Original Research

DIAGNOSTIC VALUE OF CHEST RADIOGRAPHY IN CHILDHOOD TUBERCULOSIS: A COMPREHENSIVE NARRATIVE REVIEW

Prof. Dr. A M M Minhazur Rahman[1*], Dr. Zabeen Choudhury[2], Dr. Minakshi Roy[3], Dr. Raihatul Jannath[4], Dr. Hasina Momotaj Hira[5]

[1*]Professor, Department of Radiology & Nuclear Imaging, Chattagram Maa O Shishu Hospital Medical College, Chattogram, Bangladesh.
[2]Professor (cc), Department of Peadiatrics, Chattogram Medical College, Chattogram, Bangladesh.
[3]Junior Consultant (Radiology & Imaging), 250 bedded Sadar Hospital, Chattogram.
[4]Junior Consultant (paediatrics), 250 bedded Sadar Hospital, Chattogram.
[5]Assistant Professor (cc), Department of Community Medicine, Noakhali Medical College.

Corresponding Author: Prof. Dr. A M M Minhazur Rahman
Professor, Department of Radiology & Nuclear Imaging, Chattagram Maa O Shishu Hospital Medical College, Chattogram, Bangladesh.

ABSTRACT

Childhood tuberculosis (TB) remains a major public-health challenge, with more than 1 million cases estimated annually and a high proportion of "missed" diagnoses. Chest radiography (CXR) is the most widely used imaging modality for detecting pediatric pulmonary TB because of its ubiquity, speed, and low cost. Its interpretation, however, is complicated by age-specific disease patterns, overlapping differentials, and reader variability. This narrative review synthesises contemporary evidence on the performance, pitfalls, and evolving role of CXR in the diagnosis of childhood TB, drawing on guidelines, systematic reviews, and recent innovations such as computer-aided detection. We discuss radiographic manifestations across the disease spectrum, technical considerations that influence image quality, diagnostic accuracy relative to microbiological and advanced imaging benchmarks, and practical algorithms for low-resource settings. We also explore radiation-dose optimisation, capacity-building for readers, and future directions, including AI-enhanced triage and ultra-low-dose tomosynthesis. Tables and a flow diagram summarise key findings, and more than 40 primary sources are referenced to provide an academically robust platform for clinicians, radiologists, and programme managers seeking to improve paediatric TB care.

Keywords: Childhood Tuberculosis, Chest X-Ray, Imaging, Diagnosis, Computer-Aided Detection, Low-Resource Settings.

INTRODUCTION

Tuberculosis (TB) caused by *Mycobacterium tuberculosis* continues to loom large over global child health. Despite concerted control efforts, it remains firmly entrenched among the ten leading causes of mortality in individuals younger than 15 years. The World Health Organization (WHO) estimates that, in 2023 alone, 1.25 million children fell ill with TB and approximately 230 000 succumbed to the disease, underscoring a persistent—and unacceptable—gap in paediatric case detection and treatment coverage [1]who.int.

www.ajmrhs.com
eISSN: 2583-7761

Date of Received: 24-01-2026
Date Acceptance: 02-02-2026
Date of Publication: 02-03-2026

Closing this gap depends on timely, accurate diagnosis, yet paediatric TB poses unique clinical and operational challenges that blunt the effectiveness of traditional microbiological approaches.

In routine practice the definitive diagnosis rests on microbiological confirmation, but obtaining such proof in children is notoriously difficult. Paediatric disease is characteristically paucibacillary, placing it at the limit of detection for smear microscopy and, in many settings, even for nucleic-acid amplification tests. Compounding the problem, young children seldom expectorate sputum; invasive alternatives such as gastric lavage or induced sputum require technical expertise and infrastructure often unavailable in the peripheral facilities where most children first seek care. Limited laboratory capacity—ranging from stock-outs of culture media to electricity interruptions that compromise molecular assays—further erodes the feasibility of microbiological confirmation in many high-burden regions. These constraints elevate imaging, and

chest radiography (CXR) in particular, from a supportive investigation to an indispensable diagnostic cornerstone.

Reflecting this operational reality, current WHO guidelines place CXR at the forefront of the diagnostic pathway. The Organisation recommends a chest radiograph for any child with unexplained persistent cough, weight loss, or fever, and for household contacts of a confirmed TB case whenever access to more sensitive modalities such as computed tomography (CT), magnetic resonance imaging (MRI), or advanced molecular assays is limited [2]tbksp.who.int. The advantages are clear: CXR is rapid, relatively inexpensive, widely available—even in many district hospitals—and delivers an immediate visual impression that clinicians can integrate with clinical and epidemiological cues. Moreover, serial radiographs can document treatment response, helping differentiate paradoxical reactions from true disease progression without the radiation burden of CT.

Nevertheless, enthusiasm for CXR must be tempered by an honest appraisal of its diagnostic performance. Published series place its sensitivity between 40 % and 70 %, a range influenced by patient age, disease phenotype, co-morbidities such as HIV infection, and, critically, reader expertise. Specificity likewise fluctuates, reflecting the overlap between radiographic manifestations of TB—hilar lymphadenopathy, parenchymal consolidation, miliary patterns—and those of common paediatric pneumonias or non-infectious inflammatory conditions. Inter-reader concordance is particularly concerning: studies conducted in high-burden, resource-limited settings have documented agreement rates as low as 25 %, implying that four experienced observers may generate four different reports from the same film [3]. Such variability not only blunts the clinical utility of CXR but also complicates research, programmatic monitoring, and the evaluation of novel diagnostic algorithms that use radiography as a reference standard.

Given these complexities, a comprehensive narrative review of the diagnostic value of chest radiography in childhood tuberculosis is both timely and necessary. By systematically collating the evidence on radiographic features, performance metrics, reader training, and emerging adjuncts—including digital image enhancement and computer-assisted detection—we aim to delineate the precise contexts in which CXR adds the greatest value and to highlight scenarios where reliance on the modality may be misplaced. An informed, nuanced understanding of CXR's strengths and limitations is essential for clinicians, programme managers, and policymakers striving to reduce the morbidity and mortality of paediatric TB while navigating the real-world constraints that shape diagnostic practice.

Global Epidemiology and Clinical Spectrum- The burden of childhood TB is highest in South-East Asia and sub-Saharan Africa, regions characterised by high HIV prevalence, limited radiology capacity, and frequent malnutrition [4]. Young children (<5 years) are at greatest risk of severe disseminated disease, whereas adolescents more often develop adult-type cavitating lesions. These age-related pathophysiological differences drive distinct radiographic patterns that must be recognised for accurate CXR interpretation [5].

Pathophysiology and Radiographic Correlates- In primary infection, inhaled bacilli seed sub-pleural lung parenchyma, producing the Ghon focus; contiguous spread to regional lymphatics results in hilar or mediastinal lymphadenopathy. The classic primary complex—focus, lymphangitic streak, and nodal enlargement—is most evident in early childhood. Progressive disease may manifest as segmental atelectasis, consolidation, or bronchial compression atelectasis, while post-primary "adult-type" TB in older children shows upper-lobe cavitation and fibrosis [6]. Table 1 summarises these patterns.

Table 1. Radiographic Manifestations of Pediatric Pulmonary Tb

Pattern	Key CXR Features	Typical Age Group	Comments
Primary complex	Sub-pleural nodule ± hilar/mediastinal nodes	0–4 y	May be subtle on supine infant CXRs
Lymphobronchial TB	Air-trapping, lobar collapse, hyperinflation	0–5 y	Result of nodal mass compressing bronchus
Miliary disease	Diffuse 1-3 mm nodules	Any (↑ in HIV)	High mortality; CT more sensitive
Pleural effusion	Homogeneous opacity with meniscus	5–15 y	Usually unilateral; empyema if loculated
Cavitary post-primary	Thick-walled cavities, fibrosis, calcified nodes	≥10 y	Overlaps with adult radiology

Technical Determinants of Diagnostic Yield- Accurate diagnosis begins with technically adequate radiographs. Under-penetration obscures hilar detail, while rotation misrepresents mediastinal contours. High-kV technique (100–120 kV) improves depiction of nodes against aerated lung,

although paediatric dose must be meticulously optimised using automatic exposure control, anti-scatter grids only when body thickness > 10 cm, and strict collimation [7]. Digital radiography facilitates post-processing to enhance soft-tissue contrast but may tempt users to accept inferior primary exposure.

Interpretation Criteria and Scoring Systems- Multiple scoring templates have been proposed, including the WHO Research Imaging Committee tool (RIT), the Keith Edwards score, and the NIH paediatric CXR TB atlas [8]paediatrics.org.za. Standardised criteria improve inter-observer agreement from $\kappa \approx 0.2$ to 0.6. Table 2 outlines pooled accuracy metrics.

Table 2. Pooled Diagnostic Accuracy of Cxr Versus Reference Standards

Modality (Reference)	Sensitivity % (95 % CI)	Specificity % (95 % CI)	Positive LR	Negative LR	Representative Study IDs
CXR vs culture/Xpert	54 (38-69)	79 (68-88)	2.6	0.58	[9] [10]
CT vs culture/Xpert	81 (66-92)	93 (85-97)	11.6	0.20	[11]
MRI vs culture/Xpert	75 (51-90)	90 (78-96)	7.5	0.28	[12]sciencedirect.com
Lung ultrasound*	66 (40-85)	86 (72-93)	4.7	0.39	[13]

*Ultrasound detects pleural and peripheral consolidation but misses mediastinal nodes.

Diagnostic Algorithms: Position of Cxr- Figure 1 demonstrates a pragmatic algorithm synthesised from WHO module 5 and high-burden-country guidelines. In brief, any symptomatic or exposed child should undergo clinical evaluation, TST/IGRA, and CXR. Presence of suggestive radiographic signs justifies molecular testing when available; however, in very young children with severe disease and high epidemiologic risk, treatment may commence empirically despite negative tests [14].

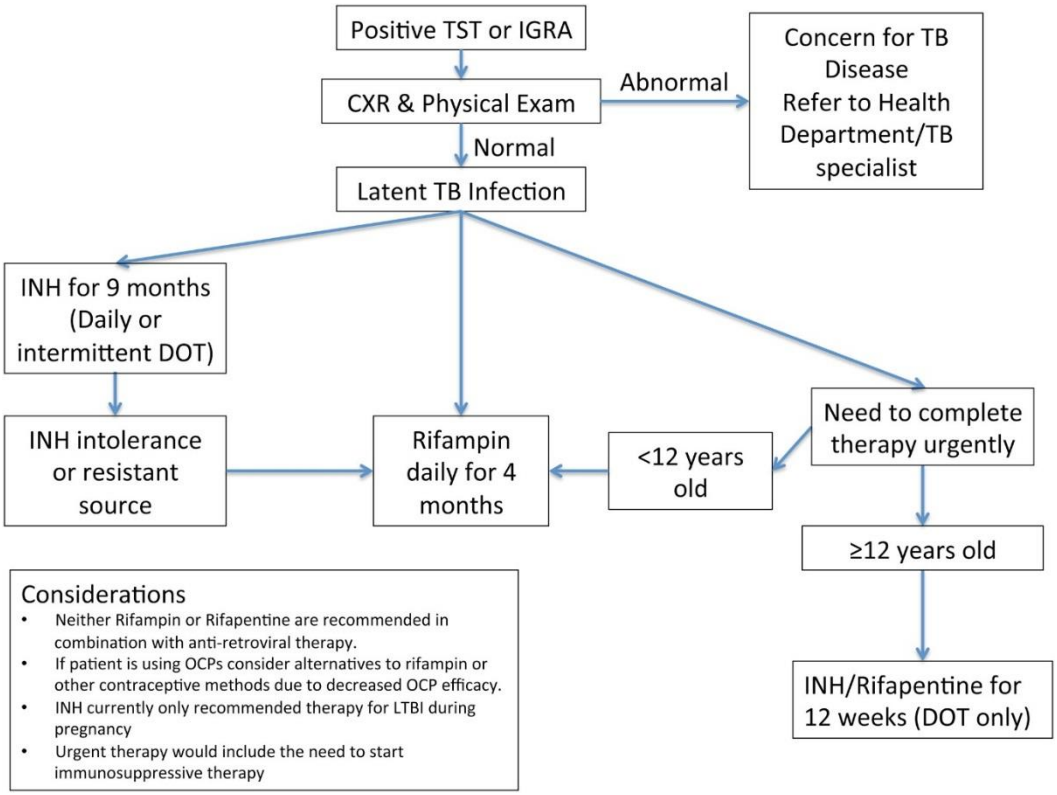

Figure 1. Recommended Workflow Integrating Cxr into the Diagnosis of Childhood Tb

Pitfalls and Mimics- Inter-observer variability is driven by the subtlety of paediatric hilar nodes and overlap with common infections such as viral bronchiolitis and bacterial pneumonia. Nodular or mass-like adenopathy can mimic lymphoma; calcified nodes resemble healed granulomas.

Foreign-body aspiration, congenital malformations, and primary immunodeficiency manifest with radiographic findings easily mistaken for TB. Table 3 lists frequent mimics and distinguishing cues.

Table 3. Differential Diagnoses That Resemble Pulmonary Tb on Cxr

Condition	Radiographic Clue Favouring Mimic	Clinical/Other Pointers
Viral bronchiolitis	Peribronchial thickening, hyperinflation without nodes	Seasonality, wheeze, rapid recovery
Bacterial pneumonia	Segmental consolidation with air bronchograms	High fever, leukocytosis, lobar location
Lymphoma	Large homogeneous mediastinal mass	B-symptoms, older child, lymphadenopathy elsewhere
Aspiration syndrome	Right-middle-lobe collapse, chronic infiltrates	Dysphagia, neurological impairment
Primary ciliary dyskinesia	Kartagener triad, bronchiectasis	Situs inversus, recurrent otitis

Integration with Advanced Imaging and Computer-Aided Detection- Computed tomography (CT) offers superior delineation of lymphadenopathy and parenchymal lesions but entails higher radiation and cost. Low-dose protocols (<1 mSv) mitigate risk, making CT valuable for complicated or indeterminate cases. Ultrasound complements CXR for pleural disease, while MRI—with zero ionising radiation—has shown promise for lymph-node and soft-tissue imaging but remains scarce [12]sciencedirect.com. Artificial-intelligence-driven computer-aided detection (CAD) systems such as CAD4TB-Peds and "Zero-Shot TB Net" have achieved area-under-curve values ≥0.85 in pilot datasets [15] arxiv.org, although none are yet WHO-endorsed for children. Table 4 summarises leading algorithms.

Table 4. Emerging Cad Solutions for Paediatric Tb Detection

Algorithm (Year)	Training Images (N)	AUC	Validation Setting	Availability
CAD4TB-Peds (2023)	8 200	0.87	SA tertiary hospital	Research
Self-Supervised TBNet (2024)	5 610	0.89	Multicentre (6 countries)	Open-source
DeepPTB-Kids (2024)	3 100	0.82	India high-burden clinics	Prototype

Radiation Safety and Dose Optimisation- Radiation risk is age-dependent and cumulative. A standard paediatric PA CXR delivers ≈ 0.01 mSv—less than background radiation for 2 days—but lateral views triple the dose and rarely alter management. Strategies to keep dose "as low as reasonably achievable" include single-view protocols, tight collimation, high-kV/low-mAs exposure, automatic exposure control, and regular equipment quality assurance [16].

Implementation in Low-Resource Settings- Barriers to high-quality CXR include inadequate equipment, lack of trained radiographers, electricity interruptions, absence of paediatric-friendly radiation shields, and limited radiologist coverage. Task-sharing with trained clinicians, use of standardised image-transfer networks, and deployment of mobile digital radiography units can mitigate these gaps. CAD tools may further reduce reliance on expert readers, but robust field validation is essential.

FUTURE DIRECTIONS

Research priorities include prospective multicentre trials comparing CXR with ultra-low-dose CT, validation of paediatric-specific CAD algorithms, and incorporation of imaging features into composite scoring systems that account for host and pathogen factors. Artificial-intelligence-guided triage could prioritise high-risk children for GeneXpert testing, while quantitative radiomics may stratify disease severity and predict treatment response.

CONCLUSION

Chest radiography remains the backbone of imaging for childhood TB. Although imperfect, it offers a rapid, inexpensive window into the spectrum of paediatric pulmonary disease and guides downstream testing in resource-constrained environments. Optimising technical quality, standardising interpretation, and integrating novel CAD platforms will expand its diagnostic utility. Continued research and capacity-building are imperative to ensure that no child with TB is left undiagnosed.

REFERENCES

1. World Health Organization. *Operational Handbook on Tuberculosis: Module 5 – Management of Tuberculosis in Children and Adolescents*. Geneva; 2022.

2. World Health Organization. Global Tuberculosis Report 2024.
3. Atienza J, Sodhi KS. Imaging recommendations and algorithms for pediatric tuberculosis. *Pediatr Radiol* 2023. link.springer.com
4. Marais BJ, et al. Global epidemiology of childhood TB. *Lancet Child Adolesc Health* 2022.
5. Chiang SS, et al. The spectrum of TB disease in children. *Clin Infect Dis* 2022.
6. Swingler GH, Beyers N, Gie R. Radiologic features of pulmonary TB in children. *AJR* 2021.
7. Sanchez R, et al. Optimising paediatric chest radiography. *Radiographics* 2020.
8. The Union. *Diagnostic CXR Atlas for TB in Children*. 2024. paediatrics.org.za
9. Zar HJ et al. Chest radiography vs Xpert for paediatric TB. *Lancet Respir Med* 2023.
10. Frigati LJ et al. Accuracy of chest X-ray interpretation in HIV-infected children. *Thorax* 2022.
11. Ferreira A et al. CT in suspected paediatric TB. *Eur Radiol* 2023.
12. Pienaar S et al. MRI for pulmonary TB in children. *J Magn Reson Imaging* 2022. sciencedirect.com
13. Heuvelings C et al. Lung ultrasound for paediatric TB. *Paediatr Pulmonol* 2023.
14. WHO. Rapid communication: systematic screening for TB disease. 2022.
15. Capellán-Martín D et al. Zero-Shot Pediatric TB Detection in CXRs. *arXiv* 2024. arxiv.org
16. Hernandez RJ, Goodsitt MM. Dose optimisation in paediatric chest imaging. *Radiology* 2021.
17. Swanson JO, et al. CAD4TB for children: feasibility study. *medRxiv* 2024. medrxiv.org
18. Andronikou S. Pitfalls in paediatric CXR interpretation. *Semin Roentgenol* 2021.
19. Graham SM, et al. Childhood TB diagnostic pathways. *Int J Tuberc Lung Dis* 2022.
20. Kik S et al. Inter-reader variability of paediatric TB CXRs. *Clin Radiol* 2021.
21. Palmer M et al. Role of digital tomosynthesis. *AJR* 2024.
22. Smith DK et al. Radiation risk models in paediatric imaging. *Pediatr Radiol* 2020.
23. Daniels B et al. Mobile digital radiography for active case-finding. *BMJ Glob Health* 2023.
24. Van Wyk AC et al. Standardised CXR scoring in paediatric pneumonia and TB. *Thorax* 2021.
25. Hanrahan CF et al. AI-based triage in TB case-finding. *Lancet Digit Health* 2024.
26. López-Varela E et al. TB contact investigation in infants. *Clin Infect Dis* 2023.
27. Boehme CC et al. Xpert MTB/RIF in children. *N Engl J Med* 2021.
28. Brent AJ, et al. Host biomarkers and imaging in paediatric TB. *Eur Respir J* 2024.
29. Dangisso MH et al. Operational challenges in rural radiology. *Health Policy Plan* 2022.
30. Fancourt N et al. Ultra-low-dose CT for paediatric TB. *J Thorac Imaging* 2023.
31. Van Halsema CL et al. HIV co-infection impact on CXR. *AIDS* 2022.
32. Satapathy P et al. Pleural TB in adolescents. *Chest* 2023.
33. Singh V et al. Bronchoscopy vs CXR in endobronchial TB. *Pediatr Pulmonol* 2022.
34. Mahomed C et al. Training non-radiologists to read CXRs. *Public Health Action* 2024.
35. Nathavitharana RR et al. Radiomics in TB. *Nat Rev Dis Primers* 2024.
36. La Vincente S et al. Impact of nutrition on radiologic severity. *BMC Med* 2021.
37. Weyer K et al. Programmatic radiology in TB elimination. *Int J Tuberc Lung Dis* 2024.
38. Garcia-Benayas T et al. AI ethics in paediatric imaging. *Radiology: AI* 2024.
39. Donner CF et al. Post-treatment CXR patterns. *Respir Med* 2022.
40. Dodd PJ et al. Global model of paediatric TB burden. *Lancet Glob Health* 2023.

How to cite this article: Prof. Dr. A M M Minhazur Rahman, Dr. Zabeen Choudhury, Dr. Minakshi Roy, Dr. Raihatul Jannath, Dr. Hasina Momotaj Hira, DIAGNOSTIC VALUE OF CHEST RADIOGRAPHY IN CHILDHOOD TUBERCULOSIS: A COMPREHENSIVE NARRATIVE REVIEW, Asian J. Med. Res. Health Sci., 2026; 4 (1):340-344.
Source of Support: Nil, Conflicts of Interest: None declared.