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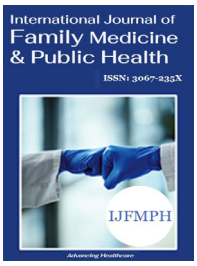

An Epidemiology, Trends, Status, and Recent Nutritional Initiatives for Tuberculosis Patients: A Comprehensive Type of Scoping Review

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ABSTRACT

Background: Tuberculosis is a chronic infectious disease caused by Mycobacterium tuberculosis. Risk factors such as undernutrition, diabetes, and lowered immunity allow tuberculosis bacteria to multiply rapidly, destroying the tissues of the lungs and other organs. Nutrition is a basic human need and a prerequisite to a healthy life. It will cause a complex variety of metabolic and nutritional changes in the body and is associated with an increase in energy expenditure and changes in macronutrient metabolism. Inadequate intake of macronutrients, micronutrients, or both leads to weight loss, wasting, and worsening of the nutritional status of patients. Thus, Tuberculosis makes undernutrition worse, and undernutrition weakens the immunity. Hence, TB has a vast and severe effect on the nutritional status of the body.

Objective:

- To review the epidemiological factors, trends, status, nutritional advances techniques among the TB patients.
- To address research gaps in nutrition, awareness, and the need for various interventions among the TB patients.

Methods: A comprehensive type of scoping review was conducted with the help of different databases. It included PubMed, Scopus, Google Scholar, Researcher Gate, Scilit, Index Copernicus, Index Medicus, Scope Med, CrossRef, and BMC for articles published and also cited for different official public health reports and books up to 2023. Studies were included based on relevance to nutrition status, epidemiological factors, trends, and recent advanced techniques among tuberculosis patients.

Results and Conclusion: The TB burden is more common in developing countries. Socioeconomic factors have a high rate of impact on TB in a low-income country. As per WHO, a low BMI [Body Mass Index] <18.5Kg/m2 is the best weight-related morbidity predictor. Malnutrition is an important risk factor for the progression of underlying active TB disease. Lifestyle characteristics were shown that significantly associated with the development and progression of disease. These include the use of alcohol and tobacco. Very often, malnutrition is neither recognized nor addressed in patients with TB. It will worsen, delay recovery, and increase the frequency and length of health care center visits. Malnutrition impacts an individual's health, well-being, and ability to work or perform daily activities. The important clinical signs and symptoms of TB-associated malnutrition were anemia, wasting, loss of lean and fat mass, etc.

Introduction

Tuberculosis disease is as old as mankind. Its reference dates to 500 BC in Hindu texts, where Tuberculosis is referred to as "Rogaraj", the king of disease, and "Rajayaakhsma, the disease which affects even kings and ordinary people. It is called "Kshaya" [wasting] since a wasting process is found to accompany all the functional activities of the body during its attack [1]. Disease caused by infection with Mycobacterium tuberculosis and affects any tissue or organ of the body, predominantly affecting the lungs. Mycobacteria a pathogenic and non-motile bacteria and are identified using the Ziehl-Nielsen Staining method or acid-fast bacillus stain of sputum samples.

Tuberculosis can be divided into two categories: pulmonary tuberculosis and extrapulmonary tuberculosis. Pulmonary Tuberculosis is the involvement of the lungs. Extrapulmonary tuberculosis affects the pleura, the intestine, the spine, the lymph node, the meninges, the genitourinary system, etc.

Pulmonary tuberculosis spreads through droplet infection. When inhaled, the TB bacteria enter the lungs and grow over several weeks. A few of the bacteria live in an inactive form and are in a latent stage. When there are certain risk factors like undernutrition, diabetes, and lowered immunity, tuberculosis bacteria multiply rapidly and destroy the tissues of the lungs or other organs, developing the tuberculosis disease [2].

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Tuberculosis is a major and one of the top ten causes of illness, the leading cause of death from a curable infectious disease, and disability worldwide. There are nearly 11 million cases, 1.3 million deaths, and 30 high-burden countries, i.e., with incidence rates of 150-400 per 100,000 in 2021.

Geographically, WHO regions, like South East Asia [44%], Africa [25%], and the Western Pacific [18%], with lesser cases in the Eastern Mediterranean [8.2%], the Americas [2.9%], and Europe [2.5%], showed a high burden. 8 countries accounted for 2/3rd of the global total: India [28%], Indonesia [9.2%], China [7.4%], the Philippines [7.0%], Pakistan [5.8%], Nigeria [4.4%], Bangladesh [3.6%], and Congo [2.9%].

Internationally, in 2021, around 82% of deaths due to tuberculosis but no HIV, and 85% of total deaths in HIV with and without people were noted in the WHO African and Southeast Asia regions. India contributed 32% of the total TB deaths in HIV positive and negative people and 36% of the global TB deaths in HIV negative people [3].

Undernutrition and Tuberculosis are major public health concerns in India, which require active interventions. WHO declared the END TB Strategy to end the TB epidemic by 2030, and the Government of India [GOI] aims to end TB by 2025, 5 years ahead of the world target [4].

Burden in India 2019, 2020, 2021, New cases reported 21 lakhs [12%] 16 lakhs [31%] 19 lakhs [19%] Incidence rates 159/1 lakh, 94/1 lakh, 153/1 lakh, Deaths 79,144, 89,823, 76,002 According to National Tuberculosis prevalence survey [2019-2021], the prevalence of TB in India was 312 per 100,000 population. The highest prevalence was observed in Delhi, which was 747 per 100,000 population, and the lowest was in Gujarat, 137 per 100,000 population. Andhra Pradesh has a prevalence of 274 per 100,000 population. Thus, tuberculosis remains a health priority in India [4-7].

Nutrition is one of the basic needs for humans to lead a healthy life. A well-balanced with nutrient-dense diet is essential for physical growth and development, maintenance of normal body function, physical activity, and health. Recommended Dietary Allowances [RDA] are nutrient-centered and tools. Since people consume food, advocating nutrition in terms of foods rather than nutrients is important; hence food-based approach should be emphasized for obtaining optimum nutritional status. Dietary guidelines are a scientific translation of RDAs of nutrients to specific dietary advice in terms of the diet to be consumed by the population.

A balanced diet should be consumed. It was varied through a wise choice as well as from a variety of food groups. Consumption of a wide variety of food groups is a universally accepted guideline for a healthy, balanced diet. A balanced diet provides all the nutrients in required amounts and proper proportions. Major food groups that constitute a healthy, balanced diet include:

1. Carbohydrates - Cereals and millets
2. Vegetables & Green leafy vegetables
3. Fruits
4. Protein – Pulses, Legumes, Meat, Fish, Poultry, Egg
5. Milk and Milk Products
6. Fats & Oils [8]

Diet diversity is a fundamental component of a high-quality diet. Dietary diversity is representative of the nutrient adequacy of the diet of individuals; it represents household access to a variety of foods and is a qualitative measure of food consumption. Dietary practices such as nutrient intake, diversified diets, and the number of meals per day influence the nutritional status. Diet diversity score can be assessed by counting food groups consumed by an individual and household in the preceding 24 hours. Household dietary score reflects the economic ability of the family to access a variety of foods and household food security. The individual dietary diversity score reflects the nutrient adequacy of the individual [9].

Infectious illness like tuberculosis causes a complex variety of metabolic and nutritional changes in the body and are associated with an increase in energy expenditure and changes in macronutrient metabolism, and can also result from inadequate intake of macro or micronutrients and both. Tuberculosis decreases dietary intake by lowering appetite due to symptoms like nausea, vomiting, and pain. TB drugs tend to induce negative nutrient-drug interactions, further depressing the intake, leading to weight loss, wasting, and worsening of the nutritional status of patients. Thus, makes undernutrition worse, and undernutrition weakens the immunity. It is one of the major risk factors for developing TB and the conversion of latent infection to active disease. Low Body mass Index [<18.5 kg/m^2] and inadequate weight gain are serious comorbidities in patients with active TB, which increases the risk of severe disease, relapse, drug toxicity, and

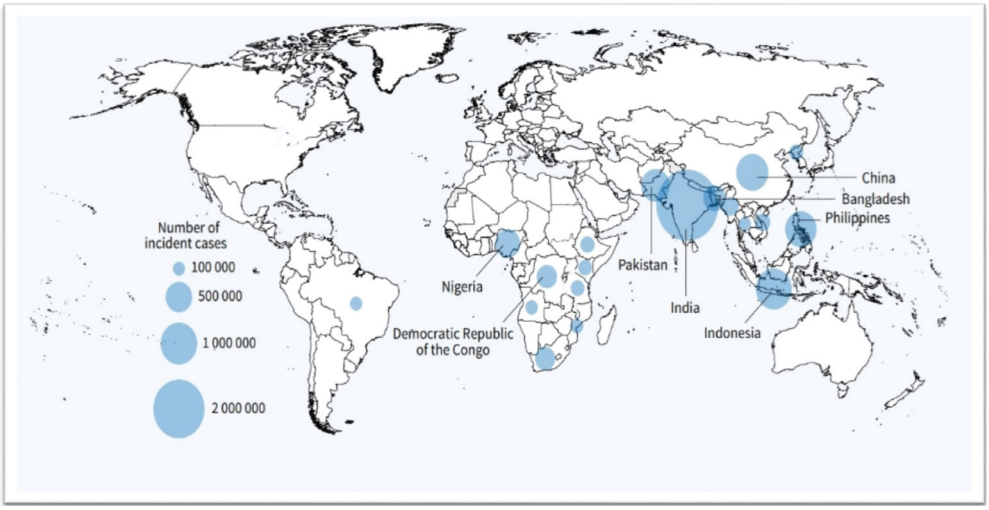

Figure 1: High burden countries in the world [Source: Global Tuberculosis Report 2022] [3].

Table 1: Burden of Tuberculosis in India during 2019 – 2021 [4-7].

Burden in India	2019	2020	2021
New cases reported	21 lakhs [12%] ↑	16 lakhs [31%] ↓	19 lakhs [19%] ↑
Incidence rates	159/ 1 lakh	94/ 1 lakh	153/ 1 lakh
Deaths	79,144	89,823	76,002

Figure 2: Logo of NTEP [11].

even death. At the time of diagnosis of active tuberculosis is a predictor of the risk of death, relapse, and outcome. Presence of high evidence that undernutrition in patients with active TB is associated with 2-4 times increase in mortality, with a five-fold risk of drug-induced hepatotoxicity [10].

Estimated that 55% of tuberculosis patients are undernourished in India, which is much higher than other risks such as HIV, diabetes, alcohol, smoking, etc. Data on weights of tuberculosis patients are found in a case-based surveillance platform, NIKSHAY, which suggests a high prevalence of underweight [28-30% below their respective reference weights] [10].

Tuberculosis has been described as a "social disease with medical implications" that occurs disproportionately among the disadvantaged groups with poverty, undernourishment, and overcrowding. Dietary practices are greatly influenced by culture, accessibility, and affordability of food, awareness regarding nutrient-rich foods, illness, and stress. Because of certain financial concerns, meals often get skipped. Additionally, store-bought food could not offer an adequately nutrient-dense diet. The biggest obstacle to vulnerable populations accessing diversified meals is a lack of money to buy food, not the absence of fresh goods in the market. It has been shown that changing from a monotonous diet to one with a variety of food options may increase individuals' intake of macronutrients and micronutrients [11].

"TB HAREEGA DESH JEETEGA" was the slogan of a campaign initiated by the GOI. Sustainable Development Goals 1, 2, and 3 aim to end poverty, hunger, achieve food security, decrease the prevalence of undernutrition, and regain the health and well-being of the population. To tackle Undernutrition in TB, under NHM and NTEP, the GOI has 9 started a financial support scheme, Nikshay Poshan Yojana, in March 2018, giving 500 rupees per month to each notified case of TB through Direct Benefit Transfer [DBT], crediting directly to their bank accounts for the duration of anti-TB treatment.

In addition, under the National Tuberculosis Elimination Programme [NTEP], along with tuberculosis treatment, nutritional assessment and counselling are included as integral components. The Central TB Division of India issued guidelines for nutritional assessment and nutritional counselling for better implementation of this component [10].

Despite these measures and effective treatment, patients are unable to regain normal weight due to reasons such as food insecurity, lack of awareness about healthy dietary practices, dietary diversity, and consumption of locally available nutrient-rich foods. There are still myths and misconceptions about costly foods and tonics, commercial food supplements, which increase the unnecessary expenditure of the patients. Implementation of nutritional counselling and education about balanced nutrition for optimal weight gain is still lacking and requires emphasis at the initial stages of treatment.

Very often, malnutrition is neither recognized nor addressed in patients with TB. This worsens the disease, delays recovery, and increases the frequency and length of hospital visits. Malnutrition impacts an individual's health, well-being, and ability to work or perform daily activities. Some important signs and symptoms of TB [e.g., anemia, wasting, loss of lean and fat mass, etc.] are also signs of malnutrition [10].

Healthy eating has a strong link to good health outcomes, like a speedy recovery from illnesses and a lower mortality rate. Low dietary diversity is a significant health indicator that is unrelated to socioeconomic level and has been related to specific nutrient deficits. Consuming a diversified diet lowers the risk of getting an excess or shortage of any one nutrient, which suggests the dietary nutrient quality [12].

Despite good scientific progress and its availability, it was still a great challenge in global health concerns. As per a WHO news there were new, active tuberculosis peoples 11 million each year, and in 2021, 1.3 million people died from the disease. Among the patients with tuberculosis, 98% live in low- and middle-income countries. This is a devastating public health issue in those countries [3,10]. Malnutrition is a determinant for the progression of underlying TB infection to active disease. Lifestyle factors are strongly associated with the development of TB infection and progression to TB disease. These include the use of alcohol and tobacco [12].

The tuberculosis burden is most significant in developing countries. Socioeconomic factors like overcrowding, poverty, malnutrition, unemployment, Food insecurity, and inadequate health facilities. They had an impact on the TB disease rate in a country, increasing in incidence and also treatment failure. To improve the health and quality of life of TB cases, proper nutrition plays a vital role. Nutritional status and immune function are closely related.

Tuberculosis and Undernutrition are interlinked bidirectionally and are part of a vicious cycle [10]. In India, nearly 20% of the population is undernourished according to the NFHS-5 survey [2019-2020] [13].

Review of Literature:

Tuberculosis [TB] is a very old disease - human skeleton studies reported that it has affected humans for thousands of years. On 24th March 1882, Dr. Robert Koch announced the bacillus Mycobacterium tuberculosis, identified, separated, and cultivated the bacillus in animal serum using the methylene blue staining process recommended by Paul Ehrlich. Finally, he inoculated the bacillus into laboratory animals and reproduced the disease.

Tuberculosis is a chronic disease that is infectious and is caused by several species of Mycobacterium collectively known as Tubercle bacilli. This pathogen is the world's most successful which having survived for over 70,000 years. In the following decades after this discovery, the Pirquet and Mantoux tuberculin tests for skin, Albert Calmette and Camille Guerin's [BCG] vaccine, Selman Waksal's streptomycin, and many other antituberculosis drugs were developed. Koch also contributed to 10 elucidations of the infectious etiology of TB. For his scientific results, a Nobel Prize in Medicine was awarded to him in 1905 [14].

As per WHO, a low Body Mass Index <18.5Kg/m^2 is the best weight-related morbidity predictor. Patients with active TB have a higher likelihood of being emaciated and have a lower BMI, with [<18.5Kg/m^2 a value being considered an undernutrition index [15].

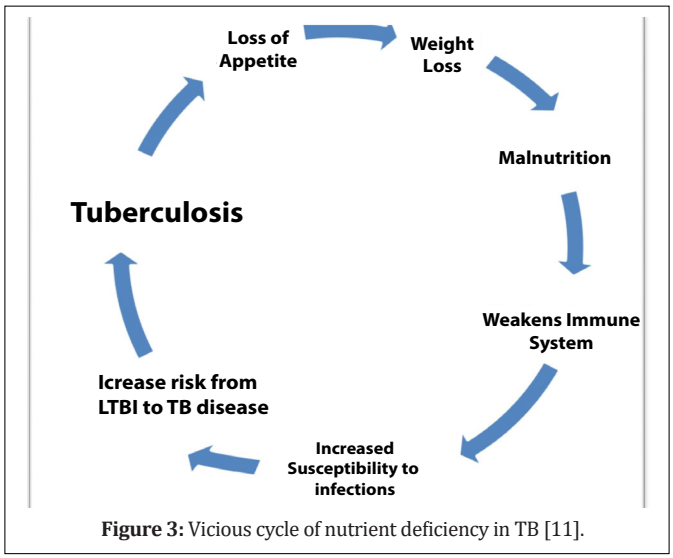

Figure 3: Vicious cycle of nutrient deficiency in TB [11].

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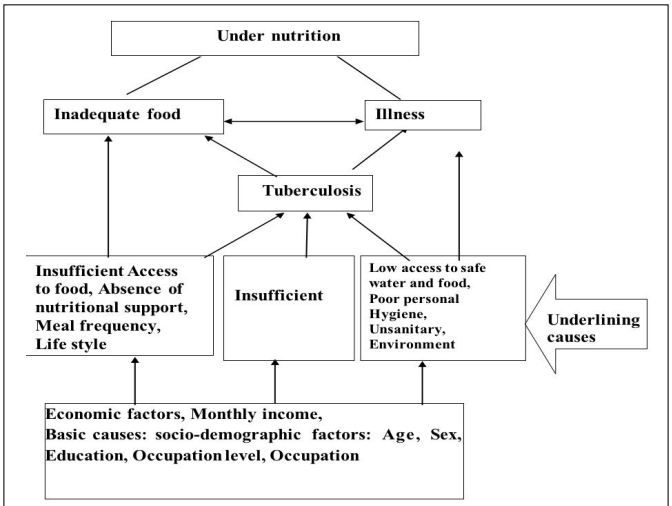

Figure 4: Conceptual framework of Tuberculosis and related risk factors [UNICEF, 2003 [12].

TB disease is related to micronutrient deficiencies and wasting. However, the information on the effects of nutritional status on an increase in TB risk and disease manifestation is still less than the effective level. TB and malnutrition are interconnected in a bidirectional and complex relationship, which worsens these conditions. TB also predisposes and worsens malnutrition [16].

Das, et al, in their cross-sectional study conducted in 2017 titled "A study of nutritional assessment of newly diagnosed tuberculosis patients in a tertiary care hospital of Tripura, India," of sample size 400, state that the majority were males [58%], 66% of the study population were undernourished, with higher rates in males [16]. Involuntary weight loss of 1.5kg or more per month. Wasting is one of the first signs that is seen in Tuberculosis patients and is most likely caused by an increased energy expenditure and reduction in appetite as part of the inflammation and body defense mechanism. If higher the involuntary weight loss, the increase the risk of malnutrition [17,18].

Moreover, important factors that affect food intake, such as appetite, food availability, medication side effects, eating patterns, traditional food taboos, lifestyles [alcohol, smoking, physical activity, caffeine intake, use of social drugs], psychological factors [depression and stress], stigma, and economic factors are also other very important factors to consider. Previous studies underlined the increasing prevalence of undernutrition in patients with tuberculosis; however, this prevalence varies widely among continents, countries, and regions, with an estimated prevalence ranging from 50% to 87%. Combating hunger, undernutrition, and tuberculosis is among the 8 United Nations Sustainable Development Goals [UN-SDGs] by 2030. Therefore, an understanding of nutritional status and its correlations could provide evidence to support the development of strategies for tuberculosis management.

For appropriate intervention regarding undernutrition in tuberculosis patients, it is important to have updated information on the magnitude of the problem as well as associated factors. Although previous studies have shown the association between tuberculosis and nutrition, additional studies can help in generating scientific information on the extent of undernutrition in tuberculosis patients in different geographic settings. Not much information is available on the extent of malnutrition and its associated factors in tuberculosis patients.

A study done by **Shukla A et al** during 2017-2018 in Lucknow titled "Nutritional status of pulmonary tuberculosis patients: A hospital-based cross-sectional study" with a sample size of 200 reports the following: Majority were males [64%], 38% were illiterate, 46% were unemployed, and 67% were living in crowded houses. 79.5% of the respondents were undernourished, and 49% had severe undernutrition. Most of them were consuming 1-2 meals per day [75%], and only 43% received diet counselling at the facility. The study reveals a high proportion of undernutrition among the tuberculosis patients [19].

Hedaoo S et al in their cross-sectional study conducted in 2018 titled "Assessment of Nutritional and Socio-Demographic Status of Tuberculosis Patients of an Urban Slum of Tuberculosis Unit in Mumbai," with a sample size of 200, observed that participants belonging to the age group16-25 years of age were higher [35.5%]. Males and females were equal in number. Illiterates were 22.5%, majority were unemployed [18%]. The study subjects with undernutrition were 79%, with the majority of them having severe undernutrition [35%]. In this study, undernutrition was more common in illiterates [46.7%], low-income groups, and retreatment cases. The study concluded that sociodemographic factors like unemployment, younger age groups contribute to undernutrition [20].

A study done by **Jagdish R et al** during 2018 in Delhi titled "Assessment of Nutritional Status of Sputum Positive Pulmonary Tuberculosis Patients in a Medical College", a cross-sectional study with a sample size 200 reports: majority belong to age group of 41 to 60 years [35.5%] male preponderance was present [66%], 86.5% were illiterate, 85.5% were unemployed. 70.5% were residing in rural areas, 37.5%were smokers, 18. 35% were alcoholics. 61.5% of the study subjects were undernourished. The study reveals a high proportion of undernutrition among the tuberculosis patients residing in rural areas, illiterates, with low family income, smokers, and alcoholics [21].

According to a study done by **Ayiraveetil R et al** in 2018 titled "Household food insecurity among patients with pulmonary tuberculosis and its associated factors in South India: a cross-sectional analysis", a cross-sectional study with sample size 765: most of the study population were in 45-59 years age group [38.2%], majority were males [79.9%], 53.4% were residing in rural area. Undernutrition was observed in 61.4% of the study population. 34.6% of the study population had fewer meals in a day and were eating a limited variety of foods [household food insecurity]. 37.7% of the participants who had household food insecurity had undernutrition [22,23].

Sadana P et al, in their study conducted in 2019 with the title "A study of factors affecting weight gain among tuberculosis patients under DOTS in district Amritsar," with a sample size of 228, observed that the majority of the study population is <45 years of age [76.75%] and predominantly males [57.89%]. 30.7% of the participants did not gain weight during the treatment. The study suggested that there is a significant association between weight gain and treatment outcome [23].

In secondary analysis conducted by **Hoyt K et al** in 2015 titled "Effect of malnutrition on radiographic findings and mycobacterial burden in pulmonary tuberculosis," with a sample size of 173, identified that the Majority were males [76%], 46% were smokers, 47% were alcoholics, and 30.6% had diabetes mellitus. 57% of the study subjects had undernutrition, and 24% had severe undernutrition [24].

Nagpal M et al conducted a study in 2014 with the title "A study on nutritional status and change in body mass index with treatment outcome in smear-positive pulmonary TB patients on DOTS in Amritsar city," with a sample size of 250. They stated that most of the cases are in the 15-59-year age group; males were of majority [59.6%]. 69.2% of the study population were undernourished, and 34% were severely undernourished. The study stated that severe malnutrition is associated with the severity of diseases in tuberculosis patients [25].

In a study done by **Bhargava A et al** in 2013 in Chhattisgarh titled "Nutritional Status of Adult Patients with Pulmonary Tuberculosis in Rural Central India and Its Association with Mortality," with a sample size of 1695, reports: Majority were males [68%], Most of them [94%] were residing in rural areas. 87.2% of the population were undernourished, with 50% having severe undernourishment [26].

Tungdim M et al conducted a cross-sectional study in 2008 in Manipur titled "Tuberculosis treatment and nutritional status among the tribals of Northeast India" with sample of 247 males between the age 20-40 years stated the following was stated: Undernutrition was observed in 64.5% of the patients at the start of treatment and 34% after completion of treatment [27].

In a matched case- control study done by **Shetty N et al** in 2003 in Bangalore titled "An epidemiological evaluation of risk factors for tuberculosis in South India: a matched case control study" with sample size of 189 identified: most of the study subjects were >45 years [33.3%], male predominance [58%] was present, 49.7% were unemployed. There was a high proportion of undernutrition [72.9%] among the study subjects. The study suggested that higher education, higher income, and past smoking were significantly associated with not being a tuberculosis patient [28].

In a study done by **Damji K et al** in 2021 titled "Cross-sectional study of nutritional intake among patients undergoing tuberculosis treatment along the Myanmar–Thailand border" with sample size of 28 reported the following: Majority were males [71.4%], 89% of the population were undernourished at the time of diagnosis and 50% having undernourishment at the time of survey. In this study, the participants' diets were low in protein and caloric intake [29].

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Endalkachew K et al In their cross-sectional study done in Ethiopia in 2020 titled "Prevalence and associated factors of undernutrition among adult TB patients attending Amhara National Regional State hospitals, Northwest Ethiopia," stated that, most of them belonged to the 18–28-year age group, and 52.3% were males. Illiterates were 41.8%, 19.3% were unemployed, 24% were living in overcrowded houses, and 70.9% were living in urban areas. 42.2% of the population were undernourished, of which severe undernourishment was seen in 10.4% of the patients. 78.5% of the study patients were consuming three or fewer meals per day. 47.9% of the population had low dietary diversity. The study stated 21 that wealth status, alcohol consumption, employment, and occupation were associated with undernutrition [30].

In a facility-based cross-sectional study done by **Muse A et al** in 2020 titled "Undernutrition and Associated Factors Among Adult Tuberculosis Patients in Jigjiga Public Health Facilities, Somali Region, East, Ethiopia," with a sample size of 296, it was stated that the majority of population were males [51.7%] 61.1% live in urban areas. The proportion of the study population undernourished was 44.3% and 8.4% were severely undernourished. Among the participants majority [70.6%] had 3 meals per day, 73% received dietary counselling. Dietary diversity was observed in only 38.2% of the patients. The study found that gender, educational status, and functional status were significantly associated with undernutrition [31].

According to a systematic review and meta-analysis study conducted by **Wondmieneh et al** in 2020 titled "Prevalence of undernutrition among adult tuberculosis patients in Ethiopia: A systematic review and meta-analysis," in twelve observational studies with a sample of 4963 participants, identified that half of them were males [53.2%]. The study showed that the pooled prevalence of undernutrition was 50.8% with the highest undernutrition being 71.35%. The study concluded that the majority of patients with pulmonary tuberculosis develop undernutrition [32].

Musuenge B et al, in their cross-sectional study done in China in 2019 titled "Nutritional Status of Patients with Tuberculosis and Associated Factors in the Health Centre Region of Burkina Faso," observed that most of them were males [65.6%]. Illiterates were 33%, 25.8% were unemployed, and 83.8% were living in urban areas. 42.2% 22 of the population were undernourished, of which severe Undernourishment was seen in 35.8% of the patients, and 7.3% of the severe undernourished [33].

Magassouba A et al, in their longitudinal cohort study done from 2016 to 2018 titled "Malnutrition prevalence and associated biochemical factors among drug-resistance tuberculosis [DR-TB] patients at key treatment sites in Conakry City, Republic of Guinea," with a sample of 218 patients, identified the following: Male predominance [68.3%]. Undernutrition was high among the study subjects [64.7%], with females more affected than males. The study proved the negative effect of malnutrition on treatment success [34].

In a cross-sectional study done by **Kurnia A et al** in 2018 in Java titled "Factors Related to the Low Nutritional Status among Tuberculosis Patients," with a sample size of 47 reported the following: Majority were females [74.5%], 44.7% were unemployed, 73% of population were severely undernourished and 75% have moderate undernourishment. In this study, the unemployed had a higher proportion of undernutrition, and the proportion of severely undernourished individuals is quite high [35].

Hussien B et al, in their cross-sectional study done in Ethiopia in 2018 titled "A Cross-sectional Study on the Magnitude of undernutrition in Tuberculosis Patients in the Oromia Region of Ethiopia," with a sample size of 450 patients, stated that most participants [80.9%] belong to the age group 18-45 years of age. Illiterates were one-third of the population, 31.6% had large families, 51.6% of the population were undernourished, of which severe Undernourishment was seen in 8.9% of the patients. In the current study, undernutrition proportion was significantly high. Factors such as age 4 were associated with undernutrition [36].

According to a cross-sectional comparative study done by **Feleke B et al.** in 2018 in Ethiopia titled "Nutritional status of tuberculosis patients, a comparative cross-sectional study," with a sample size of 5045 [1681 TB patients and 3364 tuberculosis-free residents], 53.9% of study participants were females, and 26% were from urban areas. Undernutrition was 57.17% in the tuberculosis patients, when compared to 23.37% in tuberculosis-free residents. They concluded that the proportion of undernourished TB cases was high, and the nutritional status of TB patients was affected by sex, residence, and alcohol consumption [37].

Tesfaye Anbese A et al., in their cross-sectional study done in Ethiopia in 2017 titled "Factors of Undernutrition among Adult Tuberculosis Patients Receiving Treatment in Public Health Institutions in Shashemane Town, South Ethiopia," observed that most of them were males [54.3%]. Illiterates were 28%, 38.6% were farmers, and 51.1% were living in urban areas. 28.8% of the population were undernourished, of which severe Undernourishment was seen in 5.4% of the patients. 49.5% did not receive dietary counselling. In this study magnitude of undernutrition was high. Factors such as age > 40 years, living in rural areas, and lower income status were associated with undernutrition [38].

In an interventional study done by **Khalid S et al.** in 2017 in Pakistan titled "The Effect of Nutrition Education on Nutritional Status of Tuberculosis Patients," with a sample of 100 stated the following was stated: 67% of the study population were undernourished, with 31% having severe undernourishment. In this study, it was noted that the weight of the tuberculosis patients improved significantly after 3 months of nutritional education, and dietary intake and consumption of various food groups had an overall effect on nutritional status [39].

According to a cross-sectional study done by **Ren Z et al** in 2017 in China titled "Nutritional intakes and associated factors among tuberculosis patients: a cross-sectional study in China," with a sample of 300, the Majority of the study population [53.7%] belonged to the 18-49 years of age. Most of them were males [68.7%]. 53.7% had primary education or below, and 40.7% were unemployed. This study concluded that there is inadequate intake of macro and micronutrients in poor areas and unemployed, leading to undernutrition among TB patients, which affects the effectiveness of treatment [40].

In a cross-sectional descriptive study done by **Gurung L et al** in 2016 titled "Dietary practice and nutritional status of tuberculosis patients in Pokhara: A cross-sectional study" with sample size 133 patients revealed that 21.8% were underweight at time of study, frequency of food intake was <4 meals per day in 35.3% and one-fifth of patients did not consume sufficient calories. The study concluded that the nutritional status of patients improved comparatively from the time of registration to the present situation [41,42].

Wassie M et al, in their institutional-based, longitudinal study done in 2014 in Ethiopia titled "Weight Gain and Associated Factors among Adult Tuberculosis Patients on Treatment in Northwest Ethiopia: A Longitudinal Study," with a sample of 384, reported that: Many of the participants belong to the 15-24 years of age [32%]. The majority of them were males [53.9%], 37% were illiterates, 66.9% were living in urban areas, and 28.7% had having poor wealth index. 71.4% of the participants were having undernutrition. The majority of them were having three meals per day [75.3%]. This study observed that educational status, meal frequency of 4 or above per day, were important determinants of weight gain in tuberculosis patients [42].

Patra J et al conducted a meta-analysis study in 2014 titled "Tobacco Smoking, Alcohol Drinking, Diabetes, Low Body Mass Index and the Risk of Self-Reported Symptoms of Active Tuberculosis: Individual Participant Data [IPD] Meta-Analyses of 72,684 Individuals in 14 High Tuberculosis Burden Countries" which analyzed 14 national studies observed: Majority of the respondents belong to 18-54 years of age [81%], primary education or below was more in women [34%]. Undernutrition was higher among females [20%] than males [15%]. The study found that smoking, heavy alcohol use, and diabetes are individual risk factors for active tuberculosis disease [43].

Objective:

- To review the epidemiological factors, trends, status, nutritional advances techniques among the TB patients.
- To address research gaps in nutrition, awareness, and the need for various interventions among the TB patients.

Methods:

A comprehensive type of scoping review was conducted with the help of different databases. It included PubMed, Scopus, Google Scholar, Researcher Gate, Scilit, Index Copernicus, Index Medicus, Scope Med, CrossRef, and BMC for articles published, also cited for different official published public health reports, and books up to 2023. Studies were included based on relevance to nutrition status and trends, recent advanced techniques among tuberculosis patients. Boolean operators and Medical Subject Headings [MESH] were used for precision.

Inclusion Criteria:

- Studies published in English
- Focused on the status, trends, and recent advances in nutrition initiatives

- To address research gaps in nutrition, awareness, and the need for various interventions
- An observational, Analytical, and mixed-methods study. Official public health reports also cited

Exclusion Criteria:

- Opinion pieces or non-peer-reviewed sources, Unofficial public health reports

Data Extraction and Maintenance: Data were extracted based on study designs, settings, and population, and were maintained by using the Rayyan software and Excel.

Results and Discussion:

Epidemiological Parameters:

Age:

In a study done by **Nagpal M et al.,** 94.8% of the respondents were from the 15-59 years study [25]. **Shailly et al.,** from their study, report a maximum number of cases from the 41-60 years age group [21]. **Endalkachew K et al.,** in their study in Ethiopia, reported majority of study participants were between the ages of 18-28 years, which is lower when compared to our study [30]. In a study done by **Ayiraveetil R et al.,** the mean age of their study participants was 44 years, which is similar to our study [22]. Shailly et al report a mean age of 45.36 ± 18.97, which is a little higher than the current study [21]. Similarly, **Kurnia A et al.,** in their study in Indonesia, report a higher mean age of 46 ± 11.64 [35]. Most of the tuberculosis patients were in the productive age group.

Gender:

Shukla A et al. report a male proportion of 64% [19], and **Bhargava A et al.,** with a male predominance of 68% [26]. A study done in Burkina Faso by **Musuenge B et al.** also reported a similar majority in males [65.6%] [33]. Shailly et al. also reported similar findings [21]. In a study done by **Sadana P et al.,** [23] and Shetty **N et al.,** reported in their study, males were of a higher proportion [28]. The majority of the tuberculosis patients were males from these studies.

Religion:

Shukla A et al. reported a high proportion of Hindus [62.7%], and Muslims were 37.3% [19]. The majority of Hindus [88.5%], whereas Christians were 7.1%, and 4.2% were Muslims. The study carried out by **Ayiraveetil R et al.,** [22]. The study done by **Shetty N et al.,** Hindus were 72% and Christians and Muslims together constituted 28% [28]. Hindu participants were in greater numbers, possibly because the study areas have been predominantly inhabited by Hindus.

Caste:

Mollah A et al., study reported majority belong to the general caste [79.6%]. 10.6% of the Study population belongs to the scheduled caste, 7.1% belongs to other backward caste, and 2.7% belong to the scheduled tribes [49]. Whereas NFHS-5 data suggests, in India, the other backward caste is of the majority with 43% followed by the Forward caste 25%, the scheduled caste 21% and the scheduled tribes 9.3%.

Occupation:

Shailly et al. reported in their study that 41% were unemployed, were unskilled workers 44.5%, and only 1.5% were skilled workers [21]. **Ren Z et al.** also had similar findings [were unemployed 41% and 59.3% were employed] [40]. **Shukla. A et al.,** 46.8% were unemployed; daily wage workers were 39.9% in their study. In studies by **Shetty N et al.,** and **Kurnia A et al.,** the proportion of unemployed was 49.7% and 44.7% respectively [28,35]. The majority of participants were employed. It is good that 60% of participants were working.

Education:

Muse A et al., findings literates were 47.6% and illiterates were 52.4% [31]. In a study done by **Shailly et al.,** most of the participants were illiterate, 86.5% [21]. **Endalkachew K et al.,** in their study, observed, illiteracy rates were 41.8%, and Primary education was completed in 18.8% of the study participants [30]. In the study done by **Shailly et al.,** graduates were 2% [21]. Illiteracy was major among the study participants, which ranged from 28-90%. A study participant ranged from 28-90%.

Socio-Economic Status:

Mollah A et al., study reported that the majority of participants belonging to the lower middle socioeconomic class were of a higher proportion [48.7%], lower socioeconomic class were 33.6% and middle and upper classes were 10.6% and 7.1% respectively [49]. **Q. H. Khan et al.,** in their study, also reported a higher prevalence among the lower socio-economic class [51]. **Shailly et al.** reported majority belonged to the upper lower socio-economic class [84.5%] according to the modified Kuppuswamy scale, 11% belonged to the lower middle class, 2.5% and 2% belonged to the lower and upper middle classes, respectively [21]. **Saleem M et al.** reported majority belonged to the middle class [35.3%], followed by the upper middle [30.5%], the lower middle was 22.2%, the lower class was 9.6% and the upper class was 2.4%. Most of the cases were lower SES, which is similar to other Indian studies.

Marital Status:

Ayiraveetil R et al., who reported that 74.1% were married, 17.3% were unmarried and divorced or separated or widowed, constituted 8.6% [22]. In a study by **Wassie MM et al.,** the majority were married [44%], 41% were unmarried, and 14.9% were divorced or widowed [42]. **Endalkachew K et al.,** in their study, reported that 54.6% were married, 34.6% were unmarried, and 9.4% were divorced or widowed [30]. A study by **Gurung et al** observed that 58.6% were married, were unmarried 33.9% and 7.5% were separated or widowed [41]. Marriage is a universal phenomenon, and this was observed in the studies. From the studies.

Type of Family:

A study done by **Gurung L et al.,** which reported that 54.9% were nuclear families and 45.1% were living in a joint family [28,41]. Nuclear family predominance was noted in the study.

Family Size:

A study done by **Shetty N et al** reported majority [55.6%] of their study respondents had > 4 members in their family [28], and 61.5% in a study by **Feleke B et al** had > 4 members in their family [37]. In a study done by **Musuenge B et al.,** the majority of study participants have > 4 family members [56.5%] [33]. **Shukla A et al.,** in their study, reported 67.1% had a family size of ≥ 5 members, which is similar to our present study [19]. Most of the study participants were residing in families containing more than 4 members.

Behavioral Characteristics:

Tobacco Use and Alcohol Consumption:

The study done by **Shetty N et al.,** which reported 33.8% of their study subjects had a history of smoking and 31.2% had a history of alcohol consumption [28]. Also, **Bhawalkar J et al.** reported that 34.13% of their study respondents had a history of smoking and 42.86% had a history of alcohol [51]. In the studies done by **Saleem M et al.,** and **Ren et al.,** history of smoking was 58.7% and 46.7% whereas alcohol consumption was 41.3% and 39.7% respectively. Smoking and alcoholism prevalence was found among the study population, which ranged from 31-60%.

Environmental Characteristics:

Overcrowding:

A study by **Saleem et al.,** overcrowding was seen in 57.8% of study respondents, and housing standards were poor in 25.1% of the population [47]. **Bhawalkar J et al.,** in their study, reported that 69.84% had overcrowding in their house. 47.62% were living in a kutcha house [52]. **Shetty N et al.,** study participants with overcrowding in their house were 27.5%. [20.6%] of them do not have a separate kitchen in their house [28]. More than half of the respondents [25-60%] reside in overcrowded houses. Overcrowding and poor housing standards seem to be important factors favorable for the spread of the disease.

Type of House:

In a study done by **Rao V et al.,** 96% of the houses of study participants were kutcha houses. This finding might be because the study was done in tribal areas [53]. **Bhat J et al.,** 79.8% of the study participants live in a Kutcha house. **Shukla A et al.,** study participants living in kutcha house were 40.5%, living in pucca house were 49.4% and living in semi pucca were 10.1% [19].

Kitchen:

In a study done by **Shetty N et al.,** a separate kitchen is not present in 20.6% of the houses, and biomass fuels were used for household purposes in 40.2% [28]. In a study done by **Rao V et al.,** a separate kitchen is not present in 96% of the houses [53].

Nutritional Status Assessment:

Clinical Assessment [Related to Nutritional Problems]:

In a study by **Brhane T et al.,** 43.5% of the study participants had nausea, and 43.5% had poor appetite [54]. **Tesfaye Anbese A et al.,** in their study, reported 25.9% of the patients had a history of nausea, 17.6% had a history of diarrheal diseases, and 58% had decreased appetite [38]. Nausea was found to be a predominant symptom that might have contributed to decreased appetite.

Anthropometry [BMI]:

Endalkachew K et al., in their study, observed prevalence of undernutrition was 42.2%, out of which 10.4%, 20.5% and 11.3% were having severe, moderate, and mild undernutrition. Mean BMI was 19.3 ± 2.83 [30]. In a study done by **E. A. Dodor et al.,** 51% of study respondents were undernourished. Mild, moderate, and severe undernutrition among the study participants were 24%, 12%, and 15% respectively [52]. **Mollah A et al.,** the proportion of underweight was 61.9%, among which 3.5% were extremely underweight, 5.3% were grade III underweight, 22.1% were grade II underweight, and 31% were grade I underweight. Normal was 36.3% and overweight was 1.8% [49]. **Shukla et al.** reported that 79.5% of tuberculosis patients were undernourished. 20.5% were in very severe undernutrition, 49% were in severe undernutrition, 30% were having moderate undernutrition, and 21% patients were in the category of normal weight, and three patients out of this 21% were overweight [19]. According to **Hedaoo et al.,** the proportion of underweight was 79%. 35% of study participants were severely underweight, 26% were moderately underweight, and 18% were mildly underweight. 21% of study subjects were having normal underweight. Mean BMI was 16.85 [20]. In a study by Musuenge et al., the prevalence of undernutrition was 35.8%, 61.6% had normal underweight, and 2.6% were overweight. Among underweight, severe, moderate, and mild undernutrition was present in 7.3%, 8.9% and 19.5% respectively [33]. The prevalence of undernutrition ranged from 35.8% to 79.5% The mean BMI in the present study was 18.75 ± 3.4. Compared to many Indian studies showed a higher proportion of underweight. This may be because India is a developing nation where undernutrition is still a significant public health concern. Different socioeconomic statuses of the population in different areas of study might also influence the variation in the proportion of undernutrition.

Table 2: Comparison of the prevalence of undernutrition in various studies [31-37].

S. No.	Study	Prevalence
1.	Endalkachew K et al.,	42.2%
2.	E. A. Dodor et al.,	51%
3.	Mollah A et al.,	61.9%
4.	Shukla A et al.,	79.5%
5.	Hedaoo S et al.,	79%
6.	Musuenge B et al.,	35.8%

Comparison with Areas of Study:

There were fewer comparative and review studies on urban, rural, and tribal regions. Hence, more emphasis of previous studies' comparisons and review was carried out.

Areas of Study and Age:

In a study done by **Saleem M et al.,** a higher proportion of study respondents belong to the age group 35-54 years of age in both urban [46.7%] and rural areas [49.4%]. Study respondents of age < 35 years were 28.9% in the urban population and 29.8% in rural areas. This association was not statistically significant. [47]. **Kashyap RS et al.,** in their study, done in the tribal area, reported that 78% of study respondents belong to the age group 18-40 years of age which is higher than our study. 20% belong to the age group > 40 years [56]. The higher proportion of respondents in the younger age groups in the study might be because the study was conducted in the tribal regions alone. As per **S. Chakrabarti et al.**, in tribal areas, the study respondents belonging to the age group 15- 59 years were 85.5% and 11.1% belonged to age > 60 years [57]. **Shailly et al.,** in their study, observed, the study respondents in the age group < 20 years, 57.8% were residing in rural areas and 42.1% in urban areas. The majority of study participants in the age group > 40 years were residing in rural areas [78.4%] [21]. The distribution of the study population in urban, rural, and tribal areas followed a similar pattern in older adults. Young adults were more in tribal areas.

Areas of Study and Occupation:

In a study done by **Bhat J et al.,** in tribal areas, unskilled workers were of majority [65.2%]. 25.1% were unemployed 25.1%. **Saleem M et al.,** in their study, reported unemployed individuals were of a high proportion [50%] and skilled workers were 37.8% in urban areas, whereas in rural areas, skilled workers were 49.4% and unemployed were 36.3% [47]. The proportion of unemployment is equal in rural [38.1%] and tribal [38.1%] areas, but is higher than in urban areas [34.3%]. Many of them were skilled workers from all three 3 areas of study [60 - 65%]. There is no significant association with working status and place of living [p = 0.839].

Areas of Study and Behavioral Characteristics:

In a study by **Saleem et al.,** the study participants with a history of smoking in urban areas were 68.9% and in rural areas were 46.8%. Consumption of alcohol was higher in urban areas than in rural areas [47]. **Rao V et al.,** in their study, reported that in tribal areas, 68% of the study subjects had a history of smoking and 47% had a habit of alcohol consumption [53]. **Bhat J et al.,** in their study, reported that 46.8% of the study subjects had a history of smoking and 31.5% had a habit of alcohol consumption. **Cormier M et al.,** in their systematic review study, reported that among tribal areas in India, the maximum range for the proportion of smoking was 85.7% and for alcohol consumption, the proportion was 55.3% in various studies [55]. The study participants with a history of alcohol consumption were more prevalent in tribal areas [42.9%] when compared with urban [31.4%] and rural [25.7%] areas.

Areas of Study and Environmental Characteristics:

Saleem M et al., in their study, reported that overcrowding was 57.8% in urban areas and 46.58% in rural areas. This was not statistically significant [47]. **Bhat J et al.** reported in their study that overcrowding in tribal areas was 62.9% [53]. and **Cormier M et al.,** in their systematic review study, reported that among tribal areas in India, overcrowding ranged from 20.35 – 58.3% [58]. Overcrowding ranged from 20.35% - 62.9% in several studies.

Areas of Study and Nutritional Status:

In a study by **Feleke et al.,** Underweight was found higher proportion in urban [29.3%] and rural areas [27.8%] [37]. Similar findings were also made by **Muse et al.,** undernutrition in urban areas was 23.3% and in rural areas was 20.95% [31]. **Kashyap RS et al.,** and **Tungdim MG et al.,** reported undernutrition in tribal areas to be 44% and 42.6% respectively [56,59]. **Saleem M et al.,** in their study, reported a statistically significantly higher proportion of underweight in rural areas [45.5%] when compared with urban areas [47%], whereas **Rao V et al.,** in their study, reported that the underweight study participants were 64% in tribal areas [53]. Also, in a study done by **Bhat J et al.,** undernourishment was higher in tribal areas [87%]. **Cormier M et al.,** in their systematic review study, reported that among tribal areas in India, undernutrition ranged from 15.3% - 64.5% [59]. The population residing in the tribal areas has a significantly higher proportion of underweight individuals as compared to rural areas and urban areas.

Comparison with Nutritional Status:

Nutritional Status and Age:

In a study by **Brhane et al.,** participants of age >40 years had a higher proportion of undernutrition [55.1%], followed by 31 – 40 years of age [17.3%] [54]. Shukla et al. reported that underweight was higher among the 15-25 years age group [46.2%] and the 36-49 years [39.2%]. This was statistically significant [0.041] [19]. A study done by **Hedaoo et al.,** underweight was 49.3% among the age group of ≤ 25 years, and a nearly equal proportion of underweight was observed in the age group of >25 years [51.7%] [20]. E. A. **Dodor et al.,** in their study, reported 56% of underweight in the age group of ≤ 35 years and 48% were underweight in the age group of > 35 years. [52]. Underweight was significantly associated with the older age group.

Nutritional Status and Gender:

In a study by **Shukla et al.,** underweight was higher among males [65.2%], which is similar to the current study. There is no statistical significance for this association. [19]. **Hedaoo S et al.,** in their study, reported majority [51.2%] of the undernourished were females [20]. Also, in a study by **E. A. Dodor et al.,** the proportion of underweight was higher among females [55%] than males [49%], but no statistical significance was observed [52]. Also, in a study by **Musuenge et al.,** there was no significant difference between males and females with a BMI [33]. Sex also had no association with underweight. These findings may, however, be due to the fact due depend on which gender was represented among the participants.

Nutritional Status and Socioeconomic Status:

Among the undernourished, the majority belong to middle socioeconomic status [45.6%], followed by upper middle SES [34.2%], and 14.8% of them belong to the lower middle socioeconomic class. As the SES decreased, the proportion of underweight has increased. This association is statistically significant [p < 0.009]. **Mollah A et al.,** in their study, reported a high proportion of low socio-economic background [47]. Underweight is inversely proportional to socioeconomic status; as social class increases, underweight decreases.

Nutritional Status and Education:

In a study by **Shukla et al.,** Undernutrition was higher among illiterates [32.9%] and 31.6% in those who completed primary education, and 18.4% who finished secondary education [19]. **Hedaoo S et al.,** in their study, observed that 23.4% of the underweight study participants were illiterates, which is a lower proportion. Among underweight study participants, 42.4% had completed primary education and 34.1% had completed secondary education. This association was not statistically significant [20]. Muse et al., in their study, reported that illiterates with undernutrition were [39.4%]. **E. A. Dodor et al.,** in a study, observed that 56% of the underweight population had basic education, and 49% of the underweight had no formal education. This association was statistically significant [p < 0.003] [31]. A low level of education was associated with undernutrition.

Nutritional Status and Occupation:

In a study by **Hedaoo S et al.,** 60.7% of the undernourished were unemployed, which was a much higher proportion. Among underweight study subjects, 17% were unskilled workers, and 22% were skilled and semi-skilled workers. This association was statistically significant [p < 0.028] [20]. **E. A. Dodor et al.,** in their study, observed that 57% of study participants who were unemployed had undernutrition, and 48% of the employed had undernutrition. This association was not statistically significant [52]. Undernutrition was influenced by defenses upon the type of occupation [unskilled workers].

Nutritional Status and Family Size:

In a study by **Feleke et al.,** the study participants with a family size of > 4 had higher undernutrition [48.3%] [37]. **E. A. Dodor et al.,** in their study, reported that 55% of the underweight had a family size of >4 members and 47% of the underweight had a family size of ≤ 4 members. This association was statistically significant [52]. **Shukla et al.,** in their study, observed that undernutrition was 67.1% in study participants with a family size of > 5 members and 32.9% with a family size of ≤5 members [19]. Tesfaye **Anbese A et al.,** in their study, reported that undernutrition was higher [75.7%] among respondents with a family size of > 4 [38]. Undernutrition was higher among the participants with a large family size [38]. This association has statistical significance [p-0.028].

Nutritional Status and Smoking:

In a study done by **Shukla et al.,** undernutrition among smokers was 47.5% [19]. **Shailly et al.,** in their study, reported that the proportion of undernutrition among smokers was 71% which is much higher than in other studies [21]. In a study done by Musuenge et al., undernourishment among smokers was 39.9%. This association is statistically significant [p< 0.001] [33].

Nutritional Status and Alcohol Consumption:

Musuenge B et al., in their study, reported that the proportion of undernutrition in alcoholics was 89.8% [33]. This finding was higher than in the present study. Also, **Shailly et al.,** in their study, reported that 71% of the undernourished study participants were alcoholics, which is higher than our study [21]. **Feleke et al.,** in their study, reported that 44.7% of the alcoholics in their study population were undernourished [37]. In a study done by **Shukla et al.,** 17.1% of the study subjects with a history of alcohol consumption were undernourished [19].

Nutritional Status and Environmental Factors:

Shukla et al., in their study, reported that the study respondents with overcrowding in their house had a higher proportion of undernutrition [67.1%] [19]. Overcrowding has a statistically significant association with undernutrition [p = 0.002].

Dietary Assessment:

Frequency of Meals:

In a study by **Brhane T et al.,** 10.3% of the respondents were having ≤ 2 meals per day and 89.7% were having ≥3 meals per day [54]. Muse A et al., in their study, observed majority of the study participants had 3 meals per day [70.6%]. 17.6% were having 2 meals per day [31]. Most participants take a desirable number of meals, 1- < 3per day.

Frequency of Meals and Nutritional Status:

In a study by **Musuenge B et al.,** underweight was higher among participants with 1- 2 meals per day [90.7%] than 3-4 meals per day, which was statistically significant. [p < 0.021] [33]. **Endalkachew K et al.,** in their study, observed that 82.4% of the participants with underweight had a meal frequency of <3 Meals per day [30].

Dietary Diversity Score:

In a study done by **Endalkachew K et al.,** reported that high dietary diversity was present in 53.1% of their study participants [30]. M**use A et al.,** in their study, observed that dietary diversity is followed by only 38.2% of study subjects [31]. In a study done by Brhane T et al., the study participants who practiced dietary diversity were 52.2%. All these studies showed a high dietary diversity among their study participants. This is a statistically significant association [p <0.001] [54].

Dietary Counselling:

In a study by **Brhane T et al.,** 48.3% of the participants received dietary counselling [54]. **Muse A et al.,** in their study, reported that respondents who received dietary counselling were 73% [31]. There was a statistically significant association between dietary counselling and undernutrition. In a study done by **Tesfaye Anbese A et al.,** undernutrition was higher in respondents who did not receive dietary counselling [62.6%] than those who received dietary counselling [37.3%] [38]. Undernutrition was associated with a lack of dietary counselling.

Anaemia:

A study done by **Feleke et al.,** underweight was present in 33.9% of the participants with Anaemia [37]. Shailly et al., 66% of the study participants have Anaemia. Among these, 10.5% have severe anaemia, 20% have moderate Anaemia, and 35.5% have mild Anaemia [21]. Most of the undernourished also had Anaemia.

Associated Illness:

Diabetes, Hypertension, and HIV were the associated illnesses. **Silvana et. al.,** in their study, observed that 15.3% of the diabetics were underweight. Among the study participants with underweight, 53.8% had positive HIV status [57].

Determinants of Undernutrition:

Multinomial logistic regression analysis between various variables and nutritional status of tuberculosis patients showed that study participants with increasing age group, who had no dietary counseling, and who were taking ≤ 2 meals per day, were more likely to be undernourished. Families with a size of ≤ 3 members in their family, without overcrowding in their house, and with no history of smoking, were less likely to be undernourished. **Appaiah PK et al.,** in their study, reported that tuberculosis patients were less likely to have normal nutritional status as age increases [AOR – 0.47, 95% CI: 0.98–0.93] [60]. Also, Tesfaye **Anbese A et al.,** [AOR – 3.39, 95% CI: 1.6–7.18] and **Brhane T et al.,** [AOR – 2.1, 95% CI: 1.015–4.545] reported in their studies that higher age groups were more likely to be undernourished [38,51]. **Gurung L et al.,** it was reported that study participants who were taking a lesser number of meals per day were more likely to be undernourished [AOR – 0.34, 95%CI: 0.16–0.73] [41]**. Brhane T et al.,** in their study, observed that study respondents who had not received dietary counselling were more likely to be undernourished [AOR – 3.8, 95% CI: 2.515– 5.762] [54].

Recent Advances:

The Government of India [GOI] is implementing Direct Benefit Transfer [DBT] under the National Tuberculosis Elimination Program [NTEP] for the benefit of tuberculosis patients, healthcare professionals, and others who support treatment. NPY: It helps TB patients to receive nutritional support both at the time of notification and during their treatment. Rs 500 per month is given during treatment of up to Rs 1000 as an advance. In 2017, a guideline on nutritional assistance and care for tuberculosis patients in India was created and disseminated. The Ministry of Women and Child Development [MOWCD] and the NTEP together have ensured the overall development of women and children to promote the NTEP's goal of successful treatment and improved health/nutritional status among TB patients. In order to alleviate population-level malnutrition, the annual "Poshan Mah" is observed in the month of September. N-TB App [Nutrition-TB App]: The Yenepoya Institute in Mangalore developed this software

with the cooperation of the McGill International TB Center in Canada, the RNTCP, and the WHO. The Nutrition-TB App [N-TB app] was created by the CTD with assistance from partners to simplify the technical execution of nutritional assessment and appropriate supplementation. The App is a mobile-based program that makes evaluation, counseling, and care for adult tuberculosis 118 patients who are malnourished easier. It is free to download from the Google Play and iOS app stores. This tool aids healthcare professionals in:

- Based on nutritional status, take appropriate action
- Based on nutritional status, take appropriate action
- Provides individualized nutritional counselling advice for TB patients
- Provides individualized nutritional counselling advice for TB patients
- Indicates the necessary daily calorie and protein intake
- Provides individualized nutritional counselling advice for TB patients
- Indicates the necessary daily calorie and protein intake
- Simplifies information on all food types, their caloric and protein contents, with a focus on readily available and reasonably priced items. [5,44]

Recommendations:

The implementation of national nutritional guidelines, nutritional supplementation, and incorporation with national health programs for tuberculosis patients regarding proper nutritional assessment, counseling, and management accelerated recovery and weight gain. More emphasis to be laid on the need for the provision of nutritional support care services in the tribal areas. The national program should include nutritional assessment of tuberculosis patients.

Creating diet counselling centers within hospitals can play a vital role in promoting a healthy, balanced diet for tuberculosis patients. The village-level health workers should be involved in nutritional support and counselling services after the provision of training. As a corporate social responsibility, corporates can adopt private-public partnerships and collaborations to help tuberculosis patients and provide them with nutritional support or vouchers for meals in local hotels.

Capacity building to be done through the organization of community vegetable gardens. Development of low-cost, high-nutritious products using indigenous foods can be taken up by self-help groups. They can promote and market the products. Impart education and awareness to tuberculosis patients about the role of nutrition in promoting their health and recovery from illness.

Conclusion:

Tuberculosis has affected a high proportion of the productive age group in the study. Factors like illiteracy, class III socioeconomic status, and large family size are associated with tuberculosis. Younger age groups < 20 years were more affected in tribal areas. Smoking and alcohol consumption were high among the participants from these areas. High proportions of undernutrition and anemia were found among tribal patients.

Methodological strategies need to be considered to reach the unreached regarding the health service provision and gap identification of health-seeking behavior among tribal people, which is critical to understand. Affordability for 3 meals per day is lower among the patients in tribal areas, which emphasizes the need for economic liability by the state. A higher proportion of the undernourished were residing in overcrowded houses with inadequate ventilation. Interventions need to be sensitive to these aspects.

A high prevalence of underweight was seen among tuberculosis patients. Factors significantly associated with underweight were a higher age group, male sex, lower educational status, low socioeconomic status, and large family size. Undernutrition is also high in those who had no preliminary diet counselling and no awareness about dietary diversity. The present study highlights the importance of the nutritional status of tuberculosis patients. Emphasis should be laid on the need for mainstreaming nutrition awareness in public health programs.

Limitations: The review is limited by language bias [English only], and heterogeneous study designs may limit direct comparability. Furthermore, gray literature and unpublished data were not included.

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