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Sosioeconomic, Behavioral, and Biological Determinants of Tuberculosis Incidence: A Case Study in Aceh Besar, Indonesia

Farrah Fahdhienie[1]*, Fahrisal Akbar[2]
[1]Faculty of Public Health, University of Muhammadiyah Aceh, Banda Aceh, Aceh, Indonesia
[2]Faculty of Public Health, University of Muhammadiyah Aceh, Banda Aceh, Aceh, Indonesia

***Corresponding Author:** E-mail: farrah.fahdhienie@unmuha.ac.id

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ABSTRACT

Introduction: Tuberculosis (TB) pandemic is a significant global health concern, especially in low- and middle-income countries. Every year the incidence and deaths due to TB continue to increase. Preventing and controlling TB effectively requires understanding the complex interplay of the multidimensional TB risk factors, which consist of social, behavioral, and biological determinants that contribute to its spread. This study aimed to identify and analyze the primary risk factors associated with TB incidence.

Methods: This study employed a case-control design with 44 respondents consisting of 22 laboratory-confirmed TB patients and 22 non-TB patients with matching ages and sex. This study used a structured questionnaire was used to collect data through face-to-face interviews. The questionnaire assessed risk factors across three key domains: social determinants, behavioral determinants, and biological determinants. Bivariate analysis, which used a chi-square test (p-value <0.05), and multivariate analysis, which used a logistic regression test, were performed to determine risk factors most associated with TB incidence.

Results: Low income (p-value=0.015;OR=6.923;95%CI=1.285-37.287), high TB-related stigma (p-value=0.033;OR=3.852;95%CI=1.086-13.661), insufficient TB knowledge (p-value =0.033;OR=3.852;95%CI=1.086-13.661), food insecurity (p-value=0.006;OR=5.950;95%CI=1.586-22.328), lack of preventative measures (p-value=0.015;OR=4.667;95%CI=1.299-16.761), history of contact with TB patients (p-value =0.039;OR=7.875;95%CI=0.860-72.122), and presence of comorbidities (p-value =0.031;OR=5.714;95%CI=1.051-31.072) were significantly associated with TB incidence. Comorbidities emerged as the strongest risk factor (p-value =0.020; OR=12.141;95%CI=1.486-99.231).

Conclusion: This study highlights several major factors influencing TB incidence, including social, behavioral, and biological determinants. The findings suggest that effective TB control strategies should address socioeconomic conditions, promote healthy lifestyles, and involve community leaders and TB survivors in educational campaigns, stigma reduction, and early diagnosis efforts. Understanding these health determinants can inform more targeted public policies for curbing TB incidence.

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INTRODUCTION

Tuberculosis (TB) is an infectious disease caused by the bacterium *Mycobacterium tuberculosis* (1). It remains a significant contributor to global mortality despite established preventative and treatment strategies (2). In 2022, the World Health Organization (WHO) reported an estimated 10 million diagnosed TB cases and 1.5 million deaths, solidifying its position as one of the world's deadliest infectious diseases (1).

This burden is not uniformly distributed. Developing countries experience a disproportionately high concentration of TB cases (3). Poverty, malnutrition, and high population density all essentially contribute to an increased risk of TB (4,5). Countries with a high TB burden frequently face additional challenges, such as limited access to health services, inadequate early detection programs, and the growing threat of drug-resistant TB strains (6).

Indonesia is among the 30 countries with the highest TB burden in the world (7). According to data from the Indonesian Ministry of Health, more than 800,000 TB cases were reported in Indonesia in 2022 alone (8). While Indonesian TB control programs have demonstrably strived to reduce the incidence, significant challenges persist, including drug resistance, social stigma surrounding the disease, and limitations in healthcare resources (9,10).

Aceh Besar Regency has a TB incidence rate of 250-300 cases per 100,000 population and a Success Rate of 66.01% (11). This number reflects the ongoing disease burden, requiring continued serious attention from the government and the community. The high TB prevalence in Aceh Besar Regency is likely attributed to a variety of socioeconomic, environmental, and behavioral factors. Active case finding efforts through population screening and contact tracing have helped to detect and treat more TB patients (12).

Understanding the factors influencing TB incidence is crucial for developing effective prevention and control interventions (13). Socioeconomic conditions, access to healthcare facilities, and local community behaviors and habits are all recognized risk determinants for TB infection (14). Densely populated and unhygienic living environments, limited access to health services, and unhealthy lifestyles (such as smoking and alcohol consumption) can all weaken the immune system and raise the risk of TB infection (15).

While numerous studies have explored the relationship between socioeconomic and behavioral factors in relation to the incidence of TB in Indonesia, there remains a limited understanding of how these factors specifically interact at the local level, particularly in Aceh Besar. The majority of previous studies focused on individual or group risk factors separately, without considering the complex dynamics between socioeconomic conditions, health behaviors, and biological factors in increasing the risk of TB. In addition, limited local data on socioeconomic and behavioral determinants specific to Aceh Besar hinder the development of effective evidence-based interventions for TB control. For instance, not many studies have deeply analyzed how income levels, access to health services, housing density, or smoking habits and adherence to TB treatment contribute to TB incidence in the region. Therefore, this present study attempts to fill this gap by presenting a holistic analysis of the socioeconomic, behavioral, and biological factors that influence TB incidence in Aceh Besar. Elucidating these factors will inform the development of more targeted interventions aimed at reducing TB prevalence in the region. The public health significance of this study lies in its potential to provide a scientific foundation for policymakers to design targeted TB prevention and control programs. Furthermore, the study can contribute to public health education by raising awareness about TB prevention and reducing the stigma associated with the disease.

METHOD

Study design and setting

This case-control study investigated risk factors associated with TB incidence in Aceh Besar Regency, Indonesia. The study recruited participants from the Ingin Jaya Community Health Center in 2023. A total of 44 participants were included, comprising 22 confirmed TB cases (case group) and 22 age- and sex-matched controls without TB diagnoses.

Study procedure

A structured questionnaire was used to collect data through face-to-face interviews. The questionnaire assessed risk factors across three key domains: social determinants, behavioral determinants, and biological determinants. Social determinants included education in three levels: elementary (completed elementary school/equivalent), secondary (completed junior high school/equivalent), and tertiary (completed college) (16).

Income was determined by the amount of monthly income received by respondents. It was classified as high if it equaled or exceeded the Regency Minimum Wage (IDR 3,413,666) and low if it fell below it (17). Stigma was classified as low if the score was at or above the mean and high if the score was below the mean (18). Knowledge was classified as sufficient if the score was at or above the mean and insufficient if the score was below the mean (18). Food security is a household food condition. If three indicators—food availability, affordability, and utilization—are satisfied, a household's food condition was considered food-secure; if one of the indicators was not met, it was considered food-insecure (19).

Behavioral determinants included preventive behavior. It was categorized as practiced if the score was at or above the mean and not practiced if it was less than the mean (20). Smoking habit was also considered as a behavioral determinant, measured by identifying the respondent's status as a smoker or non-smoker (21). The last behavioral determinant was contact history. If a family member had TB, the contact history was classified as having a history; if not, it was not (22). Biological determinants, which consist of comorbidities, were categorized as present if the respondent had comorbidities such as diabetes mellitus, cancer, and others. If the respondent had no comorbidities, it was classified as absent (23).

Of the 9 individual risk factors examined in this study, only three risk factors (knowledge, stigma, and TB prevention behavior) need to be tested for their reliability and validity. The analysis of validity was attained by calculating the corrected item-total correlation, which represents the correlation between a given item and all other items. The questions were valid if the corrected item-total correlation value was higher than the r table. With 88 respondents, the r table used for comparing with the corrected item-total correlation value was 0.209. The result of the validity test for the variable of knowledge (16 questions) finding all items for this variable exhibits the corrected item-total correlation value higher than the r table, except for one question with a corrected item-total correlation value of -0.099. The variable of stigma (29 questions) was the finding also indicated that one question was invalid with the corrected item-total correlation of 0.170, which was lower than the r table, and was excluded from the final questionnaire. For the preventive behavior variable, the measurement was conducted using 20 questions which all were valid and were therefore deemed suitable for inclusion in the final questionnaire. To evaluate the questionnaire's internal consistency and reliability, the Cronbach's alpha coefficient was computed. Every variable obtained a Cronbach's alpha value greater than 0.60, suggesting a satisfactory degree of dependability. The results of the reliability test indicated that variables of knowledge, stigma, and TB prevention behavior were reliable, exhibiting Cronbach’s alpha of 0.902, 0.943, and 0.945, respectively.

Data analysis

Univariate analysis was performed by calculating the frequency distribution. Bivariate analysis was conducted using the chi-square test (p-value <0.05). In addition, multivariate analysis was carried out using the logistic regression test, assuming that all significant variables were analyzed at this stage.

Ethical consideration

This study has received Ethical Approval from the Health Research Ethics Committee of the Faculty of Medicine, Syiah Kuala University Number: 017/EA/FK/2024, on January 25, 2024.

RESULTS

The Characteristics of Respondents

According to the respondents characteristics (Table 1), there were more male respondents (77.3%) than female respondents (22.7%), with the elderly making up the largest age group at 61.4% and adolescents making up 18.2%. Married respondents comprise the largest percentage of the sample (70.5%), while unmarried respondents comprise 15.9%.

Table 1. Respondent characteristics distribution

Characteristics	Frequency (n)	Percentage (%)
Sex		
Male	34	77.3
Female	10	22.7
Age		
Adolescence (≤ 25)	8	18.2
Adult (26-45)	9	20.5
Elderly (>45)	27	61.4
Marital Status		
Married	31	70.5
Unmarried	7	15.9
Widow/Widower	6	13.6

The Univariate Analysis

The study sample reflected a range of educational backgrounds, with 45.5% having completed secondary education (high school or equivalent) and a significant portion (75%) fell below the regional minimum wage in terms of income. Furthermore, the study identified concerning levels of social vulnerability and health knowledge. Over 43% of participants reported high levels of stigma associated with TB, and a similar proportion (43.2%) demonstrated insufficient knowledge about the disease. Additionally, over half (56.8%) of the households faced food insecurity (Table 2).

Table 2. Univariate analysis of TB incidence

Variable	Frequency (n)	Percentage (%)
TB incidence		
Case	22	50.0
Control	22	50.0
Education		
Tertiary	6	13.6
Secondary	20	45.5
Elementary	18	40.9
Income		
< Minimum Wage	33	75.0
≥ Minimum Wage	11	25.0
Stigma		
High	19	43.2
Low	25	56.8
Knowledge		
Insufficient	19	43.2
Sufficient	25	56.8
Food Security		
Food-Insecure	25	56.8
Food-Secure	19	43.2
Preventive Behavior		
Not Practiced	20	45.5
Practiced	24	54.5
Smoking Habit		
Yes	23	52.3
No	21	47.7
Contact History		
Have	7	15.9
Do Not Have	37	84.1
Comorbidities		
Present	10	22.7
Absent	34	77.3

The Bivariate Analysis

Bivariate analysis results indicated a significant association (p-value = 0.015) between income and TB incidence. Respondents with income lower than the minimum wage had a 6.9 times increased risk of developing TB compared to those with income equal to the minimum wage (OR = 6.9). Similarly, respondents with high stigma and insufficient knowledge regarding TB exhibited a significant association with TB incidence (p-value = 0.033). This group had a 3.8 times greater risk of TB infection. Additionally, factors such as food insecurity (p-value = 0.006), lack of preventive measures (p-value = 0.015), contact history with TB patients (p-value = 0.039), and presence of comorbidities (p-value = 0.031) were all significantly associated with increased TB incidence (Table 3).

Table 3. Bivariate analysis of TB incidence

Variable	Cases (n=22)		Control (n=22)		p-value	OR (95% CI)
	n	%	n	%		
Education						
Tertiary	2	9.1	4	18.2		
Secondary	11	50.0	9	40.9	0.482	0.500 (0.072-3.454)
Elementary	9	40.9	9	40.9	0.758	1.222 (0.341-4.381)
Income						
< Minimum Wage	20	90.9	13	59.1	0.015*	6.923 (1.285-37.287)
≥ Minimum Wage	2	9.1	9	40.9		
Stigma						
High	13	59.1	6	27.3	0.033*	3.852 (1.086-13.661)
Low	9	40.9	16	72.7		
Education						
Insufficient	13	59.1	6	27.3	0.033*	3.852 (1.086-13.661)
Sufficient	9	40.9	16	72.7		
Food Security						
Food-Insecure	17	77.3	8	36.4	0.006*	5.950 (1.586-22.328)
Food-Secure	5	22.7	14	63.6		
Preventive Behavior						
Not Practiced	14	63.6	6	27.3	0.015*	4.667 (1.299-16.761)
Practiced	8	36.4	16	72.7		
Smoking Habit						
Yes	9	40.9	14	63.6	0.131	0.396 (0.117-1.334)
No	13	59.1	8	36.4		
Contact History						
Have	6	27.3	1	4.5	0.039*	7.875 (0.860-72.122)
Do Not Have	16	72.7	21	95.5		
Comorbidities						
Present	8	36.4	2	9.1	0.031*	5.714 (1.051-31.072)
Absent	14	63.6	20	90.9		

*p-value < 0.05: significant

The Multivariate Analysis

Multivariate analysis (Table 4) identified comorbidities as the most significant risk factor associated with TB incidence (p-value = 0.020). Individuals with comorbidities were found to have a 12 times increased risk of TB infection compared to those without comorbidities (OR = 12).

Table 4. Multivariate analysis of TB incidence

Variable	p-value	OR (95% CI)
Income	0.194	6.780 (0.376-122.091)
Stigma	0.754	0.714 (0.087-5.882)
Knowledge	0.419	2.042 (0.361-11.543)
Food Security	0.424	2.160 (0.327-14.255)
Preventive Behavior	0.069	7.671 (0.854-68.931)
Contact History	0.074	24.787 (0.730-842.142)
Comorbidities	0.020*	12.141 (1.486-99.231)

*p-value < 0.05: significant

DISCUSSION

A growing body of evidence suggests an association between socioeconomic status, particularly income, and the incidence of tuberculosis (TB) (24). This relationship is likely multifaceted. Individuals with lower income may experience restricted access to healthcare services crucial for TB prevention, detection, and treatment. This limited access could stem from financial barriers, geographical remoteness of healthcare facilities, or a lack of awareness regarding TB (25).

Furthermore, low income often correlates with less favorable living conditions, characterized by inadequate nutrition and crowded environments. Such factors can contribute to increased transmission of TB as evidenced by previous research (4,24,26). Additionally, limited resources associated with lower income may hinder individuals' ability to maintain overall health, potentially impacting immune system function and thereby influencing susceptibility to TB infection (27,28).

Low-income communities frequently experience a higher prevalence of inadequate sanitation and poor ventilation within their homes, creating environments conducive to the spread of TB bacteria (29,30). Besides, limited housing options often lead to densely populated neighborhoods in these areas, increasing the likelihood of exposure to infectious individuals (31). Substandard housing conditions, characterized by poor ventilation and inadequate sanitation, are disproportionately prevalent within low-income communities. This situation creates a significant risk factor for TB transmission (32–34). Adding to the vulnerability, individuals with lower incomes may have restricted access to education and healthcare services, potentially limiting their awareness and knowledge of TB transmission risks, preventive measures and early treatment-seeking behavior (35).

Individuals with lower incomes may be more likely to hold jobs in settings with a higher risk of TB exposure, such as poorly ventilated factories or mines with significant dust generation (36). Workers in the informal sector or those with lower incomes often lack comprehensive health insurance or paid sick leave. This lack of coverage can create financial barriers to seeking healthcare and may delay the diagnosis and treatment of TB (37). Low-income individuals may frequently relocate for work opportunities. This mobility can heighten the risk of TB transmission due to temporary and crowded living situations and disruptions in access to established healthcare services in new locations (38).

All in all, low income becomes a substantial risk factor for TB incidence. It creates a breeding ground for TB transmission through a combination of social and economic disadvantages (39). Therefore, TB control strategies increasingly incorporate efforts to address social and economic equity in an attempt to decrease disease prevalence. Interventions often encompass broader socioeconomic initiatives aimed at improving income levels, living conditions, and access to quality healthcare services for vulnerable populations (40). The holistic approach that integrates socioeconomic factors into TB management is crucial for effectively reducing the incidence and spread of the disease (41).

The stigma surrounding TB presents a significant public health challenge, negatively impacting various aspects of disease prevention, detection, and treatment (42). Individuals experiencing TB symptoms may exhibit treatment-seeking delays due to apprehension regarding discrimination and social rejection within their communities or workplaces (43). Furthermore, TB-related stigma can evoke feelings of shame and diminished self-esteem, ultimately discouraging individuals from seeking a diagnosis and initiating treatment (44).

Fear of disclosure can lead patients to discontinue treatment for TB prematurely, concerned that others might discover their illness (45). This clandestine approach to treatment, which frequently lacks appropriate medical supervision, can result in non-adherence to prescribed regimens, raising the possibility that drug-resistant TB strains will emerge (9). Additionally, TB-related stigma can contribute to psychological distress, including depression and anxiety, which can negatively impact physical health and hinder a patient's ability to follow treatment protocols consistently (46).

Patients experiencing social isolation due to stigma may have diminished access to crucial social support networks, which are essential for successful TB treatment (47). Furthermore, negative TB stigma in the workplace can result in job loss or reduced income, hindering a patient's ability to follow treatment regimens consistently (48). Delays in seeking a diagnosis, often fueled by fear of stigmatization, can lead to increased TB transmission within communities as undiagnosed individuals continue to spread the bacteria (49).

Stigma can also impede health education and outreach initiatives aimed at raising awareness about TB prevention strategies (50). Policymakers and communities may be less likely to allocate resources to TB programs

due to stigma, hindering efforts to prevent and treat the disease (51). Public health programs designed to control TB may face resistance from communities experiencing stigma, leading to reduced program participation and effectiveness (52). Ultimately, mitigating stigma holds the potential to significantly reduce the incidence and overall negative impact of TB on public health (18).

A well-established body of evidence highlights the critical role of knowledge in TB incidence. Adequate understanding of the disease can significantly influence various aspects of prevention, detection, and treatment success (53). Individuals equipped with knowledge regarding TB transmission routes, specifically airborne transmission through infected coughs or sneezes, are better positioned to adopt preventive measures such as mask-wearing and maintaining distance from those suspected of infection (54).

Furthermore, knowledge about the importance of good ventilation, environmental hygiene practices, and adequate nutrition can contribute to reducing the spread of TB within communities (42). Similarly, awareness of the characteristic symptoms of TB, including a persistent cough lasting more than two weeks, fever, night sweats, and weight loss, can prompt individuals to seek medical attention earlier. Early diagnosis is crucial for minimizing transmission and maximizing cure rates (20).

Knowledge about TB screening is vital in promoting early detection of cases, particularly among high-risk populations such as individuals living with HIV or healthcare workers (55). Moreover, knowledge regarding the necessity of completing the entire TB treatment regimen, which typically spans six to nine months, is essential for promoting treatment adherence and reducing the risk of drug-resistant TB strains emerging (56).

A proper understanding of TB is essential for eliminating related anxieties and debunking common myths. Misconceptions such as the incurability of TB or the perceived ineffectiveness of treatment can be effectively countered through targeted educational interventions (57). TB education initiatives can also significantly reduce the stigma surrounding the disease. When communities understand that TB is a treatable condition, not a consequence of personal misconduct, they are more likely to offer support to infected individuals (58). Indeed, fostering a knowledge-based environment within communities can cultivate a more robust network of social support for TB patients, ultimately contributing to successful treatment outcomes and recovery (59).

Investment in educational programs designed to disseminate information about TB prevention and the importance of adhering to treatment regimens can demonstrably reduce TB incidence. Dissemination strategies can take many forms, reaching a variety of populations through mass media campaigns, workplaces, and educational institutions (60). Also, healthcare professionals equipped with a comprehensive understanding of TB diagnosis and treatment protocols are better positioned to provide high-quality care to their patients (35). Similarly, policymakers with a solid knowledge base regarding TB can advocate for the implementation of effective control policies, including securing adequate funding for prevention and treatment programs (61).

Public knowledge regarding TB and the critical importance of accessible healthcare services serves as a powerful driver for advocacy efforts aimed at establishing more inclusive and effective health systems (62). Undoubtedly, a well-informed populace is essential for successful TB control initiatives (63). Through the implementation of effective educational and outreach programs, communities can acquire a deeper understanding of TB prevention strategies, early detection methods, and treatment options. Ultimately, this enhanced knowledge base empowers communities to play a more active role in reducing TB incidence and mitigating the overall disease burden (64).

There is a documented correlation between the incidence of TB and food security. Adequate nutrition plays a critical role in maintaining a robust immune system, which is essential for preventing infections such as TB (19). Conversely, nutritional deficiencies, particularly those involving protein, vitamins, and minerals, can compromise immune function and increase an individual's susceptibility to TB infection (65).Food security contributes to overall health, which plays a significant role in preventing various diseases, including TB (66). Both forms of malnutrition, calorie deficiency and micronutrient deficiencies, have been linked to increased TB susceptibility (67). Malnutrition can also exacerbate the prognosis for individuals already infected with TB by hindering their bodies' ability to combat the infection effectively (68).

Food insecurity's complex effects make it a significant obstacle to controlling TB. Individuals experiencing food insecurity face a heightened vulnerability to TB infection. Additionally, TB patients with inadequate dietary intake experience worse health outcomes compared to their food-secure counterparts (69). Nutritional support plays a critical role in TB recovery, facilitating the healing process and enhancing the effectiveness of treatment regimens

(4). Sufficient dietary consumption gives patients the energy and stamina to follow the frequently complex and time-consuming TB treatment regimens (26). There is a close link between food security and socioeconomic status (40). Poverty can significantly restrict access to a nutritious diet, thereby contributing to increased TB incidence (70).

Furthermore, food insecurity often co-exists with substandard living conditions characterized by overcrowding and inadequate sanitation, further amplifying the risk of TB transmission within these communities (68). Implementation of programs that address food insecurity, such as targeted food distribution or nutritional supplementation initiatives, has been demonstrably effective in reducing TB incidence (71). These interventions are particularly crucial in areas with a high prevalence of food insecurity (72).

A comprehensive approach to TB control necessitates integrating healthcare services with food security programs. This collaborative approach ensures TB patients receive the necessary medical care and the critical nutritional support required for recovery (73). In addition, public health initiatives to raise awareness about the importance of good nutrition and strategies to achieve food security can empower communities to take preventative measures against TB (74).

Campaigns promoting food security can reduce vulnerability to TB and other infectious diseases (23). Integrating food security considerations into TB control strategies offers a multi-pronged approach. By addressing this crucial determinant of health, we can improve overall community health and bolster immune function, ultimately reducing the incidence and impact of TB (75). This effort requires a collaborative effort involving sectors beyond healthcare, including agriculture and economic development, to ensure equitable access to sufficient and nutritious food for all individuals (76).

Preventive behaviors demonstrably influence TB incidence rates (20). Appropriate measures can significantly reduce the risk of TB transmission and effectively control its spread within communities (61). Infected individuals should use medical masks to mitigate the airborne transmission of TB bacteria, particularly in crowded or poorly ventilated settings (47). Masks can also serve as protective equipment for healthy individuals, especially those working in high-risk environments (77).

Maintaining good ventilation within enclosed spaces is essential for reducing the concentration of infectious TB bacteria in the air and thereby minimizing the risk of transmission (78). Regularly opening windows and doors to enable air circulation is recommended in homes, schools, and workplaces (79). Covering the mouth and nose with a tissue or inner elbow when coughing or sneezing prevents the expulsion of infectious droplets into the air and protects others (20). Proper disposal of used tissues in bins, followed by thorough handwashing after coughing or sneezing, further enhances hygiene and minimizes transmission risks (79).

Following a healthcare professional's instructions for the entire course of TB treatment is essential for successful outcomes. This approach ensures complete eradication of TB infection and minimizes the risk of developing drug-resistant strains (80). Social support networks, encompassing family and community members, can play a crucial role in promoting treatment adherence among TB patients (81). Implementation of educational programs targeted at raising awareness about TB transmission routes, preventive measures, and the importance of treatment adherence can foster positive behavioral changes within communities, ultimately contributing to a healthier public health environment (61).

Disseminating accurate information about TB through various media channels, including educational institutions, workplaces, and social media platforms, can challenge existing stigma and foster preventive behaviors (70). Individuals with compromised immune systems can reduce their risk by avoiding crowded and poorly ventilated environments (33). Workplaces and companies are responsible for ensuring well-ventilated workspaces that are not overcrowded (82).

Routine TB screening programs, particularly among high-risk populations, are essential for early case identification and prompt intervention to prevent transmission (12). Healthcare facilities should prioritize early detection strategies and ensure accessibility for individuals experiencing potential TB symptoms (83). Maintaining a balanced and nutritious diet is vital in strengthening the immune system and reducing susceptibility to TB infection (4). Additionally, healthy lifestyle choices such as avoiding smoking, limiting alcohol consumption, and prioritizing general well-being can enhance TB protection (84). The consistent and widespread adoption of preventive behaviors across communities holds immense promise for significantly reducing tuberculosis (TB) incidence. Educational initiatives and supportive health policies are essential for fostering positive behavioral changes within the population.

Furthermore, collaborative efforts that bridge the gap between individuals, communities, and healthcare systems are critical to achieving effective TB control (85).

Individuals with a history of contact with infectious TB cases exhibit an exacerbated vulnerability to contracting the disease themselves (86). Household members of active TB patients are at exceptionally high risk due to their constant exposure to bacteria expelled through coughing or sneezing (87). Similarly, friends, colleagues, or others in frequent close contact with active TB patients, mainly in poorly ventilated enclosed spaces, experience a higher risk of infection (22).

Working and academic environments characterized by inadequate ventilation and overcrowding can facilitate TB transmission among individuals nearby (88). Settings with high population density and poor ventilation, such as prisons, orphanages, and dormitories, pose a significant risk for TB transmission within these communities (89). Contact tracing, a crucial public health intervention, involves identifying and evaluating individuals who may have been exposed to an active TB case. Early identification through contact tracing allows prompt intervention before symptoms develop and further transmission occurs (90).

Close contacts of active TB patients should undergo routine TB screening, which may contain a symptom examination and, if indicated, diagnostic tests such as chest X-rays or tuberculin skin tests (91). For high-risk individuals, particularly children and those with compromised immune systems, who have been exposed to TB, prophylactic therapy may be employed to prevent the progression to active disease (92). Educating close contacts on TB transmission prevention strategies, the importance of screening, and the early signs and symptoms of TB can significantly contribute to preventing further spread (93).

The use of masks by both active TB patients and their close contacts can effectively reduce the risk of airborne transmission (94). Maintaining proper ventilation in homes and workplaces and regularly practicing good hygiene are essential for preventing TB transmission in high-risk settings (86). Psychological support and counseling may be necessary for close contacts to understand their risk profile, the significance of sticking to preventive measures, and the importance of TB screening (89).

Ensuring accessible healthcare services for TB screening and treatment for close contacts is paramount for controlling TB transmission within communities (87). By implementing effective contact tracing and management protocols, healthcare systems can identify high-risk individuals and initiate interventions to prevent further TB dissemination (95). This strategy requires collaboration between individuals, communities, and healthcare systems to ensure that all close contacts receive the necessary education, screening, and treatment.

Comorbidity, the co-existence of other medical conditions alongside TB, exerts a significant influence on both the risk of developing TB and the course of treatment and disease outcomes (23). Human immunodeficiency virus (HIV) infection compromises the immune system, making individuals more susceptible to TB infection (96). Furthermore, TB is a prevalent opportunistic infection in patients with untreated HIV/AIDS (97). Treatment regimens for autoimmune diseases, such as lupus or rheumatoid arthritis, often incorporate immunosuppressive medications that can heighten the risk of TB infection (28,98). Diabetes mellitus can exacerbate the risk of developing active TB due to its immunosuppressive effects, rendering the body more vulnerable to TB bacterial infection (99).

Certain chronic health conditions, such as chronic renal failure or post-kidney transplant status, can adversely affect the immune system and increase TB susceptibility (23). Additionally, pre-existing heart or lung diseases, including chronic obstructive pulmonary disease (COPD) or severe asthma, can complicate the course of TB and impede the recovery process (28). Cancer therapies, such as chemotherapy or radiotherapy, can also weaken the immune system and increase the risk of TB infection (100).

Smoking harms lung function and diminishes the body's capacity to combat infections, including TB (101). Furthermore, poor socioeconomic conditions, characterized by limited access to healthcare and overcrowded living environments, can contribute to an increased risk of TB, particularly in vulnerable populations residing in resource-limited settings (102). The presence of comorbidities often requires adjustments to TB treatment regimens to minimize the risk of adverse drug interactions or compromised treatment efficacy (103).

Effective management of TB in patients with comorbidities demands a holistic approach that involves a coordinated healthcare team to ensure all aspects of care are addressed (101). Educating individuals with comorbidities about their heightened risk of TB is crucial for raising awareness and promoting preventive measures and early detection strategies (62). Assuring equitable access to healthcare services for TB screening, diagnosis, and treatment is paramount, especially for those with pre-existing medical conditions that elevate their TB risk (73).

By adopting a comprehensive and holistic approach that incorporates coordinated management of TB and its comorbidities, we can demonstrably reduce the burden of TB and mitigate its impact on individuals with other health conditions (23). Raising public awareness, launching educational programs, and implementing focused preventive measures can collectively control TB transmission and protect susceptible individuals with comorbidities.

Strategies to reduce TB-related stigma include public awareness campaigns through the use of social media, television, radio, and community discussions to disseminate information that TB is curable and not a disease to be ashamed of. Testimonials of survivors can encourage individuals who have recovered from TB to share their experiences to inspire others. Training for health workers by providing specialized training to medical personnel allows them to provide friendly and non-discriminatory services to TB patients. Furthermore, a community-based approach that involves community leaders, religious leaders, and health cadres can be implemented to support TB patients socially and psychologically.

Strategies to improve TB knowledge can be achieved through school and workplace education by integrating TB education into the school curriculum and workplace health programs. Community-based counseling can be carried out by holding group discussions at community health centers, integrated health posts for child health (*posyandu*), and places of worship to increase community understanding. Moreover, interactive and digital media can be utilized using infographics, animated videos, and mobile applications to disseminate information about TB in an engaging and easy-to-understand manner.

Strategies to address food insecurity as a risk factor for TB include food aid programs to provide nutritional packages to families of TB patients, especially the underprivileged, to accelerate recovery and boost immunity. Urban agriculture and food security can be organized to encourage initiatives such as community gardens or hydroponics to increase community access to nutritious food. Partnerships with the private sector, such as inviting companies and NGOs, can also be established to support the distribution of nutritious food to vulnerable groups, especially in areas with high TB rates.

CONCLUSION

The incidence of TB was discovered to be associated with low income, high stigma, insufficient knowledge, food insecurity, non-practicing TB prevention, contact history, and comorbidities. Among the analyzed variables, comorbidity emerged as the most closely associated risk factor for TB incidence. Based on the findings, it is recommended that TB awareness education campaigns be conducted, TB survivors be engaged in sharing recovery experiences, community or religious leaders be involved, and economic empowerment training be provided to risk groups. Additionally, there is a need for policy support programs for TB patients who are unable to work, food assistance or subsidies for TB patients and families, and integration of TB education in school curriculum and worker training.

AUTHOR'S CONTRIBUTION STATEMENT

All authors contributed equally to the conception and design of the study.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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BIBLIOGRAPHY

1. World Health Organization (WHO). Global Tuberculosis Report 2023. 2023; [accessed 19 Jun 2024] Available from: https://iris.who.int/.
2. Bai W, Ameyaw EK. Global, regional and national trends in tuberculosis incidence and main risk factors: a study using data from 2000 to 2021. BMC Public Health. 2024 Dec 1;24(1):1–14. [accessed 19 Jun 2024] Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-023-17495-6
3. World Health Organization (WHO). Global Tuberculosis Report 2022. 2022. [accessed 10 Sep 2023] Available from: https://www.who.int/publications/i/item/9789240061729
4. Gupta K, Gupta R, Atreja A, Verma M, Vishvkarma S. Tuberculosis and nutrition. Lung India. 2009 Jan 1;26(1):9–16. [accessed 12 May 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/20165588/
5. Erlinger S, Stracker N, Hanrahan C, Nonyane BAS, Mmolawa L, Tampi R, et al. Tuberculosis patients with higher levels of poverty face equal or greater costs of illness. Int J Tuberc Lung Dis. 2019 Nov 1;23(11):1205–12. [accessed 22 Oct 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/31718757/
6. Vesga JF, Hallett TB, Reid MJA, Sachdeva KS, Rao R, Khaparde S, et al. Assessing tuberculosis control priorities in high-burden settings: a modelling approach. Lancet Glob Heal. 2019 May 1;7(5):e585–95. doi: 10.1016/S2214-109X(19)30037-3
7. Kemenkes RI. Laporan Kinerja Direktorat Jenderal Pencegahan dan Pengendalian Penyakit Tahun 2023. Jakarta; 2023.
8. Ditjen P2P Kemenkes. Profil Kesehatan Indonesia Tahun 2022. 2023. [accessed 27 Feb 2024] Available from: https://p2p.kemkes.go.id/profil-kesehatan-2022/
9. Junaid SA, Kanma-Okafor OJ, Olufunlayo TF, Odugbemi BA, Ozoh OB. Tuberculosis stigma: Assessing tuberculosis knowledge, attitude and preventive practices in surulere, Lagos, Nigeria. Ann Afr Med. 2021 Jul 1;20(3):184–92. [accessed 10 Nov 2023] Available from: https://pubmed.ncbi.nlm.nih.gov/34558447/
10. Silva DR, Muñoz-Torrico M, Duarte R, Galvão T, Bonini EH, Arbex FF, et al. Risk factors for tuberculosis: diabetes, smoking, alcohol use, and the use of other drugs. J Bras Pneumol. 2018 Mar 1;44(2):145. [accessed 12 May 2022] Available from: /pmc/articles/PMC6044656/
11. Dinas Kesehatan Provinsi Aceh. Profil Kesehatan Aceh Tahun 2022. 2023. [accessed 4 Nov 2023] Available from: https://dinkes.acehprov.go.id/detailpost/profil-kesehatan-aceh-tahun-2022
12. Souza Filho JB de O e., Sanchez M, Seixas JM de, Maidantchik C, Galliez R, Moreira A da SR, et al. Screening for active pulmonary tuberculosis: Development and applicability of artificial neural network models. Tuberculosis. 2018 Jul 1;111:94–101. doi: 10.1016/J.TUBE.2018.05.012
13. Lin HH, Wang L, Zhang H, Ruan Y, Chin DP, Dye C. Tuberculosis control in China: use of modelling to develop targets and policies. Bull World Health Organ. 2015 Nov 1;93(11):790–8. [accessed 26 Oct 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/26549907/
14. Flores GP, Alberto IRI, Eala MAB, Cañal JPA. The social determinants of tuberculosis in the Philippines. Lancet Glob Heal. 2022 Jan 1;10(1):e38. [accessed 5 Jan 2022] Available from: https://linkinghub.elsevier.com/retrieve/pii/S2214109X21005167
15. Hassen J, Gizaw A, Mohamed S. Determinants of pulmonary tuberculosis in public health facilities of Dire Dawa City, Eastern Ethiopia: Unmatched Case-control study. Int J mycobacteriology. 2019 Apr 1;8(2):118–23. [accessed 3 Jan 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/31210152/
16. Kepres RI. Undang-undang (UU) Nomor 20 Tahun 2003 tentang Sistem Pendidikan Nasional. 2003. [accessed 25 Jun 2024] Available from: https://peraturan.bpk.go.id/Details/43920/uu-no-20-tahun-2003
17. Biro Administrasi Setda Aceh. Upah Minimum Provinsi Aceh. 2022. [accessed 14 Jun 2024] Available from: https://humas.acehprov.go.id/upah-minimum-provinsi-aceh-tahun-2023-rp-3-413-66-naik-78-persen/
18. Vericat-Ferrer M, Ayala A, Ncogo P, Eyene-Acuresila J, García B, Benito A, et al. Knowledge, Attitudes, and Stigma: The Perceptions of Tuberculosis in Equatorial Guinea. Int J Environ Res Public Health. 2022 Jul 1;19(14). [accessed 10 Nov 2023] Available from: https://pubmed.ncbi.nlm.nih.gov/35886079/
19. Susilaningrum D, Ulama BSS, Wulandari SP, Salamah M. The analysis of factors that affecting household food security of tuberculosis patients in Surabaya. J Phys Conf Ser. 2019 Nov 7;1341(9). doi: 10.1088/1742-6596/1341/9/092014

20. Puspitasari IM, Sinuraya RK, Aminudin AN, Kamilah RR. Knowledge, Attitudes, and Preventative Behavior Toward Tuberculosis in University Students in Indonesia. Infect Drug Resist. 2022;15:4721. [accessed 1 Nov 2023] Available from: /pmc/articles/PMC9416452/
21. Alavi-Naini R, Sharifi-Mood B, Metanat M. Association Between Tuberculosis and Smoking. Int J High Risk Behav Addict. 2012 Jul 25;1(2):71. [accessed 20 Jun 2024] Available from: /pmc/articles/PMC4070106/
22. Shamaei M, Esmaeili S, Marjani M, Tabarsi P. Implementing Tuberculosis Close-contact Investigation in a Tertiary Hospital in Iran. Int J Prev Med. 2018 May 1;9. [accessed 13 May 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/29899886/
23. Bates M, Marais BJ, Zumla A. Tuberculosis Comorbidity with Communicable and Noncommunicable Diseases. Cold Spring Harb Perspect Med. 2015 Nov 1;5(11). [accessed 12 May 2022] Available from: /pmc/articles/PMC4632868/
24. Djibuti M, Mirvelashvili E, Makharashvili N, Magee MJ. Household income and poor treatment outcome among patients with tuberculosis in Georgia: a cohort study. BMC Public Health. 2014 Jan 29;14(1). [accessed 7 Apr 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/24476154/
25. Su Y, Garcia Baena I, Harle AC, Crosby SW, Micah AE, Siroka A, et al. Tracking total spending on tuberculosis by source and function in 135 low-income and middle-income countries, 2000–17: a financial modelling study. Lancet Infect Dis. 2020 Aug 1;20(8):929–42. doi: 10.1016/S1473-3099(20)30124-9
26. Shaji B, Arun Thomas ET, Sasidharan PK. Tuberculosis control in India: Refocus on nutrition. Indian J Tuberc. 2019 Jan 1;66(1):26–9. [accessed 16 May 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/30797277/
27. Da Silva V. TS. WN. & BM. The Relationship Between Education, Job, and Family Income with TB Medication Dropouts in Timor-Leste. Bali Med J. 2016;5(2):279–82. [accessed 20 Jun 2024] Available from: https://balimedicaljournal.org/index.php/bmj/article/view/223/pdf_112
28. Echazarreta A, Zerbini E, De Sandro J, Sáenz C, Yessi L, Saad R, et al. Tuberculosis and comorbidities in urban areas in Argentina. A gender and age perspective. Biomedica. 2018;38(2):180–8. [accessed 2 Aug 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/30184347/
29. Clark M, Riben P, Nowgesic E. The association of housing density, isolation and tuberculosis in Canadian First Nations communities. Int J Epidemiol. 2002;31(5):940–5. [accessed 6 Jan 2024] Available from: https://pubmed.ncbi.nlm.nih.gov/12435764/
30. Amaliah L, Rufaedah AA, Nurcahyati S, Abdurakhman RN, Hidayat A, Amaliah L, et al. The relationship between the physical home environment and the event of tuberculosis. https://wjarr.com/sites/default/files/WJARR-2022-0627.pdf. 2022 Jun 30;14(3):623–8. [accessed 5 Jan 2024] Available from: https://wjarr.com/content/relationship-between-physical-home-environment-and-event-tuberculosis
31. Oktaria S, Hurif NS, Naim W, Thio HB, Nijsten TEC, Richardus JH. Dietary diversity and poverty as risk factors for leprosy in Indonesia: A case-control study. PLoS Negl Trop Dis. 2018 Mar 13;12(3). [accessed 19 Jun 2024] Available from: https://pubmed.ncbi.nlm.nih.gov/29534113/
32. Mohidem N, Osman M, Muharam F, Elias S, Shaharudin R, Hashim Z. Prediction of tuberculosis cases based on sociodemographic and environmental factors in gombak, Selangor, Malaysia: A comparative assessment of multiple linear regression and artificial neural network models. Int J mycobacteriology. 2021 Oct 1;10(4):442–56. [accessed 26 Oct 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/34916466/
33. Du CR, Wang SC, Yu MC, Chiu TF, Wang JY, Chuang PC, et al. Effect of ventilation improvement during a tuberculosis outbreak in underventilated university buildings. Indoor Air. 2020 May 1;30(3):422–32. [accessed 13 May 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/31883403/
34. Mariana D, Hairuddin MC. Kepadatan Hunian, Ventilasi dan Pencahayaan terhadap Kejadian TB Paru di Wilayah Kerja Puskesmas Binanga Kabupaten Mamuju Sulawesi Barat. J Kesehat Manarang. 2018 Jan 16;3(2):75. [accessed 31 Oct 2023] Available from: http://www.jurnal.poltekkesmamuju.ac.id/index.php/m/article/view/40
35. Gautam N, Karki RR, Khanam R. Knowledge on tuberculosis and utilization of DOTS service by tuberculosis patients in Lalitpur District, Nepal. PLoS One. 2021 Jan 1;16(1). [accessed 8 May 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/33493188/

36. Zille AI, Werneck GL, Luiz RR, Conde MB. Social determinants of pulmonary tuberculosis in Brazil: An ecological study. BMC Pulm Med. 2019 May 8;19(1):1–9. [accessed 5 Jan 2022] Available from: https://link.springer.com/articles/10.1186/s12890-019-0855-1
37. Wubuli A, Xue F, Jiang D, Yao X, Upur H, Wushouer Q. Socio-Demographic Predictors and Distribution of Pulmonary Tuberculosis (TB) in Xinjiang, China: A Spatial Analysis. PLoS One. 2015 Dec 1;10(12). [accessed 24 Oct 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/26641642/
38. Ross JM, Xie Y, Wang Y, Collins JK, Horst C, Doody JB, et al. Estimating the population at high risk for tuberculosis through household exposure in high-incidence countries: a model-based analysis. eClinicalMedicine. 2021 Dec 1;42:101206. doi: 10.1016/J.ECLINM.2021.101206
39. Khan AA, Akhtar N, Madni A, Tahir N, Rehman M, Raza A, et al. Socio-economic constrains faced by TB patients that lead to non-compliance - A cross sectional study in Southern Punjab, Pakistan. Acta Pol Pharm - Drug Res. 2017;74(3):995–1000.
40. Rutherford AE, Unruh L. Political, economic, and health system determinants of tuberculosis incidence. J Public Heal. 2019 Oct 1;27(5):541–52. doi: 10.1007/S10389-018-0991-8/TABLES/3
41. Yates TA, Ayles H, Leacy FP, Schaap A, Boccia D, Beyers N, et al. Socio-economic gradients in prevalent tuberculosis in Zambia and the Western Cape of South Africa. Trop Med Int Health. 2018 Apr 1;23(4):375–90. [accessed 1 Nov 2023] Available from: https://pubmed.ncbi.nlm.nih.gov/29432669/
42. Oladele DA, Balogun MR, Odeyemi K, Salako BL. A Comparative Study of Knowledge, Attitude, and Determinants of Tuberculosis-Associated Stigma in Rural and Urban Communities of Lagos State, Nigeria. Tuberc Res Treat. 2020 Dec 3;2020:1–14. [accessed 6 Mar 2024] Available from: https://pubmed.ncbi.nlm.nih.gov/33343936/
43. Craig GM, Daftary A, Engel N, O'Driscoll S, Ioannaki A. Tuberculosis stigma as a social determinant of health: a systematic mapping review of research in low incidence countries. Vol. 56, International Journal of Infectious Diseases. 2017. doi: 10.1016/j.ijid.2016.10.011
44. Ashaba C, Musoke D, Wafula ST, Konde-Lule J. Stigma among tuberculosis patients and associated factors in urban slum populations in Uganda. Afr Health Sci. 2021;21(4):1640–50. [accessed 27 Dec 2023] Available from: https://pubmed.ncbi.nlm.nih.gov/35283968/
45. Jing Teo AK, Jin Tan RK, Smyth C, Soltan V, Eng S, Ork C, et al. Characterizing and Measuring Tuberculosis Stigma in the Community: A Mixed-Methods Study in Cambodia. Open Forum Infect Dis. 2020 Oct 1;7(10). [accessed 6 Mar 2024] Available from: https://dx.doi.org/10.1093/ofid/ofaa422
46. Chen X, Du L, Wu R, Xu J, Ji H, Zhang Y, et al. Tuberculosis-related stigma and its determinants in Dalian, Northeast China: a cross-sectional study. BMC Public Health. 2021 Dec 1;21(1):1–10. [accessed 5 Jan 2022] Available from: https://link.springer.com/articles/10.1186/s12889-020-10055-2
47. Abebe G, Deribew A, Apers L, Woldemichael K, Shiffa J, Tesfaye M, et al. Knowledge, health seeking behavior and perceived stigma towards tuberculosis among tuberculosis suspects in a rural community in southwest Ethiopia. PLoS One. 2010;5(10). [accessed 19 Dec 2023] Available from: https://pubmed.ncbi.nlm.nih.gov/20948963/
48. Fitri S, Tahlil T, Susanti SS. Stigma in Tuberculosis Sufferers: A Study in Simeulue Regency, Aceh Indonesia. Int J Nurs Educ. 2022 Apr 13;14(2):199–208. [accessed 17 May 2022] Available from: https://medicopublication.com/index.php/ijone/article/view/18021
49. Jing Teo AK, Jin Tan RK, Smyth C, Soltan V, Eng S, Ork C, et al. Characterizing and Measuring Tuberculosis Stigma in the Community: A Mixed-Methods Study in Cambodia. Open forum Infect Dis. 2020 Oct 1;7(10). [accessed 10 Nov 2023] Available from: https://pubmed.ncbi.nlm.nih.gov/33134412/
50. Smith A, Herington E, Loshak H. Tuberculosis Stigma and Racism, Colonialism, and Migration: A Rapid Qualitative Review. Tuberc Stigma Racism, Colon Migr A Rapid Qual Rev. 2021; [accessed 27 Dec 2023] Available from: https://www.ncbi.nlm.nih.gov/books/NBK571944/
51. Courtwright A, Turner AN. Tuberculosis and Stigmatization: Pathways and Interventions. Public Health Rep. 2010;125(Suppl 4):34. [accessed 17 May 2022] Available from: /pmc/articles/PMC2882973/
52. Oladele DA, Idigbe IE, Ekama SO, Gbajabiamila T, Ohihoin AG, David AN, et al. 'Their place is beyond the town's border': A qualitative exploration of stigma associated with tuberculosis in rural and urban areas of Lagos,

Nigeria. Health Soc Care Community. 2021 Nov 1;29(6):1789–98. [accessed 6 Mar 2024] Available from: https://pubmed.ncbi.nlm.nih.gov/33491866/
53. Suleiman, Sahal, Sodemann, A Elsony A. Tuberculosis awareness in Gezira, Sudan: knowledge, attitude and practice case-control survey. East Mediterr Heal J . 2014;20(2):120–9. [accessed 10 Sep 2023] Available from: https://pubmed.ncbi.nlm.nih.gov/24945561/
54. Abu-Humaidan AHA, Tarazi A, Hamadneh Y, Al-leimon A, Al-leimon O, Aljahalin M, et al. Knowledge, attitudes, and practices toward tuberculosis among Jordanian university students. Front public Heal. 2022 Nov 21;10. [accessed 10 Sep 2023] Available from: https://pubmed.ncbi.nlm.nih.gov/36478722/
55. Kwedi Nolna S, Kammogne ID, Ndzinga R, Afanda B, Ntonè R, Boum Y, et al. Community knowledge, attitudes and practices in relation to tuberculosis in Cameroon. Int J Tuberc Lung Dis. 2016 Sep 1;20(9). [accessed 10 Nov 2023] Available from: https://pubmed.ncbi.nlm.nih.gov/27510246/
56. Nyasulu P, Sikwese S, Chirwa T, Makanjee C, Mmanga M, Babalola JO, et al. Knowledge, beliefs, and perceptions of tuberculosis among community members in Ntcheu district, Malawi. J Multidiscip Healthc. 2018;11:375–89. [accessed 10 Nov 2023] Available from: https://pubmed.ncbi.nlm.nih.gov/30147328/
57. Ndi NN, Lukong HS, Samje M. Prevalence, knowledge and practices towards tuberculosis prevention in the Bamenda III sub-division, Cameroon. Indian J Tuberc. 2023 Jul 1;70(3). [accessed 10 Nov 2023] Available from: https://pubmed.ncbi.nlm.nih.gov/37562910/
58. Hassan AO, Olukolade R, Ogbuji QC, Afolabi S, Okwuonye LC, Kusimo OC, et al. Knowledge about Tuberculosis: A Precursor to Effective TB Control—Findings from a Follow-Up National KAP Study on Tuberculosis among Nigerians. Tuberc Res Treat. 2017;2017:1–8. doi: 10.1155/2017/6309092
59. Mbuthia GW, Olungah CO, Ondicho TG. Knowledge and perceptions of tuberculosis among patients in a pastoralist community in Kenya: a qualitative study. Pan Afr Med J. 2018;30. [accessed 8 May 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/30637071/
60. Mangesho, Shayo, Makunde, Keto, Mandara, Kamugisha & I. Community knowledge, attitudes and practices towards tuberculosis and its treatment in Mpwapwa district, central Tanzania. Tanzan J Health Res. 2007;9(1):38–43. [accessed 20 Jun 2024] Available from: https://pubmed.ncbi.nlm.nih.gov/17547099/
61. Badane AA, Dedefo MG, Genamo ES, Bekele NA. Knowledge and Healthcare Seeking Behavior of Tuberculosis Patients attending Gimbi General Hospital, West Ethiopia. Ethiop J Health Sci. 2018 Sep 1;28(5):529. [accessed 19 Dec 2023] Available from: /pmc/articles/PMC6308772/
62. Kigozi NG, Heunis JC, Engelbrecht MC, Janse Van Rensburg AP, Van Rensburg HCJD. Tuberculosis knowledge, attitudes and practices of patients at primary health care facilities in a South African metropolitan: Research towards improved health education. BMC Public Health. 2017 Oct 10;17(1):1–8. [accessed 12 May 2022] Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-017-4825-3
63. Islam QS, Islam MA, Islam S, Ahmed SM. Prevention and control of tuberculosis in workplaces: how knowledgeable are the workers in Bangladesh? BMC Public Health. 2015 Dec 24;15(1). [accessed 10 Sep 2023] Available from: https://pubmed.ncbi.nlm.nih.gov/26703074/
64. Hossain S, Zaman K, Quaiyum A, Banu S, Husain A, Islam A, et al. Factors associated with poor knowledge among adults on tuberculosis in Bangladesh: results from a nationwide survey. J Health Popul Nutr. 2015;34(1). [accessed 10 Sep 2023] Available from: /pmc/articles/PMC5465564/
65. Food and Agriculture Organization (FAO), AFAD, UNICEF, WFP, WHO. The State of Food Security and Nutrition in the World 2021. The State of Food Security and Nutrition in the World 2021. FAO, IFAD, UNICEF, WFP and WHO; 2021. doi: 10.4060/cb4474en
66. Susilaningrum D, Ulama BSS, Lathifah R, Susilaningrum D, Ulama BSS, Lathifah R. Mapping the Factors Affecting Household Food Security of Tuberculosis Patients in Coastal Region of Surabaya. MS&E. 2018 Apr 25;335(1):012053. [accessed 16 May 2022] Available from: https://ui.adsabs.harvard.edu/abs/2018MS&E..335a2053S/abstract
67. Amrith N, Laksiri J, Nayanathara N, Derore IK. Food Security and Nutrition among the Tuberculosis infected patients A case study among the patients screened at Chest Clinic of Medical Research Institute of Colombo, Sri Lanka. 2014.

68. Lee GO, Paz-Soldan VA, Riley-Powell AR, Gómez A, Tarazona-Meza C, Paliza KV, et al. Food Choice and Dietary Intake among People with Tuberculosis in Peru: Implications for Improving Practice. Curr Dev Nutr. 2020 Feb 1;4(2). [accessed 20 Jun 2024] Available from: https://pubmed.ncbi.nlm.nih.gov/32025614/
69. International Food Policy Research Institute. Food Security. [accessed 31 Oct 2023] Available from: https://www.ifpri.org/topic/food-security
70. Carter DJ, 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 Heal. 2018 May 1;6(5):e514–22. doi: 10.1016/S2214-109X(18)30195-5
71. Odone A, Houben RMGJ, White RG, Lönnroth K. The effect of diabetes and undernutrition trends on reaching 2035 global tuberculosis targets. lancet Diabetes Endocrinol. 2014 Sep 1;2(9):754–64. [accessed 27 Oct 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/25194888/
72. Boccia D, Rudgard W, Shrestha S, Lönnroth K, Eckhoff P, Golub J, et al. Modelling the impact of social protection on tuberculosis: The S-PROTECT project. BMC Public Health. 2018 Jun 26;18(1):1–9. [accessed 5 Jan 2022] Available from: https://link.springer.com/articles/10.1186/s12889-018-5539-x
73. Nikovska DG, Tozija F. Social determinants of equity in access to healthcare for tuberculosis patients in Republic of Macedonia – results from a case-control study. Int J Heal Policy Manag. 2014;3(4):199. [accessed 20 Jun 2024] Available from: /pmc/articles/PMC4181969/
74. Valencia-Aguirre S, Arroyave I, García-Basteiro AL. Educational level and tuberculosis mortality in Colombia: growing inequalities and stagnation in reduction. Cad Saude Publica. 2022;38(1). [accessed 31 Oct 2023] Available from: https://pubmed.ncbi.nlm.nih.gov/35107505/
75. Rubel AJ, Garro LC. Social and cultural factors in the successful control of tuberculosis. Public Health Rep. 1992;107(6):626. [accessed 29 Oct 2022] Available from: /pmc/articles/PMC1403712/?report=abstract
76. World Health Organization (WHO). Tuberculosis Control. 2014.
77. Badane AA, Dedefo MG, Genamo ES, Bekele NA. Knowledge and Healthcare Seeking Behavior of Tuberculosis Patients attending Gimbi General Hospital, West Ethiopia. Ethiop J Health Sci. 2018 Sep 1;28(5):529–38. [accessed 27 Dec 2023] Available from: https://pubmed.ncbi.nlm.nih.gov/30607067/
78. Pai M, Delavallade C, Huddart S, Bossuroy T, Pons V, Baral S. Knowledge about tuberculosis and infection prevention behavior: A nine city longitudinal study from India. PLoS One. 2018 Oct 1;13(10). [accessed 1 Nov 2023] Available from: https://pubmed.ncbi.nlm.nih.gov/30376558/
79. Li J, Pu J, Liu J, Wang Q, Zhang R, Zhang T, et al. Determinants of self-management behaviors among pulmonary tuberculosis patients: a path analysis. Infect Dis Poverty. 2021 Dec 1;10(1):1–11. [accessed 5 Jan 2022] Available from: https://link.springer.com/articles/10.1186/s40249-021-00888-3
80. Dartois VA, Rubin EJ. Anti-tuberculosis treatment strategies and drug development: challenges and priorities. Nat Rev Microbiol 2022 2011. 2022 Apr 27;20(11):685–701. [accessed 19 Jun 2024] Available from: https://www.nature.com/articles/s41579-022-00731-y
81. Setyaningrum R, Zubaidah T, Anhar VY. Correlation between Gender, Age, Education Level, and Working Status with Anti-Tuberculosis Drug Uses (OATS) in Patients with Lung TB in Indonesia 2013. Int J Chem Mater Sci. 2013;1(1):7–13. doi: 10.31295/ijcms.v1n1.3
82. Taylor JG, Yates TA, Mthethwa M, Tanser F, Abubakar I, Altamirano H. Measuring ventilation and modelling M. tuberculosis transmission in indoor congregate settings, rural KwaZulu-Natal. Int J Tuberc Lung Dis. 2016 Sep 1;20(9). [accessed 26 Oct 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/27510239/
83. Cain KP, McCarthy KD, Heilig CM, Monkongdee P, Tasaneeyapan T, Kanara N, et al. An algorithm for tuberculosis screening and diagnosis in people with HIV. N Engl J Med. 2010 Feb 25;362(8):707–16. [accessed 20 Jun 2024] Available from: https://pubmed.ncbi.nlm.nih.gov/20181972/
84. World Health Organization (WHO). Smoking and tuberculosis: a dangerous combination. 2018 Mar 22; [accessed 12 May 2022] Available from: https://www.euro.who.int/en/health-topics/communicable-diseases/tuberculosis/news/news/2018/3/smoking-and-tuberculosis-a-dangerous-combination
85. World Health Organization. Tuberculosis. 2023. [accessed 10 Nov 2023] Available from: https://www.who.int/news-room/fact-sheets/detail/tuberculosis

86. Reichler MR, Khan A, Sterling TR, Zhao H, Moran J, McAuley J, et al. Risk and Timing of Tuberculosis Among Close Contacts of Persons with Infectious Tuberculosis. J Infect Dis. 2018 Aug 14;218(6):1000. [accessed 13 May 2022] Available from: /pmc/articles/PMC6534268/
87. Morrison J, Pai M, Hopewell PC. Tuberculosis and latent tuberculosis infection in close contacts of people with pulmonary tuberculosis in low-income and middle-income countries: a systematic review and meta-analysis. Lancet Infect Dis. 2008 Jun;8(6):359–68. [accessed 20 Jun 2024] Available from: https://pubmed.ncbi.nlm.nih.gov/18450516/
88. Fox GJ, Nhung N V., Sy DN, Hoa NLP, Anh LTN, Anh NT, et al. Household-Contact Investigation for Detection of Tuberculosis in Vietnam. N Engl J Med. 2018 Jan 18;378(3):221–9. [accessed 24 Oct 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/29342390/
89. MacPherson P, Lebina L, Motsomi K, Bosch Z, Milovanovic M, Ratsela A, et al. Prevalence and risk factors for latent tuberculosis infection among household contacts of index cases in two South African provinces: Analysis of baseline data from a cluster-randomised trial. PLoS One. 2020;15(3). [accessed 22 Oct 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/32182274/
90. Martin-Sanchez M, Brugueras S, De Andrés A, Simon P, Gorrindo P, Ros M, et al. Tuberculosis incidence among infected contacts detected through contact tracing of smear-positive patients. PLoS One. 2019 Apr 1;14(4). [accessed 24 Oct 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/30986227/
91. Yadav RP, Nishikiori N, Satha P, Eang MT, Lubell Y. Cost-effectiveness of a tuberculosis active case finding program targeting household and neighborhood contacts in Cambodia. Am J Trop Med Hyg. 2014;90(5):866–72. [accessed 22 Oct 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/24615134/
92. Fox GJ, Barry SE, Britton WJ, Marks GB. Contact investigation for tuberculosis: a systematic review and meta-analysis. Available from: www.erj.ersjournals.com
93. Khatana GH, Masoodi M, Amin M. Factors affecting applicability of "home-based interventional model" for active case finding among household contacts of index cases of pulmonary tuberculosis in Kashmir. Indian J Tuberc. 2017 Jul 1;64(3):189–95. doi: 10.1016/J.IJTB.2017.01.011
94. Kaswaswa K, MacPherson P, Kumwenda M, Mpunga J, Thindwa D, Nliwasa M, et al. Effect of patient-delivered household contact tracing and prevention for tuberculosis: A household cluster-randomised trial in Malawi. PLoS One. 2022 Sep 1;17(9). [accessed 22 Oct 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/36074775/
95. Zhou M, Wang L, Li M, Zou J, Li Y, Li J, et al. Contact investigation of tuberculosis in Shanghai, China: A 13-year cohort. Tuberculosis (Edinb). 2023 Mar 1;139. [accessed 4 Jan 2024] Available from: https://pubmed.ncbi.nlm.nih.gov/36805089/
96. Awad SF, Critchley JA, Abu-Raddad LJ. Epidemiological impact of targeted interventions for people with diabetes mellitus on tuberculosis transmission in India: Modelling based predictions. Epidemics. 2020 Mar 1;30:100381. doi: 10.1016/J.EPIDEM.2019.100381
97. Mulongeni P, Hermans S, Caldwell J, Bekker LG, Wood R, Kaplan R. HIV prevalence and determinants of loss-to-follow-up in adolescents and young adults with tuberculosis in Cape Town. PLoS One. 2019 Feb 1;14(2). [accessed 3 Jan 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/30721239/
98. Zafari P, Golpour M, Hafezi N, Bashash D, Esmaeili SA, Tavakolinia N, et al. Tuberculosis comorbidity with rheumatoid arthritis: Gene signatures, associated biomarkers, and screening. IUBMB Life. 2021 Jan 1;73(1):26–39. [accessed 24 Jun 2024] Available from: https://pubmed.ncbi.nlm.nih.gov/33217772/
99. Lu P, Zhang Y, Liu Q, Ding X, Kong W, Zhu L, et al. Association of BMI, diabetes, and risk of tuberculosis: a population-based prospective cohort. Int J Infect Dis. 2021 Aug 1;109:168–73. [accessed 26 Oct 2022] Available from: https://pubmed.ncbi.nlm.nih.gov/34217872/
100. Tamura A. Tuberculosis And Lung Cancer. Kekkaku. 2016;91(1):17–25. [accessed 24 Jun 2024] Available from: https://pubmed.ncbi.nlm.nih.gov/27192776/
101. Moon D, Jeong D, Kang YA, Choi H. Gender differences in tuberculosis patients with comorbidity: A cross-sectional study using national surveillance data and national health insurance claims data in South Korea. PLoS One. 2023 Jan 1;18(1). [accessed 24 Jun 2024] Available from: https://pubmed.ncbi.nlm.nih.gov/36662895/

102. Dzinamarira T, Imran M, Muvunyi CM. The Management of Infectious Diseases in Comorbidity with Tuberculosis. Medicina (Kaunas). 2022 Oct 1;58(10). [accessed 24 Jun 2024] Available from: https://pubmed.ncbi.nlm.nih.gov/36295567/
103. Knight GM, McQuaid CF, Dodd PJ, Houben RMGJ. Global burden of latent multidrug-resistant tuberculosis: trends and estimates based on mathematical modelling. Lancet Infect Dis. 2019 Aug 1;19(8):903–12. doi: 10.1016/S1473-3099(19)30307-X