

ORIGINAL RESEARCH

Determinants of Tuberculosis Incidence in Children: A Case Study from Indonesia

Determinantes de la incidencia de tuberculosis entre niños: un estudio de caso en Indonesia

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Abstract

Childhood tuberculosis (TB) is a significant global health issue, with an estimated 1.2 million children affected by the disease worldwide. This study aimed to identify the determinants influencing the incidence of TB in children in Indonesia. A quantitative approach was employed, utilizing a cross-sectional study design with secondary data from the 2018 Basic Health Research. The study was conducted between May and June 2023 across 37 provinces in Indonesia. The study population comprised 303,507 children aged 0–14 years, with a final sample size of 282,861 after data cleaning. Chi-square tests and Prevalence Ratio (PR) bivariate analysis were conducted using JASP Version 19 software. The results revealed significant associations between age ($p < 0.001$; PR = 1.371), asthma history ($p < 0.001$; PR = 8.12), nutritional status ($p < 0.001$; PR = 1.683), and living environment ($p < 0.001$; PR = 1.442) with the incidence of childhood TB. However, no significant associations were found between living room ventilation ($p = 0.481$; PR = 1.064) or bedroom ventilation ($p = 0.618$; PR = 0.956) and TB incidence. The findings suggest that targeted screening by age, integration of asthma management with TB control, enhanced nutritional support, and improvements in living conditions can effectively mitigate the burden of childhood TB in Indonesia.

Keywords: Asthma, Childhood Tuberculosis, Children, Living Environment, Nutritional Status.

Resumen

La tuberculosis infantil (TB) es un problema de salud global significativo, con un estimado de 1.2 millones de niños afectados por esta enfermedad en todo el mundo. Este estudio tuvo como objetivo identificar los determinantes que influyen en la incidencia de la TB en niños en Indonesia. Se empleó un enfoque cuantitativo, utilizando un diseño de estudio transversal con datos secundarios de la Investigación Básica en Salud de 2018. El estudio se llevó a cabo entre mayo y junio de 2023 con datos de 37 provincias de Indonesia. La población del estudio comprendió 303,507 niños de 0 a 14 años, con un tamaño de muestra final de 282,861 tras la depuración de datos. Se realizaron pruebas de chi-cuadrada y análisis bivariado de la razón de prevalencia (RP) utilizando el software JASP versión 19. Los resultados revelaron asociaciones significativas de la edad ($p < 0.001$; RP = 1.371), antecedentes de asma ($p < 0.001$; RP = 8.12), el estado nutricional ($p < 0.001$; RP = 1.683) y el entorno vital ($p < 0.001$; RP = 1.442) con la incidencia de tuberculosis infantil. Sin embargo, no se encontraron asociaciones significativas entre la ventilación de la sala de estar ($p = 0.481$; RP = 1.064) ni la ventilación del dormitorio ($p = 0.618$; RP = 0.956) y la incidencia de tuberculosis. Los hallazgos sugieren que la detección selectiva por edad, la integración del tratamiento para el asma con el control de la tuberculosis, un mejor apoyo nutricional y mejoras en las condiciones de vida pueden mitigar eficazmente la carga de tuberculosis infantil en Indonesia.

Palabras clave: Asma, Tuberculosis infantil, Niños, Entorno vital, Estado nutricional.



Introduction

Tuberculosis (TB) continues to be a critical global health challenge, warranting urgent attention and action⁽¹⁾⁽²⁾. According to the World Health Organization (2022), TB remains the leading cause of death from an infectious disease, affecting approximately 10 million individuals annually and resulting in approximately 1.5 million fatalities⁽³⁾. The etiological agent of TB, *Mycobacterium tuberculosis*, primarily targets the lungs, though it can also affect other organs such as the kidneys, bones, and brain⁽⁴⁾⁽⁵⁾. Transmission of TB occurs via aerosolized droplets when an individual with pulmonary TB coughs, sneezes, or spits, with the infection often spreading after inhalation of only a few mycobacteria⁽⁶⁾⁽⁷⁾.

The WHO identifies the top ten countries contributing to the global burden of pediatric TB, which include India, Indonesia, China, the Philippines, Pakistan, Nigeria, Bangladesh, South Africa, the Democratic Republic of the Congo, and Mozambique. In 2019, India reported the highest number of pediatric TB cases at 95,000, followed by Indonesia with 68,000, and China with 32,000. Other countries such as the Philippines and Pakistan recorded 23,000 and 19,000 cases, respectively⁽⁶⁾. In Indonesia, the distribution of TB cases varies significantly across regions. In 2021, West Java reported the highest number of TB cases, followed by Central Java and East Java⁽⁸⁾. North Sumatra Province ranked tenth, with a total of 16,924 reported TB cases. The ten provinces with the highest TB burden in Indonesia in 2020 were as follows: East Java (39,961 cases), Central Java (34,025 cases), Jakarta (29,047 cases), West Java (28,565 cases), Papua (24,123 cases), South Sulawesi (21,173 cases), Bali (20,864 cases), Aceh (19,377 cases), West Papua (19,142 cases), and North Sumatra (16,924 cases)⁽⁹⁾⁽¹⁰⁾.

The prevalence of TB is particularly high among infants aged 0-1 years and children aged 12-14 years, likely due to their developing immune systems and close family interactions⁽¹¹⁾⁽¹²⁾. Notably, children in the 12–14 age group have been reported in previous studies to demonstrate higher incidence rates, potentially due to factors such as BCG vaccination status, overcrowding, and their ability to produce sputum for bacterio-

logical examination⁽¹³⁾⁽¹⁴⁾. Despite advancements in diagnostic and treatment strategies, TB remains a global infectious disease, with approximately one-quarter of the world's population estimated to have latent TB infection.⁽¹⁵⁾⁽¹⁶⁾⁽¹⁷⁾ Notably, approximately 1 million new pediatric TB cases go undiagnosed each year, posing a significant threat to global child health. The overwhelming burden of TB highlights the need for pediatric healthcare providers to be well-versed in TB epidemiology, its natural history, and the management of the disease⁽¹⁸⁾⁽¹⁹⁾.

The environment plays a pivotal role in the transmission and exacerbation of TB. Poor housing conditions and inadequate sanitation are associated with an increased risk of TB transmission⁽²⁰⁾⁽²¹⁾. The persistence of *Mycobacterium tuberculosis* in indoor environments is influenced by various factors, including UV light exposure, humidity, room temperature, and population density, which can facilitate bacterial survival for extended periods⁽²²⁾⁽²³⁾⁽²⁴⁾.

Sociodemographic risk factors, such as age, gender, education, occupation, and residence type, further contribute to the spread of TB⁽²⁵⁾. Environmental risk factors, including access to healthcare services, room occupancy rates, housing quality, ventilation, and exposure to infected individuals, also significantly affect TB transmission dynamics⁽²⁶⁾.

The hygiene hypothesis proposes that improved sanitation, reduced exposure to common bacterial infections, and the Westernization of lifestyles may contribute to an increased incidence of atopic diseases, including TB. This hypothesis posits that the lack of exposure to certain environmental pathogens, prevalent in developing countries, may reduce immunity to infections like TB⁽²⁷⁾.

TB prevalence is also exacerbated by high population density, inadequate hygiene practices, suboptimal nutrition, and poor sanitation, which collectively create a conducive environment for the proliferation of *Mycobacterium tuberculosis*. The highest TB incidence rates are found in areas characterized by high humidity and low temperatures, which facilitate bacterial growth and contribute to the ongoing global TB burden⁽¹²⁾⁽²⁸⁾.

Methods

Study Setting

This study utilized a cross-sectional design and quantitative methods to analyze secondary data from the 2018 Basic Health Research in order to assess the prevalence of tuberculosis (TB) among children in Indonesia. The primary objective of the study was to examine various risk factors simultaneously, without considering the temporal relationship between the independent and dependent variables.

The study is based on a comprehensive analysis of the 2018 Basic Health Research dataset, which spans all 37 provinces in Indonesia. The dataset includes data from 303,507 children aged 0–14 years, distributed across the country's provinces.

Inclusion Criteria:

1. Individuals identified in the census block (BS).
2. Children aged between 0–14 years.
3. Children residing in Indonesia.
4. Children with complete data that aligns with the study's research variables.

After data cleaning, the final research sample consisted of 282,861 children who met the inclusion criteria.

Research Variables

The independent variables included in this study were age, a history of asthma, nutritional status, living environment, presence of windows, ventilation, and lighting within the home. The dependent variable was the incidence of tuberculosis in children.

Data Collection

Data were collected through individual questionnaires administered to various age groups using an interview technique. The questionnaire tool was designed to capture information on risk factors such as age, gender, asthma history, nutritional status, living environment, presence of windows, ventilation, and lighting at home.

Statistical Analysis

This study analyzed categorical data, and the statistical test employed was the chi-square test with a 95% confidence level. The decision rule for the chi-square test was based on a p-value threshold of <0.05 . Additionally, the prevalence ratio (PR) was calculated to determine the dominant risk factors for TB incidence in children. Cross-tabulation was used to present the relationships between the independent and dependent variables. Data analysis was performed using JASP Version 19, which was utilized for bivariate analysis and the calculation of the prevalence ratio (PR).

Results

The data presented in Table 1 show that, among children diagnosed with tuberculosis (TB), 55.4% were aged 6–14 years, reflecting the larger population size of this age group. However, the prevalence of TB was higher among children aged 0–5 years compared to those aged 6–14 years. Children aged 0–5 years were 1.371 times more likely to develop TB than children aged 6–14 years (prevalence ratio [PR] = 1.371; 95% confidence interval [CI]: 1.153–1.629), and this association was statistically significant ($p < 0.001$).

Regarding asthma history, most children diagnosed with tuberculosis (TB) did not have a history of asthma (459 children, 88.3%), while a smaller proportion had a documented history of asthma (61 children, 11.7%). Despite this distribution, a statistically significant association was observed between asthma history and childhood TB ($p < 0.001$). Children with a history of asthma were 8.12 times more likely to develop TB than children without asthma (prevalence ratio [PR] = 8.120; 95% confidence interval [CI]: 6.227–10.589).

With respect to nutritional status, a greater proportion of TB cases occurred among children with a normal body mass index (BMI), reflecting the larger size of this group. However, children with abnormal nutritional status (underweight or overweight) had a significantly higher risk of developing TB compared to those with a normal BMI (PR = 1.683; $p < 0.001$), indicating a statistically significant association between nutritional status and childhood TB.

Table 1. Distribution of Factors at Risk for the Incidence of Children Tuberculosis (0-14 years)

Variable	Children Tuberculosis				Total		P value	PR
	Yes		No		N	%		
	n	%	n	%				
Age								
0-5 Years	232	0.08	104471	36.93	104703	37.02	<0,001	1,371
6-14 Years	288	0.10	177870	62.88	178158	62.98		
Total	520	0.18	282341	99.82	282861	100.00		
History of Asthma								
Yes	61	0.02	4494	1.59	4555	1.61	<0,001	8,120
No	459	0.16	277847	98.23	278306	98.39		
Total	520	0.18	282341	99.82	282861	100.00		
Living Environment								
Urban	253	0.09	111906	39.56	112159	39.65	<0,001	1,442
Rural	267	0.09	170,453	60.26	170702	60.35		
Total	520	0.18	282,359	99.82	282861	100.00		
Body Mass Index								
Abnormal (Over/Under)	76	0.03	63180	22.34	63256	22.36	<0,001	1,683
Normal	444	0.16	219161	77.48	219605	77.64		
Total	520	0.18	282341	99.82	282861	100.00		
Ventilation in the Bedroom								
Not Eligible	256	0.09	134638	47.60	134894	47.69	0,481	1,064
Eligible	264	0.09	147703	52.22	147967	52.31		
Total	520	0.18	282.341	99.82	282861	100.00		
Ventilation in LivingRoom								
Not Eligible	209	0.07	116518	41.19	116727	41.27	0,618	0,956
Eligible	311	0.11	165823	58.62	166134	58.73		
Total	520	0.18	282341	99.82	282861	100.00		

In terms of living environment, more children diagnosed with TB resided in rural areas than in urban areas, consistent with population distribution. However, a statistically significant association was observed between place of residence and TB incidence ($p < 0.001$). Children living in urban areas were 1.442 times more likely to develop TB than those living in rural areas ($p < 0.05$).

With respect to ventilation in the living room, a higher proportion of children diagnosed with tuberculosis (TB) were from households with adequate ventilation (311 children, 59.8%) compared to those without adequate ventilation (209 children, 40.2%). However, statistical analysis showed no significant association between living room ventilation and the incidence of childhood TB

($p = 0.618$). Similarly, in households with adequate bedroom ventilation, a slightly higher proportion of children with TB was observed (264 children, 50.8%) compared to households without adequate bedroom ventilation (256 children, 49.2%). No statistically significant association was found between bedroom ventilation and childhood TB incidence ($p = 0.481$).

Discussion

Tuberculosis (TB) is a significant infectious disease affecting the lower respiratory tract and can lead to severe illness (1). Primary infection commonly occurs in children, largely due to exposure to adults with active TB. Transmission occurs through airborne droplet nuclei, while larger droplets are

typically blocked by upper airway structures. In most cases, children acquire TB from adults, as childhood TB is generally paucibacillary and non-cavitary in nature⁽¹⁵⁾.

The findings of this study indicate that children aged 0–5 years are 1.371 times more likely to develop TB than children aged 6–14 years (prevalence ratio [PR] = 1.371; 95% confidence interval [CI]: 1.153–1.629). This finding is consistent with a study conducted in Jakarta, which reported that children aged 0–4 years had a higher risk of tuberculosis, with 69% of cases occurring in this age group compared to 31% among children aged 5–14 years. Environmental factors, including place of residence, also influence TB incidence. Similar patterns have been reported in studies from Indonesia, sub-Saharan Africa, and rural settings, where factors such as population density and living conditions contribute to an increased risk of TB among children⁽¹⁴⁾.

The clinical presentation of tuberculosis (TB) in children varies by age, with school-aged children often remaining asymptomatic. Infants may present with failure to thrive, respiratory distress, organomegaly, or skin lesions, while older children may exhibit similar symptoms. Extrapulmonary manifestations of TB also vary depending on the affected site; for example, TB lymphadenitis typically presents as painless swelling without fever, whereas TB osteomyelitis may cause localized pain, fever, and reluctance to ambulate.

Our study also found a significant association between living environment and the incidence of childhood TB, with children living in urban areas being 1.442 times more likely to develop TB than those living in rural areas ($p < 0.05$). This finding is consistent with previous research indicating that children living in urban slums face a higher risk of developing pulmonary TB compared to those in rural slums⁽²⁹⁾. Proximity to dense human settlements and shared living spaces within these areas have been identified as significant risk factors for TB transmission, increasing exposure to individuals with pulmonary tuberculosis⁽²⁶⁾.

A history of asthma in children was also identified as a significant risk factor for developing TB. Children with a history of asthma were 8.12 times

more likely to develop TB than those without an asthma history (prevalence ratio [PR] = 8.120; 95% confidence interval [CI]: 6.227–10.589). Asthma, along with chronic obstructive pulmonary disease (COPD), has been associated with increased susceptibility to TB due to persistent airway inflammation⁽³⁰⁾. The International Study of Asthma and Allergies in Childhood (ISAAC) has reported an inverse correlation between asthma prevalence and TB incidence across 55 countries⁽²⁷⁾. However, the potential protective effects of prior TB exposure on asthma may be outweighed by respiratory damage resulting from neutrophilic inflammation and other mechanisms⁽³¹⁾. Furthermore, cigarette smoke exposure exacerbates the risk of TB, particularly in individuals with preexisting respiratory conditions^(28,32).

The relationship between nutritional status and tuberculosis (TB) incidence is also noteworthy. Children with abnormal nutritional status were 1.683 times more likely to develop TB than those with normal nutritional status ($p < 0.05$). Previous studies have demonstrated that poor nutritional status is a critical factor in the development of pediatric pulmonary TB, as malnutrition weakens immune function and increases susceptibility to infection⁽³³⁾. Adequate protein intake plays a crucial role in TB treatment by supporting tissue regeneration and enhancing immune responses, thereby facilitating bacterial eradication⁽³⁴⁾. Nutritional interventions, particularly those aimed at increasing energy and protein intake, have been shown to reduce TB incidence among household contacts⁽³⁵⁾.

Ventilation in the living environment has also been examined as a potential factor associated with childhood TB incidence^(36,37). Although a higher proportion of children with TB resided in households with adequate living room ventilation (59.8%) compared to those without adequate ventilation (40.2%), statistical analysis revealed no significant association between living room ventilation and TB incidence ($p = 0.618$). Similarly, while a slightly higher proportion of children with TB was observed in households with adequate bedroom ventilation (50.8%), no significant association was found between bedroom ventilation and TB incidence ($p = 0.481$).

Lighting conditions in the home also play an important role in tuberculosis (TB) prevalence. Children living in poorly lit environments are reported to be nine times more likely to develop TB and test positive for tuberculosis bacilli than those living in well-lit homes⁽³⁸⁾. Previous studies have emphasized the importance of adequate lighting and ventilation in reducing TB incidence, as insufficient light and poor ventilation contribute to the persistence of *Mycobacterium tuberculosis* in dark, enclosed spaces⁽³⁹⁾. Poor indoor air quality, resulting from inadequate ventilation and the absence of windows, further increases the risk of TB transmission within households⁽¹⁸⁾. Ensuring proper ventilation and adequate lighting is therefore an essential measure in preventing TB in children⁽⁴⁰⁾.

Conclusion

This study demonstrates a significant association between age and the incidence of childhood tuberculosis (TB) in Indonesian children. Specifically, children aged 0–5 years were more likely to develop TB than those aged 6–14 years. In addition, children with a history of asthma were at a substantially higher risk of developing TB compared to those without such a history. Nutritional status was also identified as an important factor influencing TB incidence, with children exhibiting an abnormal body mass index (BMI) being 1.683 times more likely to develop TB than those with a normal BMI. Furthermore, a significant difference in TB incidence was observed between rural and urban areas, with children living in urban settings being 1.442 times more likely to develop TB than those living in rural areas. Although household ventilation in the living room and bedroom was examined, no statistically significant association was found between ventilation and childhood TB incidence. Overall, these findings underscore the importance of addressing multiple risk factors—including young age, asthma history, poor nutritional status, and urban living conditions—in efforts to reduce the burden of childhood TB in Indonesia.

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