Original

Investigation of Toddlers in Close Contact of Tuberculosis Patients Using Molecular Rapid Test and Tuberculin Skin Test

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ABSTRACT

Background: Tuberculosis (TB) in young children remains difficult to diagnose because of the paucibacillary nature of the disease and challenges in obtaining respiratory specimens. Stool-based Molecular Rapid Tests (MRT) and the Tuberculin Skin Test (TST) have been recommended for childhood TB investigation, particularly among close contacts of TB patients. This study analysed stool MRT and TST findings among toddlers with household exposure to TB patients.
Methods: A cross-sectional study among 30 toddlers with household contact of bacteriologically confirmed active pulmonary TB patients with health facility catchment area. Medical record, demographic characteristics, nutritional status, TB symptoms, stool MRT, and TST results were analysed. Univariate and bivariate analyses were performed using IBM SPSS Statistics with association assessed using Chi-square or Fisher's exact tests at a significance level of $p<0.05$.
Results: All participants (100%) had negative stool MRT results, whereas 20 of 30 toddlers (66.7%) had positive TST results, indicating latent tuberculosis infection (LTBI). Bivariate analysis using the Chi-square test showed a significant association between age and TST positivity ($p=0.025$). No significant associations were observed between TST results and sex ($p=0.259$), relationship to the index case ($p=0.097$), nutritional status ($p=0.621$). All toddlers were asymptomatic at the time of assessment.
Conclusion: Findings confirm that stool MRT has limited sensitivity in asymptomatic toddlers, while TST can be a screening method in detecting latent TB infection. It is necessary to strengthen contact investigations, increase LTBI screening coverage, and optimize tuberculosis preventive therapy (TPT) in primary health care to prevent progression to active TB in vulnerable groups.

Keywords: Tuberculosis, Close Contact Toddlers, Molecular Rapid Tests, Tuberculin Skin Test, Latent Tuberculosis Infection.

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INTRODUCTION

Tuberculosis (TB) remains one of the leading infectious causes of morbidity and mortality worldwide. Despite ongoing global control efforts, the burden of TB continues to be substantial, with the World Health Organization reporting 8.2 million new cases in 2023, representing an increase compared with previous years.[1] Indonesia is one of the countries with the highest TB burden in the world, second only to India.[1] This situation indicates that global TB control still faces challenges, particularly in detection.

Children, particularly toddlers, are a vulnerable population often overlooked in TB control programs. Although not the primary source of transmission, the burden of childhood TB cases remains high, with approximately 135,000 cases occurring in children aged 0–14 years in 2020.[2] TB diagnosis in children also faces challenges, such as limited sputum collection and frequent negative test results due to paucibacillary disease, making conventional diagnostic methods less than optimal.[3] As an alternative, since 2020, the WHO has recommended the stool specimen-based Molecular Rapid Test (MRT) as a diagnostic method for children with TB symptoms. Furthermore, the Tuberculin Skin Test (TST) remains used to screen for latent TB infection in close contact populations. However, implementation of these two methods in primary healthcare remains limited, resulting in suboptimal utilization.[3-8]

On the other hand, TB control programs focus more on active TB than latent TB infection (LTBI), even though LTBI has a lifetime risk of developing into active TB of 5–10%, especially in toddlers. Limited LTBI screening, especially in close contact groups, indicates a gap in early detection. Dr. Soetomo Community Health Center is among the top ten TB cases in Surabaya City, with 161 cases in 2023. Of the 1,328 TB suspects, 32 were children aged 1–18 years.[4] Based on these conditions, this study was conducted to describe the results of *Mycobacterium tuberculosis* examinations using stool MRT and TST in toddlers with a history of close contact with TB patients in the Dr. Soetomo Community Health Center working area.

This study aims to analyze the results of stool MRT and TST examinations and the relationship between TST results and toddler characteristics, including age, gender, relationship to TB patients, nutritional status, and TB clinical symptoms. The results are expected to contribute scientifically to optimizing pediatric TB screening in primary health care and strengthening early TB detection in toddlers as a population.

METHODS

Study Setting: This study was conducted in the working area of Dr. Soetomo Primary Health Center, Surabaya, East Java, Indonesia. The health center serves an urban population and implements routine tuberculosis contact investigation programs. Data were obtained from medical records collected between October and November 2025.

Study Design: This was an analytical observational study with a cross-sectional design to evaluate the results of stool-based Molecular Rapid Tests (MRT) and Tuberculin Skin Tests (TST) among toddlers who were household contacts of tuberculosis patients.

Study Population: The study population consisted of toddlers who had household contact with bacteriologically confirmed pulmonary tuberculosis patients and were registered in the contact investigation program of Dr. Soetomo Community Health Center in Surabaya during the study period.

Eligibility Criteria: The inclusion criteria were toddlers aged below five years who lived in the same household as a bacteriologically confirmed pulmonary TB patient and had undergone both stool MRT and TST examinations. Medical records with incomplete data were excluded from the analysis.

Sample Size Determination: The study included all eligible toddlers identified during the study period. Because the number of eligible participants was limited, no formal sample size calculation was performed.

Sampling Methodology: A total sampling technique was used, whereby all toddlers meeting the eligibility criteria were included in the study. Thirty toddlers fulfilled the study criteria and were analyzed.

Study Variables: The primary outcome variable was the TST result, categorized as positive or negative. Independent variables included age, sex, relationship to the index TB case, nutritional status, and the presence of TB-related symptoms. Stool MRT results were also recorded and descriptively analyzed.

Measurement Tools and Definitions: The stool-based Molecular Rapid Test (MRT) was performed according to the national tuberculosis diagnostic guidelines. Tuberculin Skin Test results were interpreted 48–72 hours after administration, with an induration of ≥10 mm considered positive. Nutritional status was assessed using anthropometric data documented in

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medical records and classified according to standard pediatric nutritional categories.

Data Collection Procedures: Secondary data were retrieved from medical records of eligible toddlers. Information collected included demographic characteristics, relationship to the index case, nutritional status, TB symptoms, stool MRT results, and TST results.

Data Analysis: Data were analyzed using IBM SPSS Statistics version XX (replace with actual version used). Descriptive statistics were used to summarize participant characteristics and examination results. Bivariate analysis was performed using the Chi-square test or Fisher's exact test, as appropriate. Statistical significance was established at $p < 0.05$ with a 95% confidence level.

Ethical Considerations: This study was approved by the Health Research Ethics Committee of the Faculty of Medicine, Universitas Airlangga (Approval No. 343/EC/KEPK/FKUA/2025). The study utilized anonymized secondary data obtained from medical records, and confidentiality was maintained throughout the research process.

RESULTS

The results of the study as presented in Table 1 showed that all the 30 toddlers (100%) showed negative results, so that the MRT results were not reused, but were replaced with tuberculin tests.

Table 1. Results of *Mycobacterium tuberculosis* examination using stool molecular rapid test.

Molecular Rapid Test Result	Freq (n)	Percent (%)
Positive	0	0
Negative	30	100

Toddlers with positive TST results had a higher mean age than those with negative results (18.05 ± 8.46 vs. 10.00 ± 14.14 months). A significant association was observed between age and TST positivity ($p = 0.025$), indicating that older toddlers were more likely to have latent tuberculosis infection (Table 2).

Table 2. Tuberculin skin test based on age of toddlers in close contact with tuberculosis patients.

Tuberculin Skin Test Result	Age			Frequency		p-value
	<1 Years	1-2 Years	2-3 Years	Mean	Standard deviation	
Positive	5	8	7	18.05	8.46	0.025
Negative	2	3	5	10.0	14.14	

Table 3 presents the correlation betweet TST results and some selected characteristics of the study subjects. The proportion of TST-positive results was higher among males (76.9%) than females (58.8%). However, this difference was not statistically significant ($p = 0.259$). Among the 30 toddlers with household TB exposure, 20 (66.7%) had positive TST results. TST positivity was highest among toddlers whose mothers were the index TB cases (100%), followed by grandmothers (66.7%), fathers (61.5%), and grandfathers (50.0%). In contrast, all toddlers exposed to siblings were TST-negative. However, no significant association was found between the relationship to the TB patient and TST results ($p = 0.097$). There was no statistical relationship ($p=0.621$) between the nutritional status of toddlers in close contact with the patient and the TST results. All toddlers, whether with positive (66.67%) or negative (33.33%) TST results, did not show TB symptoms ($p=0.316$).

Table 3. Correlation between tuberculin skin test result and some selected characteristics of the toddlers' patients.

Variables	Tuberculin Skin Test Result				Total		p-value
	Positive		Negative				
	n	%	n	%	n	%	
Gender							
Male	10	76.9	3	23.1	13	100	0.259
Female	10	58.8	7	41.2	17	100	
Nutritional Status							
Underweight	2	100.0	0	0.0	2	100	0.621
Normal	15	68.2	7	31.8	22	100	

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Variables	Tuberculin Skin Test Result				Total		p-value
	Positive		Negative				
	n	%	n	%	n	%	
Overweight	2	50.0	2	50.0	4	100	
Obesity	1	50.0	1	50.0	2	100	
Relationship With Toddlers							
Biological mother	9	100.0	0	0.0	9	100	0.097
Biological father	8	61.5	6	61.5	13	100	
Biological grandmother	2	66.7	1	66.7	3	100	
Biological grandfather	1	50.0	1	50.0	2	100	
Biological sister	0	0.0	1	0.0	1	100	
Biological brother	0	0.0	1	0.0	1	100	
Symptoms							
Asymptomatic	20	66.7	10	33.3	30	100	0.316
Symptomatic	0	0.0	0	0.0	0	0	
Total	**20**		**10**		**30**	**100**	

DISCUSSION

This study evaluated the results of stool-based MRT and TST among toddlers who were household contacts of TB patients. The principal findings were that all participants had negative stool MRT results, whereas two-thirds of the toddlers showed positive TST results, suggesting latent tuberculosis infection (LTBI). Age was significantly associated with TST positivity, while sex, relationship to the index TB case, nutritional status, and TB symptoms showed no significant associations. In addition, all participants were asymptomatic at the time of assessment.

In this study, all toddlers in close contact with TB patients, had negative stool MRT results. These results may be influenced by technical factors such as sample quality and quantity, which can lead to false negatives,[9] as well as the limited sensitivity of MRT (46–73%) despite its high specificity.[10] Furthermore, the bacterial count in feces is lower than in sputum, especially in children with paucibacillary conditions, making detection more difficult.[11]

These findings align with other studies that showed a predominance of negative results in MRT testing, even in close contact populations.[12,13] This condition may also be influenced by the presence of latent TB, where the child does not show clinical symptoms and the bacteria are not yet active, thus going undetected.[14] Therefore, a negative MRT result does not rule out the possibility of TB, especially in close contact with toddlers. In contrast to the uniformly negative stool MRT results, 66.7% of the toddlers had positive TST results, indicating a substantial burden of LTBI among household contacts of TB patients. This finding suggests that a considerable proportion of exposed toddlers had already acquired *Mycobacterium tuberculosis* infection despite the absence of bacteriological confirmation and clinical symptoms. Given the increased risk of progression from LTBI to active TB in young children, particularly those under five years of age, these findings highlight the importance of routine LTBI screening and early preventive interventions in child household contacts. Therefore, negative stool MRT results should be interpreted cautiously, and TST should remain an integral component of TB contact investigation and screening programs in high-risk pediatric populations.

The results of the study indicate that age plays a role in TST results, with older toddlers more likely to show positive TST results than younger toddlers. This finding aligns with a previous study that reported TST sensitivity is influenced by the level of immune system maturity.[15] Older toddlers have a more developed immune response, allowing for a stronger reaction to exposure to *Mycobacterium tuberculosis*. Immunologically, this is supported by an increase in the number and activity of specific CD4+ T cells against TB antigens such as ESAT-6 in older children.[16] Therefore, as the toddler ages, the immune response becomes more optimal, thus increasing the chance of a positive TST reactivity. This finding confirms that age is a factor that needs to be considered in interpreting TST results in toddlers who are close contacts of TB patients.

The results of this study indicate that there is no statistically significant effect of gender on TST results. A previous study reported that a positive TST response is not influenced by gender differences.[17] This suggests that TST reactivity in toddlers is more determined by

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other factors, particularly the level of exposure to *Mycobacterium tuberculosis* and history of BCG immunization, than by the biological factor of gender. Therefore, both males and females have an equal chance of showing a positive TST result if they have a history of close contact with a TB patient.

The analysis revealed no significant association between family relationships and TST results. Although not statistically significant, this pattern suggests a tendency that the closer the relationship and the intensity of interaction, the higher the risk of exposure to *Mycobacterium tuberculosis*. Toddlers who have close contact with their mothers or grandmothers tend to be more frequently exposed because both acts as primary caregivers with high duration and frequency of contact, such as caregiving, sleeping in the same room, or direct physical contact.[18-20] Conversely, relatively limited contact with siblings has shown negative results. Furthermore, the immature immunity of toddlers makes exposure in the household environment more likely to develop into infection, even in the latent phase.[21] Thus, although family relationships do not show a statistically significant association, the intensity and closeness of contact remain important factors in increasing the risk of TB infection in toddlers with close contact.

The tuberculin skin test response is significantly influenced by immune system function. In malnourished toddlers, immune disorders can lead to false-negative TST results, even though they have latent TB infection. Conversely, toddlers with normal nutritional status have a better immune response, resulting in more accurate and easier-to-interpret TST reactions.[22] The relationship between nutritional status and TB is bidirectional, with malnutrition increasing the risk of TB, while TB can worsen nutritional status.[23] Therefore, TST results in malnourished toddlers cannot directly rule out latent TB infection and require further examination.[24]

Summary of study findings

Most toddlers in this study were asymptomatic despite having positive TST results, suggesting a high prevalence of latent tuberculosis infection (LTBI) among household contacts of TB patients. This finding highlights the limited value of symptom-based screening alone for detecting TB infection in young children. The discrepancy between TST positivity and the absence of symptoms may reflect the asymptomatic nature of LTBI and the inability of TST to distinguish latent from active disease. Therefore, TST results should be interpreted alongside clinical assessment and contact history. These findings underscore the importance of active contact investigation and LTBI screening to facilitate early detection and preventive interventions among high-risk pediatric populations.

CONCLUSION

Toddlers who were close contacts with TB patients showed no evidence of active TB based on stool MRT results; however, most had positive TST results, indicating LTBI. Age was significantly associated with TST positivity, whereas sex, relationship to the index TB case, nutritional status, and TB symptoms were not. These findings highlight the importance of TST as a screening tool for latent TB infection among high-risk child contacts and emphasize the need to strengthen contact investigation, LTBI screening, and TB preventive therapy in primary healthcare settings to reduce the risk of progression to active disease.

Strengths and limitations of the study:

This study provides valuable evidence regarding the use of stool-based MRT and TST among toddlers who were household contacts of TB patients in a primary healthcare setting. A major strength of the study is its focus on a high-risk pediatric population that is often underrepresented in tuberculosis research. Furthermore, the study evaluated both bacteriological and immunological approaches for TB investigation, providing a broader perspective on TB infection among exposed children.

However, several limitations should be acknowledged. The use of secondary medical record data restricted the availability of potentially important variables, such as duration and intensity of exposure, BCG vaccination status, socioeconomic factors, and tuberculosis preventive therapy history. All stool MRT results were negative, preventing further comparative analysis between MRT and TST findings. Finally, confirmatory tests for latent tuberculosis infection, such as interferon-gamma release assays (IGRAs), were not available.

Implications of the findings of the study:

The findings demonstrate a substantial burden of latent tuberculosis infection among toddlers who were household contacts of tuberculosis patients, despite the absence of clinical symptoms and negative stool MRT results. These results highlight the importance of active contact investigation and routine LTBI screening in young children, particularly in primary healthcare

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settings. The study also supports the continued use of TST as a practical screening tool for identifying latent infection among high-risk pediatric contacts. Strengthening LTBI screening programs and expanding access to TB preventive therapy may contribute to reducing progression from latent infection to active disease and support national TB control efforts. Future studies with larger sample sizes and prospective designs are needed to further evaluate risk factors and optimize diagnostic strategies for pediatric TB and LTBI.

Declarations

Author contributions: YT conceptualized, analyzed the data, drafted the manuscript, and supervised the study. RJS collected the data and drafted the manuscript. MR reviewed the literature and drafted the manuscript. The final draft was approved by all the authors.

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