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RESEARCH ARTICLE

Dietary Intake and Nutritional Status of Patients with Pulmonary Tuberculosis in Puducherry, South India

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Abstract

A bidirectional relationship exists between tuberculosis (TB) and nutrition. To examine the dietary intakes of tuberculosis (TB) patients and to identify the factors associated with dietary deficiencies. In this cross-sectional study, 173 newly diagnosed sputum smear-positive TB patients, and taking treatment in the National Tuberculosis Elimination Programme (NTEP) were included. Nutrient intakes were evaluated through one day 24-h dietary recall and compared with the Recommended Dietary Allowance (RDA). Data on dietary intake was analyzed using DietSoft software. The mean (SD) age of the study participants was 45.5 (18.7) years with majority male (73.4%). More than one-third (35.3%) didn't receive any formal education and 28% were unemployed. Nearly half (47%) had diabetes mellitus, 45.1% were alcoholics, 39.3% were smokers, and 36% underweight. The mean (SD) daily intake of energy was 1414.33 (458.45) kcal and the median (Interquartile Range) of protein was 43.15 (30.00-60.26) gms. The daily energy and protein intake were lower than the national guidelines for RDA. The intake of micronutrients was found to be much lower than recommended. The intake of macronutrients and selected micronutrients in TB patients were grossly inadequate. Along with vitamin supplementation, dietary counseling also is needed in this population.

Keywords: Dietary intake; Nutritional status; Risk behaviors; Tuberculosis

1. Introduction

Tuberculosis (TB) remains a major public health threat globally. According to the global TB report 2022 there are 10.6 million cases and 1.7 million deaths reported in 2021(World Health Organization. Global Tuberculosis Report 2022, 2022). [1] India contributes to 26% of all cases but 32% of all deaths due to TB. The estimated number of deaths among TB patients, excluding HIV, is 4.93 lakhs (4.53-5.36 lakhs), an increase of 13% over 2019, the mortality rate being 37 per 100,000 (34-40 per 100,000) (World Health Organization. Global Tuberculosis Report 2022, 2022). [1] The prevalence of malnutrition among TB patients ranges from 68.6 - 87% in Asians [2,3] and 29 - 61% in African populations. [4–7] Malnutrition is also common among the general Indian population, the prevalence of undernutrition (BMI<18.5 kg/m2) being 20.2% in men and 22.9% in women among adults aged 15–49 years [8]. The other common nutritional deficiency found among the Indian population is anemia. [9] Anemia is also common in TB patients. [10,11]

There is a bidirectional relationship between undernutrition and active tuberculosis. [12] Active tuberculosis leads to weight loss and underweight is a known risk factor for the development of tuberculosis, either through reactivation of latent tuberculosis or through the development of progressive primary disease following infection. [12] In a patient with active TB, undernutrition is strongly associated with a wide range of adverse outcomes. [13] Poor nutritional status among patients with TB is known to be associated with a higher burden of disease in terms of longer duration of time to sputum conversion, [14] treatment failure, higher risk of hepatotoxicity [15–17] higher mortality [18–21] and increased risk of reinfection/ recurrence. [21]

The dietary requirements for patients with TB can be considered in terms of their energy needs, macronutrients, and micronutrients. Patients with TB need more energy than the recommended dietary allowance (RDA) for the general population due to increased basal metabolite rate (BMR). [22] Inadequate intake of protein and calories can hinder the functions of host defense mechanisms that are essential for combating TB. Protein calorie malnutrition (PCM), characterized by inadequate intakes of both protein and total calories is common in TB patients. [23] Micronutrients are of great importance in the management of TB and their demand is increased by the intake of TB treatment drugs. Patients with active TB often suffer from a deficiency of micronutrients particularly iron, folate, vitamin D, and zinc. [5,24,25] Anti-TB drugs can also result in micronutrient deficiencies. For example, isoniazid administration can cause pyridoxine deficiency, and rifampicin can induce the metabolism of vitamin D, and lower its levels. Pyrazinamide, isoniazid, and rifampicin can lead to vitamin K deficiency, [26] that may hinder the physiology of blood coagulation. Cerebral hemorrhage is documented in patients suffering from congenital tuberculosis due to vitamin K deficiency. [26] These are also known as hepatotoxic anti-tuberculosis drugs. But in most cases, especially in low- and middle-income countries, under nutrition is a result of patients not being able to purchase additional food because of economic hardship due to illness and loss of jobs or because of local food insecurity. [27,28] Considering the financial burden and importance of increased nutrient intake, the national TB program in India has launched the Nikshay Poshan Yojana nationwide, a direct benefit transfer (DBT), where all the notified cases in the NIKSHAY portal receive Indian rupees (INR) 500 per month (~US$7) throughout the treatment for TB.

The nutritional status of TB patients is usually assessed using anthropometric measurements like body mass index (BMI) and mid-upper arm circumference (MUAC). [29–31] Complete nutritional status assessment can be done through measurement of biochemical parameters, but they are more difficult to do and also costly. Though few studies have reported the levels of micronutrients in the serum samples of TB patients to determine nutritional deficiencies, [32,33] literature from India on the same is limited. In a resource-constrained setting, consumption of nutrients can be known through the dietary intake of TB patients. History of diet obtained through 24-hour recall can provide information on the nutrients being consumed by the patients, which is a much easier way to assess the intake and can help in the decision-making on the requirements for additional supplements.

Among all the states and Union territories in India, Puducherry is a well-performing union territory, spending about 2.42% of GDP on health with the per capita health expenditure of about Rs.31,372. [34] Information on the deficiencies in the diets of TB patients can help in advocacy for the dietary supplementation of TB patients. Therefore, we aimed to examine the dietary intake of macro and micronutrients and associated factors among TB patients at the time of diagnosis to understand their intake patterns before they availed the benefits under the Nikshay Poshan Yojana.

2. Methods

2.1 Study design and population

This community-based cross-sectional analytical study was conducted among newly diagnosed sputum smear-positive pulmonary TB patients (18 years and above), receiving treatment from selected Primary Health Centers (PHCs) in Puducherry, South India from 2017-2019. Patients receiving anti-tubercular treatment (ATT) for more than 2 weeks, Multi-Drug Resistant, physically challenged, pregnant women, patients who underwent a blood transfusion, and individuals with chronic diseases were excluded from the study.

2.2 Study setting

According to the census 2011, the total population of the population of union territory Puducherry was 1,248,000. There are seven TB units (TUs) and 27 designated microscopy centers (DMCs), in Puducherry. All the activities are carried out as per the National Tuberculosis Elimination Programme (NTEP). The per capita income based on Net state domestic product (NSDP) for the year 2018-19 is estimated as ₹2,20,461.[34]

2.3 Sample size and sampling technique

Participants involved in this study were a part of a cohort study that was designed to describe the types of anemia and iron deficiency occurring among tuberculosis patients in Puducherry. Hundred and seventy-three patients fulfilling the inclusion and exclusion criteria and willing to participate in the study were enrolled consecutively till the required number for the cohort study was reached.

2.4 Study procedure

The study was done in coordination with health care professionals in 12 Primary Health Centres (PHC) in Puducherry. The participants were explained the purpose of the study and written informed consent was obtained before interviewing them. A pre-tested questionnaire was used to collect information on socio-demographic details such as (age, sex, residence, marital status, and occupation), risk behaviors (alcohol and smoking), and diet. Dietary assessment was done using 24 hours recall method. The participants were asked to recall all the food they had taken the previous day from the time they woke up. Standardized household measures like plates, cups, and spoons were used to estimate the amount of food. Data on dietary intake was analyzed using DietSoft (Version 1.2.0, Invincible IDeAS 2008-2009) a software package to determine the content of macronutrients and micronutrients in the diet. The results were compared with the Recommended Dietary Allowance (RDA) for Indians by National Institute of Nutrition (ICMR), Hyderabad to assess the adequacy of the dietary intake. Estimation of hemoglobin (Hb) was done with 2ml of whole blood drawn in ethylenediaminetetraacetic acid (EDTA) tube using autoanalyzer XTi 4000i (Sysmex Corporation, Kobe, Japan) in the Department of Pathology, of a tertiary care hospital.

2.5 Operational definitions

- **Alcohol use:** Consumption of any form of alcohol (one standard drink) in the past year
- **Tobacco use:** Use of smoke or smokeless form of tobacco in the past year
- **Dietary Deficiency:** Nutritional intakes lower than the RDA for the specific nutrients (Table 1) are defined as deficient.
- **Anemic status:** The participants were considered as anemic as per WHO classification for anemia. As per the classification, the patients are anemic if their Hb is less than 13 g/dL (for males) or less than 12 g/dL (for females).

Table 1. Recommened Dietary Allowance (RDA) as per the Indian Council of Medical Research (ICMR) guidelines - (RDA 2010)

Nutrients	Male	Female
Energy	2320kcal	1900kcal
Protein	60g/day	55g/day
Iron	17mg	21mg
Calcium	600g	600g
Vitamin C	40mg	40mg
Vitamin B12	1.0μg	1.0μg
Folic Acid	100 μg	100 μg

Kcal: Kilocalorie; g/day: Gram per day; mg: milligram; μg : microgram

2.6 Ethics statement

The study protocol was approved by the Institute Ethics Committee (IEC). Permission to conduct the study in the Primary Health Centre (PHC) was obtained from the State TB Control Officer (STO), the Government of Puducherry, and the State Task Force Operational Research Committee, NTEP, Puducherry. Written informed consent was taken from the patients before enrolling.

2.7 Statistical Analysis

The data analysis was done using Stata version 14 (StataCorp LP, College Station, TX, USA). Continuous variable such as age was summarized as mean (standard deviation). Iron, Calcium, Vitamin B12, Folic acid, and Vitamin C values were expressed as median (interquartile range). Categorical variables such as gender, religion, education, occupation, socioeconomic status, number of family members, marital status, intake of alcohol, smoking, and diabetes status were summarized as percentages. Association of socio-demographic characteristics and other factors with nutrient deficiency was analyzed using the Chi-square test and an unadjusted prevalence ratio (UPR) with 95% CI was calculated. Log binomial regression was performed using variables that had a p-value less than 0.2 in the unadjusted analysis and an adjusted prevalence ratio (APR) with 95%CI was calculated.

3. Results

The mean (SD) age of the participants was 42.4 (13.9) years ranging from 18 years to 75 years. Nearly three-fourths were males (73.4%), 71.1% were married and equal proportions were employed at the time of diagnosis. About 45.1% consumed alcohol, and 39.3% were smokers (Table 2).

The mean (SD) daily energy intake was 1414.3 (458.4 kcal) which is nearly 1000 kcal lower than the recommended daily allowance (RDA) of 2320 kcal. The intake of protein was 43.2 (30-60.3g), almost one-third lower than the RDA (60.0g) (Table 3). Micronutrients like iron, calcium, vitamin C, vitamin B12, and folic acid were also found to be lower than the RDA. Median (IQR) vitamin B12 and folic acid in their diet were 0.1 (0.00-0.14) mcg and 2.88 (0.00-5.76) mcg respectively.

On analysis of the factors associated with deficient intake of macronutrient among new sputum smear-positive patients, the prevalence of deficiency in energy and protein intake were higher in the middle-aged group with adjusted prevalence ratio APR of 1.08 (95% CI 0.97-1.20) and 1.40 (95% CI 1.11-1.76) among the elderly respectively as compared to younger adults (age 18-30 years). (Table 4)

Prevalence of deficiency in the intake of micronutrients like iron was 1% higher among the younger adults unadjusted prevalence ratio (UPR=1.01, 95% CI 0.90-1.14). The prevalence of deficient intake was also higher among unemployed (UPR=0.87, 95% CI 0.82-0.93) and was found to be statistically significant. (Table 5)

Table 2. Characteristics of new sputum smear positive patients in Puducherry (N=173)

Variable	Categories	N	%
Age in years	18-30	36	20.8
	31-60	122	70.5
	>60	15	8.7
Gender	Male	127	73.4
	Female	46	26.6
Religion	Hindu	152	57.9
	Christian	14	8.1
	Muslim	7	4
Education	No formal education	61	35.3
	Class1 to 5	15	8.7
	Above class 5	97	56.1
Present occupational status	Unemployed	49	28.3
	Employed	124	71.7
Ration Card	BPL	65	37.6
	APL	108	62.4
Number of family members	Up to 4	140	80.9
	More than 4	33	19.1
Marital status	Unmarried	38	22
	Married	123	71.1
	Separated	4	2.3
	Widow/Widower	8	4.6
Alcohol intake with in last 1 year	Yes	78	45.1
	No	95	54.9
Smoking status with in last 1 year	Yes	68	39.3
	No	105	60.7
Self-reported Diabetes Mellitus	Yes	81	46.8
	No	92	53.2
Anemic status†	Anemic	109	63
	Non-Anemic	64	37
BMI Kg per m‡	Underweight (<18.5)	72	41.6
	Normal (18.5-22.9)	76	43.9
	Overweight/Obese (≥ 23.0)	25	14.5
Type of Diet	Non-vegetarian	173	100

*Modified B.G Prasad 's (2019) Socio-Economic Classification
†Anemic: Males Hb<13gm/dL, females Hb<12gm/dL
‡Asia Pacific Classification of BMI, BPL below poverty line, APL above poverty line

4. Discussion

The patients in our study belonged to the urban Puducherry and their dietary pattern was representative of all the pulmonary TB patients in this area.

4.1 Macronutrients

The overall daily energy and protein consumption were insufficient among these TB patients. The overall deficit when compared with the RDA, was 76%. However, when compared to the recommended intake for TB patients as per the Guidance document for Nutritional care and support for TB patients in India, the deficit was present in a higher proportion of patients, i.e. 81.5%. This difference is because the requirement for TB patients is higher than an average healthy individual. The deficit in the intake of energy was present across all age groups but higher among the elderly (>60 years of age), 100% of them being energy deficient. Higher energy deficiencies have also been reported by Ren et al., in the older age group of 50-64 years among the TB patients.[35] As the body ages, so does the immune system.[36] There is strong evidence that a poorly functioning immune system can lead to reduced tolerance to diseases

Table 3. Dietary intakes of new sputum smear positive patients in Puducherry at the time of diagnosis (N=173)

Nutrient	Median (IQR)	Deficiency		
		n	%	95% CI
Macronutrients				
Energy (Kcals/day)	1414.3 (458.4) *	167	96.53	69.3-82.4
Energy/kg body weight (Kcals/day)	28.8 (10.4) *	144	83.2	76.8-88.5
Protein (g/day)	43.2 (30-60.3)	122	70.52	86.1-95.1
Protein/kg body weight	0.8 (0.6-1.2)	127	73.4	66.2-79.8
Micronutrients				
Iron (mg)	11.3 (7.9-14.6)	158	91.3	86.1-95.1
Calcium (mg)	337.8 (248.0-447.9)	166	96.0	91.8-98.4
Vitamin C (mg)	28.1 (14.9-39.4)	133	76.9	69.9-82.9
Vitamin B12(ug)	0.1 (0.0-0.1)	172	99.4	96.8-99.9
Folic acid (ug)	2.8 (0.0-5.7)	173	100.0	97.8-100

*Mean (SD); Mean (SD): Mean (Standard Deviation); Kcal/day: Kilocalories per day; g/day: Gram per day; mg: milligram; μg: microgram

and infections. Infections of all kinds raise the metabolic rate, making it harder for older people to consume enough to satisfy high energy demands.[37] TB being an infectious disease, patients need additional energy to sustain body function due to an increased basal metabolic rate (BMR), which contributes to weight loss.[22] Energy consumption in TB patients may also be adversely affected due to reduced appetite and gastrointestinal disorders.[35] We found that energy deficiency was higher among smokers and those who consumed alcohol. There is evidence to support the theory that smokers tend to increase their intake of alcohol and make dietary choices.[38] In general, alcohol also inhibits the natural breakdown of nutrients in many ways. In our study setting, most of the male participants tend to be smokers and alcohol users, hence, inadequacy in energy intake was observed among males.

According to RDA reference range, the diets of 70.5% of the study participants were found to be protein deficient. The prevalence of protein deficit in the diets of the elderly was 64% higher than other age groups. Also, the prevalence of protein deficiency among undernourished was 37% higher than the obese persons, which was statistically significant. To gain weight and increase body mass, a protein intake of 1.2 to 1.5 g/kg of ideal/desirable body weight per day is needed in patients with TB.[22]

Diets of TB patients in our study were found to be a deficit in calories and protein maybe because most of them did not consume the required portions of protein-rich foods such as milk and milk products, legumes, poultry, eggs, and meat. Reduced energy and protein intake were associated with immune system alteration and increases the severity of the disease. Protein deficiency not only damages the immune system but often delays recovery during ATT. Thus, the deficiencies in the intake needs to be corrected for better outcomes of TB treatment.

4.2 Micronutrients

Micronutrients are required in all metabolic and development processes.[33] In patients with tuberculosis, vitamin deficiency is common.[39] Prior studies performed in various countries have shown low intakes of essential nutrients. Most of these studies were conducted in serum samples to establish the relationship between the status of micronutrients and the outcome of tuberculosis treatment whereas we aimed to find the dietary intake. The micronutrients we assessed in the diets of TB patients are iron, calcium, vitamin C, vitamin B12, and Folic acid. Though the prevalence of dietary deficiency was high in all age groups, almost all of these micronutrients were absent in the diets of the elderly TB patients.

Iron intake was found to be lesser than the RDA in 91.3% of the study participants. There was 4% higher prevalence of dietary deficiency in a smaller family as compared to a family with more than four members. In all three groups, anemia was also found to be higher. One of the main reasons for anemia among TB patients is the deficiency in the intake of iron-rich food. Nearly, 63% of the study participants were found to be anemic which is consistent with the finding of their dietary intake.

Calcium deficit in the diet was also widely prevalent (96%) among the study participants and still higher in the elderly as compared to the other groups (100%), though not statistically

Table 4. Deficiency in the intake of macronutrients among new sputum smear positive patients at the time of diagnosis (N=173)

Variables	N	Energy deficient	UPR (95% CI)	APR (95% CI)	P-value	Protein deficient	UPR (95% CI)	APR (95% CI)	P-value
		n (%)				n (%)			
Age group (in years)									
18-30	36	32 (88.89)	1	1	1	19 (52.8)	1	1	1
31-60	122	119 (97.54)	1.09 (0.97-1.23)	1.08 (0.97-1.20)	0.119	90 (73.8)	1.39 (1.00-1.93)	1.24 (1.02-1.50)	**0.02**
>60	15	15 (100)	-	-	-	13 (86.7)	1.64 (1.13-2.37)	1.40 (1.11-1.76)	**0.00**
Gender									
Female	46	42 (91.30)	1	1	1	30 (65.2)	1	1	1
Male	127	124 (97.64)	1.06 (0.97-1.17)	1.06 (0.97-1.16)	0.182	92 (72.4)	1.11 (0.87-1.40)	-	-
Occupation									
Employed	124	119 (95.97)	1.00 (0.93-1.07)	-	-	85 (68.5)	1	1	1
Unemployed	49	47 (95.92)	1	1	1	37 (75.5)	1.10 (0.90-1.34)	-	-
Family size									
Up to 4	140	135 (96.43)	1.02 (0.93-1.12)	-	-	20 (60.6)	1	1	1
More than 4	33	31 (93.94)	1	1	1	102 (72.9)	1.20 (0.89-1.61)	-	-
Ration Card									
APL	108	103 (95.37)	1	1	1	72 (66.7)	1	1	1
BPL	65	63 (96.92)	1.01 (0.95-1.07)	-	-	50 (76.9)	1.15 (0.95-1.39)	1.14 (0.99-1.31)	0.05
Alcohol intake									
No	95	90 (94.74)	1	1	1	67 (70.5)	1.00 (0.82-1.21)	-	-
Yes	78	76 (97.44)	1.02 (0.96-1.09)	0.98 (0.95-1.01)	0.437	55 (70.5)	1	1	**1**
Smoking status									
No	105	100 (95.24)	1	1	1	72 (68.6)	1	1	1
Yes	68	66 (97.06)	1.01 (0.96-1.08)	0.97 (0.94-1.01)		50 (73.5)	1.07 (0.88-1.30)	-	-
Self-reported DM									
Absent	92	86 (93.48)	1	1	1	61 (66.3)	1	1	1
Present	81	80 (98.77)	1.05 (0.99-1.12)	-	-	61 (75.3)	1.13 (0.93-1.37)	1.07 (0.93-1.24)	0.32
BMI									
Underweight	72	69 (95.83)	1	1	1	56 (77.8)	1.29 (0.91-1.82)	1.29 (1.05-1.60)	**0.01**
Normal	76	73 (96.05)	1.00 (0.93-1.07)	-	-	51 (67.1)	1.11 (0.7-1.59)	1.08 (0.87-1.33)	0.44
Obese/Overweight	25	24 (96)	1.00 (0.91-1.09)	-	-	15 (60.0)	1	1	1

BPL below poverty line, APL above poverty line, 1=Reference range, UPR=Unadjusted prevalence ratio, APR=Adjusted prevalence ratio, DM=Diabetes Mellitus, BMI=Body Mass Index, Underweight <18.5 kg/m^2 ; Normal 18.5-22.9 kg/m2 ; Overweight 23-24.9 kg/m2; Obesity ≥25 kg/m2

Table 5. Deficiency in the intake of vitamin C among new sputum smear positive patients at the time of diagnosis (N=173)

Variables	N	Calcium	UPR (95% CI)	P-value	Iron	UPR (95% CI)	P-value	Vitamin C	UPR (95% CI)	P-value
		n (%)			n (%)			n (%)		
Age group										
18-30	36	33 (91.7)	1	1	33 (91.7)	1.01 (0.91-1.14)	0.777	28 (77.8)	1	1
31-60	122	118 (96.7)	1.05 (0.95-1.17)	0.311	110 (90.2)	1	1	91 (74.6)	1.04 (0.85-1.27)	0.68
>60	15	15 (100)	-	-	15 (100)	-	-	14 (93.3)	1.25 (1.05-1.48)	**0.01**
Gender										
Female	46	43 (93.5)	1	1	46 (100)	-	-	39 (84.8)	1	1
Male	127	123 (96.9)	1.03 (0.95-1.12)	0.40	112 (88.2)	1	1	94 (74.0)	1.14 (0.97-1.34)	0.09
Occupation										
Employed	124	118 (95.2)	1	1	109 (87.9)	1	1	94 (75.8)	1	1
Unemployed	49	48 (98.0)	1.02 (0.97-1.08)	0.31	49 (100)	0.87 (0.82-0.93)	**0.00**	39 (79.6)	1.04 (0.88-1.24)	0.58
Family size										
More than 4	33	31 (93.9)	1	1	29 (87.9)	1	1	27 (81.8)	1.08 (0.89-1.30)	0.41
Up to 4	140	135 (96.4)	1.02 (0.93-1.12)	0.57	129 (92.1)	1.04 (0.91-1.20)	0.49	106 (75.7)	1	1
Ration Card										
APL	108	104 (96.3)	1.00 (0.94-1.07)	0.77	99 (91.7)	1.00 (0.91-1.11)	0.84	83 (76.9)	1	1
BPL	65	62 (95.4)	1	1	59 (90.8)	1	1	50 (76.9)	1.00 (0.84-1.18)	0.99
Alcohol intake										
No	95	91 (95.8)	1	1	88 (92.6)	1.03 (0.9-1.133)	0.509	55 (70.5)	1	1
Yes	78	75 (96.2)	1.00 (0.94-1.06)	0.90	70 (89.7)	1	1	78 (82.1)	1.16 (0.98-1.38)	0.08
Smoking status										
No	105	101 (96.2)	1.00 (0.94-1.07)	0.847	92 (92.4)	1.02 (0.93-1.13)	0.555	83 (79.0)	1.07 (0.90-1.27)	0.41
Yes	68	65 (95.6)	1	1	61 (99.7)	1	1	50 (73.5)	1	1
Self-reported DM										
Absent	9	87 (94.6)	1.03 (0.97-1.09)	0.31	85 (92.4)	1.02 (0.93-1.12)	0.60	68 (73.9)	1	1
Present	81	79 (97.5)	1	1	73 (90.1)	1	1	65 (80.2)	1.0 (0.92-1.27)	0.32
BMI										
Underweight	72	70 (97.2)	1.05 (0.93-1.19)	0.37	68 (94.4)	1.12 (0.93-1.34)	0.20	52 (72.2)	1	1
Normal	76	73 (96.1)	1.04 (0.92-1.18)	0.49	69 (90.8)	1.08 (0.8-1.301)	0.41	60 (78.9)	1.09 (0.90-1.31)	0.34
Obese/Overweight	25	23 (92.0)	1	1	21 (84.0)	1	1	21 (84.0)	1.16 (0.93-1.45)	0.18

BPL below poverty line, APL above poverty line, 1=Reference range, UPR=Unadjusted prevalence ratio, APR=Adjusted prevalence ratio, DM=Diabetes Mellitus, BMI=Body Mass Index, Underweight <18.5 kg/m^2 ; Normal 18.5-22.9 kg/m2 ; Overweight 23-24.9 kg/m2; Obesity ≥25 kg/m2

significant. Calcium plays an important role in TB recovery as a large amount of calcium is needed for the calcification of lesions, so calcium deficiency can lead to delayed recovery.[33] Although the study population belongs to the coastal area where sufficient marine foods are taken, they were not taken in good quantities in these patients.

Nearly 76.9% of the study participants were found to be having vitamin C deficient diets., the prevalence being 25% higher among the elderly and also among the female participants in the study. Studies have indicated the role of Vitamin C in the prevention and treatment of TB through oral administration. A Safarian et al, 1990 in his study reported that the administration of vitamin C along with alpha-tocopherol, sodium nucleate, and anti-tubercular therapy, contributed to higher rates of smear conversion and shorter periods for cavity closures.

Of all the selective micronutrients assessed, vitamin B12 (99%) and Folic acid (100%), were almost universally deficient in the diets of the study participant. Clinical deficiencies in folate and Vitamin B12 are mainly due to inadequate dietary intake or, in the case of vitamin B12 deficiency in the elderly, poor absorption. Folate is found in legumes, green leafy vegetables, and certain fruits at high concentrations. The natural source of vitamin B12 are fish, meat, milk, and dairy products, so deficiency is prevalent as the consumption of these foods was limited among these TB patients.

Though studies on the nutritional status of TB patients are plenty, this to our knowledge is the first attempt at describing the nutritional intakes of TB patients and the factors associated with deficiencies of nutrients in the diet of TB patients in India. But the measurements may not be very accurate as the possibility of recall bias cannot be ruled out in the assessment of dietary intake carried out by 24-hour recall. Recall bias can result in an underestimation of nutrient intakes. Some studies reported that 24-hour recall is not enough to assess whether patients have insufficient nutrient intakes.[40] For the precise calculation of dietary practice, weighment of the food items can be a better method. The other limitation in our study is that it describes the dietary pattern of TB patients from an urban area, which may not be same as that of rural area accounting to the availability of food and cost. The guidance document on Nutritional care and support for patients with TB in India recommends supplementation with micronutrients,[22] this has not been widely implemented yet under the NTEP. The need is urgent to improve the outcomes of ATT and fasten the progress towards achievement of the END TB goals by World Health Organization (WHO) and by the Government of India.[22]

5. Conclusion

Overall, TB patients in Puducherry were found to be having a low dietary intake of macro, and micro-nutrients. As tuberculosis has a devastating effect on the body's immunity and metabolism, the dietary intake of patients with TB should be monitored during ATT. Even though the government has taken initiatives like direct fund transfer to the patient's account, credited money may not be utilized for the right purpose. Therefore, dietary counseling along with vitamin supplementation in the right dosage can be advised and monitored.

6. Recommendation

The participants of the study are from South India, where daily food consumption has its nutritional benefits like consumption of fermented food like idly and dosa. Fermentation improves the probiotic properties, vitamins C, B, and B12 of the cooked food. The South Indian diet, which is primarily based on rice, includes a limited amount of protein, fibre, and micronutrients, but is high in carbohydrates. An adequate amount of these foods can make up for the deficit in calories and to an extent the micronutrients. However, protein intake needs to be improved through cheaper sources of protein like pulses, groundnuts, and if possible through intake of boiled eggs, steamed fish, and meat. Polished white rice which is consumed by the majority of south Indian population, can be replaced with red unhusked rice which is nutritious. Intake of fruits needs to be increased with seasonal and budget-friendly fruits like guavas, sweet lime, and bananas.

The method of preparing food and blending ingredients is more important than consuming nutritious food. Patients with TB should avoid eating more oily foods, especially deep-fried foods that are available in hotels. As calcium can impede the absorption of iron, calcium-rich food should not be taken together with iron-rich food. Meals can be taken as six small meals instead of three as nausea, vomiting, and loss of appetite are frequently reported among TB patients.

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