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Risk Factors Of Childhood Tuberculosis In Makassar City

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ABSTRACT

Background: Pediatric tuberculosis (TB) is a systemic infectious disease that spreads through the bloodstream, affecting various organs and potentially causing stunted growth, disability, or death. In Makassar City, childhood TB remains a significant public health concern, but the key contributing factors are not yet fully understood.

Objective: This study aims to analyze risk factors of childhood tuberculosis in Makassar City in 2023.

Methods: The research design used in this study was an ecological study. The location of the study was Makassar City in 2024. This study used a group population, namely 153 urban villages in Makassar City and the sample was all cases of childhood tuberculosis in Makassar City in 2023. Secondary numerical data were obtained from the Makassar City Health Office, the Central Bureau of Statistics, and the Social Affairs Office. Data analysis was performed using bivariate correlation analysis with STATA software. Pearson's or Spearman's correlation coefficients were used depending on data distribution, and the results were presented in tables showing the strength and direction of the relationships.

Results: This study shows that there are 93 urban villages with low incidence rates of childhood TB, 47 urban villages with moderate categories, 4 urban villages with high categories, and 1 urban village with very high categories. Bivariate analysis showed a weak and non-significant positive correlation between childhood TB incidence and healthy home coverage, coverage of households with clean and healthy behavior, poor family numbers, and BCG immunization coverage. However, population density showed a weak but significant positive correlation, indicating that TB incidence tends to be higher in denser areas. These findings suggest that population density plays a more critical role in childhood TB incidence than other analyzed variables.

Conclusion: It is recommended that the government prioritize interventions in high-density areas, as population density has shown a significant correlation with childhood TB incidence. Efforts should focus on improving housing conditions, reducing overcrowding, and enhancing public health awareness to effectively mitigate TB transmission among children.

Keywords: *Risk Factors, Pediatric tuberculosis, Ecological Study*

1. INTRODUCTION

Tuberculosis (TB) is a significant infectious disease that is a leading cause of global mortality and a serious threat to global health security. The global prevalence of TB is enormous, and the growing number of new cases makes TB a common disease, causing suffering, disability, and high mortality rates (1). Today, tuberculosis (TB) is a disease of global concern. In accordance with the 2030 Sustainable Development Goals, the World Health Organization (WHO) aims to reduce deaths from tuberculosis by 90% and reduce incidence by 80% by 2030 (2). TB is a preventable and curable disease but remains the second leading cause of death from infections after COVID-19. The 2022 Global TB Report shows a 4.5% increase in cases, reaching 10.6 million in 2021, including 1.2 million children. Most cases occur in Asia (58%) and Africa (27%), with India, China, Indonesia, the Philippines, Pakistan, Nigeria, Bangladesh, and South Africa having the highest incidence (3).

Pediatric TB is a systemic disease that can affect various organs of the body, mainly through hematogenous spread. The disease has the potential to cause various problems, such as stunted growth, disability and even death, depending on the infected organ and the severity of the disease. Children under 5 years old are at high risk of developing primary progressive TB or miliary TB after infection. Children under 2 years old have a very high risk (30%-40%) of developing primary

progressive TB within one year (4). Notification of TB cases in children under 15 years of age in Indonesia in 2023 is 66% (not reaching the target of 90%). The provinces with the lowest coverage are Aceh (40%), Bali (42%), West Sulawesi (47%), North Maluku (52%), North Sumatra (53%), Southeast Sulawesi (53%). South Sulawesi is the province with a pediatric TB case finding coverage rate of 66% (not reaching the 90% target). The achievement of each province varied between 40% and 475%. Variations in case finding coverage in each province may be due to increased efforts to find TB cases in children after the COVID-19 pandemic, under-detection of TB cases in adults (under-diagnosis or under-reporting), and potential over-diagnosis. In addition, the coverage of Tuberculosis Preventive Therapy (TPT) among household contacts is very low, reaching only 1.3% or around 18,081 people, far from the target of 1.3 million people (5).

Data from the Makassar City Health Office shows a rising proportion of pediatric TB cases: 5.1% in 2021, 8.29% in 2022, and 11.96% in 2023. This increase is linked to airborne transmission, improved active case detection, household contact, and the integration of child health and stunting programs. TB primarily affects the lungs but can spread throughout the body. Children are usually infected through airborne droplets from adults with TB. While most bacteria are destroyed by immune cells, some survive and multiply, leading to disease and potential extrapulmonary spread. Diagnosing TB in children is challenging due to atypical symptoms that resemble other illnesses (6). Children are at risk of TB infection, with factors such as low immunity, close contact with TB patients, young age, poor nutrition, lack of BCG immunization, knowledge and attitudes towards TB prevention, limited healthcare access, overcrowded living conditions, poor sanitation, and inadequate ventilation increasing the risk. High population density raises exposure to infected individuals, while socioeconomic factors also play a role in transmission (7)(8). Environmental and socioeconomic factors significantly influence pediatric TB transmission (9). Poor housing conditions, high population density, and low economic status increase the risk (10). Limited access to healthcare in impoverished areas further contributes to TB prevalence, as seen in studies linking high TB cases to regions with many poor families (11)(12). BCG immunization is an effective TB prevention measure, reducing the risk of infection by 59% in vaccinated children.

Childhood tuberculosis can be controlled by understanding risk factors such as immunization coverage, homes with clean and healthy living behaviors, residential density, access to health services, and socioeconomic conditions. Research related to risk factors for pediatric TB is still limited compared to adult TB, although children are a vulnerable group. The incidence of pediatric TB in Makassar City continues to increase, but the main factors are not fully understood. Therefore, this study focuses on identifying the determinants of pediatric TB to provide a more comprehensive understanding and support effective control strategies.

2. PARTICIPANTS & METHODS

The research design used in this study was an ecological study. This method was chosen because the study focused on observed disease incidence rates and potential risk factors measured in groups rather than individuals. These groups were grouped based on geographical location, namely Urban Village and health center. The research was conducted in Makassar City in August-Novermber 2023. This study used a group population, namely 153 urban villages in Makassar City, South Sulawesi. The sample used is all cases of childhood tuberculosis in Makassar City in 2023. Population data by urban village were used to examine the relationship between childhood tuberculosis incidence and healthy house coverage, population density, number of poor people, coverage of families with good health, and BCG immunization coverage.

The data collected and used in this study were secondary numerical data. Secondary data were obtained from agencies located in Makassar City, namely the Makassar City Health Office, the Central Bureau of Statistics (BPS), and the Social Service. Data analysis was conducted using bivariate correlation analysis with STATA software. The relationship between childhood tuberculosis incidence and other variables was tested using Pearson's or Spearman's correlation coefficient, depending on the data distribution. The analysis results are presented in the form of tables showing the strength and direction of the relationship between variables.

Findings

Table 1. Distribution Table of Child Tuberculosis Incidence Rate, Healthy Home coverage, Population Density, coverage of households with clean and healthy behavior, Poor Families, and BCG Immunization Coverage in urban village of Makassar City in 2023

Variables	n	%
Incidence Rate of Child Tuberculosis		
Low (<19)	93	60.78
Medium (20 - 39)	47	30.72
High (40 – 59)	12	7.84

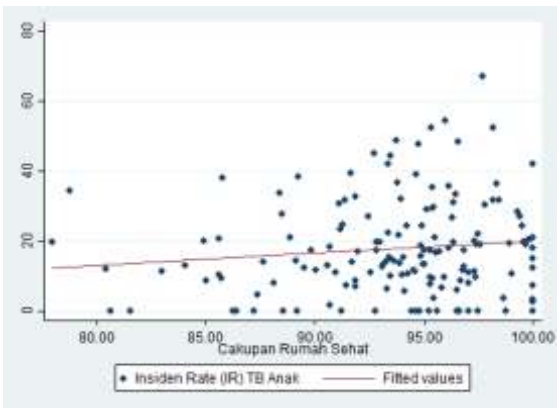
Very High (≥ 60)	1	0.65
Healthy Home Coverage		
Low (<80)	2	1.31
High (≥80)	151	98.69
Population Density		
Low	72	47.06
Medium	19	12.42
High	41	26.80
Very Dense	21	13.73
Coverage of Households with Clean and Healthy Behavior		
Low (<80)	38	24.84
High (≥80)	115	75.16
Poor Family		
Low	115	75.16
Medium	32	20.92
High	6	3.92
BCG Immunization Coverage		
Low (<90)	4	2.61
High (≥90)	149	97.39

Table 1 shows in 2023, Makassar City recorded 648 pediatric TB cases across 153 urban villages. The incidence rates vary: 60.78% of villages fall into the low category, 30.72% medium, 7.84% high, and 0.65% very high. Additionally, 1.31% of neighborhoods have low healthy home coverage, 13.73% face high population density, and 24.84% have low clean and healthy behavior coverage. Poverty remains a concern in 3.92% of villages, while 2.61% have low BCG immunization coverage.

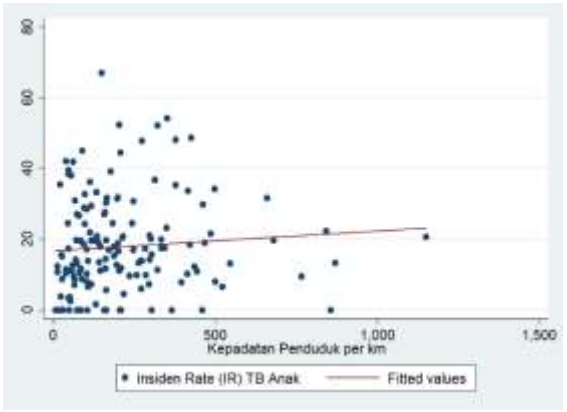
Table 2. Results of Correlation Analysis of Healthy Home Coverage, Population Density, Coverage of Households with Clean and Healthy, Poor Families, and Immunization Coverage with the Incidence Rate of Childhood Tuberculosis in Urban Village of Makassar City in 2023

Variables	*r*	p	**Description**
Healthy Home Coverage	0,086	0,288	Positive correlation, weak relationship, and not significant
Population Density	0,179	0,026	Positive correlation, weak relationship, and significant
Coverage of Households with Clean and Healthy Behavior	0,004	0,960	Positive correlation, weak relationship, and not significant
Poor Family	0,117	0,149	Positive correlation, weak relationship, and not significant
BCG Immunization Coverage	0,028	0,723	Positive correlation, moderate relationship, and not significant

Table 2 shows the correlation between various factors and the incidence rate of a childhood tuberculosis in Makassar City. There was a significant correlation between population density and the incidence rate of childhood tuberculosis (p=0.026), with a weak positive relationship (r=0.179). This positive correlation indicates that higher population density is associated with a higher incidence of childhood tuberculosis. There was no significant correlation between healthy home coverage and childhood tuberculosis incidence (r=0.086; p=0.288), nor between the coverage of households with clean and healthy behavior and childhood tuberculosis incidence (r=0.004; p=0.960). Similarly, there was no significant correlation between poverty and childhood tuberculosis incidence (r=0.117; p=0.149). BCG immunization coverage also showed no significant correlation with childhood tuberculosis incidence, despite a moderate positive relationship (r=0.028; p=0.723).



(a)



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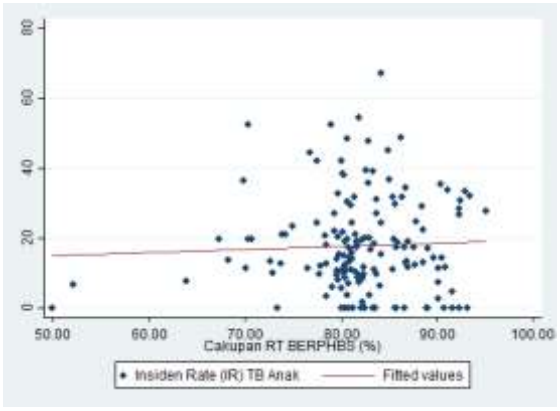

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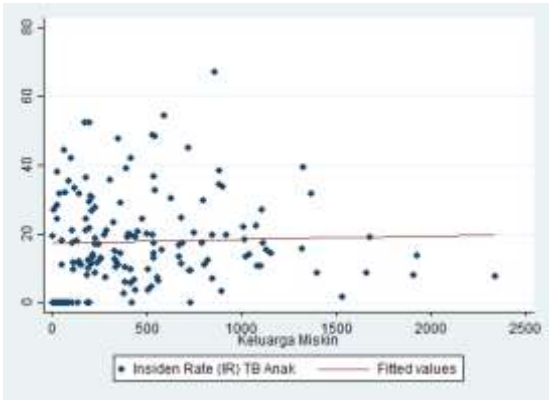

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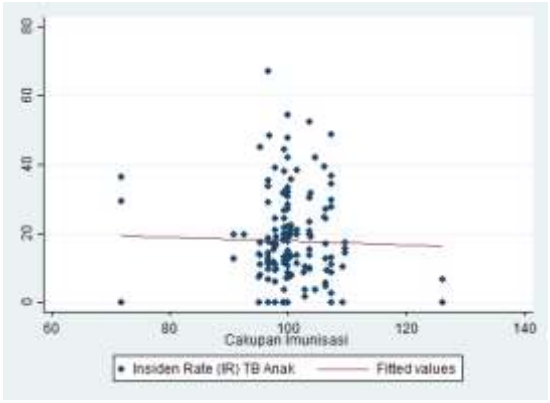

(e)

Figure 1. (a) Linearity Test Using *Scatter Plot* between Coverage of Healthy Homes in urban village Makassar City Year 2023 **(b)** Linearity Test Using *Scatter Plot* between Population Density in urban village Makassar City Year 2023 **(c)** Linearity Test Using *Scatter Plot* between Coverage of Households with coverage of households with clean and healthy behavior in urban village Makassar City Year 2023 **(d)** Linearity Test Using *Scatter Plot* between Poor Families in urban village Makassar City Year 2023 **(e)** Linearity Test Using *Scatter Plot* between BCG Immunization Coverage in urban village

Makassar City Year 2023.

Based on the results of the linearity test using scatter plots, the relationship between the incidence rate of childhood TB and various factors was analyzed in urban villages of Makassar City in 2023. Figure 1 presents the scatter plots for each variable. The scatter plot between the incidence rate of childhood TB and healthy home coverage showed a very weak positive correlation, with data points scattered randomly and a nearly flat regression line (figure 1(a)). The scatter plot between the incidence rate of childhood TB and population density showed a weak but significant positive correlation, with data points slightly aligning along an upward-sloping regression line, suggesting that areas with higher population density tend to have a higher incidence of childhood TB (figure 1(b)). Meanwhile, the scatter plot between the incidence rate of childhood TB and coverage of households with clean and healthy behavior (CHLB) showed a very weak correlation, with widely scattered points and a flat regression line (figure 1(c)). The scatter plot between the incidence rate of childhood TB and poor families showed a weak and not significant correlation, with dispersed data points and a nearly horizontal regression line (figure 1(d)). Lastly, the scatter plot between the incidence rate of childhood TB and BCG immunization coverage showed a moderate but not significant positive correlation, with randomly spread data points and a slightly inclined regression line (figure 1(e)).

Based on data from the Makassar City Health Office, there were 648 children suffering from tuberculosis in 2023. The number of urban villages in Makassar City is 153 urban villages. This study shows that the incidence rate of childhood tuberculosis per urban village in Makassar City is mostly in the low category, but not a few urban villages are still in the high and very high categories. The urban village with a very high incidence rate of childhood tuberculosis is Bontoala. The high incidence rate in an area is influenced by risk factors in the urban village such as high population density. Bontoala urban village is located in the center of Makassar city with a high population density. Areas with high population density are often centers of mobility, which can increase the risk of disease spread(13).

The coverage of healthy homes in urban village in Makassar City is mostly high (>80%) but there are still 2 urban village with a low category (<80%). The coverage of healthy homes in Makassar City is high due to several supporting factors such as proactive government programs in various environmental health programs. The percentage of households with CHLB in urban villages in Makassar City still has 38 urban villages in the low category (<80%), there are several factors that affect CHLB in the household setting, such as the level of education, knowledge, economic factors, and the role of health workers (14). There are 6 urban villages with a high number of poor families per urban village in Makassar City. The high poverty rate has an influence on the accessibility of the community in conducting tuberculosis treatment BCG immunization coverage in urban village in Makassar City still has 4 urban village with low immunization coverage (<90%). Low BCG immunization coverage can be caused by several things such as parental knowledge (15).

A healthy home plays a role in creating a physically, mentally, and socially healthy family life. Its criteria include low humidity, easy maintenance, and adequate sanitation and food storage facilities. Unhealthy housing conditions increase the risk of TB transmission, especially among children (16). Low healthy home coverage contributes to higher pediatric TB risk, aligning with studies in Samarinda that link poor sanitation, overcrowding, and low awareness to delayed TB detection (17). The Spearman correlation test results show that healthy home coverage in Makassar City has a weak and non-significant correlation with the incidence of childhood tuberculosis (TB) (r=0.086). Although healthy home coverage is high, it does not directly impact reducing childhood TB cases. A study in Bukittinggi found that environmental factors such as housing density and poor sanitation access play a greater role in increasing TB risk (18). In contrast, studies in Pekanbaru and Bandung that physical housing conditions, such as ventilation, lighting, and humidity, are significantly correlated with childhood TB incidence (19) (20). These differing results indicate that besides healthy home coverage, other factors such as housing density, access to healthcare services, and socioeconomic conditions also influence childhood TB risk. Therefore, a multisectoral approach that includes improving housing infrastructure, increasing public awareness, and optimizing TB detection and treatment is essential for effectively reducing childhood TB incidence.

High population density can increase the risk of exposure to individuals with tuberculosis (21). High-density areas facilitate the airborne transmission of *Mycobacterium tuberculosis*, thereby increasing the potential spread of the disease (22). Spearman's correlation analysis showed a weak but significant positive correlation between population density and childhood TB incidence (r=0.179), indicating that higher density areas tend to have more TB cases. Similar findings were reported in India and Surabaya, where population density was significantly correlated with TB incidence (23) (24). Overcrowded environments promote TB transmission due to frequent close contact, particularly when housing conditions are poor. This aligns with Madjid et al. who found higher TB incidence among migrant groups due to factors like high mobility, social isolation, and low awareness of TB symptoms and prevention. In Makassar City, densely populated urban areas, often inhabited by migrant communities with limited access to healthcare and substandard living conditions, further heighten TB transmission risk, particularly among vulnerable children (25).

Household Clean and Healthy Living Behavior (CHLB) is a fundamental step in preventing tuberculosis (TB) transmission within the family environment. CHLB practices such as maintaining household cleanliness, ensuring adequate ventilation, and keeping a safe distance from TB patients can help reduce the spread of Mycobacterium tuberculosis. A clean environment lowers the risk of pathogen exposure and provides greater protection, especially for children who are more vulnerable to

infections due to their developing immune systems (26). Based on the Spearman correlation test, the coverage of CHLB households showed a weak positive correlation with childhood TB incidence (r=0.004). The correlation test results in Makassar City suggest that CHLB household coverage does not have a significant influence on childhood TB incidence. Although 80% of urban villages have achieved high PHBS coverage, other factors such as population density, indoor air quality, and access to healthcare services play a more significant role in TB transmission(27). Other studies also indicate that BCG immunization, nutritional status, and household environmental conditions have a greater impact on childhood TB cases than PHBS coverage (28). Additionally, TB transmission occurs not only within households but also in external environments such as schools and densely populated communities, highlighting the need for community-based interventions (29).

Poverty is one of the main factors that can worsen health conditions, as families affected by tuberculosis (TB) face various challenges in supporting the long-term treatment required, including covering transportation costs to healthcare facilities and providing nutritious food during the recovery period (30). Spearman correlation test results indicate that poverty does not have a significant influence on the incidence of pediatric TB in Makassar City (r=0.117; p>0.149). Although poverty is often associated with TB risk, this study suggests that environmental factors such as housing density, poor ventilation, and close contact with adult TB patients play a greater role in the spread of pediatric TB. A study conducted at the Makassar Public Health Lung Center also found that economic status has a weak correlation with TB incidence compared to the physical condition of the patient's home (31). However, another study found that areas with high poverty levels tend to have higher TB prevalence due to limited access to healthcare services and poor living conditions, including malnutrition and high population density (32). These differing results indicate that the relationship between poverty and pediatric TB varies depending on local conditions, where in Makassar City, environmental factors appear to have a greater influence than family economic status.

BCG vaccination is a mandatory immunization given to infants to prevent tuberculosis; however, its effectiveness in reducing childhood TB incidence is influenced by various factors (33). Spearman's correlation test in Makassar City showed that the high BCG immunization coverage (>90%) had no significant effect on childhood TB incidence (r=0.028; p>0.723). While some studies found a correlation between low immunization coverage and increased childhood TB cases, BCG is more effective in preventing severe TB forms like meningitis rather than latent infections(16). Additionally, other research suggests that environmental factors, nutritional status, and close contact with adult TB patients play a more significant role in childhood TB incidence than BCG immunization coverage (34,35). These findings indicate that despite high BCG immunization coverage in Makassar City, the persistent TB incidence among children may be attributed to other risk factors such as household exposure, population density, and inadequate sanitation. Therefore, health education for parents plays a crucial and effective role in increasing public understanding and awareness of the importance of BCG vaccination, ensuring better TB prevention efforts in children (36).

The bivariate analysis results indicate that among the various factors analyzed, population density is the most influential factor affecting the incidence of tuberculosis (TB) in children in Makassar City. High population density increases the risk of Mycobacterium tuberculosis transmission due to close contact in confined environments, particularly in densely populated settlements and public facilities. Therefore, a more comprehensive TB control effort is needed, including raising public awareness of TB prevention, improving housing quality with adequate ventilation, and strengthening early detection and treatment systems for active TB cases. Additionally, community-based interventions such as health education, increasing BCG immunization coverage, and improving nutritional status and environmental sanitation should also be reinforced to reduce the incidence of childhood TB in Makassar City.

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Ethical Code: This research was approved by the Research Ethics Committee of the Faculty of Public Health, Hasanuddin University with number 1961/UN4.14.1/TP.01.02/2024 on August 23, 2024.

Author Contributions: St. Ainul Rachmadani, Ansariadi, Ida Leida Maria, A. Arsunan Arsin, Syamsuar: Concept and design study. ST. Ainul Rachmadani: Collecting and processing research data. All authors: Preparation of publication manuscript.

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