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Research Article

Diagnosis Of Tuberculosis Infection In Pediatric Contacts Of Tuberculosis Cases Using Tuberculin Skin Test

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ABSTRACT

Background: Tuberculosis remains a major cause of morbidity in children, particularly among household contacts of pulmonary TB cases. The Tuberculin Skin Test (TST) is an established, cost-effective tool for screening and diagnosing latent infection in this vulnerable group.
Objectives: To estimate the prevalence of TST positivity among pediatric contacts of pulmonary TB patients and to compare the clinical, socio-demographic, and hematological profiles of infected and non-infected children, identifying predictors of latent tuberculosis infection.
Methods: This cross-sectional study included 384 pediatric contacts aged >5 to <15 years. After excluding confirmed active TB, 295 children were assessed for latent infection using TST. Clinical history, socio-demographic factors, hematological and inflammatory parameters were systematically recorded and statistically analyzed.
Results: Of 295 eligible children, 174 (58.9%) were TST positive. Positivity increased with age (p=0.001) but showed no association with sex or socioeconomic status. TST-positive children had significantly lower hemoglobin, reduced TLC, elevated platelets, and higher ESR/CRP, reflecting immune alterations linked to infection.
Conclusion: Over half of exposed pediatric contacts harbored latent TB infection. TST proved reliable in identifying infection, with higher prevalence in older children and strong association with hematological and inflammatory markers, emphasizing the need for early screening and preventive strategies.

Keywords*: Tuberculosis, Pediatric contacts, Tuberculin Skin Test, Latent infection, Hematological profile, Inflammatory markers.*

INTRODUCTION

Tuberculosis (TB), caused by *Mycobacterium tuberculosis*, remains a major global health threat despite being preventable and curable [1]. In 2023, an estimated 10.8 million new cases and 1.25 million deaths were reported, placing TB once again as the leading infectious killer [2]. Nearly one-quarter of the world's population (~1.7 billion people) harbors latent TB infection (LTBI), forming a large reservoir for future disease [3]. Children are particularly vulnerable, with about 1.25 million new pediatric cases and 214,000 deaths annually, most occurring in those under five years [4,5]. India contributes the highest burden, accounting for 27–28% of global TB cases [3]. The National Prevalence Survey (2019–2021) estimated 312 cases per 100,000 population, with annual incidence exceeding 2.8 million [3]. Pediatric TB is underdiagnosed, yet India alone contributes nearly one-third of the global childhood burden [5]. Multidrug-resistant TB, overcrowding, and diagnostic delays further complicate elimination efforts [6].

Transmission occurs via inhalation of droplet nuclei from smear-positive pulmonary TB patients, with a single untreated case potentially infecting 20–25 contacts [1]. Primary TB arises with initial infection, while reactivation disease develops from dormant bacilli in immunocompromised states [1]. Effective control requires management of both active disease and LTBI.

TB Preventive Treatment (TPT) is central to global elimination strategies. Isoniazid for 6–9 months prevents up to 90% of progression to active disease, while shorter rifampicin or rifapentine-based regimens show similar efficacy with better adherence [7,8]. In household pediatric contacts, TPT reduces risk of active TB by nearly two-thirds [8].

MATERIALS AND METHODS

This was a cross-sectional observational study conducted at the Department of Pediatrics and the Tuberculosis Unit, Government Medical College, Haldwani, from December 2023 to June 2025.

Study Population:

All children aged >5 years to <15 years who were household contacts of confirmed tuberculosis (TB) cases were considered for inclusion.

Inclusion Criteria:

1. Pediatric contacts of an index TB patient.
2. Children aged >5 and <15 years.

Exclusion Criteria:

1. Children <5 or >15 years.
2. Those already diagnosed with active TB and receiving anti-tubercular therapy (ATT).
3. Children on TB preventive therapy for diagnosed latent tuberculosis infection.

Sample Size Calculation:

Using the formula $N = z^2pq/d^2$, with z = 1.96 (95% confidence level), p = 50%, q = 50%, and d = 5%, the calculated sample size was 384.

Methodology:

Children meeting the inclusion criteria were enrolled consecutively. After obtaining relevant history and clinical evaluation, a tuberculin skin test (TST) was performed. The procedure involved intradermal injection of 0.1 ml of 2 TU or 5 TU PPD (depending on availability) into the volar aspect of the forearm using a tuberculin syringe with the bevel facing upward. A 6–10 mm wheel confirmed correct placement.

TST readings were done at 48–72 hours by trained health personnel. The diameter of induration (not erythema) was measured perpendicular to the forearm. Interpretation was based on standard cut-offs:

- ≥15 mm: Confirmed TB infection regardless of BCG status.
- 10–14 mm: Possible TB infection or BCG/environmental mycobacteria-induced sensitivity.
- 5–9 mm: Likely BCG cross-reactivity unless immunosuppression is present.
- <5 mm: Considered negative unless severely immunocompromised.

Post-TST Categorization:

Children with a positive TST underwent clinical and radiological screening to rule out active TB. If no evidence of disease was found, they were classified as having latent TB infection (LTBI).

This structured, algorithm-based approach enabled targeted evaluation and appropriate categorization of TB exposure outcomes in pediatric contacts.

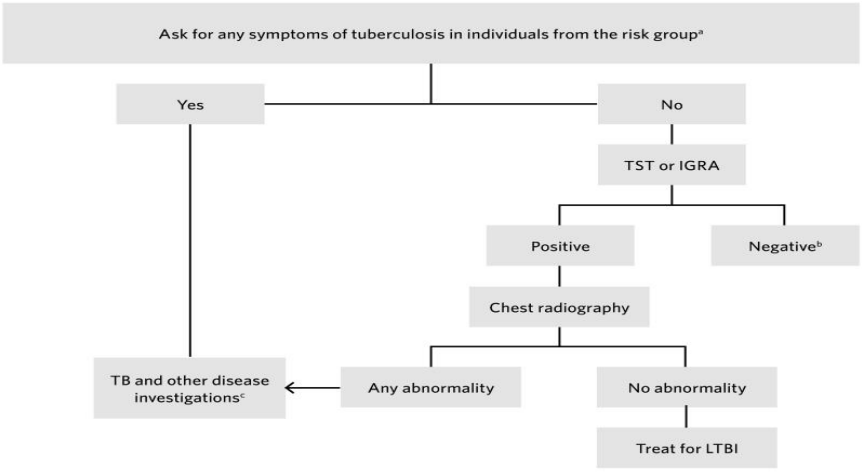

Figure 1: Algorithm for Targeted Diagnosis and Treatment of Latent Tuberculosis Infection (LTBI) and Tuberculosis (TB)

RESULTS

In this study of 295 pediatric contacts of TB cases, TST positivity significantly increased with age (χ^2=13.3, df=2, p=0.001). Among 5–8 years (n=108), 49 (45.4%) were positive; in 9–12 years (n=105), 72 (68.6%) were positive; and in 13–15 years (n=82), 53 (64.6%) were positive. Compared with 5–8 years, positivity increased by +23.2% and +19.2% in older groups. By sex, 87/157 females (55.4%) and 87/138 males (63.0%) were positive, with no significant difference (χ^2=1.77, p=0.184). Socioeconomic status showed no association (χ^2=1.45, p=0.486), with positivity ~59% in both lower middle and middle class.

Table 1. ASSOCIATION OF Treatment Outcome WITH TST

Outcome	TST (N)	TST (P)	Total
Anti-TB therapy (ATT)--ACTIVE TB	35	54	89
Preventive therapy (TPT)--LATENT TB	0	174	174
No therapy needed–NO TB	121	0	121
Total	156	228	384

In table 1 384 pediatric contacts of pulmonary TB cases were screened with TST, of which 228 (59.4%) were positive. Eighty-nine (23.2%) had active TB and received ATT, leaving 295 children for LTBI assessment. Among them, 174 (58.9%) were TST positive, confirming LTBI, while 121 (41.0%) were negative. All LTBI cases were TST positive and all uninfected children negative, validating TST as a reliable discriminator of latent infection.

Table 2. Comparison of Hematological Parameters Between TST Negative and TST Positive Groups

Parameter	TST (N) (Mean ± SD)	TST (P) (Mean ± SD)	p-value
Hemoglobin (g/dL)	11.4 ± 2.04	10.70 ± 2.29	0.001
TLC (cells/mm³)	12 214 ± 1 318	8 110 ± 744	0.001
Platelets (×10⁵/mm³)	2.62 ± 1.21	3.10 ± 1.77	0.001

Table 2 shows Among 295 pediatric contacts, TST-positive children showed lower mean hemoglobin (10.7 ± 2.29 g/dL vs. 11.4 ± 2.04 g/dL) and reduced TLC (8,110 ± 744 vs. 12,214 ± 1,318 cells/mm³), along with higher platelet counts (3.10 ± 1.77 vs. 2.62 ± 1.21 ×10⁵/mm³) compared to TST-negative contacts. All differences were statistically significant (p = 0.001), indicating that TST positivity was associated with mild anemia, leukopenia, and reactive thrombocytosis, consistent with immune alterations seen in TB infection.

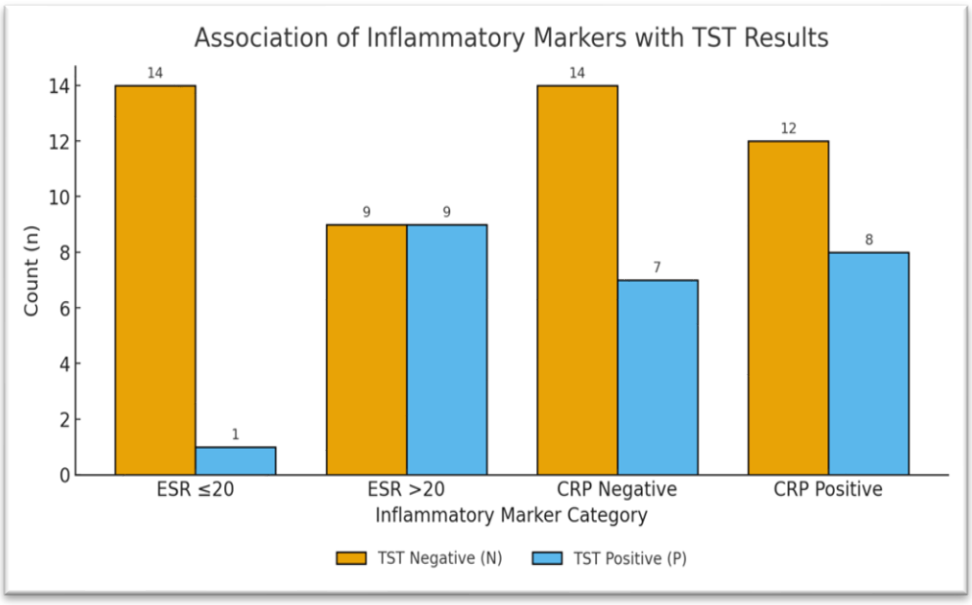

Figure 2: Association Of Inflammatory Marker With Tst

In Figure 2 among pediatric contacts, inflammatory markers showed significant association with TST status. Children with elevated ESR (>20 mm/hr) were more often TST positive (9/18; 50.0%) compared to those with normal ESR (1/13; 7.7%). This association was statistically significant (p = 0.021). Similarly, CRP positivity correlated with higher TST positivity (8/21; 38.1%) compared to CRP-negative children (7/21; 33.3%), with statistical significance (p = 0.017).

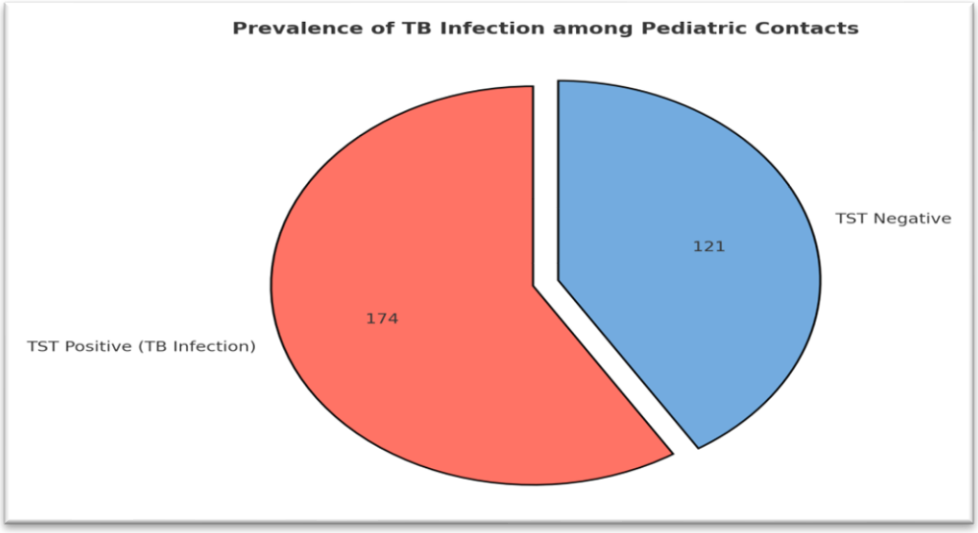

Figure 3: Prevalence of TB Infection among Pediatric Contacts

Figure 3 present cross-sectional study, 295 pediatric household/close contacts of bacteriologically confirmed pulmonary tuberculosis cases were evaluated using the Tuberculin Skin Test (TST). Out of these, 174 children (58.98%) were TST positive, while 121 (41.02%) were TST negative.This finding indicates that nearly six out of every ten exposed children harbored tuberculosis infection, reflecting either latent TB infection or early active infection. The high prevalence emphasizes the substantial hidden reservoir of infection in pediatric contacts, who are at risk of progression to active disease if left untreated.

DISCUSSION

In the present study, TST positivity was 59.4% among 384 pediatric contacts, and after excluding active TB cases, 58.9% were classified as LTBI, closely aligning with the global LTBI burden of 23% estimated by Houben and Dodd (2016)[6], though the prevalence in our cohort was substantially higher, reflecting endemic transmission. Age-wise, positivity rose from 45.4% in 5–8 years to 68.6% in 9–12 years and 64.6% in 13–15 years (χ^2=13.3, p=0.001), which parallels the rise in incidence during adolescence described by Snow et al. (2020)[5], highlighting the increasing vulnerability in older children. The lack of sex or socioeconomic association in our study contrasts with Dodd et al. (2017)[7], who noted disparities influenced by HIV and treatment gaps, though these were more prominent in global mortality than infection prevalence. Bonnet et al. (2023)[9] similarly underscored high vulnerability in malnourished and HIV-positive children, which contextualizes the hematological findings in our cohort, where TST-positive contacts demonstrated lower hemoglobin (10.7 ± 2.29 g/dL), reduced TLC (8,110 ± 744/mm³), and higher platelet counts (3.10 ± 1.77 ×10⁵/mm³) compared to negatives, all significant at p=0.001. These immune and hematological alterations are consistent with infection-related inflammatory responses. Unique to our findings is the clear demonstration that all LTBI cases were TST positive, reinforcing its reliability in identifying latent infection among exposed children.In this study, 58.9% of pediatric contacts were TST positive, reflecting a considerable burden of latent infection, consistent with the high global LTBI estimates by Houben and Dodd (2016)[6] and the vulnerability of children highlighted by Dodd et al. (2017)[7]. Elevated ESR (>20 mm/hr) and CRP positivity were significantly associated with TST positivity (p=0.021 and p=0.017), indicating an active inflammatory response, in line with Bonnet et al. (2023)[9], who noted systemic markers predicting severe outcomes. Clinically, pulmonary TB cases showed stronger TST positivity, whereas CNS TBM was mostly TST negative, reflecting the variability in immune response described by Marais et al. (2004)[8]. Unique to this study is the detailed correlation between TST reactivity and organ-specific disease patterns, with significant association (χ^2=23.01, p=0.00076).

CONCLUSION

This study demonstrated that tuberculosis infection is highly prevalent among pediatric household contacts, with 58.9% showing TST positivity after excluding active TB, underscoring a substantial hidden reservoir of infection. Positivity significantly increased with age, confirming greater vulnerability in older children, while sex and socioeconomic status showed no influence. Hematological alterations, including lower hemoglobin, leukopenia, and thrombocytosis, along with elevated ESR and CRP, were strongly associated with TST positivity, reflecting immune activation in infected children. Clinically, pulmonary TB showed strong correlation with TST reactivity, whereas CNS tuberculosis displayed poor sensitivity, highlighting variability in immune responses across disease sites. Collectively, these findings establish TST as a reliable, cost-effective tool for detecting latent infection in pediatric contacts, emphasize the importance of early screening and preventive therapy, and reinforce the need for targeted strategies to reduce progression from latent to active TB in this vulnerable population

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Ethical Approval: *Obtained.*
Consent: *Written consent secured.*

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