Consider an Indigenous woman in a high-income settler-colonial nation. Her social exclusion is rooted in historical dispossession and ongoing systemic racism, which confines her to an impoverished, overcrowded household (Cormier et al., 2019; Rourke et al., 2025). This is her poverty. Within this context, she develops TB. Her gender shapes her experience of stigma, fearing her role as a mother and caregiver will be jeopardised (Miller et al., 2017). Her Indigenous identity may lead to stereotyping and dismissive treatment within the healthcare system, a form of structural stigma (Kolahdooz et al., 2025). The convergence of her gender, ethnicity, and class creates a perfect storm: she is excluded from adequate resources, stigmatised for her identity and disease, and impoverished by the system. Her pathway through the care cascade is fraught with barriers at every step, leading to delayed presentation, potential non-adherence, and a high risk of a catastrophic outcome.
- Case Study 2: The Urban Poor in an Indian Metro. The qualitative study by Mukerji & Turan (2018) explores the manifestations of TB related stigma among women in Kolkata, India. The women lived in low-income, densely populated urban settlements. The research identified a "constellation of stigmas." Women experienced intense fear of marital rejection, leading to attempts to hide their diagnosis. This stigma led to profound social isolation and exclusion from

family life. The interaction here is critical. Their pre-existing poverty increased their vulnerability. The stigma, heavily gendered, then led to their social exclusion, which worsened their mental health and created significant barriers to adhering to treatment, as clinic visits could expose their secret. This case perfectly illustrates how gender norms amplify the toxic effects of the triad.

In conclusion, the synergy of the triad is not theoretical but a tangible, destructive force. It creates a self-reinforcing system where each determinant amplifies the others, trapping populations in a cycle of disease and disadvantage. This explains the persistence of TB despite the availability of effective antibiotics. Breaking this cycle requires integrated interventions that simultaneously address material need (poverty alleviation), psychosocial barriers (stigma reduction), and structural barriers (social inclusion). As advocated by Foster et al. (2022) and Carter et al. (2018), the response must be as interconnected as the problem itself.

XI. DISCUSSION: FROM BIOMEDICAL SILOS TO SOCIAL PRESCRIPTIONS

Reframing TB Control: The Imperative for a Paradigm Shift

The synthesis of evidence presented in this analysis leads to an inescapable conclusion: the persistent global tuberculosis epidemic is a testament to the limitations of a predominantly biomedical model. The meticulous unpacking of the triad of poverty, stigma, and social exclusion reveals a syndemic reality where these determinants do not merely coexist but interact synergistically, creating a vortex of vulnerability that biomedical interventions alone cannot overcome. Poverty biologically primes the host through pathways like malnutrition, stigma socially isolates the patient and disrupts care-seeking, and social exclusion systemically conceals the disease by limiting access to resources and services. This syndemic, as conceptualised by Coussens et al. (2024), explains why the bacillus continues to thrive despite the existence of effective diagnostics and drugs. The findings demonstrate that a person's postcode, pay cheque, and social standing are more powerful determinants of their TB trajectory than the genetic makeup of the pathogen they carry. Therefore, the central argument of this paper is that the goal of ending TB necessitates a fundamental paradigm shift: from a narrow focus on biomedical silos to a comprehensive commitment to social prescriptions.

Implications for Policy and Practice: A Multi-Level Framework for Integrated Interventions

Addressing Research Question 3, the evidence compels a move beyond isolated programmes to a multi-level, integrated framework that concurrently targets the material, psychosocial, and structural dimensions of the triad. This is not a call to abandon biomedical science, but to envelop it within a fortress of social protection and equity.

Economic Empowerment: Disrupting the Material Pathway of Vulnerability

The evidence is unequivocal: financial shock is a primary mechanism driving the TB epidemic. Our syndemic analysis demonstrates that financial shock is not a side effect but a core mechanism. Therefore, social protection is not just a component of care but a direct intervention into the material pathway of the vulnerability triad. Economic interventions must be front and centre:

- Cash Transfers and Food Support: Modelling by Carter et al. (2018) quantified this potential impact, projecting that enhanced social protection could reduce global TB incidence by up to 20%, while the ambitious target of poverty elimination could avert between 33% and 78% of incident TB cases. Direct interventions, such as providing cash transfers or food baskets, address the dual burden of malnutrition and lost income. This serves as both a preventive measure (bolstering immunity) and a supportive measure (facilitating treatment adherence). The success of such schemes in improving outcomes, as suggested in studies from India (Samuel et al., 2016), underscores their non-negotiable role.
- Catastrophic Cost Mitigation: Policies must explicitly aim to eliminate the catastrophic costs faced by TB-affected families (Siroka et al., 2016). This includes reimbursing transportation costs, providing sickness benefits to replace lost wages, and ensuring all TB care is free at the point of use.

Stigma Reduction: Neutralising the Social Toxin

If stigma is a barrier to care, then its reduction is a public health intervention. A scoping review by Foster et al. (2022) analyses various interventions, pointing towards the need for multi-pronged strategies:

- National Mass Media Campaigns: To dismantle myths and reshape public perception, replacing fear with facts.
- Training for Healthcare Workers: To combat structural stigma within health systems, clinics should be places of dignity and support, not discrimination (Sommerland et al., 2017; Wouters et al., 2020).
- Community Led Support Groups: Empowering patients and survivors to become advocates, creating peer networks that combat isolation and build resilience, as seen in the psychological benefits of community support (Nasir et al., 2024).

Structural Reform: Dismantling the Architecture of Exclusion

Ultimately, tackling the root causes requires bold, upstream structural reforms that move beyond the health sector:

- Housing and Urban Policy: Legislation and investment to improve ventilation and reduce overcrowding are direct anti-TB measures, as established by Lee et al. (2022). This is a matter of urban planning and tenancy rights.
- Empowerment of Marginalised Communities: For Indigenous, tribal, and migrant populations, policies must ensure land rights, cultural safety in healthcare, and dismantle systemic barriers. This involves co-designing TB programmes with these communities to ensure they are accessible and trusted (Kolahdooz et al., 2025; Seyedmehdi et al., 2024).
- Universal Health Coverage (UHC): Advancing UHC is perhaps the most powerful structural intervention. It ensures that every individual, regardless of their socioeconomic or legal status, can access the care they need without facing financial hardship, thereby severing the link between illness and poverty.

Beyond LMICs: Transferability of the Triad Framework to High-Income Settings

While the evidence synthesised here is drawn largely from high burden LMICs, the conceptual framework of the syndemic triad is profoundly transferable to TB contexts in High-Income Countries (HICs). In these settings, the same determinants of poverty, stigma, and social exclusion create parallel landscapes of vulnerability, albeit in different populations. The urban poor, homeless populations, incarcerated individuals, and marginalised ethnic minorities in HICs experience a convergence of these same forces. For instance, homelessness creates conditions of overcrowding and malnutrition reminiscent of those in LMICs (Lee et al., 2022), while stigma and the fear of immigration authorities can create significant barriers to care for migrants in HICs, mirroring the delays seen elsewhere (Seyedmehdi et al., 2024; Menzies et al., 2018). Therefore, the imperative for integrated, biosocial interventions is not confined by geography. The call for social protection, stigma-free clinics, and improved housing is universal. The triad framework provides a vital lens for understanding and addressing the persistent TB "hotspots" within otherwise low-incidence nations, arguing that the path to elimination in HICs equally requires tackling these foundational social determinants.

The integration of these layers is critical. A patient receiving a cash transfer (economic) is better equipped to attend a stigma-free clinic (psychosocial) located in a well serviced, non-segregated community (structural). Adherence interventions, as reviewed by Alipanah et al. (2018), are most effective when they address such multifaceted barriers.

Therefore, a paradigm shift from biomedical silos to integrated social prescriptions is not just a theoretical ideal but an operational necessity. The multi-level framework outlined encompassing economic empowerment, stigma reduction, and structural reform provides a concrete roadmap for this transition. It is with this imperative for actionable, biosocial strategies that we turn to the final conclusion and a call to action. The integrated SDH Syndemic lens applied in this review thus provides not just a diagnostic tool for understanding TB persistence, but a clear prescriptive framework for the multi-level, integrated interventions required to defeat it.

XII. CONCLUSION: A CALL TO ACTION

In conclusion, this analysis has argued that tuberculosis is a biosocial disease par excellence. Its persistence is the canary in the coal mine of global inequality, signalling deep failures in our social and economic structures. The synergistic triad of poverty, stigma, and malnutrition forms a pathogenic complex that no drug regimen can fully eradicate.

To translate this syndemic understanding into measurable impact, a new research agenda is urgently needed and aligns strategically with the priorities of major global health funders. For instance, the Global Fund's 2023-2028 strategy emphasises building resilient and sustainable systems for health, promoting human rights, and addressing gender and other inequities. To directly support these goals, research must move beyond cross-sectional studies to longitudinal, syndemic research that traces how poverty, stigma, and exclusion co evolve and amplify each other over an individual's life and across generations. This requires mixed-methods approaches that can quantify the multi-sectoral costs of these interactions. Furthermore, implementation science is critical to designing and testing integrated intervention packages that combine biomedical care with social protection, stigma reduction, and housing support directly operationalising the Global Fund's focus on multi component, community led responses. Evaluating such 'social prescriptions' will generate the evidence needed to scale up the most effective combinations of biomedical and social interventions, making them attractive, evidence-based investments for funders committed to equity and sustainable impact.

Defeating TB, therefore, is not merely a technical challenge for microbiologists and physicians; it is a moral, political, and scientific imperative for societies and governments worldwide. The fight to end TB is inextricably and fundamentally linked to the broader fight for social justice and health equity. It requires a collective commitment to build societies where a person's livelihood does not predispose them to disease, where a diagnosis does not condemn them to isolation, and where one's identity does not determine their access to care. Until we prescribe dignity, equity, and justice as core components of our TB control strategies, the goal of ending this ancient plague will remain a distant and unattainable dream. The bacillus is a simple organism; it is the complexity of our societal failures that allows it to endure.

XIII. Acknowledgement of AI and Assisted Writing Tools

In the preparation of this manuscript, the authors utilised assisted writing tools, including Grammarly and an AI-assisted language model (OpenAI's GPT-4), exclusively for editorial and formatting tasks. These tools aided in refining prose clarity, checking grammar, and ensuring consistency in citations. All conceptual development, critical analysis, interpretation of literature, and final conclusions remain the sole responsibility of the authors. These tools acted as supportive instruments under strict human oversight and did not contribute to the intellectual or scholarly substance of the work.

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