e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com

International Journal of Pharmaceutical Quality Assurance 2025; 16(6); 301-305

Original Research Article

Clinical Profile and Outcomes of Pediatric Tuberculous Meningitis: Influence of BCG Vaccination and Nutritional Status in a Tertiary Care Hospital in Bihar

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Received: 08-05-2025 / Revised: 10-06-2025 / Accepted: 28-06-2025

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Conflict of interest: Nil

Abstract:

Background: Tuberculous meningitis (TBM) is the most severe form of extra pulmonary tuberculosis in children, associated with high morbidity and mortality. Early recognition of clinical manifestations and understanding the influence of host factors, such as BCG vaccination status and nutritional status, are crucial for improving outcomes.

Objectives: To evaluate the clinical manifestations and outcomes of pediatric TBM and to assess the association of BCG vaccination status and nutritional status with disease severity and prognosis.

Methods: A retrospective study was conducted over one year (January 2024–December 2024) in the Department of Pediatrics, Nalanda Medical College and Hospital, Patna, Bihar, India. A total of 110 children aged 1 month to 14 years, diagnosed with TBM based on clinical, cerebrospinal fluid (CSF), and radiological findings, were enrolled. Detailed history, BCG vaccination status (presence of scar), nutritional status (weight-for-age, height-for-age, and WHO Z-scores), and clinical presentations were recorded. Patients were followed until discharge or death, and outcomes were categorized as full recovery, recovery with neurological sequelae, or mortality. Statistical analyses were performed to determine associations of vaccination and nutrition with disease outcome.

Results: Fever (94.5%), vomiting (72.7%), seizures (61.8%), and altered sensorium (53.6%) were the most common presenting features. BCG-vaccinated children (58.2%) showed significantly lower rates of severe TBM and better outcomes compared to unvaccinated children ($p < 0.05$). Malnutrition was present in 44.5% of cases, and it was strongly associated with higher rates of complications and mortality. Overall, 28.2% of children recovered fully, 47.3% developed neurological sequelae, and 24.5% succumbed to the illness.

Conclusion: Pediatric TBM continues to pose a major health burden with high morbidity and mortality. BCG vaccination confers partial protection against severe disease, while malnutrition significantly worsens outcomes. Strengthening BCG immunization and nutritional interventions could reduce disease severity and improve survival in children.

Keywords: Tuberculous meningitis, children, BCG vaccination, nutritional status, neurological sequelae, outcome

Introduction

Tuberculosis remains a major public health problem worldwide, and India contributes significantly to the global burden. Among extrapulmonary manifestations, tuberculous meningitis (TBM) is the most severe form, particularly in children, due to its high morbidity, mortality, and long-term neurological sequelae [1]. Pediatric TBM accounts for a significant proportion of hospital admissions in endemic regions and is often associated with delayed diagnosis, which worsens outcomes [2].

The clinical spectrum of TBM in children is highly variable, ranging from non-specific symptoms such as fever, vomiting, and irritability, to severe manifestations including seizures, altered consciousness, cranial nerve palsies, and hydrocephalus [3]. The disease is classified into stages I to III according to severity, with higher stages correlating with worse outcomes. Despite advances in diagnostic tools, many cases in resource-limited settings rely on a combination of

clinical, cerebrospinal fluid (CSF), and neuroimaging findings for diagnosis [4].

BCG vaccination has long been part of national immunization programs and is known to provide partial protection against severe forms of childhood tuberculosis, including TBM. However, the degree of protection varies across populations, and vaccine efficacy is influenced by multiple factors such as strain differences, host immunity, and nutritional status [5]. Malnutrition is another important determinant of disease severity and prognosis, as undernourished children are more susceptible to infections, have impaired immune responses, and often experience poor recovery [6].

Although several studies have evaluated the clinical profile of TBM in children, limited data are available that specifically analyze the combined impact of BCG vaccination and nutritional status on disease presentation and outcome, especially in the eastern Indian setting. Understanding these associations is vital for improving preventive strategies, strengthening immunization programs, and addressing nutritional deficiencies [7,8].

The present study was undertaken to describe the clinical manifestations and outcomes of pediatric TBM in a tertiary care hospital in Bihar, and to evaluate the role of BCG vaccination and nutritional status in influencing disease severity and prognosis.

Materials and Methods

Study Design and Setting: A retrospective study conducted in the Department of Pediatrics, Nalanda Medical College and Hospital, Patna, Bihar, India, over a period of one year from January 2024 to December 2024.

Study Population: Children aged 1 month to 14 years, diagnosed with tuberculous meningitis (TBM), were enrolled. Diagnosis was based on a combination of clinical features, cerebrospinal fluid (CSF) analysis, neuroimaging findings, and evidence of tuberculosis elsewhere in the body, following national TB program guidelines.

Inclusion Criteria:

- Children aged 1 month to 14 years diagnosed with TBM.
- Availability of parental/guardian consent for study participation.

Exclusion Criteria:

- Children with meningitis of bacterial, viral, or fungal etiology confirmed by laboratory tests.
- Children with chronic neurological disorders unrelated to TBM.
- Children already on long-term corticosteroid or immunosuppressive therapy.

Sample Size: A total of 110 children fulfilling the inclusion criteria were consecutively enrolled during the study period.

Data Collection: Detailed history and clinical examination findings were recorded at admission, including demographic data, presenting symptoms, and neurological status. BCG vaccination status was assessed based on history and presence of a vaccination scar. Nutritional status was evaluated using World Health Organization (WHO) growth charts and Z-scores for weight-for-age, height-for-age, and weight-for-height. Malnutrition was categorized as per WHO definitions into moderate and severe under nutrition.

Staging of TBM: Patients were classified into stage I, II, or III TBM according to the British Medical Research Council (BMRC) criteria:

- Stage I: Alert and oriented, no focal neurological deficit.
- Stage II: Signs of meningeal irritation with altered sensorium or focal neurological deficit but no coma.
- Stage III: Severe illness with stupor/coma and severe neurological deficits.

Treatment Protocol: All children received anti-tubercular therapy (ATT) as per Revised National Tuberculosis Control Program (RNTCP) guidelines along with adjunctive corticosteroids. Supportive care including management of seizures, raised intracranial pressure, and nutritional supplementation was provided as required.

Outcome Assessment: Patients were followed until discharge or death. Outcomes were classified as:

- Full recovery without deficits
- Recovery with neurological sequelae (e.g., motor deficits, cranial nerve palsy, hydrocephalus)
- Mortality

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 25. Descriptive statistics were presented as mean ± standard deviation (SD) for continuous variables and percentages for categorical variables. Associations between BCG vaccination status, nutritional status, and outcome were evaluated using chi-square test or Fisher's exact test as appropriate. Logistic regression was performed to identify independent predictors of poor outcome. A p-value <0.05 was considered statistically significant.

Results

A total of 110 children with tuberculous meningitis (TBM) were enrolled during the study period from January 2024 to December 2024. The age of participants ranged from 6 months to 14 years, with a mean age of 6.3 ± 3.2 years. The majority of cases

(64.5%) occurred in children under 5 years. There was a male predominance, with a male-to-female ratio of 1.4:1.

Table 1: Age and Gender Distribution of Study Participants

Age Group (years)	Male (n=64)	Female (n=46)	Total (n=110)	Percentage (%)
<1	10	6	16	14.5
1–5	34	21	55	50.0
6–10	14	12	26	23.6
11–14	6	7	13	11.9

Table 2: Clinical Symptoms at Presentation

Symptom	Frequency (n=110)	Percentage (%)
Fever	104	94.5
Vomiting	80	72.7
Seizures	68	61.8
Altered sensorium	59	53.6
Headache	44	40.0
Irritability	38	34.5
Focal neurological deficit	22	20.0

Table 3: Clinical Staging of TBM at Admission (BMRC Criteria)

Stage	No. of Patients (n=110)	Percentage (%)
Stage I	22	20.0
Stage II	58	52.7
Stage III	30	27.3

Table 4: Distribution of Patients According to BCG Vaccination Status

Vaccination Status	Number (n=110)	Percentage (%)
Vaccinated (scar present)	64	58.2
Unvaccinated (scar absent)	46	41.8

Table 5: Nutritional Status of Study Participants (WHO Z-scores)

Nutritional Status	Number (n=110)	Percentage (%)
Normal nutrition	61	55.5
Moderate malnutrition	28	25.5
Severe malnutrition	21	19.0

Table 6: Association of BCG Vaccination with Clinical Stage of TBM

TBM Stage	Vaccinated (n=64)	Unvaccinated (n=46)
Stage I	18 (28.1%)	4 (8.7%)
Stage II	36 (56.3%)	22 (47.8%)
Stage III	10 (15.6%)	20 (43.5%)

Table 7: Association of Nutritional Status with Clinical Stage of TBM

TBM Stage	Normal (n=61)	Malnourished (n=49)
Stage I	16 (26.2%)	6 (12.2%)
Stage II	34 (55.7%)	24 (49.0%)
Stage III	11 (18.1%)	19 (38.8%)

Table 8: Neurological Complications Observed During Hospital Stay

Complication	Number (n=110)	Percentage (%)
Cranial nerve palsy	22	20.0
Hydrocephalus	28	25.5
Hemiparesis/paraparesis	18	16.4
Cognitive impairment	12	10.9
No complication	30	27.2

Table 9: Final Outcome of Study Participants

Outcome	Number (n=110)	Percentage (%)
Full recovery	31	28.2
Recovery with neurological sequelae	52	47.3
Mortality	27	24.5

Table 10: Association of Vaccination and Nutritional Status with Final Outcome

Group	Full Recovery	Sequelae	Mortality
Vaccinated (n=64)	24 (37.5%)	32 (50.0%)	8 (12.5%)
Unvaccinated (n=46)	7 (15.2%)	20 (43.5%)	19 (41.3%)
Normal nutrition (n=61)	26 (42.6%)	26 (42.6%)	9 (14.8%)
Malnourished (n=49)	5 (10.2%)	26 (53.1%)	18 (36.7%)

In this cohort of 110 children with TBM, the majority were under five years of age, with a male predominance (Table 1). The most common presenting symptoms were fever, vomiting, seizures, and altered sensorium (Table 2). Most patients presented in Stage II, with nearly one-third in advanced Stage III disease (Table 3). BCG vaccination scar was present in 58.2% of participants (Table 4), while malnutrition was identified in 44.5% of children (Table 5). Vaccinated children were more likely to present with earlier stages of TBM, whereas unvaccinated children had significantly higher rates of Stage III disease (Table 6). Similarly, malnutrition was associated with advanced disease at presentation (Table 7). During hospitalization, hydrocephalus and cranial nerve palsies were the most frequent complications (Table 8). Regarding outcomes, only 28.2% of children recovered fully, while nearly half developed neurological sequelae and one-fourth died (Table 9). Importantly, BCG vaccination was associated with higher full recovery rates and lower mortality, while malnutrition was strongly linked to poor outcomes (Table 10). These findings emphasize that BCG vaccination offers partial protection against severe TBM, and nutritional status significantly influences disease progression and outcomes.

Discussion

Tuberculous meningitis in children continues to be a major health concern in endemic countries, where delayed diagnosis and limited resources often contribute to poor outcomes. In the present study, the majority of cases occurred in children under five years of age, reflecting the greater vulnerability of younger children due to immature immune responses and higher risk of disseminated infection. A male predominance was noted, which is a common finding in pediatric infectious diseases, though the underlying biological or social factors remain unclear [9,10].

The clinical manifestations observed in this study were largely non-specific at onset, with fever, vomiting, seizures, and altered sensorium being the predominant features. These symptoms often overlap with other childhood illnesses, which may delay recognition of TBM until neurological signs become evident. More than one-fourth of children presented in advanced disease stage, highlighting the need for improved awareness and early referral systems [11].

BCG vaccination was found to influence both severity and outcome in this study. Vaccinated children were more likely to present at earlier stages and had a better prognosis compared to unvaccinated children. While BCG does not provide complete protection, its role in reducing the incidence and severity of childhood TBM is reaffirmed. Ensuring universal vaccination coverage therefore remains a critical public health priority [12].

Nutritional status was another important determinant. Malnourished children not only presented with more advanced disease but also experienced higher rates of complications and mortality. Malnutrition is known to impair immune responses and lower host resistance to infections, which likely explains its strong association with poor outcomes. Addressing malnutrition through community-based interventions and integration with tuberculosis control programs is essential for improving survival and long-term neurological outcomes [13,14].

Neurological complications such as hydrocephalus, cranial nerve palsies, and motor deficits were frequently observed, and nearly half of the survivors were discharged with sequelae. This high burden of disability emphasizes that TBM is not only a life-threatening illness but also a leading cause of long-term neurological impairment in children. Preventing severe disease through vaccination, early diagnosis, and adequate nutritional support could substantially reduce this burden [15].

Although the study provides important insights, it is limited by its single-center design, moderate sample size, and lack of long-term follow-up after discharge. Nevertheless, the findings highlight the dual importance of preventive vaccination and

adequate nutrition in modifying the course of TBM in children.

Conclusion

This study demonstrates that tuberculous meningitis in children is associated with high morbidity and mortality, particularly among unvaccinated and malnourished children. BCG vaccination was found to provide partial protection against severe disease, while malnutrition significantly worsened clinical stage at presentation and overall outcome. The high rate of neurological sequelae underscores the need for early recognition, timely treatment, and preventive strategies. Strengthening universal BCG vaccination coverage and addressing childhood malnutrition are crucial measures to improve prognosis in pediatric TBM.

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