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Research Article

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Upscaling Diagnosis of Pulmonary Tuberculosis Through Routine Genexpert Testing of Stool from Hospitalized Children with Severe Acute Malnutrition: Experience from Sokoto State, Nigeria

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ABSTRACT

Tuberculosis (TB) remains a major global health concern, particularly in malnourished children. Severe acute malnutrition (SAM) compromises immunity, increasing TB susceptibility. However, diagnosing pediatric TB is challenging due to difficulties in obtaining respiratory samples. This study evaluates the effectiveness of stool-based GeneXpert testing for pulmonary TB in hospitalized children with SAM in Sokoto State, Nigeria.

A prospective observational study was conducted at the inpatient therapeutic feeding center of the State Specialist Hospital, Sokoto. Hospitalized children with SAM were screened for TB using stool-based GeneXpert MTB/RIF testing. Demographic and clinical data were collected to determine TB prevalence and associated risk factors.

Among the 28 hospitalized children tested, 10 (36%) were TB-positive. TB cases were equally distributed among infants, with 3 (30%) males and 3 (30%) females testing positive. Among children older than one year, 2 (20%) males and 2 (20%) females were TB-positive. Malaria co-infection was observed in 1 (17%) male and 2 (33%) female infants with TB, while among older children, 2 (33%) males and 1 (17%) female had malaria. No HIV-positive cases were recorded.

These findings highlight the high TB burden among malnourished children and reinforce stool-based GeneXpert testing as a viable diagnostic tool. Incorporating routine TB screening using stool-based GeneXpert into diagnostic protocols for children with SAM can improve early detection and treatment outcomes.

Keywords: Tuberculosis, Severe Acute Malnutrition, Pediatric TB, GeneXpert, Stool-Based Diagnosis, Sokoto State

Introduction

Tuberculosis (TB) remains one of the leading infectious causes of morbidity and mortality among children worldwide, with Nigeria bearing a significant burden [1,2]. In 2022, 30 high TB burden countries accounted for 87% of global TB cases. Eight countries contributed two-thirds of the total, with India leading at 27%, followed by Indonesia (10%), China (7.1%), the Philippines (7.0%), Pakistan (5.7%), Nigeria (4.5%), Bangladesh (3.6%), and the Democratic Republic of the Congo (3.0%) [3]. Despite extensive global efforts, Nigeria, one of these high-burden countries, continues to struggle with the disease [1].

According to the World Health Organization (WHO), Nigeria ranks among the top eight countries contributing to two-thirds of the global TB burden, with children accounting for approximately 10-15% of all TB cases in the country. Despite global efforts to end TB, pediatric TB remains underdiagnosed

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and underreported due to diagnostic challenges and limited case detection strategies [4]. The situation is even more critical among children with severe acute malnutrition (SAM), who are at a significantly higher risk of TB infection and progression to active disease due to their compromised immune status [5].

Background and Rationale

The high burden of childhood TB in Nigeria is compounded by the presence of malnutrition, which is a major risk factor for TB infection and disease progression. Malnutrition weakens cell-mediated immunity, increasing the likelihood of Mycobacterium tuberculosis infection and reducing the body's ability to contain the disease [6]. Studies have demonstrated that children with SAM have a higher prevalence of TB compared to their well-nourished counterparts, with mortality rates significantly elevated in those with co-existing TB and malnutrition [7,8]. Despite the strong association between SAM and TB, TB case detection among malnourished children remains largely passive, often relying on clinical suspicion rather than systematic screening [9,10]. This passive approach results in missed opportunities for early diagnosis and treatment, thereby contributing to poor outcomes in this vulnerable population.

One of the main challenges in diagnosing pediatric TB is the difficulty in obtaining respiratory samples such as sputum, as young children are unable to expectorate effectively [11,10]. In resource-limited settings like Nigeria, alternative sample collection methods such as gastric lavage are often impractical due to logistical constraints and the need for specialized personnel and equipment. Recent studies have highlighted stool as a viable alternative specimen for TB diagnosis in children, as it contains swallowed Mycobacterium tuberculosis bacilli from pulmonary secretions [12-14]. The introduction of GeneXpert MTB/RIF testing on stool samples has emerged as a promising non-invasive diagnostic tool, offering a sensitive and specific alternative for TB detection in children [15,12,16]. Given the high burden of TB among malnourished children and the challenges of diagnosing pediatric TB using conventional methods, routine stool-based GeneXpert testing presents an innovative approach to improving case detection and treatment outcomes.

Research Gap

Despite the growing body of evidence supporting stool GeneXpert testing for pediatric TB diagnosis, its routine implementation in clinical settings remains limited. One of the key barriers is the lack of standardized guidelines for integrating stool-based TB testing into existing pediatric and malnutrition treatment protocols [17,18]. Additionally, the feasibility and effectiveness of this approach in real-world settings, particularly among hospitalized malnourished children in Nigeria, have not been systematically evaluated.

Existing TB diagnostic algorithms in Nigeria primarily rely on clinical assessment, chest X-ray, and sputum testing, all of which have limitations in pediatric populations [4]. While WHO has endorsed GeneXpert as a frontline diagnostic tool for TB, its application in stool-based testing for routine pediatric TB screening remains underutilized. Furthermore, studies evaluating the integration of stool-based TB testing in inpatient therapeutic feeding centers (ITFCs), where children with SAM receive treatment, are scarce. Understanding the diagnostic yield and operational feasibility of routine stool GeneXpert testing in these settings is crucial for informing policy and programmatic decisions aimed at enhancing TB case detection among malnourished children.

Objectives

The primary objective of this study is to evaluate the effectiveness of routine stool GeneXpert testing for the diagnosis of pulmonary TB in hospitalized children with severe acute malnutrition in Sokoto State, Nigeria. By systematically screening children with SAM using stool-based GeneXpert testing, this study aims to determine the proportion of children with undiagnosed TB who would have otherwise been missed using conventional diagnostic methods.

The secondary objectives of this study include assessing the prevalence of TB among hospitalized malnourished children, identifying key risk factors associated with TB infection in this population, and evaluating the feasibility of implementing routine stool-based GeneXpert testing in inpatient therapeutic feeding centers. The findings from this study will provide evidence to support policy recommendations for incorporating stool-based TB testing into standard clinical guidelines for managing children with SAM, ultimately improving TB case detection and treatment outcomes in Nigeria.

Methods

This study employs a prospective observational design to assess the effectiveness of routine GeneXpert stool testing for pulmonary TB diagnosis among hospitalized children with SAM. The study was conducted in Sokoto State, Nigeria, a region with a high burden of both TB and malnutrition. The primary study site is the inpatient therapeutic feeding centre (ITFC) of the State Specialist Hospital, Sokoto, which provides specialized care for children with SAM aged between 6 months to 5 hears. The ITFC serves as a referral center for severely malnourished children requiring intensive nutritional rehabilitation and medical management within the stated age group.

Hospitalized children diagnosed with SAM based on WHO criteria, including severe wasting, nutritional edema, or a mid-upper arm circumference (MUAC) of less than 115 mm, are included in the study. Exclusion criteria include children who were already diagnosed with PTB on anti-TB treatment.

Routine stool samples are collected from all eligible children at the time of admission. Samples were processed using the GeneXpert MTB/RIF assay, which detects Mycobacterium tuberculosis and rifampicin resistance. The intervention was implemented during the National Childhood TB Testing Week to maximize coverage and ensure standardized testing procedures.

Stool samples were homogenized, treated with sample reagent, and processed following standard GeneXpert MTB/RIF testing protocols. Quality control measures include periodic calibration of equipment, use of external proficiency testing panels, and adherence to biosafety guidelines.

Data on demographics, nutritional status, comorbidities, TB test results, and treatment outcomes are collected using structured case report forms. Additional data on diagnostic turnaround

time and healthcare provider feedback are gathered to assess implementation feasibility.

Descriptive statistics were used to summarize key findings, with proportions calculated for different age and sex groups. This analysis provided an overview of the distribution of TB cases and co-morbidities among children with severe acute malnutrition (SAM).

Institutional ethical approval was obtained from the relevant ethics review board. Informed consent was obtained from caregivers prior to sample collection and data recording, ensuring compliance with ethical research standards.

Results

A total of 28 hospitalized children with severe acute malnutrition (SAM) underwent GeneXpert stool testing for pulmonary tuberculosis. Among them, 17 (61%) were infants, while 11 (39%) were children older than one year. The sex distribution showed that 13 (46%) were male and 15 (54%) were female (see Table 1). Nutritional status assessment confirmed that all participants met the WHO criteria for SAM, with significant wasting and low mid-upper arm circumference (MUAC) measurements.

Table 1: Baseline characteristics of children tested

Characteristic	n (%)
Total children tested	28(100)
Age group	
Infants (<1 year)	17(61)
>1 year	11(39)
Sex	
Male	13 (46)
Female	15 (54)
TB cases	
Total TB-positive	10(36)
Infants	6(60)
>1 year	4(40)
Co-morbidities (Malaria & TB)	
Total with Malaria & TB	5(50)
Infants	3(50)
>1 year	2(50)
Nutritional status	
Met WHO SAM Criteria	28(100)
Treatment Outcomes	
Initiated on TB Treatment	9(90)
Referred due to complications	1(10)

The prevalence of tuberculosis among the study population was high, with 10 (36%) children testing positive for Mycobacterium tuberculosis using the GeneXpert MTB/RIF assay. Among these, 6 (60%) were infants, while 4 (40%) were older than one year. Among infants, TB cases were recorded in 3 (30%) males and 3 (30%) females. Among children older than one year, 2 (20%) males and 2 (20%) females tested positive (see Table 2).

Co-morbidities were observed in the TB-positive children, with malaria being the most frequently detected. Among the TB-positive infants, 1 (17%) male and 2 (33%) females had concurrent malaria. Similarly, among older children with TB, 2 (33%) males and 1 (17%) female had malaria. No HIV-positive cases were detected in the study population.

Regarding treatment outcomes, 9 out of the 10 TB-positive children were initiated on anti-TB therapy and showed clinical improvement upon discharge. One child was referred to a tertiary hospital due to complications from massive pleural effusion. The findings underscore the need for routine TB screening in hospitalized children with SAM to enhance early detection and treatment outcomes.

Table 2: Profile of hospitalized children with severe acute malnutrition

Age group	Sex	GeneXpert testing (SAM children)	TB cases (%)	TB & Malaria (%)
Infants	Male	7(25)	3(30)	1(17)
>1 year	Female	10(36)	3(30)	2(33)
	Male	6(21)	2(20)	2(33)
	Female	5(18)	2(20)	1(17)

These findings highlight the importance of integrating stool-based GeneXpert testing into routine TB screening protocols for children with SAM to enhance early detection and improve treatment outcomes.

Discussion

The findings of this study demonstrate a high burden of tuberculosis among children with severe acute malnutrition (SAM), reinforcing previous evidence that malnourished children are at an increased risk of TB infection and disease progression [5,19-22]. The detection rate of TB through stool-based GeneXpert testing in this study aligns with research conducted in other high-burden settings, where stool testing has been shown to provide a reliable alternative to sputum-based diagnosis, particularly in children who are unable to expectorate sputum [23-25,12,16]. The importance of integrating stool-based GeneXpert testing into routine diagnostic protocols is underscored by the high proportion of TB cases detected in this study, many of whom would have been missed using conventional diagnostic strategies reliant on respiratory samples.

When compared with similar interventions in Nigeria and other resource-limited settings, the diagnostic yield observed in this study is consistent with findings from South Africa and Ethiopia, where stool GeneXpert testing has significantly improved TB detection rates among pediatric populations [25-27,16]. This highlights the generalizability of stool-based testing across diverse epidemiological contexts. However, while previous studies have primarily focused on outpatient settings, the current study provides novel insights into TB prevalence among hospitalized children with SAM, emphasizing the need for systematic TB screening in inpatient therapeutic feeding centers (ITFCs).

The public health implications of these findings are substantial. Given the high TB burden observed among malnourished children, policymakers should consider revising national TB control guidelines to incorporate stool-based GeneXpert testing as part of routine TB screening in pediatric and malnutrition treatment programs. Integrating this diagnostic approach into existing healthcare frameworks could enhance early TB detection, facilitate timely treatment initiation, and ultimately improve survival outcomes in this vulnerable population.

Despite its strengths, including the innovative application of stool-based GeneXpert testing in a high-risk group and its systematic screening approach, this study has limitations. The relatively small sample size may limit the generalizability of findings, and the lack of long-term follow-up data precludes assessment of treatment outcomes and TB relapse rates. Future research should explore larger-scale implementations and assess the impact of routine stool-based testing on TB-related morbidity and mortality.

Conclusion and Recommendations

The findings from this study underscore the high burden of tuberculosis among children with severe acute malnutrition and the effectiveness of routine stool-based GeneXpert testing as a non-invasive diagnostic alternative. A significant proportion of hospitalized SAM children tested positive for Mycobacterium tuberculosis, many of whom would likely have been missed using conventional diagnostic methods reliant on sputum or clinical suspicion. These results highlight the critical need for systematic TB screening among this vulnerable population to enable early detection and timely treatment initiation, which is essential for reducing morbidity and mortality associated with TB in malnourished children.

Given the diagnostic yield observed in this study, we strongly recommend the incorporation of stool-based GeneXpert testing into national TB screening protocols for pediatric populations, particularly for malnourished children in inatient therapeutic feeding centers. Policymakers should prioritize updating TB control guidelines to include stool as a routine diagnostic specimen alongside sputum, ensuring that all malnourished children undergo TB screening upon hospital admission. Additionally, strengthening laboratory capacity, ensuring adequate supply chains for GeneXpert cartridges, and training healthcare workers on stool sample processing and testing protocols will be essential for successful implementation.

Further research is needed to evaluate the feasibility and scalability of routine stool GeneXpert testing across multiple settings, including both inpatient and outpatient healthcare facilities. Large-scale studies should assess the long-term impact of stool-based TB screening on treatment outcomes, TB-related mortality, and potential cost-effectiveness in resource-limited environments. Additionally, exploring the integration of stool-based TB diagnostics into existing childhood nutrition programs could provide a holistic approach to tackling the dual burden of TB and malnutrition in endemic regions.

References

1. Ogbo FA, Ogeleka P, Okoro A, Olusanya BO, Olusanya J, et al. Page A. Tuberculosis disease burden and attributable risk factors in Nigeria, 1990-2016. Trop Med Health. 2018. 46: 34.
2. Ugwu KO, Agbo MC, Ezeonu IM. Prevalence of Tuberculosis, Drug-Resistant Tuberculosis and HIV/TB Co-Infection in Enugu, Nigeria. Afr J Infect Dis. 2021. 15: 24-30.
3. WHO. Global tuberculosis report. World Health Organization. 2023.
4. WHO. Global tuberculosis report. Geneva: WHO. Available from. 2022.
5. Chisti MJ, Graham SM, Duke T, Ahmed T, Faruque AS, et al. post-discharge mortality in children with severe malnutrition and pneumonia in Bangladesh. PLoS One. 2014. 9: 107663.
6. Bhutta ZA, Berkley JA, Bandsma RHJ, Kerac M, Trehan I, et al. Severe childhood malnutrition. Nat Rev Dis Primers. 2017. 3: 17067.
7. Vonasek BJ, Radtke KK, Vaz P, Buck WC, Chabala C, et al. Tuberculosis in children with severe acute malnutrition. Expert Rev Respir Med. 2022. 16: 273-284.
8. Feyisa JW, Berhanu RD, Lema M, Desalegn M, Merdassa E, et al. Magnitude and determinants of undernutrition among tuberculosis patients in Ethiopia: systematic review and meta-analysis. BMC Public Health. 2024. 24: 1698.
9. Gunasekera KS, Vonasek B, Oliwa J, Triasih R, Lancioni C, et al. Diagnostic Challenges in Childhood Pulmonary Tuberculosis-Optimizing the Clinical Approach. Pathogens. 2022. 11: 382.
10. Wobudeya E, Bonnet M, Walters EG, Nabeta P, Song R, et al. Diagnostic Advances in Childhood Tuberculosis-Improving Specimen Collection and Yield of Microbiological Diagnosis for Intrathoracic Tuberculosis. Pathogens. 2022. 11: 389.
11. Frieze JB, Yadav RP, Sokhan K, Ngak S, Khim TB. Examining the quality of childhood tuberculosis diagnosis in Cambodia: a cross-sectional study. BMC Public Health. 2017. 17: 232.
12. Chipinduro M, Mateveke K, Makamure B, Ferrand RA, Gomo E. Stool Xpert® MTB/RIF test for the diagnosis of childhood pulmonary tuberculosis at primary clinics in Zimbabwe. Int J Tuberc Lung Dis. 2017. 21: 161-166.
13. Walters E, Gie RP, Hesseling AC, Friedrich SO, Diacon AH, et al. Rapid diagnosis of pediatric intrathoracic tuberculosis from stool samples using the Xpert MTB/RIF Assay: a pilot study. Pediatr Infect Dis J. 2012. 31: 1316.
14. Walters E, Zalm van der MM, Palmer M, Bosch C, Demers AM, et al. Xpert MTB/RIF on Stool Is Useful for the Rapid Diagnosis of Tuberculosis in Young Children with Severe Pulmonary Disease. Pediatr Infect Dis J. 2017. 36: 837-843.
15. Evans CA. GeneXpert-a game-changer for tuberculosis control? PLoS Med. 2011. 8: 1001064.
16. Nwokoye N, Odume B, Nwadike P, Anaedobe I, Mangoro Z, et al. Impact of the Stool-Based Xpert Test on Childhood Tuberculosis Diagnosis in Selected States in Nigeria. Trop Med Infect Dis. 2024. 9: 100.
17. Newton SM, Brent AJ, Anderson S, Whittaker E, Kampmann B. Paediatric tuberculosis. Lancet Infect Dis. 2008. 8: 498-510.

18. Gutiérrez-González LH, Juárez E, Carranza C, Carreto-Binaghi LE, Alejandre A, et al. Immunological Aspects of Diagnosis and Management of Childhood Tuberculosis. Infect Drug Resist. 2021. 14: 929-946.
19. Jaganath D, Mupere E. Childhood tuberculosis and malnutrition. The Journal of infectious diseases. 2012. 206: 1809-1815.
20. Munthali T, Chabala C, Chama E, Raider Mugode, Nathan Kapata, et al. Tuberculosis caseload in children with severe acute malnutrition related with high hospital-based mortality in Lusaka, Zambia. BMC Res Notes. 2017. 10: 206.
21. VanValkenburg A, Kaipilyawar V, Sarkar S, Lakshminarayanan S, Cintron C, et al. Malnutrition leads to increased inflammation and expression of tuberculosis risk signatures in recently exposed household contacts of pulmonary tuberculosis. Front Immunol. 2022. 13: 1011166.
22. Ockenga J, Fuhse K, Chatterjee S, Malykh R, Rippin H, et al Tuberculosis and malnutrition: The European perspective. Clin Nutr. 2023. 42: 486-492.
23. Wolf H, Mendez M, Gilman RH, Sheen P, Soto G, et al. Diagnosis of pediatric pulmonary tuberculosis by stool PCR. Am J Trop Med Hyg. 2008. 79: 893-898.
24. Liu XH, Xia L, Song B, Wang H, Qian XQ, et al. Stool-based Xpert MTB/RIF Ultra assay as a tool for detecting pulmonary tuberculosis in children with abnormal chest imaging: A prospective cohort study. J Infect. 2021. 82: 84-89.
25. Segala FV, Papagni R, Cotugno S, De Vita E, Susini MC, et al. Stool Xpert MTB/RIF as a possible diagnostic alternative to sputum in Africa: a systematic review and meta-analysis. Front Public Health. 2023. 11: 1117709.
26. Alao MA, Ibrahim OR, Ogunbosi BO. Trends of Xpert MTB/RIF in the diagnosis of Mycobacterium tuberculosis and rifampicin resistance in Southwest Nigeria: A 4-year retrospective study. J Pan Afr Thorac Soc. 2023. 4: 31-41.
27. Mwanza W, Lutinala M, Mundia K, Klinkenberg E, Haas de P, et al. Stool-based Xpert testing for diagnosis of TB in children and critically ill adults. Int J Tuberc Lung Dis. 2025. 29: 75-79.