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**Original Research Article**

# Association of body mass index with drug resistance and disease pattern among tuberculosis patients in a rural area of Western Uttar Pradesh: a cross-sectional study

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## ABSTRACT

**Background:** Undernutrition is a key determinant of tuberculosis (TB), influencing susceptibility, disease progression, and treatment outcomes. Its relationship with drug resistance and disease pattern remains an area of growing interest, particularly in rural settings. This study aimed to assess the nutritional status of TB patients using body mass index (BMI) and examine its association with drug resistance and site of disease.
**Methods:** A cross-sectional study with secondary data analysis was conducted at the DOTS Centre from 2021 to 2025. A total of 812 diagnosed TB patients were included. Data were analysed using SPSS, and associations were tested using the Chi-square test.
**Results:** The mean BMI was 17.26±3.21 kg/m², with 73.2% of patients being underweight. Drug resistance was significantly higher among underweight patients (16.2%) compared to those with normal/overweight BMI (8.3%) ($\chi^2$=11.152, p=0.001). Similarly, undernutrition was more prevalent among pulmonary TB patients (73.9%) than extrapulmonary TB patients (66.7%), with a statistically significant association ($\chi^2$=4.23, p=0.04).
**Conclusions:** Undernutrition is highly prevalent among TB patients and is significantly associated with both drug resistance and pulmonary disease. Addressing nutritional deficits should be an integral component of TB control strategies.

**Keywords:** Drug resistance, Nutrition, Tuberculosis

## INTRODUCTION

Tuberculosis (TB) continues to be one of the most significant infectious disease threats globally and remains a leading cause of mortality due to a single infectious agent, particularly in high-burden countries such as India.[1] Nutritional status plays a critical role in the epidemiology and progression of TB, with undernutrition impairing cell-mediated immunity and increasing susceptibility to infection and disease activation.[2] Body mass index (BMI), a widely used indicator of nutritional status, has been shown to have a strong inverse relationship with TB incidence, with lower BMI associated with higher risk of developing active disease.[3] This relationship has been further supported by recent systematic reviews and meta-analyses demonstrating a dose–response association between BMI and TB risk.[4]

The emergence of drug-resistant TB, including multidrug-resistant (MDR) TB, has further complicated disease control efforts in India, highlighting poor treatment outcomes among affected patients.[5] Several studies have identified multiple risk factors for drug-resistant TB, among which nutritional status has emerged as an important determinant.[6] Regional evidence from India further supports the role of host and programmatic factors

in influencing the epidemiology and outcomes of drug-resistant TB.[7]

Recent research has increasingly focused on the association between BMI and drug resistance patterns. A study from China demonstrated a significant relationship between BMI and newly diagnosed drug-resistant pulmonary TB, while findings from Peru suggested that overweight and obesity may also be associated with multidrug-resistant TB, indicating a complex relationship between nutritional status and resistance patterns.[8,9] In many low- and middle-income countries, undernutrition remains highly prevalent among TB patients and continues to be a major public health concern.[10]

Apart from drug resistance, the anatomical site of disease pulmonary versus extrapulmonary TB may also be influenced by the host's nutritional and immunological status. However, evidence examining the combined relationship between BMI, drug resistance, and site of disease remains limited, particularly in rural and programmatic settings.

The present study aimed to assess the nutritional status of TB patients using BMI, to determine the association between BMI and drug resistance and to evaluate the association between BMI and site of tuberculosis.

## METHODS

A cross-sectional study with secondary data analysis was conducted at the Directly Observed Treatment, Short-course (DOTS) Centre of the Community Health Centre (CHC) which caters primarily to a rural population under the National Tuberculosis Elimination Programme (NTEP). The study included data recorded over a five-year period from January 2021 to December 2025. All presumptive tuberculosis cases registered at the centre during this period were reviewed, and a total of 5757 presumptive TB cases were identified from routine program records. Among these, 812 patients who were diagnosed with tuberculosis were included in the final analysis.

Data were extracted from the registers maintained at the DOTS centre, which contained information on socio-demographic characteristics such as age, sex, religion, and family size, along with anthropometric measurements including height and weight, clinical details such as type and site of tuberculosis, diagnostic status (bacteriologically confirmed or clinically diagnosed), and drug resistance status. Body Mass Index (BMI) was calculated using recorded height and weight (kg/m²) and was used as an indicator of nutritional status. Patients were categorized as underweight (BMI <18.5 kg/m²) and normal/overweight (BMI ≥18.5 kg/m²).

The collected data were entered into Microsoft Excel and subsequently analysed using Statistical Package for the Social Sciences (SPSS-20). Descriptive statistics such as frequencies and percentages were calculated. Appropriate inferential statistics applied. A p value of less than 0.05 was considered statistically significant.

## RESULTS

A total of 812 tuberculosis patients were included in the study. The majority of participants belonged to the 20-39 years age group (35.2%), followed by 40-59 years (31.3%), indicating that TB predominantly affected the economically productive age group. Males constituted 64.7% of the study population. Most patients were Hindus (69.2%), and nearly half (46.3%) belonged to families with 5-7 members. In terms of diagnosis, 58% of cases were bacteriologically confirmed, while the remaining 42% were clinically diagnosed (Table 1).

**Table 1: Sociodemographic factors.**

| Variable | Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| **Age group (years)** | <20 | 98 | 12.1 |
| | 20-39 | 286 | 35.2 |
| | 40-59 | 254 | 31.3 |
| | ≥60 | 174 | 21.4 |
| **Sex** | Male | 525 | 64.7 |
| | Female | 287 | 35.3 |
| **Religion** | Hindu | 562 | 69.2 |
| | Muslim | 238 | 29.3 |
| | Others | 12 | 1.5 |
| **Family size** | ≤4 members | 214 | 26.4 |
| | 5-7 members | 376 | 46.3 |
| | ≥8 members | 222 | 27.3 |
| **Type of diagnosis** | Bacteriologically confirmed | 471 | 58.0 |
| | Clinically diagnosed | 341 | 42.0 |
| **BMI category (kg/m²)** | Underweight (<18.5) | 594 | 73.2 |
| | Normal (18.5-24.9) | 188 | 23.2 |
| | Overweight (≥25) | 30 | 3.6 |

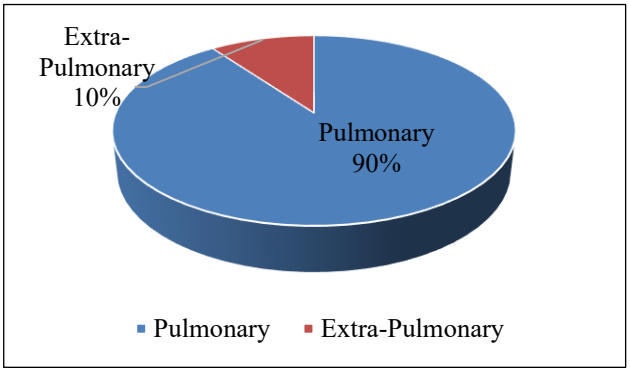


**Figure 1: Site of disease.**

Total 90% of diagnosed patient is having pulmonary tuberculosis (Figure 1).

Further analysis demonstrated a significant relationship between BMI and drug resistance. The proportion of drug resistance was notably higher among underweight patients (16.2%) compared to those with normal or higher BMI (8.3%). This difference was found to be statistically significant ($\chi^2$=11.152, p=0.001) (Table 2).

**Table 2: Association of BMI with drug resistance.**

| BMI category | Drug resistant, N (%) | Non-resistant, N (%) | Total | Test of significance |
|---|---|---|---|---|
| **Underweight (n=594)** | 96 (16.2) | 498 (83.8) | 594 | $\chi^2$=11.152, p=0.001 |
| **Normal/overweight (n=218)** | 18 (8.3) | 200 (91.7) | 218 | |
| **Total** | 114 (14.0) | 698 (86.0) | 812 | |

Assessment of nutritional status revealed that 73.2% of patients were underweight, with only a small proportion having normal (23.2%) or overweight BMI (3.6%). When BMI was analysed in relation to the site of disease, undernutrition was found to be more common among pulmonary TB patients (73.9%) compared to extrapulmonary TB patients (66.7%). This association was statistically significant ($\chi^2$=4.23, p=0.04) (Table 3).

**Table 3: Association of BMI with site of tuberculosis.**

| Site of TB | Underweight, N (%) | Normal/overweight, N (%) | Total | Test of significance |
|---|---|---|---|---|
| **Pulmonary TB (n=731)** | 540 (73.9) | 191 (26.1) | 731 | $\chi^2$=4.23, p=0.04 |
| **Extrapulmonary TB (n=81)** | 54 (66.7) | 27 (33.3) | 81 | |
| **Total** | 594 (73.2) | 218 (26.8) | 812 | |

## DISCUSSION

The present study highlights three key findings that deepen our understanding of the relationship between nutritional status and tuberculosis (TB) outcomes in a rural Indian setting. First, there was an alarmingly high prevalence of undernutrition, with 73.2% of patients classified as underweight and a mean BMI of 17.26±3.21 kg/m². Second, a significant association was observed between low BMI and drug resistance, with underweight patients showing nearly twice the prevalence of drug resistance compared to those with normal or higher BMI (16.2% vs 8.3%, p=0.001). Third, undernutrition was found to be significantly more common among patients with pulmonary TB than those with extrapulmonary disease (73.9% vs 66.7%, p=0.04). Together, these findings emphasize the critical need to incorporate nutritional assessment and support into TB control strategies, especially in resource-limited rural settings.

The high proportion of underweight individuals in our study is consistent with the well-recognized bidirectional relationship between malnutrition and TB. Similar findings have been reported in other low-resource settings, including a study that documented a comparable burden of undernutrition among TB patients.[10] This high prevalence likely reflects the socioeconomic realities of rural western Uttar Pradesh, where food insecurity, poverty, and limited access to healthcare intersect, increasing vulnerability to both malnutrition and TB. The biological basis of this association is well established; study demonstrated that malnutrition compromises cell-mediated immunity, which plays a central role in defense against *Mycobacterium tuberculosis*.[2-4] In addition, studies have consistently shown a dose–response relationship, with lower BMI associated with higher TB incidence across populations. The fact that a majority of our participants belonged to the economically productive age group (20-59 years) further underscores the broader societal and economic implications of this dual burden.

One of the most clinically significant findings of our study is the strong association between undernutrition and drug resistance. The nearly two-fold higher prevalence of resistance among underweight patients aligns with findings from previous research. A study conducted in India identified low BMI as a significant predictor of drug-resistant TB, reporting a markedly increased risk and highlighting the importance of nutritional interventions in TB control.[6] Similarly, a study from China found that underweight individuals were more likely to exhibit certain resistance patterns, while also noting associations between higher BMI and other forms of resistance, suggesting that the relationship between nutritional status and drug resistance is complex.[8] Several mechanisms may explain this association. Impaired immunity in undernourished individuals may allow higher bacillary loads, increasing the likelihood of resistant mutations. Additionally, altered pharmacokinetics in malnourished patients may result in suboptimal drug levels, and a higher incidence of adverse drug reactions may contribute to treatment interruptions an established risk factor for the development of drug resistance. Although the cross-sectional nature of our study limits causal inference, the consistency of our findings with existing literature strengthens the likelihood of a meaningful and clinically relevant association.

With regard to the site of disease, our finding that undernutrition was more prevalent among pulmonary TB patients compared to those with extrapulmonary TB is in line with observations from another study.[12] This difference may be explained by the more pronounced systemic manifestations of pulmonary TB, such as chronic cough, prolonged fever, and increased metabolic demands, all of which can contribute to reduced appetite and weight loss. Moreover, pulmonary TB is often associated with higher bacillary loads and greater tissue destruction, including cavitation, which may lead to more severe systemic inflammation and catabolism compared to most forms of extrapulmonary disease.

Despite its important findings, this study has certain limitations. The cross-sectional design restricts our ability to establish causal relationships, and the use of secondary data may introduce the possibility of measurement errors. We were also unable to account for key confounding factors such as HIV status, diabetes, and detailed socioeconomic variables. Furthermore, while BMI is a simple and practical measure, it does not fully capture body composition or micronutrient deficiencies. Nevertheless, the study has notable strengths, including a relatively large sample size and its focus on a rural population that is often underrepresented in research.

## CONCLUSION

In conclusion, this study demonstrates a high burden of undernutrition among tuberculosis patients in a rural Indian setting and highlights its significant association with drug resistance and the site of disease. Undernourished patients were found to have a substantially higher likelihood of drug-resistant TB and were more commonly affected by pulmonary disease. These findings reinforce the critical role of nutritional status as both a determinant and consequence of TB.

The results underscore the need for integrating routine nutritional assessment, particularly using BMI, into standard TB care. Nutritional support should be prioritized as an essential component of TB management, especially for undernourished patients who represent a high-risk group for poor outcomes and drug resistance. In this context, the Nikshay Mitra initiative under the National Tuberculosis Elimination Programme provides a valuable opportunity to address nutritional deficiencies through community participation. By offering sustained nutritional and social support, this initiative can play a crucial role in improving treatment adherence and overall patient outcomes, particularly in resource-limited rural settings.

Strengthening and effectively implementing such patient-centric support systems, alongside clinical management, could significantly enhance treatment success and contribute to TB elimination efforts. Further longitudinal studies are recommended to better understand causal pathways and to evaluate the impact of integrated nutritional interventions, including programs like Nikshay Mitra, on treatment outcomes and drug resistance in TB patients.

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