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Original Research

RISK FACTORS FOR PULMONARY TUBERCULOSIS IN RURAL AREAS OF TILANGO HEALTH CENTER, GORONTALO

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ABSTRACT

Risk Factors for Pulmonary Tuberculosis in Rural Areas of Tilango Health Center, Gorontalo. *The Ministry of Health of the Republic of Indonesia has set a target for pulmonary tuberculosis (TB) elimination by 2030; however, its implementation still faces various challenges in the field. This study aimed to describe the prevalence of pulmonary TB and examine the influence of indoor air quality and a history of diabetes mellitus (DM) on pulmonary TB incidence within the working area of Tilango Health Center, Gorontalo Regency. A case-control study design was employed, with each study group comprising 54 participants. The results showed that Tabumela Village recorded the highest proportion of pulmonary TB cases (31.5%), with most patients being male (55.6%) and aged 45–54 years (25.9%). Environmental factor analysis indicated that natural lighting was significantly associated with pulmonary TB incidence (p = 0.020), whereas humidity, temperature, and household ventilation (p = 0.837; 0.837; 0.558) did not show a significant relationship. A history of BCG immunization and previous COVID-19 infection (p = 0.643; 0.558) were also not significantly associated with pulmonary TB. Conversely, a strong association was observed between DM and pulmonary TB incidence (p < 0.001), indicating that individuals with DM have a higher risk. These findings underscore that pulmonary TB prevention requires improving natural lighting in homes, managing DM, and implementing integrated strategies through housing environment improvements and community education.*

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INTRODUCTION

Tuberculosis (TB) remains a significant public health issue in Indonesia, including in rural areas. Data from the World Health Organization (WHO) indicate that Indonesia is among the five countries with the highest TB burden globally[(1)]. Pulmonary TB incidence is often associated with low socioeconomic conditions, limited access to healthcare services, and unhealthy lifestyle practices, which are more prevalent in rural areas compared to urban settings[(2)]. Therefore, studies on the prevalence and risk factors of TB in rural regions are essential to strengthen prevention and control efforts.

The Ministry of Health of Indonesia has set a target for the elimination of pulmonary tuberculosis by 2030. However, field realities show significant challenges in achieving this goal[(3)]. Over three consecutive years (2022–2024), Gorontalo Regency reported the highest pulmonary TB prevalence in Gorontalo Province, with 1,219, 1,171, and 1,607 cases, respectively[4][5][6]. For instance, in Tilango District, Gorontalo Regency, pulmonary TB prevalence remains high, with 55 reported cases, including one death, resulting in a study population of 54 subjects. These data indicate the need for intensive efforts and more effective strategies to reduce pulmonary TB incidence in the area.

Risk factors for pulmonary TB in rural areas also involve individual health dimensions, such as poor nutritional status, history of close contact with TB patients, and community awareness of disease symptoms[7]. In addition, social stigma against TB patients in rural communities often hinders access to adequate treatment. This phenomenon highlights the importance of a holistic approach in TB research, encompassing not only medical but also social and cultural aspects[8]. Emphasizing environmental and individual health factors was chosen as the main focus of this study because these dimensions are specific determinants of TB risk in rural areas that have received less attention compared to clinical interventions, yet they are crucial for interrupting local transmission chains.

Tilango District in Gorontalo Regency remains a region facing major challenges in controlling pulmonary TB. The area has unique socio-cultural characteristics, with most residents working in agriculture and fisheries[9]. Previous studies indicate that rural areas like Tilango tend to have higher TB prevalence than urban areas due to environmental risk factors, such as biomass smoke exposure and poor household ventilation. Recent data from the Gorontalo Health Office also report pulmonary TB cases in recent years, despite ongoing TB control programs[10].

Research on TB prevalence and risk factors in Tilango District remains limited, although the area presents a high-risk profile. Most prior studies have focused primarily on clinical aspects or treatment, without considering local risk factors that may contribute to disease transmission. Therefore, more comprehensive research is needed to explore the epidemiological patterns of TB in this area.

This study aims to identify the prevalence and risk factors of TB in Tilango District in 2024, with a primary focus on understanding how environmental and individual health factors contribute to TB incidence. The findings are expected to provide valuable insights for TB control programs at both local and national levels. Thus, this research not only offers scientific evidence on TB in rural settings but also serves as a basis for evidence-based interventions. The study supports Indonesia's vision of achieving pulmonary TB elimination by 2030, as mandated by WHO and the Ministry of Health of Indonesia[1][3].

MATERIALS AND RESEARCH METHODS

This study is an analytical observational study with a case-control design aimed at identifying the prevalence and risk factors of pulmonary tuberculosis (TB) incidence in the rural areas of Tilango District, Gorontalo Regency, during the period of January–August 2024. A total of 54 pulmonary TB cases were recorded during this period, and with a 1:1 case-control ratio, the total study population comprised 108 participants. The case-control design was chosen due to its efficiency in assessing the relationship between exposure to risk factors, particularly residential environmental factors, and pulmonary TB incidence as the dependent variable.

The case group consisted of pulmonary TB patients registered and diagnosed both clinically and bacteriologically at Tilango Health Center. Inclusion criteria included TB patients aged ≥15 years, residing within the study area, and willing to participate, while exclusion criteria included patients with extrapulmonary TB, individuals with severe immunocompromised conditions, and respondents unable to complete the interview. The control group was selected from the surrounding community without pulmonary TB. Inclusion criteria for controls were age matched ±2 years with cases, residence in the same environment, and no history of pulmonary TB based on examination and medical records, whereas exclusion criteria included a previous history of TB or clinical symptoms suggestive of TB.

A 1:1 case–control ratio was applied to enhance statistical power and maintain balanced distribution of baseline characteristics between groups, considering the limited number of cases available in the study area. The study was conducted across the entire working area of Tilango Health Center, which encompasses eight villages: Lauwonu, Tinelo, Tenggela, Tualangu, Dulomo, Tilote, Ilotidea, and Tabumela. Bias control measures included selecting controls from the same environment as cases to minimize selection bias, standardizing environmental variable measurements using uniform instruments and methods to reduce measurement bias, and validating disease history data by cross-referencing interview responses with medical records and TB registers at the Health Center to reduce recall bias and enhance data validity.

Independent variables examined included indoor temperature (°C), relative humidity (%), natural lighting (lux), history of BCG immunization, history of COVID-19 diagnosis, and history of diabetes mellitus (DM). Temperature and relative humidity were measured using a digital thermo-hygrometer. Lighting was measured using a luxmeter according to SNI 7062-2019 Amendment1-2020[11], with measurement points focused on the areas where participants predominantly performed daily activities. DM history was obtained from secondary data of TB patients at the Health Center, whereas control group data were collected through interviews regarding disease history and the most recent blood glucose test results.

Primary data were collected through interviews, physical measurements, and direct observation of respondents' homes. Secondary data were obtained from Tilango Health Center health records for January–August 2024, with data collection conducted in September–October of the same year. Statistical analysis included the Chi-Square test to assess associations between independent and dependent variables, and logistic regression to identify the most influential risk factors. This analytical approach ensures accurate and relevant results to inform evidence-based interventions in rural areas.

RESEARCH RESULTS AND DISCUSSION

Tilango District is one of the areas in Gorontalo Regency, located at coordinates 0°33'25.31941"N 123°01'27.47420"E. The district covers an area of 8.70 km^2 with a population density of 1,923 inhabitants per km^2. Administratively, it consists of eight villages: Tualanngo, Dulomo, Tilote, Tabumela, Ilotidea, Lauwonu, Tenggela, and Tinelo. Tenggela Village has the largest area within the district, measuring 1.89 km^2, which accounts for 18.58% of the total district area. Tilango District is situated at an elevation of 7–19 meters above sea level. The average annual rainfall in the area in 2023 was 105.32 mm, which is generally considered low. Nevertheless, the average relative humidity was 80%, which is classified as suboptimal[12].

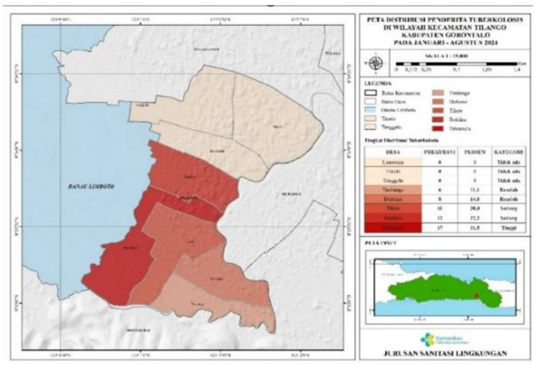

Figure 1. Distribution of Pulmonary TB Cases
by Village in the Tilango Health Center Working Area, 2024

Data collection for this study was conducted from September to October 2024; therefore, the maximum reference for case data was August 2024. A total of 55 pulmonary TB cases were recorded in the Tilango Health Center working area from January to August 2024. One patient had died and was therefore excluded from the study. Based on Figure 1, Tabumela Village had the highest prevalence, with 17 cases (31.5%). Conversely, three villages—Lauwonu, Tinelo, and Tenggela—reported no pulmonary TB cases during the January–August 2024 period.

The physical air quality parameters measured in this study included indoor temperature (°C), relative humidity (%), and natural lighting (lux). The analysis of the association between these physical air quality factors and pulmonary TB incidence in the Tilango Health Center working area, Gorontalo Regency, is presented as follows.

Table 1. Association Between Indoor Temperature and Pulmonary TB Incidence in the Tilango Health Center Working Area, 2024

Respondent Group	Indoor Temperature				Total	%	*p-value*
	NS	%	S	%			
Cases	18	33,3	36	66,7	54	100	0,837
Controls	17	31,5	37	68,5	54	100	

Based on Table 1, out of 54 respondents in the case group, 36 individuals (66.7%) resided in homes with temperatures meeting the criteria. In the control group, 37 respondents (68.5%) lived in homes with adequate temperatures. The Chi-Square test indicated no significant association between pulmonary TB incidence and indoor temperature. Indoor air temperature is influenced by several factors, including outdoor environmental temperature, household humidity levels, the presence of windows and closed ventilation, and the use of glass panels. These findings are consistent with previous research reporting that temperature was not significantly associated with pulmonary TB incidence in the Serang City Health Center working area[13]. In contrast, a study in Kuala Tungkal II, Jambi, reported a significant association between household temperature and pulmonary TB, with a p-value of 0.006[14].

The present study tends to support the findings from Serang City Health Center. Mycobacterium tuberculosis grows optimally at 37°C, which does not correspond to the ideal residential temperature range (18–30°C)[15]. The mean indoor temperature in the case group was 30.63°C, while in the control group it was 31.33°C. Overall, the average household temperature among respondents was suboptimal but still below the optimal range for bacterial growth[13]. Nevertheless, the number of case group homes with suboptimal temperature was lower than those meeting the ideal criteria. The lack of significant correlation may be influenced by other variables, such as humidity, lighting, window presence, and ventilation area[14].

Table 2. Association Between Indoor Relative Humidity and Pulmonary TB Incidence in the Tilango Health Center Working Area, 2024

Respondent Group	Indoor Relative Humidity				Total	%	*p-value*
	NS	%	S	%			
Cases	18	33,3	36	66,7	54	100	0,837
Controls	17	31,5	37	68,5	54	100	

Based on Table 2, out of 54 respondents in the case group, 36 individuals (66.7%) resided in homes with relative humidity levels meeting the standard. In the control group, 37 respondents (68.6%) lived in homes with adequate humidity levels. The Chi-Square test indicated no significant association between pulmonary TB incidence and household relative humidity. These findings are consistent with previous research conducted in the Turikale Health Center working area, Maros Regency, which reported that indoor humidity did not significantly affect pulmonary TB incidence[16]. Similarly, other studies have found no meaningful association between household humidity and pulmonary TB occurrence. This suggests that indoor relative humidity may not be a primary determinant of TB transmission, highlighting the importance of other factors such as ventilation, lighting, and household crowding in disease prevention strategies[17].

The categorization of indoor relative humidity in this study was based on the Ministry of Health Regulation No. 2 of 2023, which defines the ideal RH as 40–60%[15]. Other studies have reported that RH levels below 50% can significantly affect pulmonary TB incidence, potentially related to the disease's incubation period. Some research suggests that relative humidity has a greater impact on airborne diseases with shorter incubation periods, such as rhinitis and asthma. Pulmonary TB, however, has an incubation period of 4–8 weeks, so brief exposure to suboptimal RH is unlikely to exert a meaningful effect[18].

In contrast, a study in the Pijorkoling Health Center area found an association between relative humidity and pulmonary TB. This is attributed to the pathogen's increased survival in environments with high humidity[19]. High air moisture can influence the human circulatory system, increasing susceptibility to pulmonary TB. Elevated humidity also allows Mycobacterium tuberculosis to survive longer in airborne droplets[20]. The absence of a significant correlation between relative humidity and pulmonary TB prevalence in this study may be due to the limitation that humidity measurements were taken only in the participants' primary activity areas, rather than throughout the entire home.

Table 3. Association Between Indoor Natural Lighting and Pulmonary TB Incidence in the Tilango Health Center Working Area, 2024

Respondent Group	Indoor Natural Lighting				Total	%	*p-value*
	NS	%	S	%			
Cases	37	68,5	17	31,5	54	100	0,020
Controls	25	46,3	29	53,7	54	100	

Based on Table 3, out of 54 respondents in the case group, 17 individuals (31.5%) resided in homes with natural lighting meeting the standard. In the control group, 29 respondents (53.7%) lived in homes with adequate lighting. Chi-square analysis indicated a significant association between pulmonary TB incidence and indoor natural lighting, with a p-value of 0.020 (<0.05). This suggests that lighting is a contributing factor to pulmonary TB occurrence.

These findings are inconsistent with studies conducted in the Kabila Health Center working area ($p = 0.150$)[21] and Korleko Health Center, East Lombok Regency ($p = 0.926$)[22]. Conversely, the results align with studies conducted in the Tegal Sari Health Center ($p = 0.000$)[23] and Babakan Sari Health Center ($p = 0.012$)[24]. The design of this study is more comparable to the latter two studies in terms of lighting categorization. In this study, lighting was considered inadequate if $x < 60$ lux[23][24], whereas the studies that were not aligned used 60 lux $< x <$ 120 lux[22].

Individuals residing in homes with substandard lighting had a 2.944-fold higher risk of developing TB compared to those living in adequately lit homes[25]. Natural sunlight plays a role in controlling pathogenic microorganisms within the home. Ultraviolet exposure from morning sunlight can kill Mycobacterium tuberculosis at intensities ≥60 lux within approximately two hours[26]. The bacteria can also be killed in about 5 minutes, 24 hours, and 2–10 minutes upon exposure to iodine solution (tinctura iodii), 5% phenol, and 80% ethanol, respectively. Sunlight also contributes to preventing transmission and accelerating recovery in TB patients by stimulating vitamin D production, which can suppress inflammatory responses and reduce lung tissue damage[25].

The implications of these findings in rural contexts indicate that indoor natural lighting is an environmental factor that requires serious attention in TB control efforts. Housing conditions in rural areas are often constrained by building design, household density, and limited access to environmental health information. From a policy perspective, these results underscore the need to integrate TB control programs with healthy housing interventions, particularly by improving natural lighting through adequate window and ventilation openings to meet standards of ≥60 lux. Local governments and rural health centers can utilize these findings to strengthen promotive and preventive policies, such as healthy housing education, support for structural home improvements, and cross-sector collaboration among TB programs, environmental sanitation, and public housing.

Table 4. Association Between BCG Immunization History and Pulmonary TB Incidence in the Tilango Health Center Working Area, 2024

Respondent Group	BCG Immunization History				Total	%	*p-value*
	Yes	%	No	%			
Cases	11	20,4	43	79,6	54	100	0,643
Controls	13	24,1	41	75,9	54	100	

Based on Table 4, out of 54 respondents in the case group, 11 individuals (20.4%) had received BCG vaccination. In the control group, 13 respondents (24.1%) had a history of BCG immunization. Chi-Square analysis indicated no significant association between pulmonary TB incidence and BCG vaccination history. These findings are consistent with previous studies reporting that the effectiveness of BCG vaccination in preventing pulmonary TB in adults is variable and generally low, particularly in regions with high TB incidence. Furthermore, other meta-analyses have shown that BCG vaccine protection against Mycobacterium tuberculosis infection in adult populations is inconsistent. Therefore, although BCG vaccination plays an important role in preventing severe forms of TB in children, pulmonary TB prevention in adults requires a more comprehensive and integrated strategy(27).

Several studies indicate that BCG immunization is not significantly associated with pulmonary TB incidence. For instance, a study at Dr. Moewardi General Hospital, Surakarta, concluded that BCG vaccination had no significant association with pulmonary TB occurrence in children under five years old(28). Similarly, research at Tuminting Health Center, Manado, reported that most under-five children receiving care had been vaccinated with BCG, yet no significant association between BCG immunization and pulmonary TB was observed(29). Factors influencing the limited effectiveness of BCG include genetic differences, environmental conditions, co-infections, BCG strain variability, socioeconomic status, and nutritional status(30).

Table 5. Association Between History of COVID-19 Diagnosis and Pulmonary TB Incidence in the Tilango Health Center Working Area, 2024

Respondent Group	COVID-19 Diagnosis				Total	%	*p-value*
	Ya	%	Tidak	%			
Cases	2	3,7	52	96,3	54	100	0,558
Controls	1	1,9	54	98,1	54	100	

Based on Table 5, out of 54 respondents in the case group, 2 individuals (3.7%) had a history of COVID-19 diagnosis. In the control group, a history of COVID-19 was reported in 1 respondent (1.9%). Chi-Square analysis indicated no significant association between pulmonary TB incidence and prior COVID-19 infection. These findings suggest that previous COVID-19 infection did not significantly influence the risk of pulmonary TB among the community in the Tilango Health Center working area in 2024. This result aligns with other studies reporting that, although co-infection of TB and COVID-19 can occur, available scientific evidence is not yet strong enough to conclude that COVID-19 infection significantly increases TB incidence(31). Furthermore, while COVID-19 may impact TB control programs and delay diagnoses, there is no strong evidence linking COVID-19 infection directly to an increased risk of TB. Therefore, the lack of a significant association in this study is consistent with the existing literature.

Regarding COVID-19 diagnosis, some studies indicate that COVID-19 infection can influence pulmonary TB incidence. Systematic reviews and meta-analyses have found that TB and COVID-19 co-infection increases the risk of hospitalization and mortality compared to COVID-19 infection alone(32). Additionally, thematic reviews suggest that the COVID-19 pandemic has adversely affected TB services, such as reduced case detection and treatment continuity, which could potentially contribute to increased pulmonary TB incidence(33).

Table 6. Association Between Diabetes Mellitus History and Pulmonary TB Incidence in the Tilango Health Center Working Area, 2024

Respondent Group	Diabetes Mellitus History				Total	%	*p-value*
	Ya	%	Tidak	%			
Cases	18	33,3	36	66,7	54	100	0,000
Controls	3	5,6	51	94,4	54	100	

Based on Table 6, out of 54 respondents in the case group, 18 individuals (33.3%) were identified as having indications of diabetes mellitus (DM). In the control group, 3 respondents (5.6%) had indications of DM. Chi-Square analysis showed a significant association between pulmonary TB incidence and DM status, with a p-value of 0.000 (<0.05). These results are not consistent with studies conducted in the Dekai Health Center area, Papua Highlands (p = 0.495)(34), and a cross-sectional study in Yemen (p = 0.783)(35). The discrepancy may be attributed to the widespread occurrence of DM in the study area, differences in population age and gender distribution, and variations in treatment approaches(34)(35).

The significant association between DM history and pulmonary TB incidence in this study is consistent with findings from Haji General Hospital, Medan, which reported an F-value of 37.20 exceeding the F-table value(36), and a study in Ngawi (p = 0.001)(37). This relationship can be explained by the impact of DM on cellular immune function. Hyperglycemia disrupts macrophage microbicidal activity and affects phagocyte functions, including chemotaxis, phagocytosis, and antigen-presenting cell (APC) activity(38). In TB patients with DM, suboptimal alveolar macrophage activation reduces T-lymphocyte and macrophage interactions, rendering Mycobacterium tuberculosis elimination inefficient. Immune cell dysfunction and impaired defense mechanisms make individuals with DM more susceptible to infections, including pulmonary TB(36).

Individuals with diabetes have reduced immune resistance, resulting in an approximately threefold higher risk of developing pulmonary TB compared to non-diabetic individuals. DM relapse also negatively affects TB treatment outcomes and increases the risk of mortality. Since 2021, the Ministry of Health, through collaboration between the Pulmonary TB Working Team and the DM & Metabolic Disorders (DM-GM) Working Team, has enhanced pulmonary TB detection by conducting TB screening among DM patients using chest radiography. According to the SITB TB Paru Assistance Application as of March 15, 2024, a total of 6,973 pulmonary TB cases were identified, representing approximately 9% of the 77,488 individuals with diabetes who underwent TB screening(39).

These findings in a rural context indicate that DM is an important comorbid factor that warrants attention in pulmonary TB control efforts, given limited access to healthcare services, low public awareness of non-communicable diseases, and the high potential for delayed DM diagnosis in rural areas. From a policy perspective, these results reinforce the need for stronger integration between TB control programs and non-communicable disease management, particularly DM, through consistent bidirectional screening at rural primary health centers.

Table 7. Logistic Regression Analysis of Natural Lighting and Diabetes Mellitus History on Pulmonary TB Incidence in the Tilango Health Center Working Area, 2024

No	Variable	B	Sig.	Exp(B)	95% CI
1	Diabetes Mellitus Indication	1.893	0.001	6.639	2.073–21.264
2	Natural Lighting	-0.177	0.682	0.838	0.359–1.955
	Constant	-0.089	0.067	3.527	–

Based on Table 7, logistic regression analysis demonstrated that diabetes mellitus (DM) indications were significantly associated with pulmonary TB incidence (p = 0.001). The positive regression coefficient (B = 1.893) indicates a direct relationship, where the presence of DM contributes to an increased risk of developing pulmonary TB. The Exp(B) or Odds Ratio (OR) of 6.639 (95% CI: 2.073–21.264) suggests that individuals with indications of DM have approximately 6.6 times higher odds of developing pulmonary TB compared to those without DM.

Conversely, the natural lighting variable in the multivariate model did not show a statistically significant association (p = 0.682), which is also reflected in the confidence interval crossing one (95% CI: 0.359–1.955). Therefore, DM indication represents the most dominant risk factor influencing pulmonary TB incidence in the Tilango Health Center working area.

The finding that individuals with diabetes have a 6.6-fold higher risk of pulmonary TB in Tilango Subdistrict is highly consistent with the medical literature. Chronic hyperglycemia in diabetic patients leads to immune cell dysfunction, including impaired phagocytic activity and suboptimal alveolar macrophage function in eliminating Mycobacterium tuberculosis(36). This cellular immune impairment renders individuals with metabolic disorders significantly more susceptible to pulmonary infections compared to the general population.

Regarding natural lighting, although a significant association was observed in the bivariate analysis (Chi-Square, p = 0.020), the loss of significance in the logistic regression model (p = 0.682) indicates that this physical environmental factor has a weaker association with pulmonary TB compared to individual health conditions. This suggests that individuals with diabetes in rural Tilango remain at high risk of TB infection regardless of household lighting conditions, highlighting the importance of focusing health interventions on comorbidity management in addition to improving household sanitation and environmental quality.

CONCLUSIONS AND RECOMMENDATIONS

This study demonstrates that the incidence of pulmonary TB in the Tilango Health Center working area is influenced by both environmental factors and comorbid conditions, with diabetes mellitus (DM) emerging as the most significant finding. DM was identified as an independent risk factor for pulmonary TB, confirming a strong link between metabolic disorders and susceptibility to TB infection through mechanisms involving impaired immune function. Natural lighting in homes was associated with pulmonary TB in the bivariate analysis; however, it did not exhibit an independent effect after adjusting for DM, indicating that comorbid conditions have a more dominant contribution than certain physical environmental factors. Variables such as indoor temperature, relative humidity, BCG vaccination history, and prior COVID-19 infection were not significantly associated with pulmonary TB incidence in this study. Based on these findings, pulmonary TB control in the Tilango Health Center working area should prioritize strengthening the integration of TB and DM programs, particularly through bidirectional screening, optimal blood glucose management, and enhanced patient education and adherence to treatment for individuals with DM. Policies at the primary healthcare level should consider DM comorbidity as a priority within TB prevention and control strategies.

Meanwhile, interventions to improve housing conditions—especially enhancing natural lighting—should continue to be promoted as part of a comprehensive promotive and preventive approach to reduce TB transmission and support sustainable community health.

REFERENCES

1. World Health Organization. Global Tuberculosis Report 2025. 2025.
2. Nur'aini N, Suhartono S, Raharjo M. Faktor-faktor yang Mempengaruhi Kejadian Tuberkulosis: Sebuah Review. Sanitasi J Kesehat Lingkung. 2021;13(1):20–5.
3. Kemenkes RI. Strategi Nasional Penanggulangan Tuberkulosis di Indonesia 2020-2024. Pertemuan Konsolidasi Nasional Penyusunan STRANAS TB. 2020. 135 p.
4. Dinas Kesehatan Provinsi Gorontalo. Profil Kesehatan Provinsi Gorontalo Tahun 2022. Gorontalo; 2023.
5. Dinas Kesehatan Provinsi Gorontalo. Profil Kesehatan Provinsi Gorontalo Tahun 2023. 2024;
6. Dinas Kesehatan Provinsi Gorontalo. Profil Kesehatan Provinsi Gorontalo Tahun 2024. 2025;
7. Sarifuddin, Sabir M. Analisis Faktor Risiko Tingginya kasus Tuberkulosis Paru di Indonesia : Literature Review. J Kolaboratif Sains. 2023;6(5):469–76.
8. Nazhofah Q, Hadi EN. Dukungan Keluarga terhadap Kepatuhan Pengobatan pada Pasien Tuberculosis: Literature Review. Media Publ Promosi Kesehat Indones. 2022;5(6):628–32.
9. Akadji HD, Boekoesoe L, Kadir L. Analisis Determinan Kejadian Tuberkulosis : Data Wilayah Kerja Puskesmas Tilango, Kabupaten Gorontalo. 2023;15(2):1–7.
10. BPS Provinsi Gorontalo. 20 Februari. 2025 [cited 2025 Apr 8]. Kasus Penyakit Menurut Kabupaten/Kota dan Jenis Penyakit di Provinsi Gorontalo. Available from: https://gorontalo.bps.go.id/id/statistics-table/3/YTA1Q1ptRmhUMEpXWTBsQmQyZzBjVzgwUzB4aVp6MDkjMw==/kasus-penyakit-menurut-kabupaten-kota-dan-jenis-penyakit-di-provinsi-gorontalo--2022.html?year=2024
11. Badan Standardisasi Nasional. SNI 7062:2019/Ralat1:2020. Jakarta: BSN; 2020.
12. Badan Pusat Statistik Kabupaten Gorontalo. Kecamatan Tilango dalam Angka 2024 [Internet]. 75020.24019. Gorontalo; 2024. Available from: https://gorontalokab.bps.go.id
13. Mathofani PE, Febriyanti R. Faktor-Faktor Yang Berhubungan Dengan Kejadian Penyakit Tuberkulosis (TB) Paru di Wilayah Kerja Puskesmas Serang Kota Tahun 2019. J Ilm Kesehat Masy Media Komun Komunitas Kesehat Masy. 2020;12(1):1–10.
14. Budi DRR., Amirus K, Perdana AA. Hubungan Lingkungan Fisik Rumah dengan Penyakit Tuberkulosis Paru di Puskesmas Kuala Tungkal II, Jambi. J Kesehat Saelmakers PERDANA [Internet]. 2021;4(2):230–40. Available from: https://journal.ukmc.ac.id/index.php/jpm/article/view/270
15. Kementerian Kesehatan Republik Indonesia. Peraturan Menteri Kesehatan Republik Indonesia Nomor 2 Tahun 2023 tentang Peraturan Pelaksanaan Peraturan Pemerintah Nomor 66 Tahun 2014 tentang Kesehatan Lingkungan. Jakarta; 2023.
16. Yermi Y, Syamsul M, Aminah A. Pengaruh Kamarisasi, Pencahayaan, Suhu Dan Kelembaban Terhadap Kejadian Tuberkulosis Paru Di Kabupaten Maros, Sulawesi Selatan. UNM Environ Journals. 2022;5(3):25.
17. Nur Ainun E. Hubungan Kondisi Rumah Dengan Tb Paru. Media Penelit Pengemb Kesehat [Internet]. 2020;20(2):161–74. Available from: https://journal.poltekkes-mks.ac.id/ojs2/index.php/Sulolipu/article/view/1749
18. Huang K, Hu C yang, Yang X yao, Zhang Y, Wang X qiang, Zhang K di. Contributions of Ambient Temperature and Relative Humidity to The Risk of Tuberculosis Admissions:

A Multicity Study in Central China. Sci Total Environ [Internet]. 2022;838(May):156272. Available from: https://doi.org/10.1016/j.scitotenv.2022.156272
19. Nasution NH, Suryati, Permayasa N, Habibah N. Determinan Kejadian TB Paru di Wilayah Kerja Puskesmas Pijorkoling. Media Publ Promosi Kesehat Indones. 2022;5(9):1151–9.
20. Zulaikha Y, Syakurah RA. Manajemen Program Pencegahan dan Pengendalian Tuberculosis Saat Pandemi Covid-19 di Puskesmas Mangunharjo. J Bid Ilmu Kesehat. 2023;13(2):130–44.
21. Suma J, Age SP, Ali IH. Faktor Determinan Lingkungan Fisik Rumah terhadap Kejadian TB Paru di Wilayah Kerja Puskesmas Kabila. J Penelit Kesehat Suara Forikes. 2021;12(4):483–8.
22. Widiati B, Majdi M. Analisis Faktor Lingkungan Fisik Rumah Dengan Tuberkulosis Paru Di Wilayah Kerja Puskesmas Korleko Kabupaten Lombok Timur. Afiasi J Kesehat Masy. 2022;7(1):227–34.
23. Sikumbang RH, Eyanoer PC, Siregar NP. Faktor-Faktor yang Berhubungan dengan Kejadian TB Paru pada Usia Produktif di Wilayah Kerja Puskesmas Tegal Sari Kecamatan Medan Denai Tahun 2018. Ibnu Sina J Kedokt dan Kesehatan-Fakultas Kedokt Univ Islam Sumatera Utara. 2022;21(1):32–43.
24. Mahawati E, Surjati E, Saputra MKF, Sudasman FH, Pertiwi I. Hubungan Lingkungan Fisik Rumah Dengan Kejadian Tuberkulosis Paru. Indones Jounal Infect Dis. 2023;9(1):1–12.
25. Jannah RZ, Azizah R, Jalaludin B, Sulistyorini L, Lestari S. Meta-Analysis Study: Environmental Risk Factors of Tuberculosis (TB). J Kesehat Lingkung. 2023;15(2):84–91.
26. Sulidah, Irwan M, Elmania, Fadilah S, Hamdani-Rahil N, Nugroho A. Home Environment as A Risk Factor for Increased Incidence of Tuberculosis: A Case-Control Study. Cienc y Enferm. 2024;30(5):1–9.
27. Roy A, Eisenhut M, Harris RJ, Rodrigues LC, Sridhar S, Habermann S, et al. Effect of BCG vaccination against Mycobacterium tuberculosis infection in children: Systematic review and meta-analysis. BMJ [Internet]. 2014;349(August):1–11. Available from: http://dx.doi.org/doi:10.1136/bmj.g4643
28. Fatahillah H, Andarini I, Hidayah D. Hubungan Imunisasi BCG dengan Tuberkulosis Paru pada Anak Balita di RSUD Dr.Moewardi. Plex Med J. 2022;1(1):18–23.
29. Susanto CK, Wahani A., Rompis J. Hubungan pemberian imunisasi BCG dengan kejadian TB paru pada anak di Puskesmas Tuminting periode Januari 2012 – Juni 2012. e-CliniC. 2016;4(1).
30. Boy E, Hafizh MS, Hendarta M, Fithriyah K, Rahmadani DN, Sury DE, et al. BCG Vaccination Against Commorbidity of Pulmonary Tuberculosis in Adult Patients: A Cross Sectional Study at One of The Community Health Centers in Medan City. J Implementa Husada. 2023;4(3):230–8.
31. Tadolini M, García-García JM, Blanc FX, Borisov S, Goletti D, Motta I, et al. On tuberculosis and COVID-19. Eur Respir J [Internet]. 2020;56(2). Available from: http://dx.doi.org/10.1183/00000000.00000000
32. Wang Q, Cao Y, Liu X, Fu Y, Zhang J, Zhang Y, et al. Systematic review and meta-analysis of Tuberculosis and COVID-19 Co-infection: Prevalence, fatality, and treatment considerations. PLoS Negl Trop Dis [Internet]. 2024;18(5):1–19. Available from: http://dx.doi.org/10.1371/journal.pntd.0012136
33. Marco MH, Ahmedov S, Castro KG. The global impact of COVID-19 on tuberculosis: A thematic scoping review, 2020-2023. PLOS Glob Public Heal [Internet]. 2024;4(7):2020–3. Available from: http://dx.doi.org/10.1371/journal.pgph.0003043
34. Yalak FO, Makaba S, Togodly A, Bouway DY, Ruru Y. Faktor Risiko Kejadian

Tuberkulosis Paru Di Puskesmas Dekai Kabupaten Yahukimo Provinsi Papua Pegunungan. J Innov Creat. 2025;5(2):11201–19.

35. Alturki S, Amad M Al, Mahyoub E, Hanash N Al, Alhammadi A. Prevalence of Diabetes Mellitus among Patients with Tuberculosis and Its Associated Factors in Sana ' a , Yemen , 2021. Epidemiologia. 2023;4:202–11.
36. Batubara FA, Lukito A. Relationship Of Type II Diabetes Mellitus With The Risk Of Enhancement The Incidence Of Pulmonary Tuberculosis At Haji General Hospital Medan In 2022. Ibnu SIna J Kedokt dan Kesehat Faklutas Kedokt Univ Islam Sumatera Utara. 2024;23(2):178–85.
37. Dwi D, Wati A, Ariyanto Y, Prasetyowati I. Faktor Penyebab Diabetes pada Pasien Tuberkulosis di Kabupaten Ngawi Tahun 2022: Studi Kasus Kontrol. Damanius J Med. 2024;23(2):104–12.
38. Wei R, Li P, Xue Y, Liu Y, Gong W, Zhao W. Impact of Diabetes Mellitus on the Immunity of Impact of Diabetes Mellitus on the Immunity of Tuberculosis Patients : A Retrospective , Cross-Sectional Study. Risk Manag Healthc Policy. 2022;(15):611–27.
39. Dirjen P2P Kementerian Kesehatan. Surat Edaran Nomor: HK.02.02/C/1453/2024. Jakarta; 2024.