



## RESEARCH ARTICLE

# Nutritional Status & Dietary Pattern of Tuberculosis Patients in India: A Systematic Review

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## Abstract

This systematic review aimed to evaluate existing evidence on the nutritional status and dietary patterns of tuberculosis (TB) patients in India, with particular emphasis on undernutrition, micronutrient deficiencies, and dietary factors influencing treatment outcomes and disease management. A comprehensive literature search was conducted across PubMed, Scopus, Cochrane Library, Google Scholar, and Web of Science to identify peer-reviewed original studies published in English that assessed nutritional status or dietary patterns among adult or pediatric TB patients in India. Study selection followed PRISMA guidelines, involving title and abstract screening and subsequent full-text evaluation, while reviews, editorials, case reports, conference papers, and laboratory-based studies were excluded. Seventeen eligible studies conducted across different regions of India were included in the analysis. The findings consistently demonstrated a high prevalence of undernutrition among TB patients, with 59–80% exhibiting a body mass index below 18.5 kg/m<sup>2</sup>. Energy intake was reported to be approximately 30–40% lower than recommended levels, alongside inadequate protein consumption. Additionally, widespread deficiencies of key micronutrients, particularly zinc, vitamin D, and iron, were observed. Contributing factors included food insecurity, limited dietary diversity, lack of nutritional counselling, and poor hygiene conditions. Although selected intervention studies reported improvements in nutritional status and treatment outcomes following dietary supplementation and counselling, nutritional care remains inconsistently integrated into TB control programs. Overall, nutritional deficiencies remain an under-addressed determinant of TB outcomes in India, necessitating integrated nutritional interventions.

**Keywords:** Dietary Pattern, Food Insecurity, Micronutrient Deficiencies, Nutritional Status, TB Management, Undernutrition.

## Introduction

Tuberculosis (TB) remains a major public health challenge in India, contributing significantly to global morbidity and mortality. According to the WHO Global TB Report 2023, India accounts for nearly 28% of the global TB burden, with about 2.8 million new cases reported annually, and recent WHO updates indicate that India continues to bear the highest share of global TB incidence and mortality. TB primarily

affects the lungs but may also involve extrapulmonary organs, leading to systemic complications and reduced quality of life (Andraska *et al.*, 2021). Emerging evidence highlights the supportive role of plant-based antimicrobial and nutrition-preserving approaches in infection control and health protection. Herbal formulations derived from neem and aloe vera exhibit antimicrobial effectiveness against pathogenic microorganisms, supporting their relevance in disease prevention (Khan *et al.*, 2021). Similarly, tulsi-based herbal edible coatings demonstrate antimicrobial activity and help preserve food quality and nutritional value, indicating potential benefits for nutritional health (Saini *et al.*, 2019). In addition, plant biotechnology studies on protein-rich pigeonpea emphasize the importance of nutrient-dense crops for food security in vulnerable populations (Jharna *et al.*, 2013). Collectively, these findings underscore the interconnected roles of nutrition, plant-derived therapeutics, and infection control in addressing the broader burden of tuberculosis.

The high burden of TB in India is closely linked with socio-economic factors such as poverty, undernutrition, and substandard healthcare, which all act as facilitators in the increased prevalence, progression, and mortality of the

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disease. Regardless of the progress made in the diagnostic procedures and treatment regimen, the high incidence of a complex bidirectional relationship between tuberculosis and malnutrition continues to form the biggest hurdle in the control of TB (Anigbo *et al.*, 2018; Banyal *et al.*, 2023).

Malnutrition has been suggested to compromise both innate and adaptive immune responses, heightening vulnerability to tuberculosis infection, accelerating disease progression, and diminishing treatment effectiveness. Active tuberculosis induces a catabolic condition characterized by heightened energy expenditure, diminished food absorption, and appetite suppression, collectively resulting in significant nutritional deficiencies (Bhargava *et al.*, 2021). In India, it has been estimated that 50% of tuberculosis patients present for diagnosis in a state of undernutrition, with protein-energy malnutrition and micronutrient deficiencies being the most prevalent issues. A deficiency in numerous crucial micronutrients—vitamins A, D, and E, iron, and zinc—impairs immunity, prolongs sputum conversion, and heightens the likelihood of treatment failures and further relapses (Bhargava *et al.*, 2013; Brown *et al.*, 2015).

Das *et al.* (2018) reported that dietary intake among TB-affected populations in India is frequently inadequate in both diversity and quantity, failing to meet the increased metabolic demands imposed by the disease. Dietary practices are strongly influenced by regional, cultural, and socio-economic determinants and are often dominated by monotonous cereal-based foods with limited nutritional value. Large-scale evidence further indicates that nearly 70% of TB-affected households in India experience some level of food insecurity, substantially increasing the risk of undernutrition and poor treatment outcomes, particularly among vulnerable groups such as women and children (Făcă *et al.*, 2025). In this context, plant-based antimicrobial and nutrition-supportive strategies have shown relevance; neem- and aloe-vera-based herbal formulations exhibit effective antimicrobial protection (Khan *et al.*, 2021), while tulsi-derived edible coatings help preserve food quality and nutritional value (Saini *et al.*, 2019). Additionally, research on protein-rich pigeonpea regeneration highlights the broader importance of nutrient-dense crops for improving food security in vulnerable populations (Jharna *et al.*, 2013).

Food-related interventions such as dietary counselling, macronutrient supplementation, and micronutrient fortification show an encouraging effect in improving clinical outcomes and reducing mortality related to TB. However, massive gaps prevail in the accessibility, coverage, and constant implementation of these programs. As per a recent review, malnutrition prevalence among TB patients ranges from 35% to 75%, reflecting regional heterogeneity in India due to differences in dietary culture, socio-economic status, and access to healthcare (Frediani *et al.*, 2016). Missing is the consistent screening for nutrition, and its integration into

treatment protocols for TB is poor; hence, there is also a lack of awareness amongst health workers, all factors that contribute to poor treatment for malnutrition whereby these patients are concerned (Hwalla *et al.*, 2021).

Being screened for malnutrition and provided with targeted nutritional support should be the tertiary line of defense in the management of TB in India. Malnutrition identification at the very outset allows application of individualized dietetic measures in the treatment, thus enhancing follow-up, diminishing complications, and speeding up recovery. If not addressed, nutritional deficits exacerbate the disease process; they even increase incidence of drug-related adverse reactions, relapses, and death among these patients (Iqbaal *et al.*, 2024).

The aim of this review is to present a critical and comprehensive analysis of the evidence on the nutritional status and dietary trends among patients with tuberculosis in India, thereby emphasizing the need for nutritional evaluation and support as part of an integrated TB management framework.

## Methodology

### **Data Sources and Eligibility**

The review authors conducted an exhaustive search of the relevant publications for this systematic review. PubMed, Scopus, Cochrane Library, and so on, were scoured for the appropriate studies. Search engines such as Google and Google Scholar were also exploited to make the search more complete. The review sought empirical data on the nutritional status, diet, and factors influencing these among tuberculosis patients in India. Any studies that dealt with quantitative assessments of malnutrition, dietary diversity, food insecurity, and micronutrient deficiencies among TB patients were considered. But editorials, commentaries, and abstracts were disqualified. Equally, publications that were either not in English or did not have full text were excluded to uphold consistency and quality of data.

### **Inclusion Criteria**

This systematic review gives precedence to the original research studies. Any quantitative, qualitative, or mixed-method study assessing nutritional status or dietary patterns among tuberculosis patients in India would have been included. Studies conducted on adult or pediatric populations with active tuberculosis, including both pulmonary and extra-pulmonary forms, were considered. Research that explored malnutrition, undernutrition, dietary habits, nutrient intake, food security, or the role of nutrition in TB management was eligible. Both clinical and community-based studies were included to capture a comprehensive understanding of the issue. Only studies published in English were reviewed.

### Exclusion Criteria

Studies were excluded based on predefined criteria to maintain the relevance and quality of the review. Abstracts, reviews, editorials, commentaries, and case reports were excluded as they did not provide primary empirical data. Studies not conducted in India or unrelated to tuberculosis patients were excluded. Research focusing solely on treatment outcomes or drug resistance without examining nutritional aspects was not considered. Animal studies, experimental laboratory investigations, and studies on general nutrition unrelated to TB were excluded. Duplicates and studies without full-text availability or published in languages other than English were also excluded to ensure consistency and avoid translation bias.

### Screening Strategy

Search terms were organized into key categories and combined using Boolean operators (AND, OR) to identify relevant studies on the nutritional status and dietary patterns of TB patients across databases such as PubMed and Google Scholar (Table 1). Titles and abstracts were systematically screened, and studies unrelated to the objective or lacking a clear focus on nutrition or dietary patterns among TB patients were excluded.

### Data Verification for Consistency

Data extracted from the studies included was systematically organized to ensure efficient data management using Microsoft Excel (Office 2019). The dataset was then subjected to an external quality check to ascertain its correctness and consistency. Whenever conflicts within the dataset were found, they underwent a validation process to resolve them and maintain the reliability of the review findings.

## Results

### Literature search

The literature search was conducted in a very structured and comprehensive manner through five major scientific databases: PubMed, Scopus, Web of Science, Cochrane Library, and Google Scholar. Original, peer-reviewed research articles were sought for publication between

2013 and 2025 in assessing nutritional conditions, dietary patterns, and related deficiencies in TB patients in India. The search strategy was limited to English-language studies and focused exclusively on original research that reported quantitative nutritional indicators such as body mass index (BMI), caloric and protein intake, micronutrient levels (e.g., zinc, vitamin D, iron), and food insecurity status. An initial pool of 1,748 articles was retrieved. After a meticulous screening process, 1,321 studies remained for title and abstract review. This reduction was achieved by removing not only obvious duplicates but also entries with metadata overlaps cases where the same study appeared multiple times across databases with variations in author formatting, indexing structure, or title truncation. This ensured both thoroughness and accuracy in the deduplication process. Of these, 986 articles were excluded based on predefined criteria, including review papers (n = 142), commentaries and editorials (n = 114), and publications unrelated to TB or nutrition (n = 730). A full-text review was performed on the remaining 335 studies, from which 318 articles were excluded due to absence of nutritional data (n = 123), indirect relevance to TB populations (n = 92), or methodological concerns such as unclear design, limited sample size, or lack of validated tools (n = 103). Finally, 17 original research studies met the eligibility criteria and were included in the present systematic review. These studies provided detailed, region-specific data on the nutritional profile of TB patients and served as the foundation for synthesis and interpretation in the subsequent sections provided in Figure 1.

### Summary of Included Studies

The final selection comprised 17 original research studies conducted between 2013 and 2025, covering a range of geographical regions across North, South, East, and Central India. These studies collectively investigated various dimensions of nutritional health among tuberculosis (TB) patients, including undernutrition, dietary intake gaps, food insecurity, and micronutrient deficiencies. Most of the studies employed cross-sectional designs, while a few adopted cohorts, case-control, longitudinal, or randomized controlled trial (RCT) methodologies. Study settings varied from tertiary care hospitals and DOTS (Directly Observed Treatment, Short- course) centers to community-based surveillance sites, reflecting both urban and rural contexts. Sample sizes ranged from 46 to over 800 participants, and the populations studied included adult pulmonary TB patients, patients in the intensive phase of treatment, as well as those with drug-resistant TB or TB-HIV co-infection. Nutritional assessments were conducted using anthropometric measures such as BMI and MUAC, dietary recall tools for estimating calorie and protein intake, and biochemical evaluations to determine serum levels of micronutrients like vitamin D, iron, zinc, and selenium. Several studies also examined behavioral and environmental factors influencing

**Table 1:** Planned Search Terms and Criteria for Review

Field	Search Terms
Abstract	Tuberculosis OR TB OR pulmonary tuberculosis OR extra-pulmonary tuberculosis
Abstract OR	Nutritional status OR malnutrition OR undernutrition OR dietary pattern OR micronutrient deficiency OR diet OR food security
Any Field AND	Systematic review OR cross-sectional OR cohort OR longitudinal OR clinical study

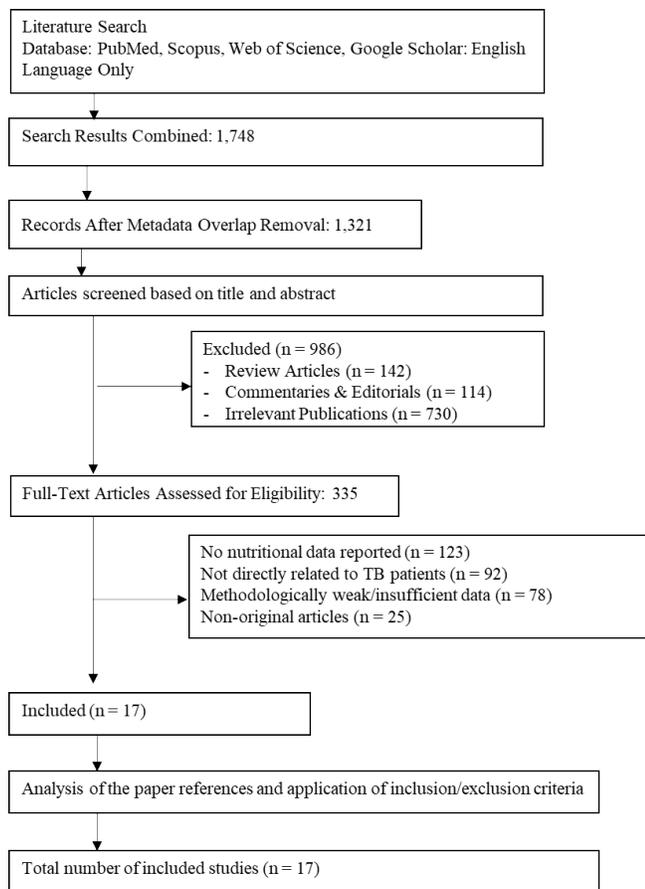


Figure 1: PRISMA flowchart.

nutrition, such as food choices, household food insecurity, dietary counseling, sanitation practices, and comorbidities like diabetes. A summary of the methodological features, sample demographics, and major nutritional findings of these 17 studies is provided in Table 2.

### Nutritional Status of Tuberculosis Patients

Undernutrition, predominantly assessed using body mass index (BMI), was a consistently reported concern across the reviewed studies. Research conducted in northern and eastern India documented a high prevalence of BMI <18.5 kg/m<sup>2</sup>, ranging from 59% to 79.5%, with up to 49% of patients classified as severely malnourished (BMI <16 kg/m<sup>2</sup>) (Panda *et al.*, 2025). One study further reported a notable sex-specific disparity, with female patients exhibiting a higher prevalence of undernutrition (Thurstans *et al.*, 2020). In comparison, studies from southern India reported moderate levels of anthropometric undernutrition (46–60%), while also highlighting the emergence of dual malnutrition—characterized by coexisting indicators of both undernutrition and overnutrition. This was particularly evident among urban and peri-urban populations, where low BMI co-occurred with central obesity and elevated HbA1c levels (Bhargava *et al.*, 2013).

Other studies that did not directly quantify BMI still reported associated nutritional deficits, including low fat-free mass in MDR-TB patients, vitamin D deficiency correlated with poor glycemic control, and severe micronutrient depletion in HIV-TB co-infected individuals, suggesting the presence of functional and subclinical malnutrition not captured by anthropometry alone provided in Table 3.

Table 2: Characteristics and Key Nutritional Findings of Original Research Studies Included in the Systematic Review on Tuberculosis Patients in India (2013–2025)

Author (Year)	Study Design	Location	Sample Size	Key Nutritional Findings	References
Bhargava <i>et al.</i> , (2013)	Cross-sectional	Uttar Pradesh	872	59% had BMI <18.5; 35% severely malnourished; undernutrition associated with delayed recovery.	(Bhargava <i>et al.</i> , 2013)
Sinha <i>et al.</i> , (2021)	Cohort	Bihar & Maharashtra	415	72% undernutrition; low dietary diversity; vitamin D and iron deficiencies common.	(Sinha <i>et al.</i> , 2021)
Mclvor <i>et al.</i> , (2018)	Cross-sectional	Tamil Nadu	142	67% had protein- energy malnutrition; 81% had micronutrient deficiencies (iron,zinc).	(Mclvor <i>et al.</i> , 2018)
Jovita <i>et al.</i> , (2022)	Cross-sectional	Puducherry, South India	173	Mean intake: 1414kcal/day, 43g protein; energy and micronutrient intakes below RDA.	(Jovita <i>et al.</i> , 2022)
Shukla <i>et al.</i> , (2019)	Cross-sectional	Jaipur, Rajasthan	200	62% underweight; low protein/iron intake	(Shukla <i>et al.</i> , 2019)
Sinha <i>et al.</i> , (2019)	Mixed method	Bihar	124	72% moderate-to-severe food insecurity; dietary gaps	(Sinha <i>et al.</i> , 2019)
Iqbal <i>et al.</i> , (2025)	Cross-sectional	Aligarh, Uttar Pradesh	410	Mean calorie intake: ~1516kcal/day; 83% of patients consumed < RDA calories; 71% consumed < RDA protein; 52% had inadequate fat intake. Undernutrition prevalent in majority	(Iqbal <i>et al.</i> , 2025)

Ahmad <i>et al.</i> , (2019)	Case-control	Lucknow, UP	86	Active TB cases had significantly lower serum zinc, retinol, Hb compared to controls	(Ahmad <i>et al.</i> , 2019)
Yu <i>et al.</i> , (2020)	Cross-sectional	Rural Southern India	834	91.7% had $\geq 1$ indicator of malnutrition; 34.6% had both undernutrition and overnutrition signs (double burden); ~33% had elevated HbA1c ( $\geq 5.7\%$ ) despite low BMI/WC; low serum vitamin D associated with higher risk of glycemic abnormality (adjusted RR 1.61)	(Yu <i>et al.</i> , 2020)
Nath <i>et al.</i> , (2024)	Cross-sectional study	Tertiary Care Center under NTEP, India	49	Mean calorie intake: $1525.2 \pm 897$ kcal/day vs required $2231.6 \pm 409.2$ kcal/day; mean protein intake: $39.2 \pm 15.4$ g/day vs requirement $66.9 \pm 15.2$ g/day; significant calorie and protein deficit noted in most patients.	(Nath <i>et al.</i> , 2024)
Nguyen <i>et al.</i> , (2023)	Cross-sectional	National Lung Hospital, Vietnam (Indian patients included)	221	45.8% of patients malnourished by BMI; 60.2% by MUAC; 57.9% at risk per SGA; average calorie intake ~1243 kcal/day; >85% consumed below required calories; >90% failed to meet magnesium, calcium, zinc, and vitamin D intake.	(Nguyen <i>et al.</i> , 2023)
Mahapatra <i>et al.</i> , (2024)	Phased implementation (step-wedge) study	Odisha	761	Patients receiving locally sourced food supplements (e.g., sattu plus dietary counselling) showed significantly higher favorable outcomes (87% vs 77%, $p=0.0017$ ), greater weight gain (avg. 5.2 kg vs 2.8 kg control), BMI increase (to ~19 vs <18.5), improved MUAC and quality-of-life scores, and faster sputum conversion.	(Mahapatra <i>et al.</i> , 2024)
Kumar <i>et al.</i> , (2022)	Randomized controlled trial	Puducherry, India	46	Dietary counselling led to significant improvements in BMI ( $p = 0.0053$ ), total protein ( $p=0.0025$ ), and serum albumin ( $p=0.0048$ ). SGRQ symptom scores improved significantly in underweight intervention group ( $p=0.0036$ ).	(Kumar <i>et al.</i> , 2022)
Das <i>et al.</i> , (2018)	Cross-sectional study	Agartala, Tripura	400	66% of TB patients were undernourished (BMI < 18.5); mean BMI = $17.9 \text{ kg/m}^2$ ; undernutrition higher in females (71%)	(Das <i>et al.</i> , 2018)
Karoli <i>et al.</i> , (2020)	Cross-sectional	Lucknow, Uttar Pradesh	264	76% of TB patients had vitamin D deficiency; lower serum 25(OH)D levels in diabetic TB patients; negative correlation with HbA1c and TB severity	(Karoli <i>et al.</i> , 2020)
Frediani <i>et al.</i> , (2016)	Longitudinal study	Mumbai, Maharashtra	191	Macronutrient intake increased over 16 weeks energy/protein higher than controls but BMI, fat-free mass improved; MDR-TB patients showed blunted anabolic response	(Frediani <i>et al.</i> , 2016)
Banyal <i>et al.</i> , (2023)	Case-cohort study	North India	100	HIV-TB patients had significantly lower serum zinc and selenium, elevated ferritin; micronutrient deficits associated with incident TB among HIV + subjects	(Banyal <i>et al.</i> , 2023)

### Dietary Patterns and Macronutrient Intake

A recurring theme across the included studies was the inadequacy of caloric and protein intake among tuberculosis patients in India. Reported means daily energy intake ranged from approximately 1243 to 1525 kcal, while protein intake ranged from 39.2 to 43 g/day, both of which fall significantly short of the recommended dietary allowances (RDA) of ~2230 kcal and ~67 g protein, respectively (Jovita *et al.*, 2022; Nath *et al.*, 2024).

One study quantified a mean caloric intake of 1525 kcal/day and a protein intake of 39.2 g/day, revealing substantial deficits even in tertiary care settings (Nath *et al.*, 2024). Similar deficiencies were reported in urban contexts, where the average intake remained well below RDA thresholds despite access to healthcare services (Jovita *et al.*, 2022). Another study highlighted that over 85% of patients consumed less than the recommended calorie requirement, with dietary

**Table 3: Undernutrition & Anthropometric Indicators in TB Patients**

<i>Authors (Year)</i>	<i>Region</i>	<i>Sample size</i>	<i>%Undernourished (BMI &lt;18.5)</i>	<i>Anthropometric Deficits</i>	<i>References</i>
Bhargava et al., (2013)	Wardha, Maharashtra	872	59%	35% severely malnourished (BMI <16)	(Bhargava et al., 2013)
Shukla et al., (2019)	Rajasthan	200	79.50%	49% very severely underweight	(Shukla et al., 2019)
Das et al., (2018)	Tripura	400	66%	Higher prevalence in females	(Das et al., 2018)
Jovita et al., (2022)	Puducherry	173	46.90%	Malnutrition despite access to urban health services	(Jovita et al., 2022)
Yu et al., (2020)	South India	834	91.7% ( $\geq 1$ indicator)	34.6% had dual under- and overnutrition indicators	(Yu et al., 2020)
Iqbal et al., (2025)	Eastern Uttar Pradesh	410	~71%	BMI <18.5 prevalent in majority	(Iqbal et al., 2025)
Frediani et al., (2016)	Mumbai, Maharashtra	191	Not reported	FFM gain lower in MDR-TB group despite energy/protein supplementation	(Frediani et al., 2016)
Karoli et al., (2020)	Lucknow, Uttar Pradesh	264	Not reported	Vitamin D deficiency is associated with low BMI and poor glycemic control	(Karoli et al., 2020)
Nguyen et al., (2023)	India & Vietnam (IN subset)	221	45.8% (BMI), 60.2% (MUAC)	>85% below calorie RDA; also reported poor MUAC & malnutrition risk by SGA	(Nguyen et al., 2023)
Banyal et al., (2023)	North India	100	Not reported	HIV-TB patients had severe micronutrient depletion, indicating hidden wasting	(Banyal et al., 2023)

profiles frequently lacking in essential micronutrients such as zinc, calcium, and magnesium (Iqbal et al., 2025).

Another major cause had to do with behavioral determinants. These included skipping meals, diet monotony, and infrequent consumption of foods derived from animals, all of which aggravated existing macronutrient deficits (Sinha et al., 2021). The clinical aspects manifested during reports of protein-energy malnutrition (PEM), which included over two-thirds of the patients in one study, accompanied by iron and zinc deficiencies in most (Mclvor et al., 2018).

Some even studied the effects of nutritional measures, but the results were different. While one trial demonstrated significant improvements in BMI, total protein, and serum albumin following structured dietary counselling Kumar et al., 2022), another reported a blunted anabolic response in MDR-TB patients despite protein-calorie supplementation, suggesting impaired nutrient assimilation or metabolic resistance (Frediani et al., 2016). Overall, these findings underscore that macronutrient deficiency is both widespread and multifactorial among Indian TB patients. The persistence of caloric and protein gaps, along with dietary monotony and poor nutrient density, emphasizes the need for individualized, nutrient-enriched dietary support as an integral component of tuberculosis management and recovery frameworks provided in Table 4.

### **Food Insecurity and Associated Socioeconomic Factors**

The reviewed literature revealed substantial regional disparities in nutritional outcomes, with higher prevalence of

undernutrition and food insecurity consistently reported in studies from northern and eastern India, particularly in Uttar Pradesh, Rajasthan, Bihar, and Odisha. These outcomes were frequently associated with rural residence, limited access to healthcare, and inadequate sanitation infrastructure (Shukla et al., 2019 ; Iqbal et al., 2025).

Conversely, studies from southern India, including Tamil Nadu and Puducherry, demonstrated slightly better anthropometric indicators, yet continued to report micronutrient deficiencies and caloric insufficiency, especially among urban slum dwellers and socioeconomically marginalized groups (Mclvor et al., 2018). One study also highlighted the emerging dual burden of malnutrition, where undernutrition and overnutrition coexisted within the same population, posing significant challenges for nutritional and clinical management (Yu et al., 2020).

Environmental and infrastructural factors were prominent determinants of food and nutrition insecurity. Issues such as open defecation, unsafe drinking water, inadequate water, sanitation, and hygiene (WASH) conditions were repeatedly linked with low BMI, poor dietary diversity, and increased risk of malnutrition, particularly in tribal and rural populations (Yu et al., 2020).

Importantly, intervention-based studies demonstrated that targeted support could yield positive outcomes. For instance, community-based food distribution systems and nutritional counseling initiatives implemented in resource-limited regions led to improvements in weight gain, BMI, and overall treatment outcomes (Kumar et al., 2022). These findings underscore the importance of context-specific,

**Table 4: Macronutrient Intake and Dietary Patterns**

Authors (Year)	Mean calorie Intake	Mean protein Intake	Reported deficits	Dietary pattern	Reference s
Nath <i>et al.</i> , (2024)	1525 kcal/day	39.2 g/day	Calorie deficit ~706 kcal; Protein deficit ~28 g	Cereal- dominant diet, low diversity	(Nath <i>et al.</i> , 2024)
Jovita <i>et al.</i> , (2022)	1414 kcal/day	43 g/day	Below RDA for both, undernourished	Lacked animal- source foods	(Jovita <i>et al.</i> , 2022)
Sinha <i>et al.</i> , (2021)	Not specified	Not specified	Low dietary diversity; frequent meal skipping	Animal protein rarely consumed	(Sinha <i>et al.</i> , 2021)
Iqbal <i>et al.</i> , (2025)	~1516 kcal/day	<RDA in 71%	Majority consumed <RDA	Low fat and micronutrient density	(Iqbal <i>et al.</i> , 2025)
Mclvor <i>et al.</i> , (2018)	Not specified	Not specified	67% PEM; 81% iron and zinc deficiencies	Clinical signs of PEM widespread	(Mclvor <i>et al.</i> , 2018)
Nguyen <i>et al.</i> , (2023)	~1243 kcal/day	Not available	>85% below calorie requirement	Deficient in zinc, calcium, magnesium	(Nguyen <i>et al.</i> , 2023)
Frediani <i>et al.</i> , (2016)	Increased over 16 weeks	Higher than controls	Blunted anabolic response in MDR-TB	Protein-calorie supplementation studied	(Frediani <i>et al.</i> , 2016)
Kumar <i>et al.</i> , (2022)	Not specified	Not specified	BMI & albumin improved post-counseling	Improved SGRQ scores in underweight group	(Kumar <i>et al.</i> , 2022)

regionally adapted nutritional interventions, especially within the framework of the National TB Elimination Program (NTEP), to mitigate socioeconomic and environmental barriers to nutrition provided in Table 5.

### Regional and Environmental Disparities

The nutritional status of tuberculosis patients exhibited marked regional disparities across India. Studies conducted in the northern and eastern regions notably in Rajasthan,

Uttar Pradesh, and Bihar reported the highest prevalence of undernutrition, ranging from 59% to 79.5%, alongside severe food insecurity levels of up to 72%. These adverse outcomes were closely linked to structural and infrastructural deficits, including poor sanitation, open defecation, low household income, and limited access to healthcare services (Iqbal *et al.*, 2025).

In contrast, studies from southern India, including Puducherry, Tamil Nadu, and multi-site cohorts across

**Table 5: Food Insecurity and Socioeconomic Factors in TB Patients**

Authors (Year)	Food insecurity (%)	Contributing factors	Socioeconomic notes	References
Sinha <i>et al.</i> , (2019)	72%	Moderate to severe insecurity	Limited access to nutritious food in Bihar	Sinha <i>et al.</i> , (2019)
Jovita <i>et al.</i> , (2022)	59.2%	Linked to poor dietary intake	Undernutrition observed even in urban settings	Jovita <i>et al.</i> , (2022)
Shukla <i>et al.</i> , (2019)	Not quantified	Tobacco use, open defecation	Higher odds of underweight; better BMI in diabetic TB patients	Shukla <i>et al.</i> , (2019)
Yu <i>et al.</i> , (2020)	Not quantified	Maternal behavior, WASH issues	Impact on pediatric dietary diversity	Yu <i>et al.</i> , (2020)
Banyal <i>et al.</i> , (2023)	Not quantified	HIV comorbidity, oxidative stress	Micronutrient depletion (zinc, selenium)	Banyal <i>et al.</i> , (2023)
Mahapatra <i>et al.</i> , (2024)	Not specified	Improved with public food support	Government food distribution improved nutrition outcomes	Mahapatra <i>et al.</i> , (2024)
Iqbal <i>et al.</i> , (2025)	Not specified	Low income, low education	Food affordability and 71% undernutrition prevalence	Iqbal <i>et al.</i> , (2025)
Nguyen <i>et al.</i> , (2023)	>85% below RDA	Multi- dimensional poverty	Micronutrient deficiencies in India-Vietnam cohort	Nguyen <i>et al.</i> , (2023)
Mclvor <i>et al.</i> , (2018)	Not specified	Urban poverty, inadequate diet	67% protein- energy malnutrition in Tamil Nadu	Mclvor <i>et al.</i> , (2018)
Nath <i>et al.</i> , (2024)	Not specified	Rural-urban nutritional disparity	Greater calorie/protein gap in rural males	Nath <i>et al.</i> , (2024)

the South, reflected moderate rates of anthropometric undernutrition (46–60%) but emphasized persistent micronutrient deficiencies, low dietary diversity, and the coexistence of undernutrition and overnutrition within the same individuals. This double burden of malnutrition was particularly pronounced in urban and peri-urban settings, indicating that proximity to healthcare infrastructure does not always translate into improved nutritional status (Jovita *et al.*, 2022).

Environmental and behavioral factors further shaped these regional nutritional outcomes. Elements such as maternal dietary practices, inadequate access to clean water, and urban–rural disparities in food affordability and availability were strongly associated with poor dietary intake and suboptimal nutritional profiles (Nguyen *et al.*, 2023). Even within urban MDR-TB cohorts, nutritional supplementation did not always translate into improved physiological outcomes. For example, one study noted suboptimal fat-free mass gains in patients receiving dietary support, suggesting the presence of metabolic or functional limitations despite food access (Frediani *et al.*, 2016). Crucially, evidence from intervention-based studies demonstrated that localized, context-sensitive approaches can lead to meaningful improvements. In Odisha, a targeted public food distribution program integrated with dietary counseling significantly enhanced weight gain, BMI, and treatment adherence among TB patients, reinforcing the potential of region-specific nutritional interventions (Mahapatra *et al.*, 2024) provided in Table 6.

## Discussion

Tuberculosis (TB) continues to be a significant public health burden in India, with its impact extending beyond the pulmonary system into broader social and nutritional domains (Bhargava *et al.*, 2021). The relationship between TB and malnutrition is both bidirectional and complex. Undernutrition impairs immune function, increasing susceptibility to TB infection and disease progression, while active TB leads to appetite loss, nutrient malabsorption, and catabolic waste (Chandrasekaran *et al.*, 2017). Despite India's high TB burden, the nutritional dimension of TB care remains inadequately addressed in policy and practice (Ramraj *et al.*, 2025). This systematic review synthesizes findings from 17 original research studies conducted between 2010 and 2025, providing a comprehensive understanding of the nutritional challenges faced by TB patients across diverse geographic, clinical, and socioeconomic settings. The included studies show a big picture of undernutrition, caloric and protein deficits, micronutrient inadequacies, and food insecurities among TB-affected individuals. The review aims to address gaps in evidence by analyzing the common trends, contextual determinants, and intervention outcomes to lay down the basis of integrated nutritional support and to inform national TB control programs with region-specific insights.

The common factor across the various studies has been a higher incidence of underweight TB patients. Studies by Bhargava *et al.*, (2013), Jovita *et al.*, (2022) Shukla *et al.*, (2019),

**Table 6:** Regional and Environmental Disparities in Nutritional Status of TB Patients

<i>Authors (year)</i>	<i>Region</i>	<i>Key nutritional concern</i>	<i>Environmental/contextual notes</i>	<i>References</i>
Bhargava <i>et al.</i> , (2013)	Wardha, Maharashtra	59% undernutrition; 35% severely malnourished	Rural access barriers; pre-treatment nutritional gaps	Bhargava <i>et al.</i> , (2013)
Shukla <i>et al.</i> , (2019)	Rajasthan	79.5% underweight; 49% severely underweight	Open defecation, tobacco use, poor sanitation	Shukla <i>et al.</i> , (2019)
Iqbal <i>et al.</i> , (2025)	Eastern Uttar Pradesh	71% with BMI <18.5	Low income, education, food insecurity	Iqbal <i>et al.</i> , (2025)
Sinha <i>et al.</i> , (2019)	Bihar	72% food insecurity	Poor infrastructure, nutrition-linked poverty	Sinha <i>et al.</i> , (2019)
Jovita <i>et al.</i> , (2022)	Puducherry	46.9% undernourished; 59.2% food insecurity	Urban but still lacking dietary diversity and intake	Jovita <i>et al.</i> , (2022)
Mclvor <i>et al.</i> , (2018)	Tamil Nadu	67% PEM; 81% micronutrient deficiency	Urban TB population; double burden of malnutrition	Mclvor <i>et al.</i> , (2018)
Yu <i>et al.</i> , (2020)	South India (multi-site)	Pediatric malnutrition; under & overnutrition mix	Maternal behavior, sanitation, rural-urban dietary divide	Yu <i>et al.</i> , (2020)
Nguyen <i>et al.</i> , (2023)	India & Vietnam (multisite)	>85% calorie deficit; 60.2% undernourished by MUAC	Micronutrient inadequacies; includes India-specific analysis	Nguyen <i>et al.</i> , (2023)
Frediani <i>et al.</i> , (2016)	Mumbai	Low fat-free mass gain in MDR-TB patients	Nutritional therapy setting; urban TB cohort	Frediani <i>et al.</i> , (2016)
Mahapatra <i>et al.</i> , (2024)	Odisha	Improved nutrition via food support	Effective local-level food distribution implementation	Mahapatra <i>et al.</i> , (2024)

and Das *et al.*, (2018) all observed more than half of their TB patients being unduly nourished, and among them, many were classified as severely or very severely underweight. These studies also suggested that undernutrition was associated with delayed sputum conversion, longer recovery processes, and a greater risk of poor outcomes. This consistency of findings, appearing both from the northern and southern regions, emphasizes that undernutrition is a nationwide public health issue in TB care.

The review turned up evidence that protein-energy malnutrition and caloric deficits affected nearly all the study subjects. Several of the studies (McIvor *et al.*, 2018; Jovita *et al.*, 2022; Nath *et al.*, 2024) documented that the participants' daily intake fell far below the Recommended Dietary Allowances for energy and protein.

Even in urban or tertiary-care hospital settings, patients were reported to consume less than 1500 kcal/day and less than 45 g of protein, both inadequate amounts for metabolic requirements during infection. To further complicate matters, micronutrient deficiencies were also prevalent, especially zinc, vitamin A, and iron (Ahmad *et al.*, 2019; Banyal *et al.*, 2023), yet such deficiencies rarely get screened for or addressed in routine care. A notable outlier was the study by Yu *et al.*, (2020), which not only confirmed the dual burden of under- and over nutrition but also explored the metabolic implications of vitamin D deficiency and elevated HbA1c levels, presenting a more nuanced clinical profile of TB patients .

Another pattern that emerged was the consistent impact of food insecurity and socioeconomic vulnerabilities. Studies by Sinha *et al.*, (2019), Jovita *et al.*, (2022), and Shukla *et al.*, (2019) identified poor sanitation, household poverty, limited access to diverse foods, and tobacco use as key contributors to malnutrition in TB patients. Several studies also noted that diet counselling was either absent or insufficient, and culturally appropriate dietary interventions were lacking. While a few interventional studies (e.g., Mahapatra *et al.*, 2024; Kumar *et al.*, 2022) demonstrated the efficacy of dietary counselling and food supplementation, these were limited in scale and not integrated into mainstream TB protocols .

Despite the collective strength of the findings, there are notable gaps in existing literature. First, most studies were cross-sectional, precluding causal inferences between nutritional status and TB outcomes. Second, biochemical assessments of micronutrients were inconsistently conducted, and often limited to a narrow range of nutrients. Third, only a few studies employed validated tools for dietary intake measurement, leading to variability in reported intakes. Additionally, certain high-risk subgroups including pediatric patients, pregnant women, tribal communities, and drug-resistant TB cases remain underrepresented. Lastly, there is minimal exploration of behavioral, psychosocial, and gender-specific barriers affecting nutritional access during TB care.

This systematic review also has some limitations. Only studies published in English and accessible through selected databases were included, which may introduce publication bias. While efforts were made to ensure only original research was used, variability in study quality and design (especially in smaller observational studies) may have influenced the strength of findings. Also, due to heterogeneity in reporting formats, it was not feasible to perform a meta-analysis or standardized statistical synthesis, limiting quantitative comparisons.

Nevertheless, the novelty of this review lies in its India-specific focus on nutritional issues among TB patients, synthesizing evidence from both clinical and community settings, while incorporating not only anthropometric but also dietary, biochemical, and socioeconomic dimensions. This review does not merely document prevalence but also connects nutritional status with treatment outcomes, food security, and programmatic gaps. Importantly, it brings attention to emerging trends such as dual burden malnutrition, the role of micronutrients in TB prognosis, and the need for regionally tailored interventions. Such comprehensive insights are essential for strengthening the nutritional component of India's National Tuberculosis Elimination Program (NTEP) and guiding future research and policy formulation.

## Conclusion

In conclusion, this systematic review highlights the persistent and varied nature of malnutrition, dietary inadequacy, and food insecurity impacting TB populations throughout different regions of India. Low BMI, calorie, and protein shortages, as well as widespread micronutrient deficiencies, particularly in zinc, iron, vitamin D, and retinol, were recurrent findings across investigations. Socioeconomic obstacles, stigma associated with treatment, lack of access to dietary counseling, and inadequate incorporation of nutritional assistance within TB care services all contributed to these nutritional issues. Although some synecdochic studies demonstrated how interventions like food supplements and dietary counseling can improve BMI and quality of life, this evidence is limited and mostly restricted to cross-sectional studies that lack longitudinal follow-up, region-adaptable protocols, and the use of standardized tools. It is difficult to generalize and operationalize the existing results because of this, as well as variations in evaluation technique and a lack of focus on susceptible populations like drug-resistant TB or TB-HIV co-infection within studies. Therefore, it is appropriate to advocate for multicentric, long-term studies that are in line onal Tuberculosis Elimination Program (NTEP) and include appropriate dietary evaluation, micronutrient profiling, and focused intervention. To improve treatment results, reduce relapses, and end the combined burden of TB and malnutrition in India, it would be crucial to

strengthen nutrition integration in TB care via the creation of standardized assessment frameworks, policy-level commitment, and multi-sectoral interface interoperability.

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