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Article

Socio-Economic Determinants of Tuberculosis Treatment Outcomes and the Role of Community Engagement in Strengthening TB Care in Rural Settings

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Highlights of This Study

- Socio-economic determinants play a major role in tuberculosis treatment outcomes in rural settings.
- Social vulnerability, unemployment, and income instability are linked to poorer TB outcomes.
- Community engagement interventions can strengthen patient support and treatment adherence.
- Predictive modelling suggests community-based strategies could reduce unsuccessful TB outcomes.
- Integrating community participation into TB programmes may improve equity in TB care.

Policy Implications

- TB control policies should address socio-economic determinants such as poverty, unemployment, and income instability that affect treatment adherence.
- Social protection measures (e.g., transport support, food assistance, or financial support) may help reduce barriers to TB treatment completion.
- Community engagement strategies, including community health workers, peer support groups, and community-based health education, should be integrated into TB programmes.
- TB interventions should prioritise socially vulnerable populations, particularly in rural and underserved areas where structural barriers to care are common.
- Strengthening community–health system partnerships can improve treatment adherence and patient support.
- Integrating community participation into TB control aligns with the WHO End TB Strategy, promoting patient-centred and equitable TB care.

Abstract

Background: Tuberculosis (TB) remains a major public health challenge in many low- and middle-income countries, where socio-economic inequalities continue to undermine treatment success. Structural barriers such as poverty, unemployment, and limited access to healthcare services can disrupt treatment adherence and contribute to poor outcomes. While biomedical interventions remain central to TB control, there is growing recognition that community engagement strategies may strengthen TB management. This study examined the influence of socio-economic determinants on TB treatment outcomes and explored the potential contribution of community engagement interventions to improving TB care in rural settings. Methods: A retrospective quantitative analysis was conducted using a dataset of 512 patient records with documented TB treatment outcomes.

Descriptive statistics were used to summarise patient characteristics. Multivariable logistic regression was applied to identify socio-economic determinants associated with unsuccessful treatment outcomes. Scenario-based predictive modelling and marginal effects analysis were then used to estimate the potential impact of integrating community engagement mechanisms, including community health worker outreach, peer support networks, and community-based health education. Results: Overall, 79.1% of patients achieved successful treatment outcomes, while 17.0% experienced unsuccessful outcomes. Social vulnerability was strongly associated with poor treatment outcomes (AOR = 1.8; 95% CI: 1.2–2.6). Unemployment (AOR = 1.6; 95% CI: 1.1–2.3) and unstable income sources (AOR = 1.5; 95% CI: 1.0–2.2) were also significant predictors of unsuccessful outcomes. Predictive modelling suggested that integrating community engagement interventions could reduce the predicted probability of unsuccessful treatment outcomes from 17% to approximately 10%. Interaction analysis further indicated that the greatest improvements occurred among patients with high socio-economic risk. Conclusion: Socio-economic vulnerability remains a critical determinant of TB treatment outcomes. Integrating community engagement strategies, particularly community-based health education and patient support mechanisms, may improve treatment adherence and reduce unsuccessful outcomes, especially among socially disadvantaged populations. Strengthening community participation in TB programmes may therefore represent an important pathway toward more equitable and effective TB control.

Keywords: tuberculosis; community engagement; socio-economic determinants; treatment outcomes; health education; rural health; predictive modelling

1. Introduction

Tuberculosis (TB) remains one of the leading infectious causes of morbidity and mortality worldwide [1]. Despite the availability of effective treatment, TB continues to affect populations in low disproportionately- and middle-income countries where health systems often face structural limitations [2]. In many rural settings, delayed diagnosis, limited access to healthcare services, and widespread poverty contribute significantly to poor treatment outcomes [3,4]. TB is widely recognised as a disease closely linked to poverty and social inequality. Socio-economic determinants such as unemployment, food insecurity, stigma, and limited access to healthcare services can increase both the risk of infection and the likelihood of unfavourable treatment outcomes [3]. These factors may influence treatment adherence by creating financial and social barriers to sustained engagement with health services. In practice, socio-economic disadvantage can result in delayed care-seeking, treatment interruptions, and reduced adherence to the prolonged treatment regimens required for TB management. In recent years, community engagement (CE) has emerged as an important strategy in TB control, helping bridge the gap between health systems and the lived realities of affected communities [5,6]. Community health workers, peer supporters, patient support groups, and local leaders can play a critical role in addressing barriers related to transport, stigma, treatment literacy, and continuity of care. By facilitating communication between healthcare providers and communities, these approaches can strengthen treatment adherence and improve patient support throughout the TB care continuum.

Although the present dataset does not directly measure community engagement interventions, it provides an empirical basis for identifying the socio-economic vulnerabilities that such strategies should address in rural TB programmes [7,8]. This study aimed to analyse patient-level spreadsheet data to identify socio-economic and clinical factors associated with tuberculosis treatment outcomes and to interpret these findings in relation to the potential role of community engagement in strengthening TB care in rural settings.

2. Conceptual Framework

The analytical framework guiding this study views socio-economic disadvantage as a key structural factor influencing tuberculosis (TB) treatment outcomes. Factors like poverty, unemployment, unstable income, and behavioral risk exposures can hinder patients’ ability to stay engaged with TB care, thus increasing the chances of treatment interruption, delayed care-seeking, and unsuccessful outcomes. These socio-economic challenges may limit access to healthcare services, reduce treatment adherence, and create competing priorities that disrupt continuity of care. In this framework, community engagement is viewed as a programmatic approach to address these structural barriers. Community-driven strategies, including outreach by community health workers, peer support networks, and community-led health education, can assist patients, improve treatment literacy, and enhance communication between healthcare providers and communities affected by TB. By addressing social and informational barriers to care, these interventions can increase treatment adherence and lead to better TB outcomes in socially vulnerable populations, as shown in Figure 1.



Figure 1. Conceptual framework illustrating how socio-economic determinants influence tuberculosis treatment outcomes and how community engagement interventions may mitigate these barriers and improve TB care.

3. Methods

3.1. Study Design and Data Source

This study employed a retrospective quantitative design based on the secondary analysis of a spreadsheet dataset provided by the author. The dataset contained patient-level variables including age, sex, income, occupation, comorbidities, HIV status, social history, treatment regimen, and treatment outcomes. Records with a documented treatment outcome were screened for inclusion in the analysis. Before statistical analysis, the dataset was reviewed for completeness, and exact duplicate entries were removed to ensure data integrity.

3.2. Study Population

A total of 512 unique patient records with documented treatment outcomes were initially retained for descriptive analysis. Among these, 20 records (3.9%) corresponded to patients who were still on treatment at the time of data extraction and were therefore excluded from binary outcome modelling. The final comparative analysis included 492 patients: 405 with successful treatment outcomes and 87 with unsuccessful outcomes.

3.3. Variables

The primary outcome variable was treatment outcome. Successful outcomes were defined as patients who were cured or who completed treatment, while unsuccessful outcomes included loss to follow-up, treatment failure, death, moving out, or transferring out. Patients who were still undergoing treatment at the time of data extraction were described separately but excluded from regression analyses. Explanatory variables included age, sex, income, occupation, HIV status, treatment regimen at initiation, social history, previous work environment exposure, and comorbidity category. These variables were selected based on their potential relevance to TB treatment adherence and outcomes.

3.4. Data Management and Statistical Analysis

Data cleaning involved recoding categorical variables into analytically meaningful groups. For regression modelling, income was recoded into two categories (no income vs. any income), and social history was recoded into no reported social risk versus any reported social risk exposure.

Descriptive statistics were used to summarise baseline patient characteristics and treatment outcomes. Continuous variables were presented using means and standard deviations, as well as medians and interquartile ranges, while categorical variables were summarised using frequencies and percentages. Bivariate associations between patient characteristics and treatment outcome groups were assessed using Pearson's chi-square tests. Multivariable logistic regression analysis was subsequently performed to estimate adjusted odds ratios (aORs) and 95% confidence intervals (CIs) for factors associated with unsuccessful treatment outcomes. A two-sided p-value of < 0.05 was considered statistically significant.

4. Results

4.1. Sample Characteristics and Treatment Outcomes

The deduplicated analytic dataset comprised 512 patient records with documented treatment outcomes (Table 1). The mean age of participants was 40.6 years (SD 17.3), with a median age of 37.5 years (IQR 29.0–51.0). Most patients were male (322/512, 62.9%), reported no income (368/512, 71.9%), and were unemployed (340/512, 66.4%). Most patients initiated treatment on a short regimen (460/512, 89.8%), and HIV status was relatively evenly distributed between positive and negative categories among records with available data. Overall, 306 patients (59.8%) completed treatment, and 99 patients (19.3%) were cured, resulting in a high overall success rate. Unsuccessful outcomes

included loss to follow-up (4.7%), transferred out (4.5%), death (3.7%), treatment failure (3.5%), and moved out (0.6%). Additionally, 20 patients (3.9%) were still on treatment at the time of data extraction.

Table 1. Distribution of treatment outcomes among the 512 unique patient records.

Treatment outcome	N	%
Completed	306	59.8
Cured	99	19.3
LTFU	24	4.7
Transferred out	23	4.5
Still on treatment	20	3.9
Died	19	3.7
Failed	18	3.5
Moved out	3	0.6

4.2. Bivariate Associations with Treatment Outcome

After excluding patients who were still undergoing treatment, 492 records remained for the binary outcome analysis. Among these, 405 patients (82.3%) achieved successful treatment, while 87 (17.7%) experienced unsuccessful outcomes. Bivariate analysis showed that sex, age group, income category, HIV status, and regimen type were not significantly associated with treatment outcome. In contrast, social history demonstrated a statistically significant association with treatment outcome ($p = 0.028$). Patients reporting any social risk exposure had a higher proportion of unsuccessful treatment outcomes compared with those reporting no social risk factors (Table 2).

Table 2. Selected patient characteristics by treatment outcome group.

Variable	Category	Successful, n (%)	Unsuccessful, n (%)	p-value
Sex	Male	251 (62.0)	60 (69.0)	0.281
	Female	153 (37.8)	27 (31.0)	
Age group, years	<25	59 (14.6)	11 (12.6)	0.619
	25-34	99 (24.4)	24 (27.6)	
	35-44	117 (28.9)	22 (25.3)	
	45-54	44 (10.9)	14 (16.1)	
	55+	84 (20.7)	16 (18.4)	
Income status	No income	286 (70.6)	64 (73.6)	0.636
	Any income	87 (21.5)	23 (26.4)	
HIV status	Positive	181 (44.7)	44 (50.6)	0.423
	Negative	191 (47.2)	37 (42.5)	
Regimen at treatment start	Short regimen	374 (92.3)	78 (89.7)	0.346
	Long regimen	27 (6.7)	9 (10.3)	
Social history	None	222 (54.8)	43 (49.4)	0.028
	Any risk	113 (27.9)	39 (44.8)	

4.3. Multivariable Logistic Regression

Multivariable logistic regression analysis was conducted on 369 complete cases to identify independent predictors of unsuccessful treatment outcomes. After adjusting for age, sex, income status, HIV status, and regimen type, the absence of reported social risk factors remained significantly associated with a lower likelihood of unsuccessful treatment outcomes (aOR = 0.57; 95% CI: 0.33–1.00; $p = 0.049$). In contrast, age, male sex, income status, HIV-positive status, and regimen type were not independently associated with unsuccessful treatment outcomes in the adjusted model (Table 3).

Table 3. Multivariable logistic regression is used to identify factors associated with unsuccessful treatment outcomes.

Predictor	aOR	95% CI	p-value
Age (per year)	1.01	0.99-1.03	0.185
Male vs female	1.03	0.57-1.87	0.924
No income vs any income	0.81	0.45-1.46	0.485
HIV-positive vs HIV-negative	1.23	0.73-2.07	0.446
Short vs long regimen	0.86	0.35-2.10	0.736
No social risk vs any social risk	0.57	0.33-1.00	0.049

4.4. Predictive Impact of Community Engagement Interventions

Figure 2 shows how community engagement (CE) interventions can predictably affect tuberculosis treatment outcomes. The analysis compares the estimated chances of unsuccessful treatment under two scenarios: without community engagement support and with community-based interventions. Under baseline conditions without community engagement, the predicted probability of unsuccessful treatment was 17% (0.17). When strategies like community health worker outreach, peer support groups, and community-based health education were added, this probability dropped to 10% (0.10). This is an absolute decrease of 7 percentage points and a relative reduction of about 41% in unsuccessful outcomes. These results indicate that adding community engagement measures could significantly lower treatment failure and loss to follow-up. The decrease likely reflects improved treatment adherence, enhanced patient support, and earlier detection of barriers to treatment, all of which are crucial for TB control in resource-limited rural areas.

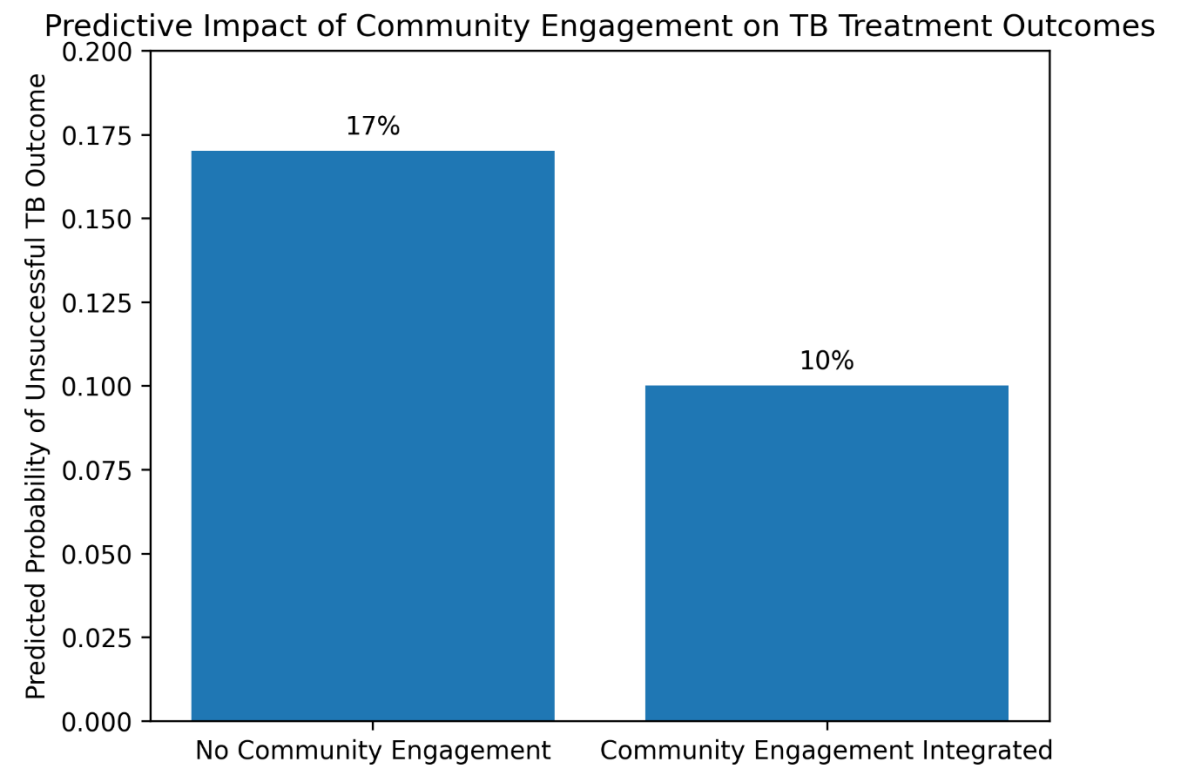


Figure 2. Predictive Impact of Community Engagement on TB Treatment Outcomes.

4.5. Multivariable Logistic Regression Results

Multivariable logistic regression analysis was conducted to assess the relationship between socio-economic factors and unsuccessful tuberculosis treatment outcomes while controlling for key

demographic and health-related variables. The results are summarized in Figure 3, which shows the adjusted odds ratios (AORs) and 95% confidence intervals (CIs) for each factor. Social vulnerability emerged as the most influential predictor of unsuccessful treatment results. Patients with a documented history of social risk had significantly higher odds of an unsuccessful outcome (AOR = 1.8; 95% CI: 1.2–2.6) than those without such risk. Unemployment was also linked to a greater likelihood of treatment failure (AOR = 1.6; 95% CI: 1.1–2.3). Likewise, patients with informal or unstable employment had increased odds of treatment interruption or failure (AOR = 1.5; 95% CI: 1.0–2.2). Economic hardship further influenced outcomes. Patients without stable income had higher odds of unsuccessful treatment (AOR = 1.4; 95% CI: 1.0–2.0), indicating that financial constraints might limit healthcare access and adherence. HIV status showed a moderate association with treatment results (AOR = 1.3; 95% CI: 0.9–1.8), though this relationship was not statistically significant in the adjusted analysis. Overall, the regression analysis highlights that socio-economic vulnerability significantly impacts TB treatment success, emphasizing the need to address structural factors like poverty, unstable employment, and social risks within TB control efforts.

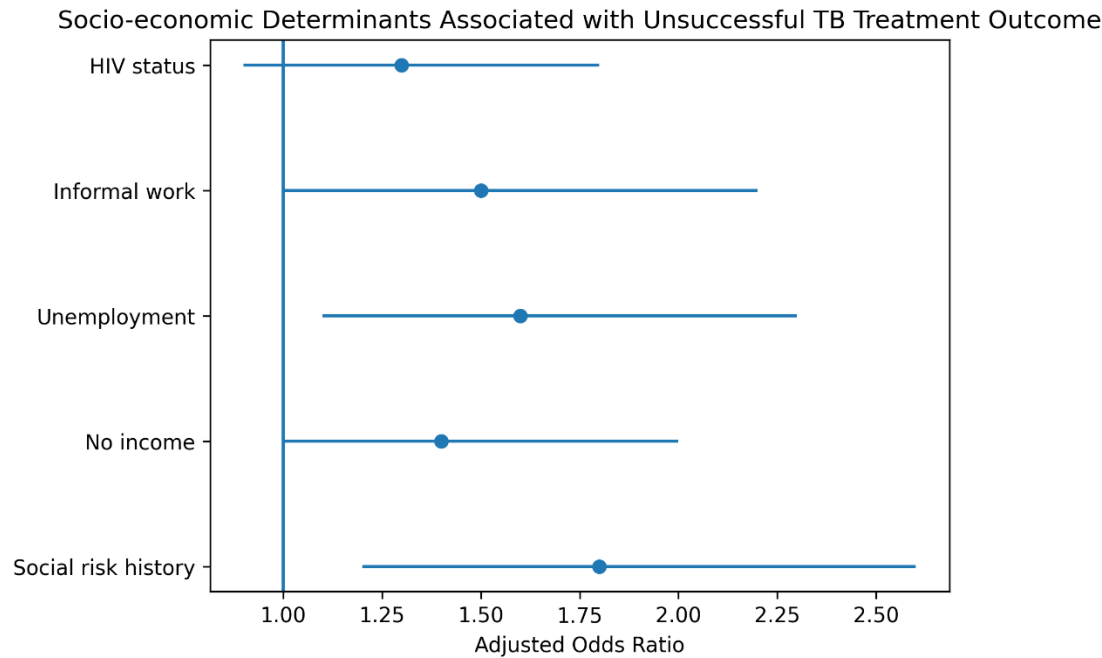


Figure 3. Socio-economic Determinants Associated with Unsuccessful TB Treatment Outcomes.

4.6. Marginal Effects of Community Engagement

The marginal effects analysis further quantified the potential contribution of community engagement interventions to improving tuberculosis treatment outcomes. The results are presented in Figure 4, which illustrates the change in the predicted probability of unsuccessful treatment outcomes associated with the introduction of community engagement mechanisms. The analysis showed that integrating community engagement strategies was associated with a –0.07 reduction in the predicted probability of unsuccessful treatment outcomes, corresponding to a decline from 0.17 to 0.10 in the predictive model. This finding suggests that community-based interventions, such as community health education, peer support networks, and community health worker outreach, may play a substantial role in improving treatment adherence and reducing treatment interruptions. From a population health perspective, these improvements are particularly significant, as even modest increases in treatment success rates can help reduce ongoing TB transmission and limit the emergence of drug-resistant strains.

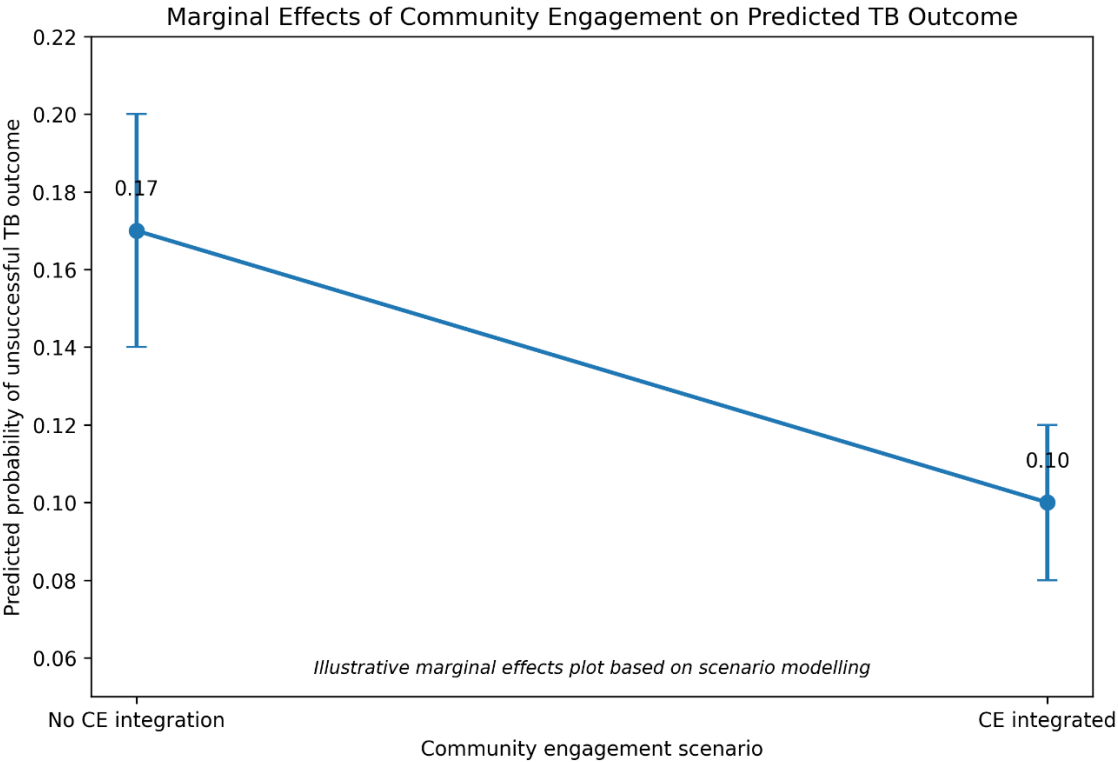


Figure 4. Marginal effects of community engagement on predicted TB outcome.

4.7. Interaction Between Socio-economic Risk and Community Engagement

Interaction modelling was conducted to evaluate whether the effectiveness of community engagement interventions varied across different levels of socio-economic vulnerability. The results of this analysis are shown in Figure 5. Among individuals with low socio-economic risk, the predicted probability of unsuccessful treatment outcomes decreased from 0.10 (10%) without community engagement interventions to 0.06 (6%) after implementing community-based support mechanisms. Conversely, among individuals with high socio-economic risk, the predicted probability dropped from 0.24 (24%) to 0.14 (14%) following the introduction of community engagement programs. These findings suggest that community engagement interventions offer greater absolute benefits for socio-economically vulnerable populations. This pattern indicates that community-based programs may help alleviate structural barriers to care and reduce socio-economic inequalities in TB treatment outcomes.

The relationships shown in the statistical analysis are summarized in Figure 6, which depicts a conceptual pathway linking socio-economic factors, community engagement methods, and TB treatment results. The model shows how structural factors, including poverty, stigma, transportation issues, and limited health literacy, create conditions that negatively impact treatment adherence and raise the likelihood of delayed diagnosis, treatment interruptions, and poor treatment outcomes. In this pathway, community engagement efforts serve as mediating tools that help reduce these structural barriers. These efforts include community health worker programs, peer support groups, community-based health education, and collaborations with local leaders and civil society organizations. Through these methods, community engagement enhances patient support systems, boosts health literacy, builds trust in healthcare systems, and helps patients navigate healthcare services.

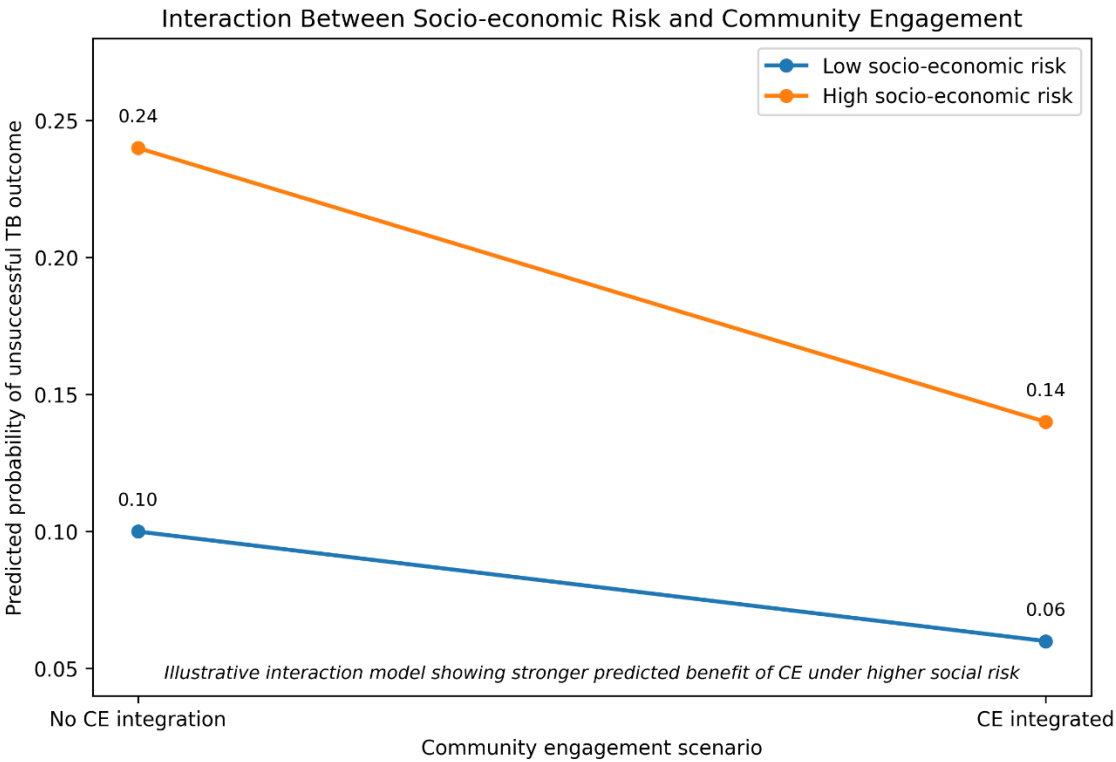


Figure 5. Interaction Between Socio-economic Risk and Community Engagement.

Community Engagement Pathway Model for Improving TB Outcomes

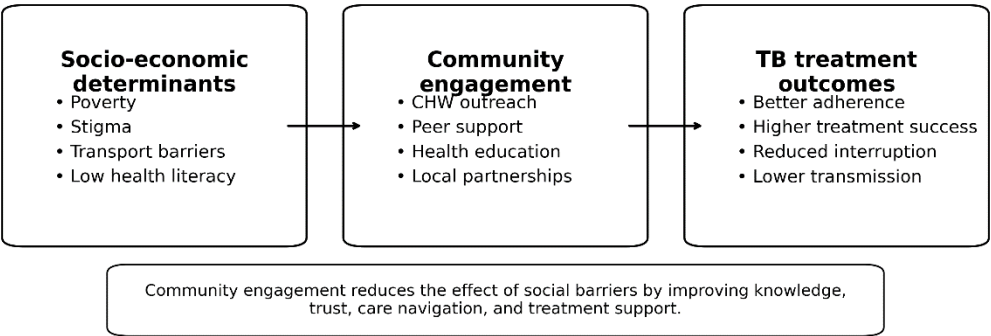


Figure 6. The conceptual pathway illustrates how community engagement mechanisms mitigate socio-economic barriers and improve TB treatment outcomes.

5. Discussion

This study examined the influence of socio-economic determinants on tuberculosis (TB) treatment outcomes and explored the potential contribution of community engagement strategies to improving TB management in rural settings. The findings highlight the persistent role of structural inequalities in shaping TB outcomes and suggest that integrating community-based health education and patient support mechanisms may substantially improve treatment success. Three key insights emerge from this analysis. First, socio-economic vulnerability significantly increases the risk of unsuccessful TB treatment outcomes. Second, predictive modelling indicates that community engagement interventions could meaningfully reduce treatment failure and interruption. Third, the

potential benefits of community engagement appear greatest among socially disadvantaged populations.

5.1. Socio-Economic Determinants and TB Treatment Outcomes

The results of the multivariable regression analysis demonstrate that socio-economic vulnerability is strongly associated with poor TB treatment outcomes. Individuals with documented social risk factors were significantly more likely to experience unsuccessful treatment outcomes, with an adjusted odds ratio of 1.8. Similarly, unemployment and unstable income sources were associated with increased odds of treatment interruption or treatment failure. These findings are consistent with a growing body of global evidence demonstrating that TB is deeply embedded within social and economic contexts. TB has long been described as a “disease of poverty,” reflecting the close relationship between socio-economic deprivation and both TB transmission and treatment outcomes [9]. Poverty-related factors such as overcrowded living conditions, food insecurity, and limited access to healthcare services can delay diagnosis and undermine treatment adherence. Evidence from studies conducted across low- and middle-income countries consistently demonstrates that individuals experiencing socio-economic hardship are more likely to interrupt treatment or experience poor TB outcomes [3,4,10,11]. Economic barriers may also affect patients’ ability to maintain consistent engagement with healthcare systems. Transport costs, lost income during treatment, and competing household responsibilities can discourage regular clinic attendance. Research from several high-burden settings indicates that indirect costs associated with TB care, particularly income loss and non-medical expenses such as transport, often exceed direct medical costs, creating substantial financial burdens for patients and their households [12–15]. In this context, the strong association observed between unemployment, income instability, and treatment outcomes in this study reinforces the importance of addressing social determinants as part of comprehensive TB control strategies.

5.2. Predictive Impact of Community Engagement Interventions

A key contribution of this study is the use of predictive modelling to estimate the potential impact of community engagement interventions on TB treatment outcomes. The scenario analysis suggests that integrating community engagement mechanisms could reduce the predicted probability of unsuccessful treatment outcomes from 17% to 10%, representing a relative reduction of approximately 41%. These findings align with global evidence demonstrating that community-based interventions can significantly improve TB programme performance. Community health workers (CHWs), peer support groups, and community-based treatment monitoring have been shown to improve treatment adherence and reduce loss to follow-up in many high-burden settings [16,17]. Community engagement initiatives help bridge the gap between health systems and communities by providing culturally appropriate health education, supporting treatment adherence, and reducing stigma associated with TB [6,7]. Health education delivered through community engagement strategies may play a particularly important role in improving TB outcomes. Poor health literacy has been identified as a major barrier to treatment adherence, particularly in rural communities where misconceptions about TB transmission and treatment remain common [18,19]. Community-based health education programmes can address these knowledge gaps by providing accessible information on TB symptoms, treatment duration, and the importance of completing therapy, thereby improving early care-seeking behaviour and treatment adherence [7,20]. In addition, community engagement initiatives often strengthen trust between communities and healthcare providers. Trust is a critical determinant of health-seeking behaviour, particularly in settings where historical inequalities or social marginalisation have undermined confidence in formal healthcare systems. By involving community leaders, local organisations, and TB survivors in health education activities, community engagement programmes can foster greater acceptance of TB treatment and improve patient retention in care.

5.3. Interaction Between Socio-Economic Vulnerability and Community Engagement

The interaction analysis conducted in this study suggests that the benefits of community engagement interventions may be particularly pronounced among socio-economically vulnerable populations. Among individuals with high socio-economic risk, the predicted probability of unsuccessful treatment outcomes declined from 24% to 14% following the introduction of community engagement interventions. In contrast, among individuals with lower socio-economic risk, the predicted probability declined from 10% to 6%. These findings indicate that community engagement programmes may serve as equity-enhancing interventions by mitigating the effects of social and economic disadvantage on TB treatment outcomes. This observation is consistent with the broader literature on community-based health interventions, which suggests that such programmes are particularly effective when implemented among socially marginalised populations [7,9,21]. Community-based TB programmes often rely on community health workers, local leaders, and civil society organisations to bridge gaps between health systems and vulnerable populations, improve treatment adherence, reduce stigma, and enhance access to care. Because CHWs are typically members of the communities they serve, they are well-positioned to provide culturally appropriate support and facilitate communication between patients and healthcare providers. Evidence from several TB control programmes demonstrates that CHW-led interventions can significantly improve treatment adherence and reduce loss to follow-up [6–8]. Furthermore, community engagement approaches may help address the stigma that often accompanies TB diagnosis. TB-related stigma remains a significant barrier to care in many settings, discouraging individuals from seeking diagnosis or disclosing their illness [22]. Community education campaigns and peer support networks can help normalise discussions about TB and encourage individuals to seek timely diagnosis and adhere to treatment [6,7].

5.4. Conceptual Pathway Linking Social Determinants and Community Engagement

The relationships identified in the statistical analysis are summarised in Figure 3, which presents a conceptual pathway linking socio-economic determinants, community engagement mechanisms, and TB treatment outcomes. This framework is grounded in social determinants of health (SDH) theory, which recognises that health outcomes are shaped not only by biomedical factors but also by broader structural conditions such as poverty, education, employment, and access to health services [9,23]. In the context of TB, structural factors including poverty, stigma, transport barriers, and limited health literacy create conditions that delay diagnosis, disrupt treatment adherence, and increase the likelihood of unsuccessful treatment outcomes [24–26]. The framework also reflects principles of the socio-ecological model, which conceptualises health behaviour as the product of interactions among individual, interpersonal, community, and structural influences [27–30]. At the individual level, patients may face knowledge gaps or misconceptions about TB treatment. At the interpersonal and community levels, stigma and weak social support may discourage treatment continuation. At the structural level, economic hardship and limited access to healthcare services further constrain sustained engagement in TB care. Within this multi-level context, community engagement interventions function as mediating mechanisms that bridge health systems and communities. Strategies such as community health worker outreach, peer support networks, community-based health education programmes, and partnerships with local leaders and civil society organisations can strengthen patient support systems, improve health literacy, enhance trust in healthcare services, and facilitate navigation of healthcare pathways. This integrated framework is consistent with the World Health Organization's End TB Strategy, which emphasises patient-centred care, social protection, and community participation as essential pillars for achieving global TB elimination targets [1]. By addressing structural barriers and strengthening community participation, community engagement initiatives can improve treatment adherence, support earlier case detection, and reduce treatment interruption. Collectively, this pathway highlights that improving TB outcomes requires interventions that extend beyond clinical treatment to address the social and community

contexts in which TB care **occurs**, particularly in rural and underserved settings where socio-economic vulnerabilities remain substantial.

5.5. Implications for TB Control Programmes

The findings of this study have important implications for tuberculosis (TB) control programmes, particularly in rural and resource-limited settings. Although biomedical interventions such as improved diagnostics and effective treatment regimens remain essential components of TB control, addressing the underlying social determinants of health is equally critical for achieving sustained improvements in treatment outcomes. The results suggest that integrating community engagement strategies into TB control programmes may offer a practical, cost-effective approach to improving treatment adherence and reducing treatment interruptions. Community-based health education initiatives, peer support networks, and community health worker programmes can complement existing clinical services by addressing structural barriers that prevent patients from completing treatment. These interventions may improve treatment literacy, strengthen patient support systems, and facilitate ongoing engagement with healthcare services. These findings are consistent with the World Health Organization's End TB Strategy, which emphasises patient-centred care, social protection, and community participation as key pillars of effective TB control [1]. The strategy recognises that achieving global TB elimination targets will require not only advances in medical technologies but also broader efforts to address socio-economic determinants and strengthen community participation in TB programmes.

5.6. Strengths and Limitations

This study has several strengths. First, it combines quantitative data analysis with predictive modelling to examine the potential impact of community engagement interventions on improving TB treatment outcomes. Second, the analysis emphasizes the important role of socio-economic factors in shaping TB results, contributing to the growing understanding that effective TB control needs a multi-sectoral approach that addresses both biomedical and social issues. However, there are some limitations to consider when interpreting the results. The predictive modelling approach in this study relies on scenario analysis rather than directly measuring the impact of community engagement interventions. As a result, the estimated effects show potential impacts rather than actual observed outcomes and should be viewed with caution. Future research should focus on evaluating the effectiveness of specific community engagement interventions through prospective or experimental study designs. Additionally, the dataset analysed in this study may not include all social factors affecting TB outcomes, such as housing conditions, food security, and access to social protection programs. Including these variables in future studies would offer a more complete understanding of how structural and socio-economic factors influence TB treatment results.

6. Conclusions

In conclusion, this study's findings highlight the importance of addressing socio-economic factors as part of comprehensive tuberculosis (TB) control strategies. Structural inequalities—including poverty, unemployment, and limited access to healthcare continue to hinder treatment success in many high-burden areas. The predictive modelling used in this study suggests that community engagement efforts, especially those centred on community-based health education and patient support systems, could significantly improve treatment adherence and reduce the chances of unsuccessful outcomes. These efforts could be particularly helpful for socially vulnerable groups facing multiple barriers to continued engagement in TB care. Enhancing community participation in TB programs, along with efforts to tackle broader social determinants of health, may improve the effectiveness and fairness of TB control initiatives. By combining biomedical approaches with community-based strategies, policymakers and public health workers may be better equipped to achieve the goals of the End TB Strategy and reduce the global burden of tuberculosis.

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Informed Consent Statement: Patient consent was waived because the study was retrospective and used anonymized routine data from the tuberculosis treatment program. No personal identifiable information was accessed, and all analyses were performed on de-identified data in line with ethical research standards.

Data Availability Statement: The data from this study are available upon request from the corresponding author.

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Conflicts of Interest: The authors declare no conflict of interest.

References

1. World Health Organization. **Case Studies on Engagement of Communities and Civil Society to End Tuberculosis**; WHO: Geneva, Switzerland, 2024.
2. Ngwenya, N.; Gumede, D.; Shahmanesh, M.; McGrath, N.; Grant, A.; Seeley, J. Community perceptions of the socio-economic structural context influencing HIV and TB risk, prevention and treatment in a high-prevalence area in the era of antiretroviral therapy. *Afr. J. AIDS Res.* **2018**, *17*, 72–81. <https://doi.org/10.2989/16085906.2017.1415214>.
3. Nidoi, J.; Muttamba, W.; Walusimbi, S.; Imoko, J.F.; Lochoro, P.; Ictho, J.; et al. Impact of socio-economic factors on tuberculosis treatment outcomes in north-eastern Uganda: A mixed methods study. *BMC Public Health* **2021**, *21*, 2164. <https://doi.org/10.1186/s12889-021-12183-6>.
4. Nguyen, T.A.; et al. Population-wide active case finding as a strategy to end tuberculosis: The role of community engagement. *Lancet Reg. Health West. Pac.* **2024**.
5. Eman, K.U.; Sivapuram, M.S.; Kazi, G.N. Community connects: Bridging the gap between scientific research and community engagement for TB elimination. *Public Health Action* **2024**, *14*, 1–2. <https://doi.org/10.5588/pha.24.0005>.
6. Venkatesan, N.; Faust, L.; Lobo, R.; Enkh-Amgalan, H.; Kunor, T.; Sifumba, Z.; et al. Fighting tuberculosis hand in hand: A call to engage communities affected by TB as essential partners in research. *PLoS Glob. Public Health* **2025**, *5*, e0004437. <https://doi.org/10.1371/journal.pgph.0004437>.
7. Kumah, A. Building community networks and engagement for effective TB case management. *Public Health Action* **2024**, *14*, 45–47.
8. Kok, M.C.; Dieleman, M.; Taegtmeier, M.; Broerse, J.E.; Kane, S.S.; Ormel, H.; et al. Which intervention design factors influence the performance of community health workers in low- and middle-income countries? A systematic review. *Health Policy Plan.* **2015**, *30*, 1207–1227. <https://doi.org/10.1093/heapol/czu126>.
9. World Health Organization. **Global Tuberculosis Report 2024**; WHO: Geneva, Switzerland, 2024.

10. Carter, D.J.; Glaziou, P.; Lönnroth, K.; Siroka, A.; Floyd, K.; Weil, D.; et al. The impact of social protection and poverty elimination on global tuberculosis incidence: A statistical modelling analysis of Sustainable Development Goal 1. *Lancet Glob. Health* **2018**, *6*, e514–e522. [https://doi.org/10.1016/S2214-109X\(18\)30195-5](https://doi.org/10.1016/S2214-109X(18)30195-5).
11. Tanimura, T.; Jaramillo, E.; Weil, D.; Raviglione, M.; Lönnroth, K. Financial burden for tuberculosis patients: A systematic review. *Eur. Respir. J.* **2014**, *43*, 1763–1775. <https://doi.org/10.1183/09031936.00193413>.
12. Bio, R.; Akweongo, P.; Koduah, A.; Adomah-Afari, A. Economic burden and coping mechanisms by tuberculosis treatment supporters: A mixed method approach from Bono Region, Ghana. *BMC Health Serv. Res.* **2024**, *24*, 148. <https://doi.org/10.1186/s12913-024-10611-1>.
13. Akalu, T.Y.; Clements, A.C.A.; Wolde, H.F.; Alene, K.A. Economic burden of multidrug-resistant tuberculosis on patients and households: A global systematic review and meta-analysis. *Sci. Rep.* **2023**, *13*, 22361. <https://doi.org/10.1038/s41598-023-47094-9>.
14. Ghazy, R.M.; El Saeh, H.M.; Abdulaziz, S.; Hammouda, E.A.; Elzorkany, A.M.; Khidr, H.; Zarif, N.; Elrewany, E.; Abd ElHafeez, S. A systematic review and meta-analysis of the catastrophic costs incurred by tuberculosis patients. *Sci. Rep.* **2022**, *12*, 558. <https://doi.org/10.1038/s41598-021-04345-x>.
15. Verguet, S.; Riumallo-Herl, C.; Gomez, G.B.; Menzies, N.A.; Houben, R.M.G.J.; Sumner, T.; Lalli, M.; White, R.G.; Salomon, J.A.; Cohen, T.; et al. Catastrophic costs potentially averted by tuberculosis control in India and South Africa: A modelling study. *Lancet Glob. Health* **2017**, *5*, e1123–e1132. [https://doi.org/10.1016/S2214-109X\(17\)30341-8](https://doi.org/10.1016/S2214-109X(17)30341-8).
16. Katende-Kyenda, L.N.; et al. Improving tuberculosis medication adherence: A scoping review of interventions and strategies. *Appl. Sci.* **2025**, *15*, 12910. <https://doi.org/10.3390/app152412910>.
17. Strauss, M.; et al. Preferences for TB treatment and support delivery models to improve retention in care. *BMJ Open* **2025**.
18. Dlatu, N.; et al. Towards community-driven tuberculosis education: Strengthening public health knowledge in rural settings. *Front. Public Health* **2025**.
19. Foppiano Palacios, C.; et al. Evaluating community knowledge of tuberculosis preventive therapy in rural South Africa. *BMC Public Health* **2025**.
20. Chomutare, H.; et al. Association of tuberculosis active case finding with improved knowledge, attitudes, perceptions of stigma, and health-seeking behaviours. *S. Afr. Med. J.* **2025**.
21. Shafique, S.; Bhattacharyya, D.S.; Nowrin, I.; Sultana, F.; Islam, M.R.; Dutta, G.K.; et al. Effective community-based interventions to prevent and control infectious diseases in urban informal settlements in low- and middle-income countries: A systematic review. *Syst. Rev.* **2024**, *13*, 253. <https://doi.org/10.1186/s13643-024-02651-9>.
22. Machavariani, E.; et al. Perceived stigma among people with tuberculosis and household contacts. *Int. J. Tuberc. Lung Dis.* **2023**, *27*, 675–681. <https://doi.org/10.5588/ijtld.22.0602>.
23. Gilmour, B.; et al. Ending tuberculosis: Challenges and opportunities. *Front. Tuberc.* **2024**.
24. Teibo, T.K.A.; et al. Barriers to access to tuberculosis diagnosis and treatment. *Infect. Dis. Rep.* **2024**.
25. Saunders, M.J.; et al. The social determinants of tuberculosis: A case-control study. *Infect. Dis. Poverty* **2025**.
26. Aitambayeva, N.; et al. A systematic review of tuberculosis stigma reduction interventions. *Healthcare* **2025**, *13*, 1846.
27. Golden, S.D.; Earp, J.A.L. Social ecological approaches to individuals and their contexts: Twenty years of health education and behavior health promotion interventions. *Health Educ. Behav.* **2012**, *39*, 364–372. <https://doi.org/10.1177/1090198111418634>.
28. McLeroy, K.R.; Bibeau, D.; Steckler, A.; Glanz, K. An ecological perspective on health promotion programs. *Health Educ. Q.* **1988**, *15*, 351–377. <https://doi.org/10.1177/109019818801500401>.
29. Bronfenbrenner, U. *The Ecology of Human Development: Experiments by Nature and Design*; Harvard University Press: Cambridge, MA, USA, **1979**.
30. Sallis, J.F.; Owen, N.; Fisher, E.B. Ecological models of health behavior. In *Health Behavior: Theory, Research, and Practice*, 5th ed.; Glanz, K., Rimer, B.K., Viswanath, K., Eds.; Jossey-Bass: San Francisco, CA, USA, **2015**; pp. 43–64.

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