Nutritional status of tuberculosis patients, a comparative cross-sectional study

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Abstract

Background Each year, more than 13.7 million people became an active case of tuberculosis and more than 1.5 million cases of tuberculosis patient will die. The association between tuberculosis and malnutrition is bi-directional, tuberculosis leads the patient to malnutrition, and malnutrition increases the risk of developing active tuberculosis by 6 to 10 times higher. Improving the nutrition of individual greatly reduces tuberculosis. The objectives of this study were to assess the nutritional status and determinants of tuberculosis patients. Methods A comparative cross-sectional study design was implemented. The sample size was calculated using Epi-info software. The data were collected from July 2015- May 2018. The data were collected by interviewing method, measuring anthropometrics indicators and collecting the stool and blood samples. The data were entered into the computer using Epi-info software and analyzed using SPSS software. Descriptive statistics were used to identify the proportion of malnutrition. Binary logistic regression was used to identify the determinants of malnutrition. Results A total of 5045 study participants were included giving the response rate of 93.1%. The prevalence of underweight among tuberculosis patients was 57.17% (95% CI: 54.80% -59.54%) and 88.52% of tuberculosis patients were anemic. The prevalence of malnutrition (underweight) among tuberculosis free residents was 23.37% (95% CI: 21.93-24.80). The nutritional status of tuberculosis patients were determined by site of infection AOR: 0.68[0.49-0.94], sex of the patient AOR: 0.39 [0.25-0.56], residence AOR: 3.84 [2.74-5.54], intestinal parasite infection AOR: 7 [5.2-9.95], alcohol use disorder AOR: 1.52 [1.17-2.13]. Conclusion High proportion of tuberculosis patients was malnourished. Tuberculosis patients were highly susceptible to malnutrition and even a very distal factor for malnutrition in the community became a proximal factor for tuberculosis patients.

Background

Underweight is a malnutrition stage in which the body mass index(BMI) of adult scores less than 18.5 cut points[1, 2]

TB is an infectious chronic inflammatory disease caused by mycobacterium species. World health organization estimates that each year 10 million incident cases of tuberculosis were affected and 1.3 million people have died as a result of tuberculosis [3]. The association between TB and malnutrition is bi-directional, TB leads the patient to malnutrition, and malnutrition increases the risk of developing active TB by 6 to 10 times higher [4-10]. One-quarter of TB in the world was as a result of malnutrition, improving the nutritional status of clients decreases the risk of TB [11]. Malnutrition not only increases the risk of morbidity associated with tuberculosis, it also increases the mortality associated with tuberculosis. Nutritional status of TB patients predicts mortality associated with TB [12-14].

The treatment outcome of TB patients can be improved by studying their nutritional status [12, 15]. Good nutritional status during DOTS leads to successful treatment outcomes [16-20]. Nutritional supplementation during DOTS increases the probability of good treatment outcome in TB patient and

improves the survival of the patients [21-24]. Malnutrition increases the risk of relapse and death [13, 15, 24-27].

The prevalence of malnutrition in South American content ranges from 20 % - 50 %[28, 29],

in the Asian continent malnutrition among TB patients ranges from 68.6 % - 87 % [10, 15] and in the United Kingdom the body mass index of TB patients 13% lower than the general community [30]. In the African continent, malnutrition among TB patients ranges from 29 % to 61 % [13, 20, 31-34].

The nutritional intervention part of TB treatment was neglected. Decision makers were not giving priority for the nutritional intervention because of the absence of information regarding their nutritional status. This study will give baseline information to give attention to the nutritional intervention part of TB treatment.

The objectives of this research were to estimate and compare the proportion of underweight and their determinants among the TB patients in a resource-limited setting.

Methods

A comparative cross-sectional study design was implemented. This study was conducted in Amhara regional state of Ethiopia. The region contain 25 000000 population and every year more than 25 000 tuberculosis cases were reported from the health facilities. The target population was TB patients receiving the directly observed therapy in the health centers of the Amhara region. TB patients unable to communicate properly were excluded. The nutritional status of TB patients was compared with TB free residents. The sample size was calculated using Epi-info software version 7 assuming 95 % CI, 90 % power, 50 % proportion of malnutrition in TB patients, TB patients to TB free resident's ratio of 3, design effect of 2 and a 5 % non-response rate. Finally, the estimated sample size was 1806 TB patients and 3612 TB free residents. Systematic random sampling procedures were used to selected TB patients. Patient under Directly observed therapy (DOTS) from selected governmental health facility of the region was included using systematic random sampling. Ethiopia adapts the tree health tier system; primary level health care (including the health center and district hospital and expected to serve up to 100000 population), secondary level health care (includes the general hospital and expected to serve up to 1.5 million population) and the tertiary level health care (includes the specialized referral hospitals and expected to serve up to 5 million people). TB free residents were selected from the community from the nearby house of the TB patients. The data were collected from July 2015- May 2018.

The data were collected using an interview technique, measuring anthropometric indicators and collecting the stool and blood samples. For the interview part first, the questionnaire was prepared in English then translated to Amharic (local language) then back to English to keep its consistency. The interview was conducted by 30 diploma nurse professionals and supervised by 8 first degree holder health professionals. Weight and height of each study participants were measured by clinical nurses. Digital weight scale was used to measure the weight of each study participant and weight was measured

to the nearest 0.1 kilograms. Height was measured using the vertical measuring rod to the nearest 0.1 cm. The participants' shoes, hair clips, and braids were removed during the measurement, participants were positioned feet together, feet flat on the ground, heels touching the back plate of the measuring instrument, legs straight, buttocks against the backboard, scapula against the backboard and arms were loosely at their side[1, 35].

The blood and stool samples were collected by 13 first degree holder laboratory technologists and supervised by second-degree holder laboratory technologists. From each study participants, one gram stool sample was collected in 10 ml SAF (sodium acetate-acetic acid-formalin solution) and transported with a preservative to the regional laboratory. A concentration technique was used. The stool samples were well mixed and filtered using a funnel with gauze then centrifuged for one minute at 2000 RPM (revolution per minute) and the supernatant was discarded. 7 ML (Milliliter) normal saline was added, mixed with a wooden stick, 3 ML ether was added and mixed well then centrifuged for 5 minutes at 2000 RPM. Finally, the supernatant was discarded and the whole sediment was examined for parasites. 5 ML blood sample was collected from study participant following standard operating procedures to measure the hemoglobin level and the red cell indices of patients using Mindray hematology analyzer[36]. CAGE tool was used to assess the problematic alcohol intake. Study participants unable to read and write were labeled as illiterate.

To maintain the quality of the data pretest was conducted, training was given for data collectors and supervisors. The whole data collection process was closely supervised by the investigators and supervisors.

The data were entered in the computer using Epi-info software transferred into SPSS software version 20 and WHO Anthro-plus software for the analysis. Descriptive statistics were used to identify the proportion of malnutrition. Binary logistic regression was used to identify the determinants of malnutrition. Variables with a p-value less than 0.05 were declared as predictors of malnutrition. Body mass index was used to assess the nutritional status. BMI was computed as = weight (in kilogram)/ (height in meter) ^{2}. BMI less than 18.5 was considered as underweight[1].

Ethical clearance was obtained from the University of Bahir Dar ethical review committee. Formal permission was obtained from Amhara National Regional State Health Bureau ethics committee and the respective authorities. Written informed consent was obtained from each study participants. The confidentiality of the data was kept at all steps. Study participants the right to withdraw from the study at any points were respected. Study participants with intestinal parasites or low hemoglobin counts were linked to the nearby health facility.

Results

A total of 5045 study participants were included giving for the response rate of 93.1 %, 286 study participant were not volunteer to be participated and 87 study participants were excluded due to

incomplete data. The mean age of the study participants was 28 years (standard deviation [SD] ±14 years), the age of youngest participant was 18 years, 1681 of the study participants was TB patients and 3364 of the study participants was TB free residents. Female constitute 53.9 % (2721) of the study participants, 26% of the study participants were from urban residents, 90% of the study participants were Amhara by ethnicity and 96.7% of the study participants were orthodox Christian believers.

Profile of TB patients

A total of 1681 TB patients were included giving for the response rate of 93 %. The mean age of the study participants was 27.78 years (SD ±13.98 years), 42.3 % of TB patients were from the urban region and 76.8 % of TB patients were pulmonary TB patients (Table 1).

Table 1: Profile of TB patients (n=1681).

S[i][1]	*Population profile*		*Frequency*	*Percentage*
1.	Sex	Male	1162	69.1
		Female	519	30.9
2.	Residence	Urban	711	42.3
		Rural	970	57.7
3.	Site of infection	Pulmonary tuberculosis	1297	76.8
		Extra-pulmonary TB	390	23.2
4.	HIV status	Positive	595	35.2
		Negative	1089	64.8
5.	Income in birr[2]	<1000	1170	69.6
		1000-2000	316	18.8
		≥2001	195	11.6
6.	Occupation	Farmer	835	49.7
		Others	846	50.3
7.	Family size	≤4	648	38.5
		>4	1033	61.5
8.	Marital status	Single	694	41.3
		Married	966	57.5
		Divorced	18	1.1
		Widowed	3	0.2
9.	Anemia	Present	1488	88.5
		Absent	193	11.5
10.	Age	<25	1350	80.3
		≥25	331	19.7
11.	Intestinal parasitic infection	*Ascaris Lumbricoides*	409	24.3
		Hookworm	282	16.8
		Strongloid stercolaris	75	4.5
		Others	127	7.6
		Not infected	788	46.9

The prevalence of underweight among TB patients was 57.17 % (95% CI: 54.80 % -59.54 %), 88.52 % of TB patients were anemic (95% CI: 86.99 %- 90.04 %) and 48.25% (718) of anemia was the result of iron deficiency anemia (Table 2).

Table 2: The type of anemia among TB patients (n=1488)

			Mean corpuscular volume (MCV)				
			Normocytic	**Microcytic**	**Macrocytic**	**Total**	
						No.	**%**
Mean corpuscular hemoglobin concentration (MCHC)	**Normocromic**		672	15	6	693	46.57
	Hypocromic		15	718	4	737	49.53
	Hypercromic		14	12	32	58	3.90
	Total	**No.**	701	745	42	1488	100
		%	47.11	50.07	2.82	100	

Table 3: Malnutrition predictors in TB patients (n=1681).

Variables		Malnutrition		COR[1] [95 % CI]	AOR[2] [95% CI]	p-value
		Underweight	Normal			
Type of TB	Pulmonary TB	735	556	0.96 [0.76 - 1.21]	0.68[0.49-0.94]	0.02
	Extra-pulmonary TB	226	164	Reference	Reference	
Sex	Male	635	527	0.71[0.58 - 0.88]	0.39 [0.25-0.56]	<0.01
	Female	326	193	Reference	Reference	
Residence	Urban	493	218	2.43 [1.98 – 2.98]	3.84 [2.74-5.54]	<0.01
	Rural	468	502	Reference	Reference	
Educational status	Literate	756	544	1.19 [0.95 – 1.5]	0.72 [0.52-1.02]	0.06
	Illiterate	205	176	Reference	Reference	
Intestinal parasitic infection	Present	658	235	4.48 [3.64 – 5.51]	7 [5.2-9.95]	<0.01
	Absent	303	485	Reference	Reference	
Alcohol intake	Yes	430	277	1.29 [1.06 – 1.58]	1.52 [1.17-2.13]	<0.01
	No	531	443	Reference	Reference	
Anemia	Present	834	654	0.66 [0.48 – 0.91]	3.23 [1.89-5.51]	<0.01
	Absent	127	66			
Age	≥25	124	207	0.37 [0.29 – 0.47]	0.31 [0.21-0.46]	<0.01
	<25	837	513	Reference	Reference	
HIV infection	Positive	285	307	0.57 [0.46 – 0.70]	1.96 [1.47-2.7]	<0.01
	Negative	676	413			
Family size	≥4	812	221	12.30 [9.65 – 15.69]	15.75 [11.58-21.42]	<0.01
	<4	149	499			
Believe in avoiding a certain type of food	Yes	588	209	3.85 [3.13 – 4.74]	3.19 [2.37-4.31]	<0.01

No	373	511

After adjusting for type of tuberculosis, sex, residence, educational status, intestinal parasitic infection, alcohol intake, age, HIV infection, family size, belief in avoiding a certain type of foods, income, smoking, and occupation; the following results were obtained: The odds of malnutrition among extra pulmonary TB patients were 47 % higher than pulmonary TB patients (AOR 0.68: [95% CI; 0.49-0.94]. In female TB patients, the odds of malnutrition were 2.56 higher than male. (AOR: 0.39 [95% CI; 0.25-0.56]). The odds of malnutrition among TB patients were 3.84 folds higher in the urban areas (AOR 3.84 [95% CI: 2.74-5.54]). The odds of malnutrition were 7 folds higher among intestinal parasites positive TB patients (AOR 7: [95% CI: 5.2-9.95]). Alcoholic TB patients had 1.52 folds higher risk of malnutrition (AOR 1.52: [95% CI: 1.17-2.13]). Anemia increases the odds of malnutrition by 3.23 folds higher in TB patients (AOR 3.23: [95% CI; 1.89-5.51]). The odds of malnutrition was 3.23 higher in TB patients whose age was greater than 25 years (AOR 0.31 [95% CI; 0.21-0.46]). The odds of malnutrition were 1.96 folds higher among HIV positive TB patients (AOR 1.96: [95% CI; 1.47-2.7]). The odds of malnutrition were 15.75 folds higher among TB patients with high family size (AOR 15.75: [95% CI; 11.58-21.42]). Believe in avoiding certain types of food increase the odds of malnutrition by 3.19 folds higher (AOR 3.19: [95% CI: 2.37-4.31]). (Table 3).

Profile of TB free study participants

A total of 3364 TB free study participants were included giving for the response rate of 93.13 %. The mean age of the study participants was 28.3 years (SD ±14.03 years). Female constitute 65.5 % of the study participants, and 81.8% of the study participants were from rural areas (Table 4).

Table 4: Profile of TB free study participants (n=3364)

SN	Population profile		Frequency	Percentage
1.	Sex	Male	1162	34.5
		Female	2202	65.5
2.	Residence	Urban	611	18.2
		Rural	2753	81.8
3.	HIV status	Positive	31	0.9
		Negative	3333	99.1
4.	Income in birr	<1000	2558	76
		1000-2000	316	9.4
		≥2001	490	14.56
5.	Occupation	Farmer	507	15.1
		Others	2857	84.9
6.	Smoking	Yes	88	5.2
		No	1593	94.8
7.	Family size	≤4	151	4.5
		>4	3243	95.5
8.	Marital status	Single	1474	43.8
		Married	1854	55.1
		Divorced	33	1
		Widowed	3	0.1
9.	Anemia	Present	1742	51.8
		Absent	1642	48.2
10.	Age in years	<25	2622	77.9
		≥25	742	22.1
11.	Intestinal parasitic infection	Ascaris Lumbricoides	530	15.8
		Hookworm	401	11.9
		Strongloides stercolaris	99	2.9
		Others	433	12.9
		Not infected	1901	56.5

Malnutrition in the TB free residents

The prevalence of malnutrition (underweight) among TB free was 23.37 % (95% CI: 21.93-24.80). The prevalence of anemia was 51.78 % (95 % CI: 50.09% - 53.47%). The predominant type of anemia was Normocromic Normocytic accounting for 63.32 %, followed by Hypocromic Microcytic anemia 32.72 %.

Table 5: The type of anemia among TB free residents (n=1742)

		Mean corpuscular volume (MCV)			
		Normocytic	**Microcytic**	**Macrocytic**	**Total**
Mean corpuscular hemoglobin concentration (MCHC)	**Normocromic**	1103	11	6	1120
	Hypocromic	2	570	4	576
	Hypercromic	2	12	32	46
	Total	1107	293	42	1742

Table 6: Predictors of malnutrition among TB free residents (n=3364)

Variables		Malnutrition		COR [95 % CI]	AOR [95% CI]	p-value
		Underweight	Normal			
Smoking	Yes	21	119	0.57 [0.34 – 0.93]	0.64 [0.39-1.05]	0.076
	No	765	2459			
Sex	Male	311	851	1.33 [1.12 – 1.57]	2.5[1.72-3.63]	<0.01
	Female	475	1727			
Residence	Urban	160	451	1.21 [0.98 – 1.48]	0.89 [0.71 – 1.13]	0.34
	Rural	626	2127			
Income	<2000 birr	734	2442	0.79 [0.56 – 1.11]	1.434 [1.00 – 2.06]	0.06
	≥2000 birr	52	136			
Intestinal parasitic infection	Present	471	992	2.39 [2.02 – 2.82]	3.07 [2.38 – 3.96]	<0.01
	Absent	315	1586			
Alcohol intake	Yes	251	878	0.91 [0.76 – 1.08]	1.07 [0.88 – 1.29]	0.53
	No	535	1700			
Anemia	Present	267	1475	0.38 [0.32 – 0.46]	7.82 [5.74 – 10.63]	<0.01
	Absent	519	1103			
Age	≥25	148	594	0.77 [0.63 – 0.95]	0.73 [0.59 – 0.91]	<0.01
	<25	638	1984			
HIV infection	Positive	16	15	3.55 [1.66 – 7.61]	4.51 [2.13 – 9.53]	<0.01
	Negative	770	2563			
Family size	≥4	36	115	1.03 [0.69 – 1.53]	0.96 [0.63 – 1.43]	0.81
	<4	750	2463			
Believe in avoiding a certain type of food	Yes	447	1283	1.33 [1.13 – 1.57]	0.87 [0.73 – 1.05]	0.14
	No	339	1295			

After adjusting for sex, residence, educational status, intestinal parasitic infection, alcohol intake, age, HIV infection, family size, believe in avoiding a certain type of food, income, smoking, and occupation; the following results were obtained :

The odds of malnutrition were 2.5 folds higher in male (AOR 2.5: [95% CI; 1.72-3.63]). Intestinal parasitic infection increases the odds of malnutrition by 3 folds higher (AOR 3.07: [95% CI; 2.38 – 3.96]). The odds of malnutrition were 7.82 folds higher among anemic patients (AOR 7.82: [95% CI; 5.74 – 10.63]). The odds of malnutrition among study participants whose age was ≥25 years was 27 % lower (AOR 0.73 [95% CI; 0.59 – 0.91]). HIV infection increases the odds of malnutrition by 4.51 folds higher (AOR 4.5:1 [95% CI; 2.13 – 9.53]). (Table 6).

[1] SN=serial number

[2] 1 US dollar =23 birr

[1] COR= crude odds ratio

[2] AOR= adjusted odds ratio

Discussion

The prevalence of underweight among TB patients was 57.17 %; the prevalence of underweight among TB free residents was 23.37 %. This proportion was statistically significant (X^2 565.8, P-value <0.01). This finding indicates that 33.8 % excess malnutrition was observed as a result of tuberculosis. This is because TB infection increases the anabolic process and consumes additional energy[37], additionally, TB infection manifests with a reduction in appetite, nutrient malabsorption, finally increasing the risk of underweight [38].

The prevalence of anemia among TB patients was 88.52 %; the prevalence of anemia among TB free residents was 51.78 %. TB patients had 36.74 % excess burden of anemia as compared to the residents. This results was statistically significant at X^2 656.7 p-vale <0.01. This is due to the effect of TB on red blood cell production like decreasing the erythrocyte lifespan, poor erythrocyte iron incorporation, and decreased sensitivity to or supply of erythropoietin[39].

The odds of malnutrition among extra pulmonary TB patients were 47 % higher than pulmonary TB patients. This finding was in line with finding from Nepal [40]. This is due to the reason that the diagnosis of extra-pulmonary TB is not easy as compared to pulmonary TB and patients were not early detected for the intervention [41]The odds of malnutrition were 2.5 times higher in female TB patients.. This finding agrees with finding from Ghana [15]. This is due to the reason that the severity of TB was more virulent in female [42]. Additionally Male could have better access to food compared to female who might need to prioritize their families, especially their children.

The odds of malnutrition among TB patients were 3.84 folds higher in the urban areas. This finding disagrees with finding from India [43]. This is due to the reason that most urban residents in Ethiopia

were living in the overcrowded condition [44].

The odds of malnutrition were 7 folds higher among intestinal parasites positive TB patients. This finding agrees with finding from Butajira [45]. This is due to the fact that intestinal parasites decrease the food intake, interfere with the absorption of nutrients and also they share the host nutrients [46].

Alcoholic TB patients had 1.52 folds higher risk of malnutrition. This finding agrees with research finding from Tanzania [47]. This is due to the reason that alcoholic patients eat poorly, had poor digestion, storage, utilization, and excretion of nutrients [48].

Anemia increases the odds of malnutrition by 3.23 folds. This finding agrees with finding from Brazil [49]. This is due to the effect of red blood cells in the transportation of nutrients and minerals [50].

The odds of malnutrition were 3.23 folds higher among tuberculosis patients whose age was greater than 25 years. This finding agrees with finding from Ghana [34]. This is due to the reason that the risk of co morbid illness like non-communicable diseases was the higher age [51].

The odds of malnutrition were 1.96 folds higher among HIV positive TB patients. This finding agrees with finding from Tanzania [47]. This is due to the reason that HIV positive patients were not economically productive so that they can't get the access to the different variety of foods [52], HIV positive patients have a poor appetite, poor absorption of nutrients [53, 54].

The odds of malnutrition were 15.75 folds higher among TB patients with high family size. This finding agrees with finding from India [15]. This is due to the fact that high family size decreases the household income leading to the low dietary intake of household members [55].

Believe in avoiding a certain types of food increase the odds of malnutrition by 3.19 folds higher. This finding was in line with finding from Ghana[56]. This is due to the reason that patients will not take important nutrients due to their behavior of avoiding that type of food [57].

Family size and believe in avoiding a certain type of food were not the predictors of malnutrition among the tuberculosis-free residents, but these variables were the predictors of malnutrition among TB patients. These indicate that TB patients are very susceptible to malnutrition even the very distal factor for malnutrition in the community became a proximal factor for TB patients.

The limitation of the study might be related to the cross sectional nature of the study which makes difficult to identify whether the exposure precedes the outcome However this limitation works only for modifiable variables thought time.

Conclusion

A very high proportion of TB patients were malnourished. TB patients were highly susceptible to malnutrition and even a very distal factor for malnutrition became proximal for TB patients. The

nutritional status of TB patients was affected by the site of infection, sex, residence, intestinal parasite infection, alcohol.

Recommendation

The directly observed treatment strategy for TB intervention should consider additional nutritional support for the patients. Because significant proportions of TB patients were malnourished, they can't afford access to nutritional rich foods and administering the anti-TB drugs alone will decrease the treatment success rate. Also, the guideline should consider iron supplementation and deworming as part of the treatment of tuberculosis.

Abbreviation

AOR: adjusted odds ratio

COR: crude odds ratio

BMI-Body Mass Index

CI-Confidence Interval

DOTS-Directly Observed Treatment Strategy

H.nana- Hemnolephus Nana

HC-Health Center

IT-Information Technology

MDR-TB-Multidrug Resistance Tuberculosis

ML-Milliliters

MCHC: Mean corpuscular hemoglobin concentration

MCV: Mean corpuscular volume

OPD –Out Patient Department

OR-Odds Ratio

RPM-Revolution per Minute

SAF-Sodium Acetate Acetic Acid Formulation

SD-Standard Deviation

SPSS-Statistical Soft Ware for Social Science

TB-TB

USA-United State of America

WHO-World Health Organization

Declarations

Ethics approval and consent to participate

Ethical clearance was obtained from the Bahir Dar University ethical review committee. Permission to conduct the study was also obtained from the Amhara national regional state health bureau. Written consent was obtained from each patient.

Consent for publication

Not applicable

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declares that they have no competing interests

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Author contribution

BEF and TEF conceived the experiment; BEF, FB and TEF performed the experiment, plan the data collection process, analyzed and interpreted the data. BEF, FB and TEF wrote the manuscript and

approved the final draft for publication.

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