

## CORRELATION BETWEEN LIVABLE HOUSING, BCG IMMUNIZATION COVERAGE, AND POPULATION DENSITY WITH CHILD TUBERCULOSIS INCIDENCE IN EAST JAVA PROVINCE 2020-2022

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### Abstract

**Introduction:** *Mycobacterium tuberculosis* bacteria can cause tuberculosis disease. In 2022, East Java Province reported 8,398 cases of child tuberculosis with a discovery coverage of 105.6%. This study aims to describe the distribution of child tuberculosis incidence in East Java Province by mapping and analyzing the correlation between livable houses, BCG immunization coverage, and population density with the incidence of child tuberculosis in 38 districts/cities in East Java Province from 2020 to 2022. **Methods:** This was a descriptive approach with a population correlation study design using the Spearman correlation statistical test. Secondary records from the East Java Health Profile 2020, 2021, and 2022 were used in this study. Thirty-eight districts/cities in the province of East Java comprised the study's population. **Results and Discussion:** This study showed that there has been a positive correlation between BCG immunization coverage in 2020 ( $r=0.043$ ); 2021 ( $r=0.140$ ); 2022 ( $r=0.214$ ) and population density 2020 ( $r=0.082$ ); 2021 ( $r=0.102$ ); and 2022 ( $r=0.174$ ) with the incidence of child tuberculosis. Meanwhile, the correlation between livable houses and the incidence of child tuberculosis is negative in 2020 ( $r=-0.990$ ) and 2022 ( $r=-0.047$ ) but positive in 2021 ( $r=0.078$ ). **Conclusion:** The increase in BCG immunization coverage and population density aligns with the increase in child tuberculosis cases. Meanwhile, an increase in the percentage of access to livable houses is followed by a decrease in the incidence of child tuberculosis.

## INTRODUCTION

Transmission of *Mycobacterium tuberculosis* is the leading cause of global infection. Tuberculosis is a contagious disease caused by the gram-positive bacteria *Mycobacterium tuberculosis*. The disease spreads through the air and most usually affects the lungs. Tuberculosis can also target the, bones, meninges, joints, lymph nodes, intestines, skin, and different bodily tissues, resulting in extra-pulmonary tuberculosis (1). This disease, if left untreated or incompletely treated, can lead to dangerous complications, including death. According to the World Health Organization (WHO), tuberculosis remains the world's tenth-largest cause of death in 2016 (2). *Mycobacterium tuberculosis* does not only affect adults. There are 450,000 deaths in children under the age of 15 caused by TB. As many as 70,000

cases or about 8.2% of TB cases are known to attack children under 15 years old (3). Children's tuberculosis is an important component of TB control as children aged less than 15 years account for 40-50% of the population and there were 1 million new child TB cases worldwide in 2016 (4). Coughing, fatigue and lethargy, weight loss, fever, and night sweats are symptoms of child tuberculosis. There is a higher risk for children with compromised immune systems to become infected with severe forms of tuberculosis such as meningitis or miliary tuberculosis (5).

The low case notification rate makes tuberculosis a health problem that needs to be consistently taken seriously (6). The gap in child's tuberculosis case finding is a major challenge. According to the WHO, from 2018 to 2021, about 46% of TB cases in children under the age of

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15 went undiagnosed and unreported (7). In Indonesia, the provinces with the largest cases of TB in 2021 were West Java, Central Java, and East Java. The number of tuberculosis cases in East Java has fluctuated throughout the last three years, from 2020 to 2022. Primarily based on the East Java Provincial Health Profile, in 2020 there were 42,922 cases of tuberculosis, in 2021 there were 42,560 cases and in 2022 it increased dramatically to 78,799 cases (8).

Tuberculosis continues to be one of the most frequent infectious diseases in children. Tuberculosis is an important cause of morbidity and mortality in children. However, the incidence of childhood tuberculosis has received less attention in tuberculosis epidemiology because >95% of children with tuberculosis have BTA (-) sputum, thus not contributing directly to the transmission of tuberculosis (9). Tuberculosis can affect all age groups from children to adults. However, pulmonary tuberculosis occurs more in productive age, namely 15-64 years old (10). In 2021, East Java Province placed fourth in Indonesia for the highest number of cases of child tuberculosis, with 2.779 cases in children aged 0-14 years and case-finding coverage rate of 24%. This number has increased from the previous year, when there were 2.734 cases of child tuberculosis in East Java with a case-finding coverage rate of 23.8% (8). Meanwhile, in 2022, there were 8,398 reported cases of child tuberculosis with a case-finding coverage of 105.6% (11).

The BCG immunization program is one of several measures to prevent tuberculosis. Immunization is an attempt to intentionally cause or build someone's immunity to a disease so that, if exposed to it in the future, they will not become ill or just have moderate pain. Immunization has been an achievement tale for global health and development, saving tens of millions of lives and protecting population health year after year (12). According to Basic Health Research, the percentage of Indonesian infants immunized with BCG was 87.6% in 2013 and 86.9% in 2018. According to the Indonesian Pediatric Association, the best timing for BCG immunization is when the child is under three months old (0-2 months) (13).

In addition to BCG immunization, there are numerous environmental risk factors for child TB, namely population density and livable homes. Tuberculosis can be transmitted through environmental conditions, namely in an unhealthy home environment, especially in densely populated residential areas with poor access to sanitation (14). The high burden of TB cases in an area can occur due to the high population density in the area (15). Population density can accelerate the transmission

and transfer of disease from one person to another (16). Tuberculosis can be transmitted through droplets of sputum released by a person with tuberculosis when they sneeze or cough. Each BTA-positive tuberculosis patient can transmit the disease to 10 to 15 people (17). Therefore, high population density will lead to problems such as the emergence of slums and, decreased environmental quality and quality of life, accelerating the spread of tuberculosis (18).

Regulation of the Minister of Health of the Republic of Indonesia Number 67 of 2016 concerning TB Control stated that dense and slum housing environments will facilitate the transmission of TB (19). Therefore, it is important to improve livable housing to prevent disease infection and improve quality of life. A habitable house is a house that meets the requirements of building safety and minimum building area adequacy, as well as the health of its occupants. A livable house is composed of several indicators, including indicators of building resilience (roof, wall, and widest floor material), adequacy of floor area per capita of a minimum of 7.2 m<sup>2</sup>, access to decent consuming water sources, and access to proper sanitation (20). Research conducted in West Java states that healthy homes positively correlate with the discovery of tuberculosis (21).

This study aims to describe the distribution of child tuberculosis incidence in East Java Province by mapping and analyzing the correlation between livable houses, BCG immunization coverage, population density with and the incidence of child tuberculosis in 38 districts/cities in East Java from 2020 to 2022.

## METHODS

This study uses a descriptive approach with a populace correlation study design. The secondary data used in this research were sourced from the East Java Health Profile for 2020, 2021, and 2022. The population and sample in this research were 38 districts/cities in East Java Province. The dependent variable in this study was the number of child tuberculosis cases and the independent variables used were BCG immunization coverage in infants, residential density, and livable houses. The data analysis measured the relationship between the dependent variable, the incidence of child TB, and the independent variables, BCG immunization coverage in infants, population density, and livable housing. Data on of child TB cases and BCG immunization coverage variables were sourced from the East Java Provincial Health Profile. Meanwhile, the other independent variables, population density and livable houses, were obtained from the publication of the Central Bureau of Statistics of East Java Province. The

data analysis technique used was the EpiMap mapping software application. The data analysis used was the Pearson and Spearman correlation test.

**RESULTS**

**Correlation of Livable Housing, BCG Immunization Coverage, and Population Density with the Incidence of Child Tuberculosis in East Java Province in 2020-2022**

Table 1. Shows the results of the Spearman correlation test between livable housing, BCG immunization coverage, and population density with the incidence of child tuberculosis in East Java Province from 2020 to 2022.

**Table 1. Correlation of Livable Housing, BCG Immunization Coverage, and Population Density with the Incidence of Tuberculosis in Children in East Java in 2020-2022**

Risk Factors	Correlation	Coefficient
<b>2020</b>		
Livable Housing	-0.990	Very Strong
BCG Immunization Coverage	0.043	Very Weak
Population Density	0.082	Very Strong
<b>2021</b>		
Livable Housing	0.078	Very Weak
BCG Immunization Coverage	0.140	Very Weak
Population Density	0.102	Very Weak
<b>2022</b>		
Livable Housing	-0.047	Very Weak
BCG Immunization Coverage	0.214	Very Weak
Population Density	0.174	Very Weak

**Distribution and Correlation between Livable housing and Incidence of Child Tuberculosis in East Java Province in 2020-2022**

Housing that does not meet the requirements is one of the risk factors for pulmonary tuberculosis. The incidence of child tuberculosis in 2021 is 2,792 cases, which increased from the previous year, only 2,747 cases. In 2021, 19 districts/cities experienced an increase in the percentage of livable housing. Of these 19 districts/cities, only nine districts/cities had an increase in the percentage of livable housing followed by an increase in child TB cases. The nine districts/cities were Ponorogo District, Situbondo District, Tuban District, Kediri City, Probolinggo City, Mojokerto City, Madiun City, and Batu City.

The condition of livable housing in East Java in 2022 was 66.28%, which means that around 6,623 households out of every 10,000 households had livable housing. This also means that around one-third of households in East Java still do not have livable housing (5). The lowest percentages of households with access to livable houses are Bondowoso District (42.93%), Bangkalan District (44.29%), and Situbondo District (45.10%).

Based on the correlation test results between the percentage of livable housing and the incidence of child tuberculosis, the relationship showed a negative direction in 2020 and 2022, while in 2021 it showed a positive direction. The negative value indicates that the increasing percentage of livable housing in districts/municipalities in East Java was followed by a decrease in children's TB cases in 2020 and 2022. Meanwhile, the positive correlation value in 2021 indicates that a decrease in the percentage of livable houses in districts/cities in East Java is followed by an increase in child TB cases.

**Distribution and Correlation between BCG Immunization Coverage and Incidence of Child Tuberculosis in East Java Province 2020-2022**

In 2020, the incidence of child tuberculosis in East Java Province was 2,747 cases, with 98.8% BCG vaccine coverage. Surabaya City, Jember District, and Pasuruan District had the highest rates of child tuberculosis in 2020. In 2021, the cases of child tuberculosis in East Java Province doubled from the previous year to 2,792 cases. Meanwhile, BCG vaccine coverage in 2021 dropped to 95.6%. Although the incidence of child tuberculosis in East Java Province grew in 2021, 15 districts/cities had a drop in the number of cases. Only four of the 15 districts/cities had an increase in BCG vaccine coverage for babies as the number of child tuberculosis cases decreased. The four districts/cities are Lumajang, Madiun, Blitar, and Madiun City, whereas, in 2022, there was a drastic increase in the cases of child tuberculosis in East Java Province to 8,398 cases. This year, all districts/cities in East Java experienced an increase in child tuberculosis cases compared to the previous year. The three districts/cities with the highest cases are Surabaya City, Sidoarjo Regency, and Jember Regency. Thus, for three consecutive years, from 2020 to 2022, Surabaya City ranked first for the highest number of child tuberculosis cases in East Java Province.

The Spearman correlation test results show a positive relationship between BCG immunization coverage and the incidence of child tuberculosis. These results indicate that an increase in BCG immunization coverage in districts/cities in East Java was followed by an increase child tuberculosis cases in 2020, 2021, and 2022..

**Distribution and Correlation between Population Density and Incidence of Child Tuberculosis in East Java Province in 2020-2022**

Child tuberculosis in East Java Province reached 2,747 cases in 2020. Surabaya City, Jember Regency, and Pasuruan Regency had the most tuberculosis cases

in children in 2020. Of the three districts/cities, only Surabaya City has a high population density of  $\geq 1,250$  people/km<sup>2</sup> according to BPS Regulation No. 37 of 2010 concerning Urban and Rural Classification in Indonesia. Meanwhile, Kabupaten Jember and Kabupaten Pasuruan had a medium population density in 2020.

In 2021, more than 50% or 20 districts/cities in East Java had a greater population density than last year. It was also followed by an increase in the number of children TB cases from 2,747 cases to 2,792 cases. There were nine districts/cities that experienced an increase in child TB cases and an increase in population density. The nine districts/cities are Malang District, Situbondo District, Mojokerto District, Magetan District, Tuban District, Gresik District, Sumenep District, Malang

City, Mojokerto City, and Surabaya City.

In 2022, the incidence of children's TB in all districts/cities in East Java increased compared to the previous year with a total of 8,398 cases. This is in line with the increased population density in 34 districts/cities, and only four districts/cities have decreased in population density, namely Pacitan District, Kediri District, Jombang District, and Nganjuk District.

Based on the Spearman correlation test results between population density and the incidence of child tuberculosis, the direction of the relationship is positive. These results indicate that the increase in population density in districts/cities in East Java was followed by an increase in child tuberculosis cases in 2020, 2021, and 2022.

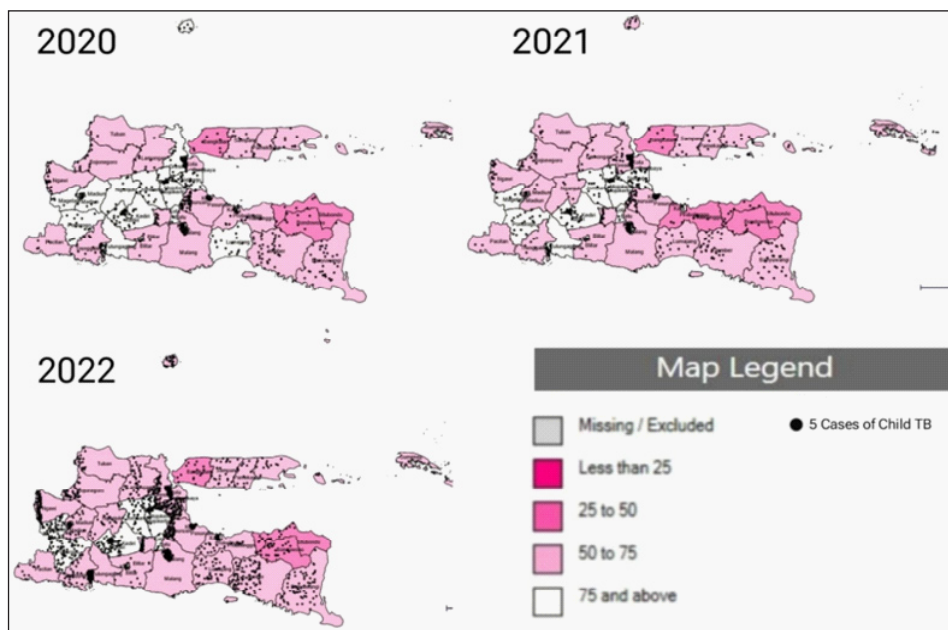


Figure 1. Distribution Map of Livable Housing and Child TB Incidence in East Java Province 2020-2022

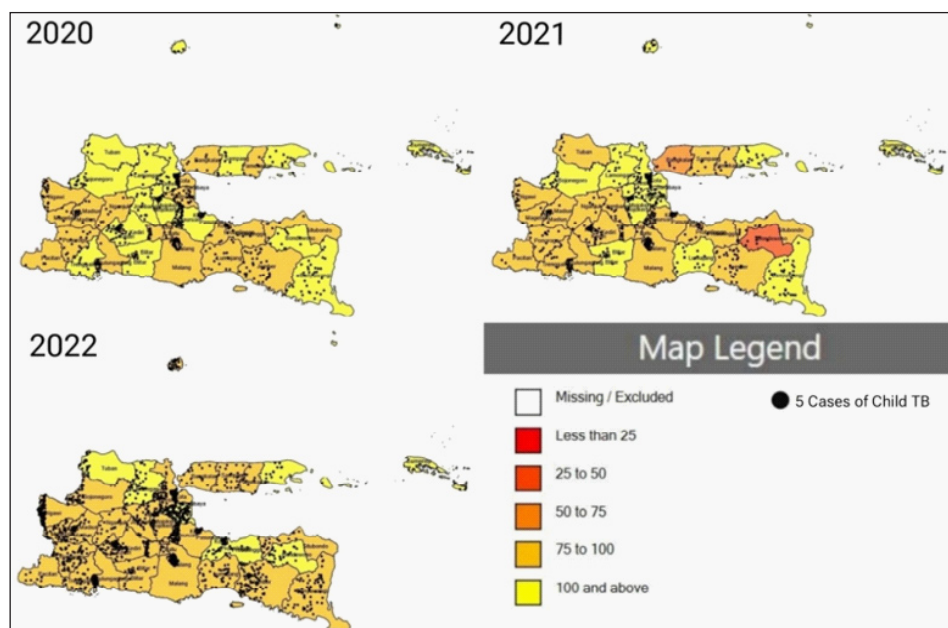


Figure 2. Distribution Map of BCG Immunization Coverage and Child TB Incidence in East Java Province 2020-2022

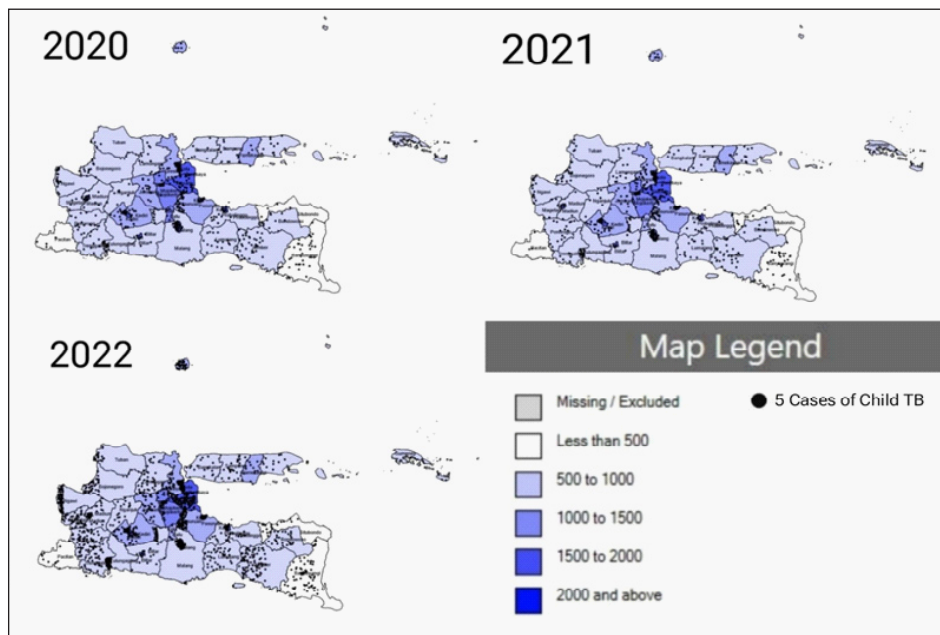


Figure 3. Distribution Map of Population Density and Child TB Incidence in East Java Province 2020-2022

### DISCUSSION

Every year, more than 15 million children are exposed to tuberculosis, and an estimated 7.5 million children are latently infected. In the province of East Java, Surabaya City always ranks first in contributing the most cases of pediatric tuberculosis due to its high population and the large number of migrants who often carry the bacteria that cause tuberculosis, thereby increasing transmission. Of the children infected with latent tuberculosis each year, approximately 1-1.2 million are estimated to develop active disease, more than half of whom are under 5 years of age. A combination of immunological, environmental and behavioral factors means that children under 5 years old have the highest incidence and greater risk of developing tuberculosis than adults. In areas with a high incidence of tuberculosis, as much as 20% of the total TB burden is estimated to be in children (22).

The presence of a source of transmission, contact history of patients, socioeconomic status, exposure level, virulence of the bacillus, low body resistance due to genetics, nutritional status, fecal factors, age, nutrition, immunization, and environmental factors, such as the condition of the physical environment of housing (temperature, ventilation, lighting, humidity, and the surrounding environment) and work are all factors that contribute to tuberculosis disease (23). A study conducted in Southeast Brazil showed that children can only be infected through close contact with a person suffering from active bacillary TB (24). There is twice the risk of tuberculosis infection among children living in poor neighborhoods, compared to children living in non-poor neighborhoods (25). The habit of living with

a large family in one house is one of the environmental risk factors for tuberculosis transmission. Therefore, a standard of residential density is based on a simple house building of at least 10m<sup>2</sup> inhabited by one person (26).

If housing conditions do not fulfill health standards, this could be a factor in the spread of multiple diseases, including tuberculosis. Research conducted at the Jember Regency stated that there was a relationship between temperature, humidity, lighting and ventilation area with the incidence of child tuberculosis (27). The sufficient floor size per person of at least 7.2 m<sup>2</sup> is one of the criteria for a livable home in East Java Central Bureau of Statistics. The correlation value for 2020 and 2022 is consistent with a study in Yogyakarta City that demonstrated a negative relationship between the incidence of tuberculosis and residential density, with the incidence of tuberculosis increasing with decreasing residential density (28). In addition, poor communities are more susceptible to TB as they tend to have poorly constructed, poorly ventilated and overcrowded homes. One of the things that can affect the incidence of tuberculosis in children is the lack of ventilation and population density. Furthermore, appropriate sanitation is another indicator. Long-term disruptions in family health can result from uncomfortable physical sanitation at home (29).

In childhood, growth and development occur very rapidly. So more efforts are needed to maintain their health, create a healthy, smart, and quality next generation, and decrease child mortality rates. Efforts to improve and maintain children's health can be made from the womb until the child is 18 years old. Meanwhile,

children in the first five years of life still have a low immune system so they are vulnerable to diseases including pulmonary tuberculosis (30). Children are usually infected with tuberculosis from adults who have progressive cavitory lesions that release infected droplets into the air. Prolonged contact (such as through repeated exposure to coughing, kissing, and dust in the environment) must occur before the child develops active tuberculosis disease (31). Exposure to tuberculosis patients increases the risk of infection for neonates and children. Most cases occur within weeks after contact investigations, and prophylaxis is ineffective (32).

The small correlation between population density and the incidence of childhood tuberculosis may be due to a combination of unhealthy home environment factors and the quality of tuberculosis prevention programs such as BCG immunization. One of the most popular immunizations for infants and young children in the 20th century was the *Bacillus Calmette-Guérin* (BCG) vaccine, used to eradicate tuberculosis. The WHO advises administering BCG immunization to infants in nations where tuberculosis is highly prevalent. This vaccination is meant to protect children from tuberculosis, but it offers far less protection to adults (33). The BCG is more effective in protecting newborns against severe types of tuberculosis (34).

The small correlation between BCG immunization coverage and the incidence of child TB in this study is not a problem because the small strength of the correlation is due to the incidence of TB being more related to the child's immune system. Children are very susceptible to TB infection. One of the causes of TB in children is nutritional status. A poor one causes a weak immune system, making contracting tuberculosis easier (35). The developing immune system in young children reacts to infection with *M. tuberculosis* with a broad array of patterns that would help the diagnosis and could also be used as biomarkers to follow the disease progression (36). TB germs become active if the immune system cannot stop them from growing. It is called active TB disease when TB germs are active (multiplying in your body). Children with active TB disease feel sick and they may also be able to spread the germs to people they spend time with every day.

The findings of this study are consistent with research conducted in Central Java Province, which found a positive association ( $r=0.406$  and  $r=0.324$ ) between the incidence of child tuberculosis and BCG vaccine coverage (37). Furthermore, a study by Bangka Regency demonstrates that the incidence of child tuberculosis and the BCG vaccination program are significantly correlated, with an OR=6.87 (38). This results indicate that the risk

of tuberculosis was 6.87 times greater among children who did not receive the BCG vaccination than in those who did. On the other hand, a study carried out at RSUD Dr. Moewardi Surakarta produced contradictory findings, indicating no significant correlation between the incidence of pulmonary tuberculosis in children under five and the BCG vaccination program (39). Because the body's immune response to BCG immunization is impacted by several factors, including age, genetics, nutrition, past infection history, and the type of vaccine strain used, BCG vaccinations' efficiency may vary (40).

Population density is a condition that describes the number of residents versus the area (41). Interactions with TB patients can increase the risk of transmission of the disease. Therefore, this may occur in neighborhoods with high population density (42). Each region's population density increases each year because people tend to move to cities or regencies that provide many jobs. This study's findings are similar to research conducted in India, which discovered a positive and strong correlation ( $r=0.7651$ ) between the number of tuberculosis cases per 1000 people and population density (43). People living in densely populated and poorly ventilated areas are more likely to be infected with tuberculosis. Population density can accelerate disease transmission from one person to another, especially in diseases transmitted through air/droplets. In tuberculosis disease, in a dense population *Mycobacterium tuberculosis* in the air can be inhaled easily by many people, thus facilitating infection (44).

The global commitment to end tuberculosis is outlined in the End TB Strategy, which aims to reduce tuberculosis incidence by 80% and deaths from tuberculosis by 90% by 2030. Efforts to reduce the risk of childhood tuberculosis transmission are important at the family level because children spend much time with their families at home. Unhealthy behavior can increase the number of tuberculosis cases. Examples of these behaviors are utilizing eating or drinking utensils together, inadequacy of lighting in the house, and the habit of spitting carelessly. There are still many myths related to tuberculosis transmission in the community. For example, people assume that the cause of tuberculosis is not due to direct contact with people with tuberculosis but due to smoking, drinking alcohol, eating junk food, sleeping on the floor, and sleeping late at night (45). Risk factors for children's TB infection occur because of history of contact with adult TB, so it is important to detect early in children by tracing the source of contact in adults to organize prevention for children (46). One form of preventing childhood TB in schools is by sharing roles with schools in the prevention and control of TB, namely in the form of health promotion efforts in schools,

efforts to control risk factors for TB transmission in schools, activities to support the creation of Clean and Healthy Living Behavior in schools in preventing TB and improving health (47).

### CONCLUSION

Tuberculosis is a contagious disease caused by *Mycobacterium tuberculosis*. BCG immunization is one of the efforts to prevent tuberculosis by providing immunity to infants and children by introducing vaccines into the body. The data analysis found a very strong positive correlation in 2020 between BCG immunization coverage and the incidence of child TB, while in 2021 and 2022 the correlation value is very weak. This suggests that the larger the coverage of BCG vaccine, the greater the incidence of child tuberculosis. The correlation between population density and the incidence of child tuberculosis in 2020, 2021, and 2022 is positive with a very weak strength. Thus, the higher the population density, the higher the incidence of child tuberculosis. Meanwhile, the correlation between livable housing and the incidence of child tuberculosis was negative in 2020 and 2022 with very strong and very weak strengths, respectively. For 2021, the correlation between livable housing and the incidence of child tuberculosis is positive.

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