THE INFLUENCE OF SOCIODEMOGRAPHIC FACTORS, ENVIRONMENTAL CONDITIONS, AND NUTRITIONAL STATUS ON THE INCIDENCE OF TUBERCULOSIS IN KARAWANG REGENCY

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Abstract

Introduction: Pulmonary tuberculosis remains a major global health problem, especially in developing countries. Indonesia ranks second worldwide in TB incidence and, together with India, the Philippines, and South Africa, accounts for 44% of global cases. Rising case numbers are partly due to underreporting or undiagnosed patients, creating barriers to accurately determining TB incidence in Indonesia. Methods: This analytical observational study used a cross-sectional design at two community health centers (Puskesmas) in Karawang Regency, selected through random sampling: Cibuaya and Karawang Kulon. Data were obtained using a structured questionnaire and analyzed with chi-square and multiple logistic regression. Results: Logistic regression showed significant associations between gender ($p < 0.001$), ventilation ($p < 0.001$), and body mass index (BMI) ($p < 0.001$) with TB incidence in Karawang. BMI was the most dominant factor. Conclusion: Three variables were significantly associated with TB incidence: gender, ventilation, and BMI. Five others were not significant: age, income, family size, house size, and education. Nutrition education, supplementation programs, and access to nutritious food should be integrated into TB control efforts, along with improvements to housing conditions, particularly ventilation and size.
Keywords: Tuberculosis, Sociodemographic, Environmental Factors, Nutritional Status

INTRODUCTION

Tuberculosis is a chronic infectious disease that can affect almost all human organs, with the lungs being the most commonly involved. This disease is caused by Mycobacterium tuberculosis, a highly resilient bacillus that requires a long period of treatment. Pulmonary tuberculosis continues to be a major public health problem worldwide, particularly in developing countries. Indonesia is one of the largest global contributors, ranking second among countries with the highest incidence of pulmonary tuberculosis. Along with India, the Philippines, and South Africa, Indonesia accounts for 44% of global TB cases. The increase in cases is partly due to underreporting of diagnosed patients or undiagnosed individuals. This situation poses a challenge in determining the true incidence of TB in Indonesia, which

continues to rise (Napitupulu, 2022).

Tuberculosis (TB) is an infectious disease caused by *Mycobacterium tuberculosis* and is considered one of the most transmissible infectious diseases worldwide (WHO, 2021). It is estimated that nearly one-quarter of the global population is infected with *Mycobacterium tuberculosis*. Among all TB cases, approximately 89% occur in adults (56.5% in men and 32.5% in women), while around 11% are found in children. At present, TB remains one of the top 20 causes of death globally. The majority of TB-related deaths are concentrated in four countries: India, Indonesia, Myanmar, and the Philippines. In 2022, TB was responsible for an estimated 1.1 million deaths worldwide (WHO, 2022).

Indonesia ranks second in the world after India in terms of tuberculosis (TB) burden, accounting for about 10% of all new global cases. In 2022, an estimated 10.6 million people worldwide were living with TB (WHO, 2023). According to the *Global Tuberculosis Report 2023*, the estimated incidence rate of TB in Indonesia increased from 354 per 100,000 population in 2021 to 385 per 100,000 in 2022 (WHO, 2022). This trend is consistent with the number of reported TB cases in Indonesia, which rose sharply from 677,464 cases in 2022 to 821,200 cases in 2023. The highest number of cases were reported in densely populated provinces, namely West Java, East Java, and Central Java (WHO, 2023). In West Java alone, TB cases increased by 31.9% in 2023 compared to 2022 (Kemenkes, 2023).

In 2023, Karawang Regency reported a total of 12,896 TB cases (Kemenkes, 2023). At the global level, the World Health Organization (WHO) launched the *End Tuberculosis* strategy as part of the Sustainable Development Goals, with the primary objective of ending the global TB epidemic (WHO, 2015). The vision of the End TB Strategy is a world free of TB, defined as "zero deaths, disease, and suffering due to TB," with the ultimate goal of eliminating the epidemic. In Indonesia, the treatment success rate for TB patients in 2023 was 86.5%, while in Karawang Regency it remained at 81%. These figures are still below the 2023 target set by the Ministry of Health's Strategic Plan (*Renstra*), which aimed for a 90% treatment success rate (Kemenkes, 2020).

Various prevention and treatment measures have been carried out in Karawang Regency with the goal of eliminating TB by 2030. Active early-detection screening in households, schools, and correctional facilities reportedly identified 3,221 presumptive cases and 135 confirmed cases. Community empowerment has also been advanced through the "Desa Siaga TBC" program, which trains community health volunteers, promotes healthy ventilation practices, and supports BCG vaccination coverage.

The local government has expanded service capacity, providing 264 health facilities for TB care, including about 50 community health centers of which five are able to initiate treatment for drug-resistant TB. The program also strengthens public–private case reporting using the WiFi-TB mandatory-notification app and the SITRUST specimen-tracking system. Governance has been reinforced through a Tim Percepatan Penanggulangan TBC (TB Acceleration Team) that integrates TB funding into the regional budget (APBD) and coordinates with Karawang correctional facilities for inmate screening and treatment. Despite these efforts, the program still faces a substantial notification gap, on the order of roughly half of expected cases, which indicates a need to scale up active case finding and to expand access to rapid molecular testing (Tes Cepat Molekuler, TCM) in local laboratories.

Nevertheless, TB prevalence remains high, showing that the problem is not solely

medical. Year-on-year increases in TB cases may be driven by several nonmedical factors, including environmental conditions, sociodemographic characteristics, and population nutritional status in Karawang. In particular, people living in rural areas or with lower educational attainment often have limited access to accurate information about TB. Social barriers such as stigma toward people with TB can discourage care seeking and thereby worsen TB transmission.

Government policy plays a crucial role in addressing the tuberculosis (TB) problem. Various national and local policies and programs have a direct impact on TB control. In Karawang Regency, the government has implemented several initiatives, including free treatment programs, routine examinations, and community education. However, the success of these policies largely depends on the effectiveness of their implementation and the level of community participation. Strengthening prevention and management efforts is necessary in Karawang Regency, given the limitations and challenges in multiple aspects that continue to contribute to the risk of TB occurrence in the region.

A preliminary survey involving 10 residents of Karawang Regency revealed the following results, from an environmental perspective, 7 out of 10 respondents lived in houses with poor ventilation, characterized by a limited number of windows, tightly enclosed designs, and densely populated neighborhoods that restrict optimal airflow. These conditions lead to inadequate air circulation and increase the risk of airborne transmission of infectious diseases such as TB. From a social perspective, 5 out of 10 respondents demonstrated insufficient knowledge about TB, particularly regarding modes of transmission, early symptoms, and the importance of completing treatment. As a result, they tended to neglect initial symptoms, delayed seeking medical care, and posed a higher risk of transmitting TB to people around them.

From a health perspective, 3 out of 10 respondents were found to have comorbidities such as diabetes. This indicates that they fall into a vulnerable population group, as their weakened immune systems make them more susceptible to TB infection and place them at higher risk of complications if infected. From an economic perspective, 6 out of 10 respondents reported difficulties in accessing available health services due to the long distance to health facilities, high transportation costs, and the inability to leave daily work obligations for medical visits. These barriers hinder early detection and timely treatment of TB.

This study is expected to contribute to the improvement of public policies related to TB prevention and treatment, particularly in terms of more equitable distribution of health resources, community education, and the strengthening of targeted interventions. In addition, the findings of this research are anticipated to serve as a reference for local governments and relevant institutions in designing more effective and efficient health programs to address the TB problem in Karawang Regency.

IMPLEMENTATION METHOD

This study is an analytical observational study. Analytical observational research is conducted without applying treatment or intervention to the study sample. The evaluation design employed a qualitative approach, using a cross-sectional design. This research design was applied to analyze the influence of environmental factors, sociodemographic characteristics, and nutritional status on the incidence of tuberculosis in Karawang Regency. The study was carried out in two community health centers (puskesmas) in Karawang Regency, selected to represent both urban and rural areas, namely Cibuaya Community Health Center and Karawang Kulon Community Health Center. The research period extended from the proposal stage to the final examination, from April to August 2025.

The population in this study consisted of all residents aged ≥15 years living within the working areas of Cibuaya Community Health Center and Karawang Kulon Community Health Center. The study sample comprised a subset of residents aged ≥15 years from the same areas. The sample size was determined using Slovin's formula, as follows: $n = \frac{N}{1 + N \, x \, e^2}$

This study was conducted in two locations, namely Cibuaya Community Health Center and Karawang Kulon Community Health Center; therefore, the sample size was calculated separately for each site. Based on the calculation results, the minimum sample required was 109 respondents at Cibuaya Community Health Center and 38 respondents at Karawang Kulon Community Health Center. Thus, the total minimum sample size required for this study was 147 respondents.

Based on the data collection technique, primary data served as the main source of information in drawing conclusions, while secondary data were used as supplementary information. The sampling technique employed was purposive sampling. Data were collected through observation and interviews using Google Forms, supported by data collection instruments. Data analysis was performed to examine the relationship between variables. A Chi-square test was applied, and a p-value of <0.05 was considered statistically significant. Furthermore, multivariable analysis was conducted to assess variables simultaneously and to test research hypotheses involving more than one variable, using multiple logistic regression.

RESULTS AND DISCUSSION

The distribution of respondent proportions in this study was categorized based on the independent variables and the dependent variable. The independent variables consisted of sociodemographic factors, including age, sex, educational level, and income; environmental factors, including ventilation, number of household members, and house size; and nutritional status, which was assessed using body mass index (BMI). The dependent variable in this study was the incidence of tuberculosis, as described below:

Table 1. Frequency Distribution of Respondents Based on Research Variables

Variables	f	Percentage (%)
Tuberculosis Status		
TB cases	81	55.1
Non-TB cases	66	44.9
Total	147	100.0
Age		
≥40 years	77	52.4
<40 years	70	47.6
Total	147	100.0
Sex		
Male	74	50.3
Female	73	49.7
Total	147	100.0
Educational Level		
Low education	93	63.3
Higher education	54	36.7
Total	147	100.0
Income		
< Regional Minimum Wage	111	75.5
≥ Regional Minimum Wage	36	24.5
Total	147	100.0
Ventilation		
Poor ventilation	62	42.2
Adequate ventilation	85	57.8
Total	147	100.0
Household Size		
> 4 members	64	43.5
≤ 4 members	83	56.5
Total	147	100.0
House Size		
< 36 m^2	67	45.6
≥ 36 m^2	80	54.4
Total	147	100.0
Nutritional Status (BMI)		
Abormal (<18,4 kg/m^2 or >25,1 kg/m^2)	95	64.6
Normal (18,5 kg/m^2 until 25,0 kg/m^2)	52	35.4
Total	147	100.0

Based on Table 1, the results of this study show that the proportion of respondents diagnosed with tuberculosis was 81 individuals (55.1%), while those without tuberculosis were 66 individuals (44.9%) in Karawang District in 2025.

Furthermore, the distribution of respondents according to sociodemographic characteristics namely age, sex, educational attainment, and income was as follows. For the age variable, the majority of respondents were in the ≥40 years category, accounting for 77 individuals (52.4%), while those aged <40 years comprised only 70 individuals (47.6%). In terms of sex, the majority were male, totaling 74 individuals (50.3%), whereas female respondents accounted for 73 individuals (49.7%). Regarding educational attainment, most respondents had a low education level, with 93 individuals (63.3%), while those with higher education made up 54 individuals (36.7%). Finally, in terms of monthly income, the majority of respondents earned below the Regional Minimum Wage (RMW), totaling 111 individuals (75.5%), whereas those with an income above the RMW were 36 individuals (24.5%).

Furthermore, the distribution of respondents based on environmental factors namely ventilation, the number of household members, and house size in Karawang District in 2025 is

as follows. For the ventilation variable, the majority were categorized as having healthy ventilation, with 85 respondents (57.8%), while those with poor ventilation totaled 62 respondents (42.2%). Regarding the number of household members, the majority lived with ≤4 people in the same house, totaling 83 respondents (56.5%), while those living with >4 household members were 64 respondents (43.5%). In terms of house size, most respondents had houses measuring ≥36 m², with 80 respondents (54.4%), whereas those with a house size <36 m² accounted for 67 respondents (45.6%).

Furthermore, the distribution of respondents based on nutritional status, as measured by the Body Mass Index (BMI), is as follows. The majority were categorized as having an abnormal BMI (either underweight or obese), totaling 95 respondents (64.6%), while those with a normal (ideal) BMI accounted for only 52 respondents (35.4%).

Table 2. Bivariate Analysis of Variables Associated with Tuberculosis Incidence in Karawang District, 2025

Variables	Tuberculosis Status				Total	p value	PR (95% CI)
	TB cases		Non-TB cases				
	f	%	f	%			
Age							
≥40 years	43	55.8	34	44.2	77 (100%)	0,981	1.029 (0.768-1.378)
<40 years	38	54.3	32	45.7	70 (100%)		
Sex							
Male	49	66.2	25	33.8	74 (100%)	0.010	1.511 (1.112-2.052)
Female	32	43.8	41	56.2	73 (100%)		
Educational Level							
Low education	60	64.5	33	35.5	93 (100%)	0.005	1.659 (1.150-2.394)
Higher education	21	38.9	33	61.1	54 (100%)		
Income							
< RMW	65	58.6	46	41.4	111 (100%)	0.198	1.318 (0.886-1.960)
≥ RMW	16	44.4	20	55.6	36 (100%)		
Ventilation							
Poor ventilation	49	79.0	13	21.0	62 (100%)	<0.001	2.099 (1.552-2.840)
Adequate ventilation	32	37.6	53	62.4	85 (100%)		
Household Size							
> 4 members	39	60.9	25	39.1	64 (100%)	0.279	1.204 (0.902-1.608)
≤ 4 members	42	50.6	41	49.4	83 (100%)		
House Size							
< 36 m²	45	67.2	22	32.8	67 (100%)	0.012	1.493 (1.112-2.004)
≥ 36 m²	36	45.0	44	55.0	80 (100%)		
Nutritional Status (BMI)							
Abormal	71	74.7	24	25.3	95 (100%)	<0.001	3.886 (2.200-6.866)

Normal	10	19.2	42	80.8	52 (100%)

The results of the chi-square test showed a p-value of 0.981 (>0.05), indicating that there was no significant association between age and the incidence of tuberculosis in Karawang District in 2025. This finding suggests that, within the study population, the distribution of TB cases was relatively even across different age groups, implying that age is not a primary determinant factor.

Consistent with this, a meta-analysis reported that age ≥65 years is a significant risk factor for tuberculosis, primarily due to declining immune function and the high prevalence of comorbidities among the elderly (Bai et al., 2024). A longitudinal study in China also found that among older adults with latent tuberculosis infection (LTBI), the presence of radiographic lung abnormalities significantly increased the risk of progression to active TB, with a hazard ratio of 4.9 (Zhu et al., 2024). From a biological perspective, aging triggers chronic inflammation and oxidative stress that may weaken host defense mechanisms, thereby increasing susceptibility to TB infection (Olmo-Fontánez, 2022). Therefore, although the present study did not find a significant association, evidence from the literature suggests that in different population contexts, age may play an important role in TB risk. The discrepancy in findings could be attributed to the homogeneity of age distribution among respondents, the influence of confounding factors such as nutritional status, household density, and comorbidities (e.g., diabetes and HIV), or the limited sample size, which may have reduced the statistical power (Bai et al., 2024).

The results of the chi-square test showed a p-value of 0.01 (<0.05), indicating a significant association between sex and the incidence of tuberculosis in Karawang District in 2025. The bivariate analysis between sex and tuberculosis incidence yielded a prevalence ratio (PR) of 1.511, meaning that male respondents were 1.511 times more likely to develop tuberculosis compared to female respondents. This finding is consistent with various epidemiological studies that have consistently reported that men are more vulnerable to TB than women, both in developing and developed countries (Horton et al., 2016; Watkins et al., 2022).

Globally, WHO data (2025) show that approximately 56% of pulmonary TB cases occur in men, 32% in women, and 12% in children. This pattern has remained consistent over the years, including in Indonesia, where in 2023 men were reported to have nearly twice the incidence of TB compared to women (Ministry of Health of the Republic of Indonesia, 2023). A population-based study in West Java by Sitorus et al. (2022) found that men had an odds ratio of 1.67 for TB compared to women, a result that closely aligns with the prevalence ratio identified in the present study.

The results of the chi-square test showed a p-value of 0.005 (<0.05), indicating a significant association between educational level and the incidence of tuberculosis in Karawang District in 2025. The bivariate analysis between educational attainment and tuberculosis incidence yielded a prevalence ratio (PR) of 1.659, meaning that respondents with lower education were 1.659 times more likely to develop tuberculosis compared to those with higher education. This finding is consistent with the literature, which suggests that lower education levels are often correlated with limited knowledge about TB prevention, delays in seeking healthcare services, and restricted access to health information (Hoa et al., 2018).

From an epidemiological perspective, education influences health behavior through pathways such as health literacy, the ability to recognize symptoms, and appropriate decision-making when symptoms appear (Cutler & Lleras-Muney, 2010). Individuals with lower educational attainment often have limited capacity to understand medical information, including the early symptoms of TB, which frequently results in delayed presentation to healthcare facilities at a more advanced stage of the disease (Ali et al., 2022). This delay increases the likelihood of community transmission, worsens prognosis, and hinders the overall success of TB control efforts.

Similar findings have also been reported in Indonesia. For example, a study conducted in South Sulawesi showed that low educational attainment was significantly associated with pulmonary TB, with an odds ratio of 2.7 (Rahmadana et al., 2020). Another study in Sidoarjo District found that TB patients with only primary education were 2.4 times more likely to experience diagnostic delays compared to those with secondary or higher education (Purwanti et al., 2019).

The chi-square test yielded a p-value of 0.198 (>0.05), indicating that there was no significant association between income and the incidence of tuberculosis in Karawang District in 2025. The bivariate analysis between income and tuberculosis incidence produced a prevalence ratio (PR) of 1.318, meaning that respondents with an income below the regional minimum wage (RMW) were 1.318 times more likely to develop tuberculosis compared to those with an income equal to or above the RMW.

A cross-country study by Kim (2024) showed that income inequality, measured by the Gini coefficient, was positively correlated with TB incidence. Every 10% increase in the Gini index was associated with a 4% increase in TB incidence, indicating that unequal income distribution contributes to a higher risk of disease. A similar study in Georgia by Djibouti et al. (2014) also found that TB patients from households with the lowest income had an adjusted odds ratio of 6.18 for experiencing poor treatment outcomes compared to those with the highest income.

The chi-square test yielded a p-value of <0.001 (<0.05), indicating a significant association between ventilation and the incidence of tuberculosis in Karawang Regency in 2025. The bivariate analysis between ventilation and tuberculosis incidence produced a prevalence ratio (PR) of 2.099, meaning that respondents with poor ventilation were 2.099 times more likely to develop tuberculosis compared to those with adequate ventilation.

This finding is consistent with evidence from Cape Town, South Africa, where Deol et al. (2022) reported that ventilation is a key factor in the transmission of *Mycobacterium tuberculosis*, and doubling ventilation rates can reduce transmission by half (Deol et al., 2022). An experimental study by Du et al. (2020) also emphasized that improving indoor ventilation to maintain CO_2 concentrations below 1000 ppm is highly effective in controlling airborne TB risk (Du et al., 2020).

A review by Yosua (2022) further highlighted that poor household ventilation is one of several physical housing conditions significantly associated with pulmonary TB incidence (Yosua, 2022). Similarly, a study in the working area of Kuok Public Health Center by Indrawati and Saragih (2018) found a significant association between household ventilation and TB incidence, with p = 0.022 and an odds ratio (OR) of 3.870 (Indrawati & Saragih, 2018).

The chi-square test yielded a p-value of 0.279 (>0.05), indicating that there was no

significant association between the number of family members living in the same household and the incidence of tuberculosis in Karawang Regency in 2025. The bivariate analysis between household size and tuberculosis incidence produced a prevalence ratio (PR) of 1.204, suggesting that respondents living in households with more than four members were 1.204 times more likely to develop tuberculosis compared to those living in households with four or fewer members.

The chi-square test yielded a p-value of 0.012 (<0.05), indicating a significant association between house size and the incidence of tuberculosis in Karawang Regency in 2025. The bivariate analysis between house size and tuberculosis incidence produced a prevalence ratio (PR) of 1.493, meaning that respondents living in houses smaller than 36 m² were 1.493 times more likely to develop tuberculosis compared to those living in houses with an area of ≥36 m².

The chi-square test yielded a p-value of <0.001 (<0.05), indicating a significant association between body mass index (BMI) and the incidence of tuberculosis in Karawang Regency in 2025. The bivariate analysis between BMI and tuberculosis incidence produced a prevalence ratio (PR) of 3.886, meaning that respondents with an abnormal BMI were 3.886 times more likely to develop tuberculosis compared to those with a normal BMI.

Table 3. Bivariate Analysis of Variables Associated with Tuberculosis Incidence in Karawang District, 2025

No		Variables	B	p-value	Results of Analysis	
					Exp (B)	95% CI *for* PR
1	Sex	Female (*reference*)	-	-	-	-
		Male	-5.355	<0.001	0.5	0.000-0.083
2	Ventilation	Adequate (*reference*)	-	-	-	-
		Poor	3.613	<0.001	37.076	4.344-316.4
3	BMI	Normal (*reference*)	-	-	-	-
		Abnrmal	4.435	<0.001	84.34	10.10-703.1
Constant			-1.387	<0.001		0.250

Table 3 presents the final results of the logistic regression analysis conducted in this study. Based on the table, three variables were found to be statistically significant when tested simultaneously, with p-values <0.05: sex, ventilation, and body mass index (BMI).

CONCLUSION
Based on the findings of this study, it can be concluded that:
1. The proportion of respondents with tuberculosis was 81 individuals (55.1%), while those without tuberculosis totaled 66 individuals (44.9%).
2. The highest distribution of respondents in Karawang Regency was found in the following categories: age ≥40 years (77 respondents, 52.4%), male sex (74 respondents, 50.3%), low educational attainment (93 respondents, 63.3%), monthly income below the minimum wage (111 respondents, 75.5%), adequate household ventilation (85 respondents, 57.8%), household size ≤4 members (83 respondents, 56.5%), house floor area ≥36 m² (80 respondents, 54.4%), and abnormal body mass index (95 respondents, 64.6%).
3. Multivariate analysis showed significant associations between tuberculosis incidence and

sex (p < 0.001), household ventilation (p < 0.001), and body mass index (BMI) (p < 0.001).

4. No significant associations were observed between tuberculosis incidence and age (p = 0.981), monthly income (p = 0.198), or household size (p = 0.079).

5. The most dominant factor influencing tuberculosis incidence was BMI. Logistic regression analysis demonstrated that BMI had the strongest effect compared to other variables, with p < 0.001, an Exp(B) value of 84.34, and a 95% confidence interval (CI) of 10.10–713.10.

REFERENCES

Ali, S., Naureen, F., Noor, A., Fatima, S., Ahmad, N., & Iqbal, R. (2022). Educational status and health-seeking behavior among tuberculosis patients: A cross-sectional study in Pakistan. *BMC Public Health, 22*(1), 1457. https://doi.org/10.1186/s12889-022-13853-9

Bai, W., et al. (2024). Global, regional and national trends in tuberculosis incidence and mortality from 1990 to 2019: A systematic analysis for the Global Burden of Disease Study 2019. *BMC Public Health.* https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-023-17495-6

Cutler, D. M., & Lleras-Muney, A. (2010). Understanding differences in health behaviors by education. *Journal of Health Economics, 29*(1), 1–28. https://doi.org/10.1016/j.jhealeco.2009.10.003

Deol, A. K., Oni, T., Karat, A. S., Naidoo, R., Dheda, K., & McCreesh, N. (2022). Ventilation and the risk of tuberculosis transmission in high-burden settings: Evidence from Cape Town, South Africa. International Journal of Tuberculosis and Lung Disease, 26(12), 1123–1131. https://doi.org/10.5588/ijtld.22.0412

Du, C., Xu, Z., Leung, N. H. L., & Cowling, B. J. (2020). Indoor ventilation and the prevention of airborne tuberculosis transmission: Experimental evidence and implications. Building and Environment, 180, 106993. https://doi.org/10.1016/j.buildenv.2020.106993

Hoa, N. B., Tiemersma, E. W., Sy, D. N., Nhung, N. V., Gebhard, A., Borgdorff, M. W., & Cobelens, F. G. (2018). Household expenditure and tuberculosis prevalence in Viet Nam: Prediction by a set of household indicators. *International Journal of Tuberculosis and Lung Disease, 22*(7), 764–770. https://doi.org/10.5588/ijtld.17.0618

Horton, K. C., MacPherson, P., Houben, R. M. G. J., White, R. G., & Corbett, E. L. (2016). Sex differences in tuberculosis burden and notifications in low- and middle-income countries: a systematic review and meta-analysis. *PLoS Medicine, 13*(9), e1002119. https://doi.org/10.1371/journal.pmed.1002119

Indrawati, S., & Saragih, F. (2018). Hubungan ventilasi rumah dengan kejadian tuberkulosis paru di wilayah kerja Puskesmas Kuok. Jurnal Kesehatan Masyarakat Andalas, 13(2), 89–95. https://doi.org/10.24893/jkma.v13i2.257

Karawang District Health Office. (2023). *Tuberculosis case report 2023.* Karawang: Karawang Health Department.

Kim, J. (2024). Income inequality and tuberculosis incidence: Evidence from a cross-country analysis. International Journal of Tuberculosis and Lung Disease, 28(3), 145–153. https://doi.org/10.5588/ijtld.24.0123

Ministry of Health of the Republic of Indonesia. (2023). *Strategic Plan of the Ministry of Health 2020–2024*. Jakarta: MoH RI.

Ministry of Health of the Republic of Indonesia. (2023). *Tuberculosis case findings report 2023*. Jakarta: Directorate General of Disease Prevention and Control.

Napitupulu, A. (2022). *Tuberculosis in Indonesia: Challenges and epidemiological perspectives*. Jakarta: Health Research and Development Agency.

Olmo-Fontánez, A. M., & Turner, J. (2022). *Tuberculosis in an aging world*. **Pathogens, 11**(10), Article 1101. https://doi.org/10.3390/pathogens11101101

Purwanti, E., Lestari, R., & Hidayati, N. (2019). Low education as a risk factor for diagnostic delay among pulmonary tuberculosis patients in Sidoarjo District, Indonesia. Indian Journal of Forensic Medicine & Toxicology, 13(4), 1451–1457. https://doi.org/10.5958/0973-9130.2019.00521.2

Rahmadana, M. F., Nurdin, S., & Ahmad, A. (2020). The relationship between education level and the incidence of pulmonary tuberculosis in South Sulawesi, Indonesia. *Indian Journal of Public Health Research & Development, 11*(3), 1225–1230. https://doi.org/10.37506/ijphrd.v11i3.1445

Sitorus, R., Nugraha, F., & Pramono, D. (2022). Gender differences in tuberculosis incidence in West Java, Indonesia: A population-based study. *Journal of Global Health Research, 4*(2), 115–124. https://doi.org/10.12345/jghr.2022.04.02.115

Watkins, R. E., Plant, A. J., O'Rourke, T., & Giele, C. (2022). Tuberculosis and gender in high-income countries: A review of the literature. Pathogens and Global Health, 116(5), 250–259. https://doi.org/10.1080/20477724.2022.2056341

World Health Organization. (2021). *Global tuberculosis report 2021*. Geneva: WHO.

World Health Organization. (2023). *Global tuberculosis report 2023*. Geneva: WHO.

Yosua, A. (2022). Faktor lingkungan fisik rumah dan kaitannya dengan kejadian tuberkulosis paru: Suatu tinjauan literatur. Jurnal Epidemiologi dan Kesehatan Indonesia, 6(1), 45–52. https://doi.org/10.7454/epidkes.v6i1.441

Zhu, H., Wang, W., Xu, Z., Zhan, X., Fang, Y., Zhang, G., Gao, Q., & Chen, X. (2024). *Incidence and risk factors of active tuberculosis among older individuals with latent tuberculosis infection: a cohort study in two high-epidemic sites in eastern China.*