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Factors associated with the occurrence of latent tuberculosis in the working area of UPT Puskesmas Padang Bulan in 2025

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ABSTRACT

Latent tuberculosis is an asymptomatic condition caused by Mycobacterium tuberculosis that can progress to active TB if not properly controlled. A preliminary survey at the Padang Bulan Community Health Center (UPT Puskesmas) identified 40 individuals receiving tuberculosis preventive therapy (TPT) in 2024–2025. This study aimed to identify factors associated with the incidence of latent TB (LTBI) in the Padang Bulan Community Health Center (UPT Puskesmas) working area in 2025. This analytical study used a cross-sectional design with 44 respondents selected by purposive sampling. Data were collected through questionnaires, observations, and health center records, then analyzed using the Chi-square test. The results showed that age was not significantly associated with the incidence of latent TB (p=0.160). Meanwhile, duration of contact (p=0.037), occupation (p=0.044), clean and healthy living behaviors (p=0.042), residential density (p=0.019), and BCG vaccination history (p=0.019) showed a significant association with LTBI. Respondents with prolonged contact, high-risk occupations, poor health behaviors, overcrowded housing, and not being vaccinated against BCG were more likely to develop LTBI. These findings emphasize the need for more intensive LTBI screening, better health education, and increased vaccination coverage to reduce the risk of LTBI in the community.

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1. Introduction

Tuberculosis (TB) is an infectious disease caused by *Mycobacterium tuberculosis* bacteria and can be transmitted through the air when an infected person coughs, sneezes, or speaks. Although the disease primarily affects the lungs, it can also spread to other organs such as the brain, bones, and lymph nodes. Following the Covid-19 pandemic, tuberculosis has become the second leading cause of death among infectious diseases worldwide. According to the World Health Organization (WHO), there were 10.6 million tuberculosis cases globally in 2022, consisting of 5.8 million men, 3.5 million women, and 1.3 million children. In the same year, an estimated 1.3 million people died due to tuberculosis. Approximately 90–95% of infected individuals develop latent TB, while 5–10% progress to active TB. As part of the Sustainable Development Goals (SDGs), latent TB has become a key focus in global TB control programs (WHO, 2023).

Latent tuberculosis infection (LTBI) occurs when the immune system of an infected person is unable to completely eliminate the bacteria but is capable of suppressing it to prevent clinical symptoms. However, if the immune system weakens, the infection can progress to active TB, which is

contagious. A person is diagnosed with latent TB if the *Tuberculin Skin Test* (TST) or *Interferon Gamma Release Assay* (IGRA) yields a positive result, but chest X-rays and sputum examinations are normal (Kemenkes RI, 2020b). WHO estimated that approximately 1.7 billion people worldwide were infected with latent TB in 2019, with 35% of cases originating from Southeast Asia. Indonesia is among the countries with a high number of laten90t TB infections.

At the national level, the number of individuals with latent TB who have a history of contact with active TB patients is estimated to reach 2,795,994. This figure reflects a large population at risk that could become a potential source of further transmission if not properly managed (Kemenkes RI, 2020a). Based on the 2022 national TB program report, North Sumatra is among the eight priority provinces for TB screening and preventive therapy implementation. Medan City and Deli Serdang Regency are two regions with the highest TB burden in Indonesia. Of 131,139 targeted household and close contacts, 68,788 individuals (52%) underwent symptom screening, and 12,176 received preventive therapy (Dirjen P2P, 2023). The researchers chose Padang Bulan Community Health Center as the study location because it is an area with a high number of tuberculosis preventive therapy (TPT) recipients and a dense population of close contacts. However, detailed epidemiological data on latent TB infection is still lacking. Although Padang Bulan has actively conducted screening and contact tracing, information on specific factors contributing to latent TB in this area remains limited. Most available reports focus on active TB cases, while the characteristics, risk factors, and determinants of LTBI at the local level are poorly documented. This knowledge gap highlights the need for research that more comprehensively examines latent TB in Padang Bulan to support targeted interventions and strengthen prevention strategies. Given this situation, focusing on latent TB is crucial because individuals with latent infection serve as a silent reservoir for future active TB cases. While active TB has a more immediate public health impact, the progression from latent to active disease contributes significantly to ongoing transmission. National strategies, including WHO guidelines and the 2020–2024 National TB Strategy, have emphasized early detection and infection management as key components of TB elimination efforts. However, local data on the determinants of latent tuberculosis infection in Medan, particularly in the Padang Bulan Community Health Center (UPT Padang Bulan), remains limited, highlighting the need for this study.

According to the Medan City Health Office report, by the end of 2022 there were 10,100 cases of active pulmonary tuberculosis. However, the number of latent TB cases is believed to be significantly higher, as many infected individuals remain asymptomatic. Epidemiological studies indicate that one in three infected individuals may develop latent TB, which can progress to active TB. Therefore, with the high number of active cases in Medan, the potential for transmission from undiagnosed latent TB cases is considerable (Dirjen P2P, 2023).

Several factors have been identified as being associated with latent TB infection, including age, duration of contact, clean and healthy lifestyle behavior, occupation, housing density, and BCG vaccination history. Increasing age is associated with a decline in immune function, making older and productive-age individuals more vulnerable to latent infections (Nopita et al., 2023). Prolonged close contact with active TB patients also represents a major risk factor, particularly in environments with poor ventilation (Karbito, 2023). Behavioral factors such as poor clean and healthy lifestyle behavior practices can increase the risk of TB transmission (Satria, 2020).

Occupational exposure is another contributing factor, particularly among healthcare workers who have frequent contact with TB patients (Ismah et al., 2024). Overcrowded housing conditions further facilitate the airborne spread of infectious diseases, including tuberculosis (Nopita et al., 2023). In addition, BCG vaccination has been proven to provide protection against TB infection, especially among children (Akbar B. et al., 2022).

A preliminary survey conducted at UPT Puskesmas Padang Bulan on January 23, 2025, recorded 40 patients receiving tuberculosis preventive therapy (TPT) for latent TB cases. However, this figure may not reflect a true increase in the incidence of latent TB, but it does reflect increased coverage of screening and contact tracing at health centers, leading to higher detection of latent TB cases. Nevertheless, the presence of 40 people in TPT indicates the presence of a substantial reservoir of

latent infection and requires further investigation. Based on observations and interviews, several factors were found to be associated with the occurrence of latent TB, including duration of contact, clean and healthy lifestyle behavior, occupation, and BCG vaccination history. Therefore, this study aims to analyze the factors associated with the occurrence of latent tuberculosis in the working area of UPT Puskesmas Padang Bulan in 2025.

2. Methods

This study is an analytic research with a cross-sectional design, aiming to analyze the factors associated with the occurrence of latent tuberculosis in the working area of UPT Puskesmas Padang Bulan in 2025. The independent variables in this study include age, duration of contact, type of occupation, clean and healthy lifestyle behavior, housing density, and history of BCG vaccination, while the dependent variable is the occurrence of latent tuberculosis. The research was conducted in the working area of UPT Puskesmas Padang Bulan from February to June 2025, involving a population of 80 individuals consisting of 40 patients with latent tuberculosis and 40 individuals with a history of contact with active TB patients. The sample consisted of 44 respondents, determined using the Slovin formula and selected through a purposive sampling technique based on specific inclusion and exclusion criteria relevant to the research objectives. Purposive sampling was chosen because this study required respondents who only met certain criteria, such as confirmed latent TB status or a history of contact with an active TB patient. This approach ensured that only individuals relevant to the study's objectives were included. To ensure the reliability of the interview and observation process, the questionnaire was expertly reviewed by two health workers familiar with the tuberculosis program. Researchers also followed a standardized interview guide to ensure consistency across respondents.

The data used in this study comprised primary, secondary, and tertiary data. Primary data were collected through questionnaires and direct observations, covering information on age, duration of contact, occupation, clean and healthy lifestyle behavior, housing density, and history of BCG vaccination. Latent TB status was also determined using community health center medical records, which included Tuberculin Skin Test (TST) results and clinical evaluation. Only individuals with a positive TST result and no radiological or clinical signs of active TB were classified as having latent TB. Secondary data were obtained from existing records and reports from UPT Puskesmas Padang Bulan, while tertiary data were derived from credible scientific literature, textbooks, and previous research studies. The collected data underwent several stages of processing, including editing, coding, entry, and tabulation, before being analyzed. Univariate analysis was conducted to describe the characteristics of the respondents, while bivariate analysis using the Chi-Square test ($\alpha = 0.05$) was employed to examine the relationship between independent variables and the occurrence of latent tuberculosis. The results were considered statistically significant if the *p*-value was less than 0.05. Other potential contributing factors, such as nutritional status, comorbidities, and immune status, have been identified; however, these variables were not included in the current analysis due to data limitations. Their potential influence on the association between the independent variables and latent TB was considered in interpreting the findings. Prior to statistical analysis, data cleaning and verification were performed to ensure the accuracy of the data obtained and processed. The assumptions of the chi-square test, including the expected number of cells and the independence of observations, were checked before interpreting the results. Inclusion criteria for this study included individuals aged 15 years and older who resided within the Padang Bulan Community Health Center (Puskesmas) working area, had documented Tuberculin Skin Test (TST) results, and were classified as latent TB cases or close contacts of active TB patients. If individuals were <15 years old, their parents or relatives were interviewed. Exclusion criteria included individuals with incomplete medical records, those exhibiting symptoms suggestive of active TB, and respondents unwilling to participate in the study. The sample size of 44 respondents was determined using the Slovin formula with a population (N) of 80 and a margin of error $(d)^2$ of 0.1.

The questionnaire used in this study was not statistically tested for validity and reliability; however, to ensure reliability and consistency of the interview and observation process, the instrument

was reviewed by two healthcare professionals experienced in tuberculosis programs. The researchers also used a standardized interview guide to ensure uniformity among all respondents.

Data analysis was conducted using SPSS version 22. Ethical considerations included providing respondents with information about the purpose, procedures, and confidentiality of the study. Participation was voluntary, and respondents were given the option to agree ("willing") or refuse ("not willing") before completing the questionnaire. No identifying information was collected, and respondent anonymity was strictly maintained.

3. Results and Discussion

Results

This study involved 44 respondents consisting of individuals with latent tuberculosis and those with a history of contact with active TB patients in the working area of UPT Puskesmas Padang Bulan, Medan. All respondents met the inclusion criteria and completed the data collection process; no respondents refused participation and no data were excluded from analysis. The analysis included six independent variables; age, duration of contact, occupation, clean and healthy lifestyle behavior, housing density, and BCG vaccination history while the dependent variable was the occurrence of latent tuberculosis.

Table 1.
Relationship Between Independent Variables and Latent Tuberculosis Incidence

Variable	p-value	Significance
Age	0.160	Not Significant
Duration of Contact	0.037	Significant
Occupation	0.044	Significant
clean and healthy lifestyle behavior	0.042	Significant
Housing Density	0.019	Significant
BCG vaccination history	0.019	Significant

Source: Processed Primary Data, 2024

The study involved 44 respondents residing in the working area of UPT Padang Bulan Health Center. Most respondents were in the productive age group, with a balanced distribution of males and females. The majority had a moderate level of education and occupations varying from private employees to housewives.

Based on bivariate analysis using the Chi-square test ($\alpha = 0.05$), several variables showed a significant relationship with the incidence of latent tuberculosis infection (LTBI). Duration of contact ($p = 0.037$), occupation ($p = 0.044$), clean and healthy living behavior ($p = 0.042$), housing density ($p = 0.019$), and BCG vaccination history ($p = 0.019$) were found to have statistically significant associations with LTBI.

In contrast, age did not show a significant association with LTBI incidence ($p = 0.160$). This suggests that latent TB infection can occur across various age groups and is more strongly influenced by behavioral and environmental factors.

Respondents who had close or prolonged contact with active TB patients were more likely to test positive on the Tuberculin Skin Test (TST). Likewise, those living in crowded housing conditions or lacking proper ventilation demonstrated higher LTBI prevalence. Respondents without BCG vaccination history also had a greater likelihood of infection. Overall, these results indicate that both individual and environmental determinants play an essential role in the spread of latent TB in the community.

Discussion

The results of this study revealed that five variables duration of contact, occupation, clean and healthy lifestyle behavior (CHLB), housing density, and BCG vaccination history had a statistically significant association with the incidence of latent tuberculosis ($p < 0.05$), while age did not show a significant correlation ($p = 0.160$). These findings indicate that behavioral, environmental, and preventive factors play a dominant role in influencing latent TB infection within the working area of UPT

Puskesmas Padang Bulan. The findings of this study are consistent with national data showing that close contact, housing conditions, and BCG vaccination remain key determinants of tuberculosis infection in Indonesia. According to the 2022 National TB Report, household contact screening and overcrowded living environments are among the strongest predictors of latent TB, particularly in high-burden provinces such as North Sumatra. Similar patterns are observed in Medan, which is among the regions with the highest TB burden, where more than 50% of close contacts screened were found at risk for latent infection. The significant association between duration of contact, housing density, and BCG vaccination in this study aligns with these national and regional findings, suggesting that the epidemiological pattern in Padang Bulan reflects broader trends observed in Indonesia.

Although age was not statistically related to latent TB, the role of aging in immune resilience should not be overlooked. Older adults have diminished immune responses, predisposing them to infection, especially when compounded by comorbidities such as diabetes or HIV. Zhou et al., 2023 and Audina et al., 2025 both confirmed diabetes as an independent predictor of latent TB due to immune dysfunction. However, the lack of significance in this study may reflect the relatively uniform age structure of respondents. This non significant finding is influenced by the homogeneity of the sample, where the narrow age range of respondents reduces variability and weakens statistical differences between groups. Similar observations were reported by Nopita E., Suryani L., 2022, who found that environmental and housing factors often outweigh age in influencing TB risk. The WHO, 2022 further emphasized that biological aging interacts with social determinants, particularly ventilation and household crowding, to shape infection vulnerability.

The duration of contact emerged as a key determinant of latent TB. Longer or repeated exposure to individuals with active TB markedly increases the risk of infection through inhalation of *Mycobacterium tuberculosis* aerosols. This aligns with Karbito, 2023, who identified prolonged cohabitation as a major transmission driver. Meta-analyses among people living with HIV also confirmed duration of contact as a global risk factor for LTBI (Zhang et al., 2023). In addition, Assefa, 2023 explained that infection exists on a continuum, where cumulative exposure accelerates the transition from latent to active disease. Preventive strategies such as household ventilation, mask use, and tuberculosis preventive therapy (TPT) are therefore essential for close contacts (Coleman et al., 2023).

Occupational exposure also showed a significant relationship with LTBI. Occupations involving frequent public interaction or direct patient contact, such as healthcare work and informal trade, heighten exposure risk. Ismah et al., 2024 demonstrated that healthcare workers have higher latent TB rates due to continuous contact with infected patients. Comparable findings were observed in the Turkish study Assefa, 2023, which reinforced the need for periodic screening among high-risk professions. Moreover, socioeconomic limitations particularly among informal laborers restrict access to protective measures, as observed in the (Deniati et al., 2022). Strengthening occupational health surveillance and infection control in the workplace remains crucial to breaking transmission chains.

Clean and healthy lifestyle behavior (CHLB) was found to be another significant determinant. Individuals lacking basic hygiene practices, such as maintaining household ventilation or avoiding indoor smoking, experienced higher rates of infection. This result aligns with Satria, 2020, who showed that poor CHLB triples the risk of pulmonary tuberculosis. Ariyani et al., 2023 further emphasized that community education and family involvement can effectively improve adherence to preventive behavior. Similarly, Wong et al., 2023 stressed the need for tailored behavioral interventions in marginalized communities. These findings reaffirm that behavior-centered education programs can substantially lower LTBI prevalence when combined with environmental improvements.

Housing density and environmental conditions also had a notable influence on LTBI occurrence. Overcrowding increases airborne transmission potential, particularly in poorly ventilated or humid dwellings. The current findings support Adinda Mega Putri et al., 2022, who reported that ventilation, wall type, and humidity significantly affect TB risk. Studies conducted in Indonesia Irwan et al., 2024 (confirmed that sunlight exposure and air circulation strongly modulate transmission risk. Spatial analyses in Yogyakarta by Ardiyanti & Puratmaja, 2021 and Helmy et al., 2022 further demonstrated

clustering of TB cases in densely populated areas. Environmental interventions such as ventilation improvement and housing redesign remain indispensable in TB prevention efforts.

The interaction between environmental and behavioral factors plays a significant role in shaping the risk of latent TB infection. Poor living conditions, such as overcrowding, limited ventilation, and minimal exposure to sunlight, create an environment that allows Mycobacterium tuberculosis to persist in the air for extended periods. When these environmental risks are combined with inadequate hygiene and health practices, such as inadequate ventilation, prolonged indoor stays, or the lack of mask use when in contact with TB patients, the likelihood of infection increases substantially. Therefore, behavioral practices either amplify or mitigate the effects of environmental exposures, suggesting that latent TB transmission in the community is influenced not by isolated factors, but by the interaction of daily habits and living conditions.

The protective effect of BCG vaccination was also confirmed in this study. Participants with no history of BCG vaccination were more likely to test positive for latent infection. Akbar B. et al., 2022 demonstrated that BCG immunization significantly lowers TB incidence by enhancing long-term immune memory. *Latent Tuberculosis Infection in Children: Diagnosis and Management by* Kaswandani et al., 2022 reaffirmed that early vaccination provides partial protection even against latent infection. Maintaining high BCG coverage, particularly among infants and healthcare workers, supports the national TB control strategy outlined in the *Kemenkes RI STRANAS TB 2020–2024*.

Moreover, preventive pharmacological approaches remain essential, as reviews have shown that tuberculosis preventive therapy (TPT) significantly reduces reactivation risk among high-risk populations (Yoopetch et al., 2023). Overall, the findings highlight the complex interaction between behavioral, environmental, and preventive factors in shaping latent TB risk. Integrated health interventions that combine individual behavior change, household environmental improvement, and vaccination coverage expansion are necessary to reduce the burden of latent TB in UPT Puskesmas Padang Bulan.

4. Conclusion

This study concludes that several factors namely duration of contact, occupation, clean and healthy lifestyle behavior, housing density, and BCG vaccination history are significantly associated with the incidence of latent tuberculosis in the working area of UPT Puskesmas Padang Bulan in 2025. Meanwhile, age showed no significant relationship with latent TB occurrence, suggesting that environmental and behavioral determinants play a greater role than biological factors in influencing infection risk. The uniqueness of this study lies in its focus on a high-burden work area with intensive contact tracing activities, where latent TB detection has increased following the expansion of TPT screening. Unlike many latent TB studies conducted at the provincial or national level, this study provides micro-level evidence from community health centers, offering local insights into transmission dynamics in densely populated environments. This is an understudied context and fills an important evidence gap. The findings also provide concrete implications for evidence-based policy. Strengthening community-based health promotion, improving household ventilation standards and housing density, expanding BCG vaccination coverage, and intensifying screening among high-risk occupational groups can be integrated into local TB control strategies. These insights can support the Padang Bulan Community Health Center (UPT Puskesmas) and the Medan City Health Office in designing targeted interventions and prioritizing resource allocation based on risk profiles. The results highlight the importance of strengthening preventive measures through public education, improving housing conditions, and maintaining BCG vaccination coverage as part of community-based TB control programs. This research contributes to the understanding of local TB epidemiology by emphasizing modifiable risk factors that can be addressed through health promotion and early screening. However, this study was limited by its cross-sectional design and relatively small sample size, which may restrict causal interpretation. To strengthen causal inference, future research should employ a longitudinal cohort design that tracks individuals over time to observe the progression from exposure to latent or active TB infection. This design allows for a clearer understanding of temporal relationships and a more accurate assessment of causality among identified risk factors. Future research should explore longitudinal

analyses and include additional variables such as nutritional status, comorbidities, and treatment adherence to develop a more comprehensive prevention strategy. Overall, these findings support the need for an integrated, multi-sectoral approach to reduce the burden of latent tuberculosis in urban communities.

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