Original Article

Individual and Environmental Factors Associated with Pulmonary Tuberculosis: A Cross-Sectional Study in an Urban Community

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ABSTRACT

Background: Tuberculosis is a contagious disease caused by the bacterium Mycobacterium tuberculosis. TB cases have increased at the Balongsari Health Center in recent years. The research aims to analyze individual and environmental factors related to pulmonary tuberculosis incidence at the center.

Methods: This study applied the STROBE guidelines. It was an analytical observational study using a cross-sectional design. The study population comprised 152 tuberculosis (TB) patients and TB suspects registered at the Balongsari Health Center between January and December 2022. The sample consisted of pulmonary TB patients (TCM+) and TB suspects (TCM−) in a 1:1 ratio, selected through simple random sampling. The variables assessed included age, sex, HIV/AIDS status, diabetes mellitus, nutritional status, smoking history, lighting conditions, and housing occupancy density. Data were analyzed using the Chi-Square test.

Results: The analysis showed that the factors significantly associated with the incidence of pulmonary tuberculosis at the Balongsari Health Center were age ($p = 0.01$), diabetes mellitus ($p < 0.001$), nutritional status ($p < 0.001$), smoking history ($p < 0.001$), and lighting conditions ($p < 0.001$). In contrast, gender ($p = 0.15$), HIV/AIDS status ($p = 0.08$), and occupancy density ($p = 0.10$) were not significantly associated with the incidence of pulmonary tuberculosis.

Conclusion: Factors associated with the incidence of pulmonary tuberculosis included age, diabetes mellitus, smoking history, nutritional status, and lighting conditions. Conversely, gender, HIV infection, and occupancy density were not associated with pulmonary tuberculosis incidence.

Keywords: Individual, Environmental, Pulmonary, Tuberculosis.

Implications for Practice:

- Treat and strengthen screening strategies for high-risk groups, including individuals with diabetes mellitus, smoking history, and undernutrition.
- Integrate environmental interventions, such as improving household lighting, into routine tuberculosis control programs.
- Utilize these findings to refine local tuberculosis prevention guidelines, ensuring they are adaptable to low- and middle-income country (LMIC) contexts.

Introduction

Tuberculosis is still a global health problem, including in Indonesia, with complex medical, social, economic, and cultural impacts (Choliq et al., 2020) . Tuberculosis is an infectious disease caused by Mycobacterium tuberculosis, with rising incidence and mortality rates (Tornu & Quarcoopome, 2022). An increase in tuberculosis cases also occurred in the Balongsari Health Center area. Causative factors include germs, individuals, and the environment, but the influence of each has not been explained. According to *the Global* Tuberculosis Report 2021, there are 9.9 million cases of TB in the world, with Indonesia ranking third highest after India and China, with 824,000 cases (Ritchie & Horton, 2023) . National TB data for the first and second quarters of 2022 shows that East Java ranks 8th with 27,677 cases, of which Surabaya accounts for 29.9%. Based on SITB, confirmed cases in Surabaya increased from 4,151 (2020) to 6,950 (2022). At the Balongsari Health Center, cases increased from 58 (2020) to 100 (2022), or an increase of 92 (Sofiana & Nugraheni, 2022). Balongsari Health Center ranks 3rd after the Orange Health Center and Putat Jaya Health Center.

The working area of the Balongsari Health Center is near industrial and warehousing areas, so many migrants settle in dense boarding houses and squeeze each other. The incidence of tuberculosis is influenced by three factors: germs (Mycobacterium tuberculosis), individuals (such as low immunity, HIV/AIDS, malnutrition, diabetes, and smoking), and the environment (such as poor lighting and housing density) (Fauziah et al., 2024).

Research at the Cipayung Health Center, Depok, showed that contact history and smoking behavior were related to the incidence of tuberculosis (Rosyanti et al., 2020). Rusdianto's research shows the relationship between contact history and smoking with the incidence of tuberculosis in the Inobonto Health Center area (Rusdianto, 2020). Risk factors for tuberculosis include low body mass index, lack of sunlight at home, lack of artificial ventilation, and a history of contact with patients (Pralambang & Setiawan, 2021). Efforts to detect new cases through active and passive screening represent concrete actions to interrupt tuberculosis transmission in the community (Nguyen et al., 2024). Breaking the chain of tuberculosis transmission is a collective responsibility. Therefore, it is essential to investigate individual and environmental factors that contribute to tuberculosis incidence in urban settings (Zahroh et al., 2023).

Methods

Study Design

The study used a cross-sectional observational design and was reported in accordance with the STROBE guidelines.

Participants

The study population comprised tuberculosis (TB) patients with positive TCM results and TB suspects with negative TCM results who underwent examination and treatment at the Balongsari Public Health Center, Surabaya, Indonesia, between January and December 2022, totaling 180 individuals. The study was conducted at the same health center. A probability sampling approach was used, and the sample was selected via simple random sampling, yielding 124 respondents.

The inclusion criteria were bacteriologically confirmed TB patients (TCM-positive) and TB-suspect patients (TCM-negative) registered in the SITB application of the Balongsari Public Health Center between January and December 2022; individuals who were not severely ill and able to communicate effectively. No

respondents were excluded during the study.

Instruments

The research instrument was a structured questionnaire developed to address the study objectives and answer the research questions. Demographic and individual characteristics were collected using the questionnaire, which included respondent identifiers, sociodemographic information, nutritional status, smoking history, lighting conditions, and occupancy density (Nursalam, 2020).

Instrument validity was assessed using item–total correlation, with values ≥ 0.30 considered acceptable. Reliability was evaluated using Cronbach's alpha, with coefficients ≥ 0.70 indicating satisfactory internal consistency.

Data Collection

Respondents provided written informed consent after receiving information about the study and agreeing to participate, which constituted the initial stage of data collection. Research data were obtained using a closed-ended questionnaire covering individual factors (age, gender, smoking history, HIV/AIDS status, diabetes history, and nutritional status) and environmental factors (population density and lighting) (Gunawan, 2019). Data collection was carried out in June 2023 by the research team, who ensured accuracy and completeness of all collected information.

Data Analysis

Data were analyzed using the Chi-square test, with statistical significance set at $p < 0.05$. All analyses were performed using SPSS software, version 16.

Ethical Considerations

This study received ethical approval from the Health Research Ethics Committee of Universitas Nahdlatul Ulama Surabaya (Decree No. 0193/EC/KEPK/UNUSA/2022).

Results

Table 1. Cross tabulation of respondents' individual factors and incidence of tuberculosis (n=124)

Individual Factor	Tuberculosis incident				P value	OR
	Yes		No			
	n	%	n	%		
Age						
Non Productive	17	35.4	31	64.6	0.01	6.737
Productive	45	59.2	31	40.8		
Gender						
Woman	29	43.9	37	56.1	0.15	2.08
Man	33	56.9	25	43.1		
Smoking history						
Smoker	59	84.3	11	15.7	0.00	87.84
Not a smoker	3	5.6	51	94.4		
HIV/AIDS Infection						
Positive	0	0	3	10	0.24	4.23
Negative	62	51.2	59	48.8		
Diabetes Mellitus						
DM	32	74.4	11	25.6	0.00	16.22
Non DM	30	37.1	51	62.9		
Nutritional status						
Malnutrition	46	92	4	8	0.00	67.33

Individual Factor	Tuberculosis incident				P value	OR
	Yes		No			
	n	%	n	%		
Normal	10	19.2	42	80.8		
Overnutrition	6	27.3	16	72.7		

Table 1 illustrates the dietary association between individual characteristics and tuberculosis incidence. Productive-age respondents were significantly more likely to experience tuberculosis than their non-productive counterparts, and this age group showed a markedly elevated odds ratio. Gender did not demonstrate a statistically significant relationship with disease incidence.

Individuals with a history of smoking showed a powerful association with tuberculosis, reflected in an exceptionally high odds ratio, indicating smoking as a major risk determinant. Conversely, HIV/AIDS status did not show a significant effect in this cohort.

Diabetes mellitus emerged as a statistically significant predictor, with diabetic individuals exhibiting substantially higher risk compared to non-diabetics. Nutritional status was also strongly linked to tuberculosis: those with malnutrition had the highest probability of infection relative to those with normal or excessive dietary status.

Table 2. Cross tabulation of respondents' environment factor and incidence of tuberculosis (n=124)

Environmental Factor	Tuberculosis incident				P value	OR
	Yes		No			
	n	%	n	%		
Occupancy density						
Congested	15	65.2	8	34.8	0.11	2.65
Not congested	47	46.5	54	53.5		
Illumination						
Bad/gloomy	55	62.5	33	37.5	0.00	19.99
Good	7	19.4	29	60.6		

Table 2 illustrates the association between environmental conditions and tuberculosis incidence. Although respondents living in congested housing showed a higher likelihood of tuberculosis than those in non-congested settings, this relationship did not reach statistical significance.

Conversely, household illumination showed a strong, significant association with tuberculosis. Individuals residing in poorly lit environments were substantially more likely to develop tuberculosis, reflected in a markedly elevated odds ratio. At the same time, adequate lighting appeared to play a protective role against infection.

Discussion

In this study, age was categorized into two groups: productive age (15–58 years) and non-productive age (<15 years and >58 years). The bivariate analysis showed a significant association between age and the incidence of TB at Balongsari Surabaya-Indonesia Public Health Center, Surabaya. Individuals in the productive age group had a 6.7-times higher risk of developing pulmonary tuberculosis compared to those in the non-productive age group. These findings are consistent with Hiswani's 2010 study, which identified age, education, knowledge, and occupation as population characteristics associated with a higher risk of tuberculosis (Zahroh et al., 2023).

According to the Global TB Report 2024, the highest number of tuberculosis cases occurs among individuals in the productive age group, particularly those aged 25–34 and 45–54 years (Samsugito & Hambyah, 2018). This age is the age when the majority of people work and have high mobility, so the possibility of contact with TB sufferers is greater (Agustian et al., 2022).

In this study, the respondents' diabetes mellitus (DM) status was obtained from their medical records. The bivariate analysis showed a significant association between DM and TB incidence at Balongsari Public Health Center, Surabaya. Individuals with DM had a 16-times higher risk of developing pulmonary tuberculosis compared to those without DM. Diabetes is a known risk factor that can delay sputum conversion in TB patients, increasing both the risk of transmission and the potential for drug resistance (Sofiana & Nugraheni, 2022). DM disease is an independent risk factor for activation of latent TB infection (Safitri & Mahyuvi, 2024). Diabetes can be a cause of worsening of symptoms and increase the severity of TB infection (Ho et al., 2016).

The bivariate analysis showed a significant association between nutritional status and the incidence of TB at Balongsari Surabaya-Indonesia Public Health Center, Surabaya. Individuals with poor nutritional status had a 67-times higher risk of developing pulmonary tuberculosis compared to those with normal or above-normal nutritional status. These findings are consistent with previous research (Izzati et al., 2015, which found a significant relationship between nutritional status and the incidence of tuberculosis in the Andalas Health Centre service area. This suggests that individuals with poor nutritional status are 9.4 times more likely to develop TB compared to those with normal or excess nutritional status. Inadequate nutrition impairs T-lymphocyte-mediated immunity, making individuals more susceptible to infections, including tuberculosis (Potty et al., 2023).

The bivariate analysis showed a significant association between smoking history and the incidence of TB at Balongsari Surabaya-Indonesia Public Health Center, Surabaya. Smokers had an 87-times higher risk of developing pulmonary tuberculosis compared to non-smokers. These findings are consistent with the study by Hapsari et al., which also reported a significant relationship between smoking history and TB incidence among patients in the Srondol Health Centre service area in Semarang (Hapsari et al., 2013). Although smoking is not the primary cause of tuberculosis, it can impair the lung's defense mechanisms, making it easier for pathogens like the TB bacteria to invade and cause infection (Fauziah et al., 2024).

The bivariate analysis showed a significant association between household lighting and the incidence of TB at Balongsari Surabaya-Indonesia Public Health Center, Surabaya. Houses with poor (dark) lighting had a 19 times higher risk of developing pulmonary tuberculosis than houses with adequate (bright) lighting. These findings are consistent with the study by Monintja (2020), which found a significant association between natural lighting and pulmonary tuberculosis in the Bailaing Health Centre service area. According to research, Individuals living in homes with inadequate lighting are 4.214 times more likely to develop pulmonary tuberculosis compared to those living in well-lit homes. Many types of bacteria, including the tuberculosis bacillus, can be destroyed by direct sunlight. Ultraviolet (UV) rays from sunlight, especially in the morning, are effective in killing germs, making early sunlight exposure beneficial for maintaining a healthy living environment. (Ritchie & Horton, 2023).

A healthy home must have adequate sunlight—neither too little nor excessive. Insufficient sunlight, especially natural sunlight, can create an uncomfortable environment and provide a suitable breeding ground for disease-causing germs. Sunlight is essential because it can eliminate pathogenic bacteria inside the home, including Mycobacterium tuberculosis. Therefore, a healthy house should have window openings or light sources that amount to at least 15% of the total floor area to ensure proper natural lighting (Monintja, 2020). Limitation. Since the majority of the TB patients at the Urban Health Centre were adults, the study's limitation is that it collected samples only from adult patients.

Implications and limitations

This study presents the magnitude of association between selected factors and the incidence of pulmonary tuberculosis, including age, sex, HIV/AIDS status, diabetes mellitus, nutritional status, smoking history, lighting, and housing density. Although multiple determinants influence pulmonary tuberculosis, only a subset of factors was examined due to constraints related to the researchers' knowledge scope, time availability, resources, funding, and equipment. Consequently, the findings should be interpreted in light of these limitations.

Relevance to Practice

These findings highlight the need for targeted promotive and preventive interventions based on identified individual and environmental risk factors. Community nurses and primary health professionals should prioritize screening among productive-age adults, smokers, people with diabetes, and individuals with poor nutritional status, as they exhibit greater vulnerability to tuberculosis. Moreover, the environmental results suggest that improving household lighting and monitoring overcrowding should be considered as part of home-based prevention strategies. This underscores the importance of health education, behavior change advocacy, improvements in housing and sanitation, and cross-sector collaboration to create healthier living conditions and reduce tuberculosis incidence within communities.

Conclusion

The study demonstrates that both individual and environmental factors contribute meaningfully to tuberculosis incidence. Productive age, smoking history, diabetes, poor nutritional status, and inadequate household lighting were strongly associated with higher risk, while housing congestion showed a weaker effect. These findings emphasize that tuberculosis prevention requires a dual approach—addressing modifiable personal risks and improving living conditions—to reduce disease burden in affected communities effectively.

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CrediT Authorship Contributions Statement

Chilyatiz Zahroh: Conceptualization, Methodology, Supervision, Writing - Original Draft

Sudarianik: Conceptualization, Methodology, Supervision, Writing - Original Draft

Eppy Setiyowati: Software, Validation, Formal Analysis, Writing - Review & Editing

Nur Ainiyah: Investigation, Resources, Data Curation, Project Administration

Umdatus Soleha: Writing - Original Draft, Review & Editing, Visualization, Funding Acquisition
Mulyadi: Writing - Original Draft, Review & Editing, Visualization, Funding Acquisition

Conflicts of Interest

This research has no conflict of interest.

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