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Prevalence and Risk Factors of Malnutrition among Tuberculosis Patients at National Program for the Control of Tuberculosis and Respiratory Disease in Sana'a City – Yemen

Aisha Faisal Ahmed Al-Wadhaf
aishaalwadhaf@gmail.com
Al-Razi University
Fawz Mohammed Abol Gaith
Sanàa University
Nabil Ahmed Ahmed Al-Rabeei
Al-Razi University
Ghaida'a Ibrahim Ahmed Hafedh
Al-Razi University
Lina Saeed Saif Al-Sofiani
Al-Razi University
Baliq Amin Yousef Al-Aswadi
Al-Razi University
Ahlam Mugahed saleh AL-Mugahed
Al-Razi University
Alaa Khaled Algubari
Al-Razi University
Anwar Khaled Algubari
Al-Razi University
Sohaib Abdulhakeem Mohammed Al-Shadadi
Al-Razi University
Shadi Ali Qaied Al-Selwi
Al-Razi University
Alàa Adin Mohammed Ali Orbah
Al-Razi University
Nawar Ali Ali Farea
Al-Razi University
Abdul Wahab Ebrahim Hutaem
Al-Razi University

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Abstract

Background

Malnutrition is common problem among tuberculosis patients and it's associated with poor treatment outcomes and increased morbidity and mortality. In low resource settings, behavioral and sociodemographic factors may further increase the risk of malnutrition among tuberculosis patients.

Objective

this study aimed to assess the prevalence and risk factors of malnutrition among tuberculosis patients at national program for the control of tuberculosis and respiratory disease in sana'a city – Yemen.

Methods

A cross-sectional study was conducted among tuberculosis patients attending the national program for the control of tuberculosis and respiratory disease in sana'a city – Yemen. A structured questionnaire was used to collect sociodemographic, life style, dietary habits and nutritional assessment, nutritional status was assessed using body mass index BMI. Data were collected using patients interviews and medical record review. Bivariate and multivariable logistic regression analyses were performed. Crude odds ratios (CORs) and adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were estimated.

Results

A total 305 tuberculosis patients were included in the study. the prevalence of malnutrition was high 60% among participants. In the multivariable logistic regression analysis, sociodemographic factors were associated with malnutrition among tuberculosis patients, diploma-level education (AOR = 6.94, 95% CI: 1.51–31.98), unemployment (AOR = 4.39, 95% CI 1.12–17.12), family size ≥ 4 persons (AOR = 2.56, 95% CI: 1.02–6.39). and passive smoker (AOR = 1.95, 95% CI: 1.06–3.59). were independently associated with malnutrition among tuberculosis patients. In contrast, participants with monthly income > 150K YER were less likely to develop malnutrition (AOR = 0.12, 95% CI: 0.02–0.63).

conclusion

The prevalence of malnutrition among tuberculosis patients in sana`a city was considerably high 60%, indicating a significant public health concern. Several sociodemographic and life style factors include education level, occupation, family size, and passive smoker were associated with increased risk factors of malnutrition.

1. Introduction

Mycobacterium tuberculosis infection causes tuberculosis, a chronic infectious disease [1]. According to the Global Tuberculosis Report 2022, there will be around 10.6 million cases of tuberculosis globally, 6.40 million new cases, and up to 1.60 million fatalities in 2021. This makes tuberculosis the second leading cause of death from a single infectious agent, after COVID-19 [2]. Additionally, it was found that around 50% of tuberculosis patients received a delayed diagnosis during COVID-19, which led to more severe symptoms in hospitalized patients [3]. Under the direction of the World Health Organization, there has been some progress in the prevention and treatment of pulmonary tuberculosis (PTB). However, PTB is still common and challenging to treat because of high rates of transmission, increasing drug resistance, long treatment regimens, delayed access, and poor treatment compliance. As a result, tuberculosis continues to have a high disease burden. [1]

Undernutrition is a risk factor for developing active tuberculosis (TB) and a common clinical finding in TB patients. Undernutrition and tuberculosis are correlated in both directions. One pathway is from undernutrition to active TB: a systematic study found a linear relationship between body mass index (BMI) and the incidence of active TB (one rise in BMI results in a 13.8% decrease in incidence of active TB). On the other hand, undernutrition can result from having TB. Individuals with TB frequently lose weight and have decreased appetite, and undernutrition can be brought on by metabolic changes during TB therapy. [4, 5]

Poor nutritional status and compromised immune function are the results of inadequate dietary intake. Undernutrition and tuberculosis (TB) have been found to be linked in a vicious cycle whereby undernutrition raises the risk of TB, which can then cause undernutrition. Additionally, undernutrition was more likely in TB-HIV co-infected individuals; this is frequently seen in TB-DM co-morbidity because of decreased cell-mediated immunity, renal failure, vitamin insufficiency, and pulmonary microangiopathy. [6]

Undernutrition is also linked to behavioral issues. For example, smoking increases the risk of undernutrition, which may be linked to decreased appetite and higher resting energy expenditure due to nicotine's effects on body metabolism. [6]

The association between TB and malnutrition is bi-directional since malnutrition may also result from TB itself, driven by inflammation-related cachexia, anorexia, and malabsorption. [17, 19]

Due to metabolic changes and decreased consumption, malnutrition is quite common in TB patients, with an estimated frequency of ~ 48% (range from 1% to 92%). Poor nutrition, low income, living in a rural area, HIV infection, and bacteria-positive pulmonary tuberculosis are risk factors. The danger of death is greatly increased by severe starvation. [7, 21]

Malnutrition and undernutrition are important contributors to immune system subversion and the reactivation of latent tuberculosis in developing and impoverished economies. One of the main causes of the rise in tuberculosis infections in Southeast Asia and India is undernutrition. Once tuberculosis takes hold, the already-existing malnutrition is exacerbated by an increase in metabolism and a decrease in appetite. [15]

2. Objective

To the assess prevalence and risk factors of malnutrition among Tuberculosis patients at national program for the control of Tuberculosis and Respiratory Disease in Sana'a City – Yemen.

3. Methods

3.1 Study design and setting

A cross-sectional study was conducted to assess prevalence and risk factors of malnutrition among Tuberculosis patients. the study was carried out at the national program for the control of tuberculosis and respiratory disease in Sana'a City – Yemen. this program is only the national program in the governmental health care facilities responsible for the diagnosis, treatment, counselling and health education are located, and follow-up of tuberculosis patients and other chest diseases.

3.2 Study population and Sample size determination

The study population comprised all Tuberculosis patients admitted to the national program for the control of tuberculosis and respiratory disease in Sana'a City – Yemen, who treated during the data collection period from March to December 2022. Epi Info version 7.2.6.0 (StatCalc) Program was used to calculate a sample size based on Sample Size and Power for population survey and descriptive study, with considering the following: population size = 1649 according to national program for the control of tuberculosis and respiratory disease in Sana'a City – Yemen data; expected frequency = 42.2% according to [6], acceptable margin of error= (5%); design effect = 1.0; clusters = 1. Based on these criteria, the required sample size with confidence level 95% was 305 Tuberculosis patients.

3.3 Data collection tool and instruments

The data was collected through a structured questionnaire with multiple questions, some of which are multiple, to find out about malnutrition in tuberculosis patients. The questionnaire was modified from previous studies [16, 18–20–22–5], the study includes an interview with patients and companions, and it consists of 5 sections.

- **The first part** includes the patient's personal information such as: age, Sex, marital status, residence, educational status, family size, occupation, income level, performed by the patient.
- **The seconds part** includes the health status such as: the type of tuberculosis, when the disease was diagnosed, types of medications, chronic diseases, and communicable diseases.
- **The third part** includes habits such as: tobacco use and qat chewing, physical activities.
- **The fourth part** includes the Dietary habits such as: How many meals does the patient eat per day and is the food varied between vegetables, fruits, meat and chicken.
- **The fifth part** body measurement Body mass index "BMI" patients who less than 18 underweight and 18–25 normal according to WHO criteria [8]

3.5 Data analysis

Data were analyzed using IBM SPSS Statistics version 27. Descriptive statistics were used to summarize the characteristics of participants. Categorical variables were presented as frequencies and percentages, with the proportion of Tuberculosis patients among malnutrition and normal expressed as column percentages. Bivariate (univariate) logistic regression was conducted to examine associations between each independent variable and Malnutrition. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were calculated. Variables with $p < 0.05$ in the bivariate analysis were considered statistically significant. Statistical significance was set at $p < 0.05$.

3.6 Ethical considerations

Ethical approval

was obtained from Al-Razi University and national program for the control of tuberculosis and respiratory disease in Sana'a City – Yemen. Verbal informed consent was obtained from patients prior to participation. Confidentiality and anonymity of participants were ensured throughout the study.

4. Results

4.1 sociodemographic characteristic of participants (N = 305)

The highest frequency of participants was in the 25–44 years category (41.6%). The majority of the participants were males (55.7%). Most of the study participants were married (63.0%). Most of the participants had primary education (36.7%). (57.7%) of the participants were unemployed; (60.7%) of the participants had a monthly income of less than 50,000 YER. The most represented category was family size with ≥ 4 members (87.2%). Slightly more (51.1%) participants lived in urban areas compared to those living in rural areas. [Insert Table 1 here]

Table 1
sociodemographic characteristic of participants *(N = 305)*

Variables	***N***	***%***
Age		
• 15 Y to 24 Y	88	28.9
• 25 Y to 44 Y	127	41.6
• 45 Y to 64 Y	58	19.0
• >= 65 Y	32	10.5
Gender		
• Male	170	55.7
• Female	135	44.3
Marital Status		
• Single	95	31.1
• Married	192	63.0
• Divorced	5	1.6
• Widowed	13	4.3
Educational Status		
• Illiteracy	71	23.3
• Primary	112	36.7
• Secondary	83	27.2
• Diploma	21	6.9
• Bachelor and above	18	5.9
Occupation		
• Employee	20	6.6
• Manual Labor	109	35.7
• Unemployed	176	57.7
Income Level		
• < 50k YER	185	60.7
• 50- 99k YER	77	25.2
• 100- 150k YER	30	9.8
• > 150k YER	13	4.3
Family Size		
• < 4 persons	39	12.8
• ≥ 4 persons	266	87.2
Residence		
• Urban	156	51.1
• Rural	149	48.9

4.2 Health statues of participants *(N = 305)*

More than half of the participants had pulmonary tuberculosis (54.1%). Majority had no chronic diseases (74.1%) and no communicable diseases (73.4%). [Insert Table 2 here]

Table 2
Health statues of participants *(N = 305)*

Variables	***N***	***%***
Type of tuberculosis		
• Pulmonary Tuberculosis	165	54.1
• Extra pulmonary Tuberculosis	133	43.6
• Multi-drug resistance tuberculosis (MDR)	7	2.3
Presence of chronic disease		
• No	226	74.1
• Yes	79	25.9
Presence of communicable diseases		
• No	224	73.4
• Yes	81	26.6

4.3 Life Style of participants *(N = 305)*

More than half of the participants had moderate level of physical activity (50.2%); while majority did not engage in regular exercise (83.3%). A higher percentage of participants (80.3%) were non-tobacco users. Majority were pervious smokers (63.0%) while increased percentage of participants (61.0%) were exposed to passive tobacco smoke. Regarding Qat chewing; the highest percentage (36.7%) of the participants reported chewing Qat. [Insert Table 3 here]

Table 3
Life Style of participants (N = 305)

Variables	***N***	***%***
Physical activity level		
• Sedentary activity	107	35.1
• Moderate activity	153	50.2
• Hard work activity	45	14.8
Regular exercises		
• No	254	83.3
• Yes	51	16.7
Tobacco use		
• No	245	80.3
• Yes	60	19.7
Pervious smoker		
• No	192	63.0
• Yes	113	37.0
Passive smoker		
• No	119	39.0
• Yes	186	61.0
Chewing Qat		
• No	107	35.1
• Yes	112	36.7
• Sometimes	86	28.2

4.4 Dietary Habits of participants *(N = 305)*

The majority of participants consumed equal to or greater than 3 meals per day with (83.0%) classified as such. Most participants consumed fresh vegetables (70.8%) and fruits (65.9%) on a habitual basis. The highest proportions of participants reported a habitual intake of red meat (50.5%) and white meat (55.4%). [Insert Table 4 here]

Table 4
Dietary Habits of participants (N = 305)

Variables	N	%
Diet a day		
• ≥ 3 Males	253	83.0
• ≤ 2 Males	52	17.0
Eating fresh vegetables		
• Habitual	216	70.8
• Occasional	89	29.2
Eating fresh fruits		
• Habitual	201	65.9
• Occasional	104	34.1
Eating meats (red meat)		
• Habitual	154	50.5
• Occasional	151	49.5
Eating chicken or fish (white meat)		
• Habitual	169	55.4
• Occasional	136	44.6

4.5 Prevalence of Malnutrition in Tuberculosis Patients *(N = 305)*

The figure shows that the majority of TB patients had malnutrition (60%) compared to those with normal nutrition (40%). This shows a high prevalence of malnutrition among the TB patients which could be a public health concern in the study population. [Insert Fig. 1 here]

4.6 Bivariate analysis of sociodemographic characteristic factors associated with Malnutrition among TB patients at the national program for the control of tuberculosis and respiratory disease in Sana'a City – Yemen

The analysis revealed that only a few variables were significantly associated with malnutrition among TB patients; the majority of variables tested did not show a statistically significant relationship. Age, the older ages (25 Y – 44Y, 45 Y – 64Y and older or equal than 65 Y) show no significant association between normal and malnutrition among TB patients (p = 0.277; COR = 1.582; 95% CI: 0.691–3.621), (p = 0.836; COR = 1.086; 95% CI: 0.497–2.375) and (p = 0.922; COR = .975; 95% CI: 0.401–2.283). Gender, there was no significant association found between normal and malnutrition among TB patients (p = 0.240; COR = 0.757; 95% CI: 0.476–1.204). Marital Status, there was no significant association between marital status (married, divorced and widowed) and malnutrition among TB patients (p = 0.783; COR = 0.931; 95% CI: 0.562–1.455), (p = 0.337; COR = 0.407; 95% CI: 0.065–1.679) and (p = 0.276; COR = 0.523; 95% CI: 0.163–1.679). Educational levels, there was a strong significant association between educational levels (primary, secondary, diploma, bachelor and above) and malnutrition among TB patients with (p = 0.004; COR = 5.426; 95% CI: 1.727–17.050), (p = 0.043; COR = 3.110; 95% CI: 1.039–9.309), (p = 0.010; COR = 4.361; 95% CI: 1.418–13.410) and (p = 0.002; COR = 11.050; 95% CI: 2.465–49.525). Occupation, there is no significant association found between occupation (manual labor and unemployed) with (p = 0.099; COR = .456; 95% CI: 0.179–1.160). and (p = 0.166; COR = .709; 95% CI: 0.435–1.154). Income Level, we found a strong statistically significant association between income level (50–99K YER, 100–150K YER and more than 150K YER) and malnutrition status with (p = 0.003; COR = 10.651; 95% CI: 2.290–49.534), (p = 0.022; COR = 6.264; 95% CI: 1.301–30.161) and (p = 0.014; COR = 8.250; 95% CI: 1.546–44.017). Lower income levels were associated with increased odds of malnutrition, suggesting that income is an important predictor of nutritional status. Family Size, we observed a strong significant association between family size and malnutrition, (p = 0.004, COR = .365, 95% CI .183–.728). Having a larger family size with four members or more was found to significantly increase the risk of malnutrition possibly due to sharing of limited resources. Residence, there was a significant association between being in disadvantaged residential setting and higher odds of malnutrition (p = 0.025; COR = .589; 95% CI: .371–.937). [Insert Table 5 here]

Table 5

Bivariate analysis of sociodemographic characteristic factors associated with Malnutrition among TB patients at the national program for the control of tuberculosis and respiratory disease in Sana'a City – Yemen

Variables	*Body Mass Index Score in TB Patients*		*COR*	*P-Value*	*95% C.I*	
	Normal n (%)	*Malnutrition %)) n*			*Lower*	*Upper*
Age						
• 15 Y to 24 Y	29 (9.5)	59 (19.3)	*Ref*			
• 25 Y to 44 Y	53 (17.4)	74 (24.3)	1.582	.277	.691	3.621
• 45 Y to 64 Y	26 (8.5)	32 (10.5)	1.086	.836	.497	2.375
• ≥ 65 Y	14 (4.6)	18 (5.9)	957.	.922	.401	2.283
Gender						
• Male	73(23.9)	97 (31.8)	*Ref*			
• Female	49 (16.1)	86 (28.2)	757.	240.	.476	1.204
Marital Status						
• Single	36 (11.8)	59 (19.3)	*Ref*			
• Married	76 (24.9)	116 (38.0)	.931	.783	.562	1.544
• Divorced	3 (1.0)	2 (0.7)	.407	.337	.065	2.553
• Widowed	7 (2.3)	6 (2.0)	.523	.276	.163	1.679
Educational Status						
• Illiteracy	23 (7.5)	48 (15.7)	*Ref*			
• Primary	51 (16.7)	61 (20.0)	5.426	**.004***	1.727	17.050
• Secondary	31 (10.2)	52 (17.0)	3.110	**.043***	1.039	9.309
• Diploma	4 (1.3)	17 (5.6)	4.361	**.010***	1.418	13.410
• Bachelor and above	13 (4.3)	5 (1.6)	11.050	**.002***	2.465	49.525
Occupation						
• Employee	11 (3.6)	9 (3.0)	*Ref*			
• Manual Labor	48 (15.7)	61 (20.0)	.456	.099	.179	1.160
• Unemployed	63 (20.7)	113 (37.0)	.709	.166	.435	1.154
Income Level						
• < 50k YER	63 (20.7)	122 (40.0)	*Ref*			
• 50- 99k YER	36 (11.8)	41 (13.4)	10.651	**.003***	2.290	49.534
• 100- 150k YER	12 (3.9)	18 (5.9)	6.264	**.022***	1.301	30.161
• > 150k YER	11 (3.6)	2 (0.7)	8.250	**.014***	1.546	44.017
Family Size						
• < 4 persons	24 (7.9)	15 (4.9)	*Ref*			
• ≥ 4 persons	98 (32.1)	168 (55.1)	. 365	**.004***	.183	.728
Residence						
• Urban	72 (23.6)	84 (27.5)	*Ref*			
• Rural	50 (16.4)	99 (32.5)	. 589	**.025***	.371	.937

COR=Crude Odds Ratio; CI=Confidence Interval; Ref=Reference category

4.7 Bivariate analysis of Health statues factors associated with Malnutrition among TB patients at the national program for the control of tuberculosis and respiratory disease in Sana'a City – Yemen

Type of Tuberculosis, (extra pulmonary tuberculosis and multi-drug resistance tuberculosis) there is no significant association between the type of Tuberculosis and malnutrition in tuberculosis patients (p = 0.240; COR = 0.277; 95% CI: 0.033–2.354) and (p = 0.153; COR = 0.209; 95% CI: 0.024–1.785). Presence of Chronic Disease, there is no significant association between the chronic disease and malnutrition in tuberculosis patients (p = 0.522; COR =

1.185; 95% CI: 0.705–1.992). Presence of Communicable Diseases, there is no significant association between the communicable diseases and malnutrition in tuberculosis patients (p = 0.711; COR = .906; 95% CI: 0.538–1.526). [Insert Table 6 here]

Table 6

Bivariate analysis of Health statues factors associated with Malnutrition among TB patients at the national program for the control of tuberculosis and respiratory disease in Sana'a City – Yemen

Variables	*Body Mass Index Score in TB Patients*		*COR*	*P- Value*	*95% C. I*	
	Normal	*Malnutrition*			*Lower*	*Upper*
	N %	*N %*				
Type of tuberculosis						
• Pulmonary Tuberculosis	62(20.3)	103(33.8)	*Ref*	[illegible]	[illegible]	[illegible]
• Extra pulmonary Tuberculosis	59(19.3)	74(24.3)	.277	.240	.033	2.354
• Multi-drug resistance tuberculosis (MDR)	1(0.3)	6(2.0)	.209	.153	.024	1.785
Presence of chronic disease						
• No	88(28.9)	138(45.2)	*Ref*	[illegible]	[illegible]	[illegible]
• Yes	34(11.1)	45(14.8)	1.185	522.	.705	1.992
Presence of communicable diseases						
• No	91(29.8)	133(43.6)	*Ref*	[illegible]	[illegible]	[illegible]
• Yes	31(10.2)	50(16.4)	906.	711.	.538	1.526
COR=Crude Odds Ratio; CI=Confidence Interval; Ref=Reference category						

4.8 Bivariate analysis of life style factors associated with Malnutrition among TB patients at the national program for the control of tuberculosis and respiratory disease in Sana'a City – Yemen

Physical Activity Level, (moderate and hardworking activities) there is no significant association between Physical activity level and malnutrition in tuberculosis patients (p = 0.482; COR = 1.288; 95% CI: 0.636–2.607) and (p = 0.583; COR = 1.207; 95% CI: 0.617–2.361). Regular Exercises, there is no significant association between regular exercises and malnutrition in tuberculosis patients (p = 0.093; COR = .572; 95% CI: 0.298–1.098). Tobacco Use, there is no significant association between using tobacco and malnutrition in tuberculosis patients (p = 0.769; COR = .917; 95% CI: 0.315–1.637). Previous Smoker, there is no significant association between previous smoker and malnutrition in tuberculosis patients (p = 0.498; COR = 1.178; 95% CI: 0.734–1.889). Passive Smoker, there is significant association between being a passive smoker and malnutrition in tuberculosis patients, (p = 0.007; COR = .521; 95% CI: .325–.834). Chewing Qat, "sometimes" chewing qat is associated with a risk of malnutrition in tuberculosis patients probably because it suppresses appetite (p = 0.021; COR = 1.995; 95% CI: 1.112–3.579). [Insert Table 7 here]

Table 7

Bivariate analysis of life style factors associated with Malnutrition among TB patients at the national program for the control of tuberculosis and respiratory disease in Sana'a City – Yemen

Variables	*Body Mass Index Score in TB Patients*		COR	*P-Value*	*95% C. I*	
	Normal	*Malnutrition*			*Lower*	*Upper*
	N (%)	N (%)				
Physical activity level						
• Sedentary activity	41(13.4)	66(21.6)	*Ref*			
• Moderate activity	61(20.0)	92(30.2)	1.288	.482	.636	2.607
• Hard work activity	20(6.6)	25(8.2)	1.207	.583	.617	2.361
Regular exercises						
• No	107(35.1)	147(48.2)	*Ref*			
• Yes	15(4.9)	36(11.8)	572.	093.	.298	1.098
Tobacco use						
• No	99(32.5)	146(47.9)	*Ref*			
• Yes	23(7.5)	37(12.1)	917.	769.	.513	1.637
Pervious smoker						
• No	74 (24.3)	118 (38.7)	*Ref*			
• Yes	48(15.7)	65 (21.3)	1.178	498.	734.	1.889
Passive smoker						
• No	59(19.3)	60(19.7)	*Ref*			
• Yes	63(20.7)	123(40.3)	521.	**.007***	.325	.834
Chewing Qat						
• No	48(15.7)	59(19.3)	*Ref*			
• Yes	34(11.1)	78(25.6)	1.069	819.	605.	1.890
• Sometimes	40(13.1)	46(15.1)	1.995	**.021***	1.112	3.579

COR=Crude Odds Ratio; CI=Confidence Interval; Ref=Reference category

4.9 Bivariate analysis of Dietary habits factors associated with Malnutrition among TB patients at the national program for the control of tuberculosis and respiratory disease in Sana'a City – Yemen

Diet a Day, there is a significant association between number of males a day and malnutrition in tuberculosis patients with (p = 0.008; COR = .390; 95% CI: 0.195–.779). Eating Fresh Vegetables, there is a significant association between eating vegetables and malnutrition in tuberculosis patients with (p = 0.014; COR = .516; 95% CI: 0.304–.876). Eating Fresh Fruits, there is no significant association between eating fruits and malnutrition in tuberculosis patients with (p = 0.105; COR = 0.665; 95% CI: 0.406–1.088). Eating Red Meat, there is a significant association between eating red meat and malnutrition in tuberculosis patients with (p = 0.004; COR = .504; 95% CI: 0.316–.803). Eating White Meat, there is no significant association between eating white meat and malnutrition in tuberculosis patients with (p = 0.301; COR = 0.783; 95% CI: 0.493–1.245). [Insert Table 8 here]

Table 8

Bivariate analysis of Dietary habits factors associated with Malnutrition among TB patients at the national program for the control of tuberculosis and respiratory disease in Sana'a City – Yemen

Variables	*Body Mass Index Score in TB Patients*		*COR*	*P-Value*	*95% C. I*	
	Normal	*Malnutrition*			*Lower*	*Upper*
	N (%)	**N (%)**				
Diet a day						
• ≥ 3 Males	110(36.1)	143(46.9)	*Ref*			
• ≤ 2 Males	12(3.9)	40 (13.1)	.390	**.008***	.195	.779
Eating fresh vegetables						
• Habitual	96 (31.5)	120 (39.3)	*Ref*			
• Occasional	26 (8.5)	63 (20.7)	.516	**.014***	.304	.876
Eating fresh fruits						
• Habitual	87 (28.5)	114 (37.4)	*Ref*			
• Occasional	35 (11.5)	69 (22.6)	.665	.105	.406	1.088
Eating meats (red meat)						
• Habitual	74 (24.3)	80 (26.2)	*Ref*			
• Occasional	48 (15.7)	103 (33.8)	.504	**.004***	.316	.803
Eating chicken or fish (white meat)						
• Habitual	72 (23.6)	97 (31.8)	*Ref*			
• Occasional	50 (16.4)	86 (28.2)	.783	.301	.493	1.245

COR=Crude Odds Ratio; CI=Confidence Interval; Ref=Reference category

4.10 Multivariate analysis of Risk factors associated with Malnutrition among TB patients at the national program for the control of tuberculosis and respiratory disease in Sana'a City – Yemen

The multivariate analysis identified several independent predictors of malnutrition among TB patients after controlling for potential confounders. Educational status showed a significant association, particularly among patients with diploma "level of education", who had markedly higher odds of malnutrition compared to illiterate patients (AOR = 6.939; p = 0.013; 95% CI: 1.505–31.983). The unexpected finding may reflect contextual socioeconomic or behavioral factors influencing dietary practices despite higher educational attainment. occupation was also significant predictor, as unemployed patients were more likely to be malnourished compared to employed individuals (AOR = 4.386; p = 0.033; 95% CI: 1.124–17.119) this highlights the critical role of economic stability in ensuring adequate nutrition among TB patients. Regarding income levels, patients with higher income (> 150.000 YER) were significant less likely to be malnourished compared to those earing < 50,000 YER (AOR = 0.116; p = 0.012;95%CI:0.0022–0.626), indicating a strong protective effect of higher income on nutritional status. family size remained significantly associated with malnutrition, where individuals from larger households (≥ 4 members) had increased odds of malnutrition (AOR = 2.558; p = 0.044;95%CI;1.024–6.389). This supports the concept of resource dilution within larger families. Among lifestyle factors, passive smoking emerged as a significant risk factor (AOR = 1.949; p = 0.032;95%CI:1.057–3.592), indicating that exposure to secondhand smoke nearly doubled the likelihood of malnutrition. In contrast, other variables-including gender, most categories of educational status, manual labor occupation, lower- and middle-income levels, residence, type of tuberculosis, regular exercise, chewing Qat, dietary patterns (meal frequency, vegetable, fruit, and meat consumption) -were not statistically significant($p > 0.05$), as their confidence intervals included unity. This suggests that these factors were not independently associated with malnutrition after adjustment for confounders. [Insert Table 9 here]

Table 9. Multivariate analysis of Risk factors associated with Malnutrition among TB patients at the national program for the control of tuberculosis and respiratory disease in Sana'a City – Yemen

Risk Factors	*Body Mass Index Score in TB Patient*				*AOR*	*P-value*	*CI 95 %*	
	Normal		*Malnutrition*					
	N	*%*	*N*	*%*			*lower*	*upper*
Gender								
• Male	73	23.9	97	31.8	*Ref*			
• Female	49	16.1	86	28.2	1.019	.959	.492	2.113
Educational Status								
• Illiteracy	23	7.5	48	15.7	*Ref*			
• Primary	51	16.7	61	20.0	.703	.335	.342	1.441
• Secondary	31	10.2	52	17.0	1.516	.330	.656	3.500
• Diploma	4	1.3	17	5.6	6.939	**.013***	1.505	31.983
• Bachelor and above	13	4.3	5	1.6	.454	.267	.113	1.828
Occupation								
• Employee	11	3.6	9	3.0	*Ref*			
• Manual Labor	48	15.7	61	20.0	2.773	.131	.738	10.411
• Unemployed	63	20.7	113	37.0	4.386	**.033***	1.124	17.119
Income Level								
• < 50k YER	63	20.7	122	40.0	*Ref*			
• 50- 99k YER	36	11.8	41	13.4	.680	.236	.359	1.287
• 100- 150k YER	12	3.9	18	5.9	.864	.759	.339	2.204
• > 150k YER	11	3.6	2	0.7	.116	**.012***	.022	.626
Family Size								
• < 4 persons	24	7.9	15	4.9	*Ref*			
• ≥ 4 persons	98	32.1	168	55.1	2.558	**.044***	1.024	6.389
Residence								
• Urban	72	23.6	84	27.5	*Ref*			
• Rural	50	16.4	99	32.5	1.632	.086	.933	2.853
Type of tuberculosis								
• (PTB)	62	20.3	103	33.8	*Ref*			
• (EPTB)	59	19.3	74	24.3	.678	.181	.383	1.198
• (MDR)	1	0.3	6	2.0	1.067	.956	.107	10.651
Regular Exercises								
• No	107	35.1	147	48.2	*Ref*			

• Yes	15	4.9	36	11.8	1.942	.103	.875	4.310
Passive Smoker								
• No	59	19.3	60	19.7	*Ref*	□□□□□	□□□□□	□□□□□
• Yes	63	20.7	123	40.3	1.949	**.032***	1.057	3.592
Chewing Qat								
• No	48	15.7	59	19.3	*Ref*	□□□□□	□□□□□	□□□□□
• Yes	34	11.1	78	25.6	1.376	.348	.707	2.677
• Sometimes	40	13.1	46	15.1	.594	.178	.279	1.267
Diet a day								
• · ≤ 3 Males	110	36.1	143	46.9	*Ref*	□□□□□	□□□□□	□□□□□
• ≥ 2 Males	12	3.9	40	13.1	1.450	.370	.643	3.269
Eating Fresh Vegetables								
• Habitual	96	31.5	120	39.3	*Ref*	□□□□□	□□□□□	□□□□□
• Occasional	26	8.5	63	20.7	2.238	.180	.689	7.264
Eating Fresh Fruits								
• Habitual	87	28.5	114	37.4	*Ref*	□□□□□	□□□□□	□□□□□
• Occasional	35	11.5	69	22.6	.591	.347	.197	1.770
Eating Fresh Meats (Red Meat)								
• Habitual	74	24.3	80	26.2	*Ref*	□□□□□	□□□□□	□□□□□
• Occasional	48	15.7	103	33.8	1.300	.443	.666	2.537

AOR=Adjusted Odds Ratio; CI=Confidence Interval; Ref=Reference category

**(PTB), Pulmonary Tuberculosis; (EPTB), Extra-Pulmonary Tuberculosis; (MDR), Multidrug- resistant tuberculosis*.

5. Discussion

5.1. Prevalence of malnutrition among tuberculosis patients

This study shows a high prevalence of malnutrition among the TB patients which could be a public health concern in the study population. TB patients had malnutrition (60%) compared to those with normal nutrition (40%), the high prevalence of malnutrition observed in this study may be explained by the synergistic relationship between tuberculosis and malnutrition. Tuberculosis increases energy expenditure and reduces appetite, while poor national statues weaken immunity and worsens disease progression. Additionally, poverty, food insecurity, and limited healthcare access in Yemen may have contributed to the elevated prevalence identified in this study. in line with, [1] The prevalence of malnutrition was 48.0% (95% CI, 40.9–55.2%). This is in the line with previous study [9] The pooled prevalence of undernutrition among tuberculosis patients in Ethiopia was 50.8% (95% CI 43.97, 57.63). also, in this study [6] the prevalence of under nutrition was 42.2% [95%CI: 32.8, 51.6]. and in this article, [11] The overall prevalence of undernutrition was 43.6% (95% CI 38.2–49.1%). furthermore, in [14] The magnitude of undernutrition was 44.3% [95% CI (38.2, 49.7)]. this may be due to loss of appetites in TB patients and the tiredness that because disease.

The current study identified several independent predictors of malnutrition among TB patients in Sana'a City, Yemen. Multivariate analysis showed that malnutrition was significantly associated with educational status, occupation, income level, family size and passive smoking.

Educational status, patients with diploma level of education were significantly more likely to be malnourished than illiterate patients (AOR = 6.939, p = 0.013, 95% CI: 1.505–31.983). This finding is inconsistent with a previous Ethiopian study [4] which found low educational status was significantly associated with undernutrition (AOR = 3.939, 95% CI: 2.285–6.792). Similarly, another study [11] showed that the odds of undernutrition were higher among people with no

formal education (AOR = 1.76, 95% CI: 1.01–3.08). The difference in the present study may be related to the low number of patients with diploma-level education, or to differences in socioeconomic and cultural characteristics.

Occupation was another important predictor of malnutrition. Unemployed participants had higher risk of malnutrition than employed participants (AOR = 4.386, p = 0.033, 95% CI: 1.124–17.119). This finding is consistent with the previous study [10] which revealed the odds of undernutrition were significantly higher among unemployed TB patients (AOR = 2.46, 95% CI: 1.18–5.13). The possible explanation is that unemployment reduces household income and food affordability and thus has a negative effect on nutritional intake.

The level of income was strongly associated with nutritional status. Participants with income more than 150,000 YER were significantly less likely to be malnourished compared to participants with income less than 50,000 YER (AOR = 0.116, p = 0.012, 95% CI: 0.022–0.626). This finding is consistent with previous studies which reported low income as a major determinant of malnutrition in TB patients. A meta-analysis [9] reported low income was associated with an increased risk of malnutrition (OR = 1.44, 95% CI: 1.11–1.86). Similarly, another study [6] revealed that the odds of undernutrition were significantly higher among children with poor wealth status (AOR = 2.39, 95% CI: 1.19–4.79). Also, a study among TB patients showed that being below the poverty line was a significant risk factor for undernutrition (AOR = 1.9, 95% CI: 1.0–3.6). These findings together indicate the significant role of socioeconomic status in maintaining satisfactory nutritional health in TB patients.

Family size was significantly associated with malnutrition. Participants from households with ≥ 4 family members had increased odds of malnutrition (AOR = 2.558, p = 0.044, 95% CI: 1.024–6.389). This finding is consistent with previous research. In the study [11] a significant association was observed between larger family size and undernutrition (AOR = 2.62, 95% CI: 1.43–4.82), and the meta-analysis [9] showed that family size greater than four members was associated with a higher prevalence of malnutrition (54.5%). Large household size may lead to competition for limited food resources in particular in low-income settings.

Passive smoking. Those exposed to passive smoking were almost twice as likely to be malnourished than those who were not exposed (AOR = 1.949, p = 0.032, 95% CI: 1.057–3.592). Few studies have specifically looked at passive smoking, but previous evidence has shown that smoking-related exposures adversely affect respiratory health, appetite, and immune function and thereby worsen nutritional outcomes in TB patients. However, one meta-analysis [9] suggested that smoking needs further evaluation, owing to inconsistent evidence in studies.

On the other hand, gender was not significantly associated with malnutrition in the current study (AOR = 1.019, p = 0.959, 95% CI: 0.492–2.113). This finding is in agreement with the meta-analysis (9) which indicated that male gender was not a significant risk factor for malnutrition (OR = 1.04, 95% CI: 0.85–1.26). In contrast, it is inconsistent with another study from Ethiopia [4], in which female sex was a predictor of undernutrition (AOR = 1.769, 95% CI: 1.035–3.024).

Residence was not significantly associated with malnutrition (AOR = 1.632, p = 0.086, 95% CI: 0.933– 2.853) although rural participants had higher odds of malnutrition. This finding is in contrast to the meta-analysis [9] which indicated that rural residence was a significant risk factor for malnutrition (OR = 1.51, 95% CI: 1.20–1.89).

Type of tuberculosis also did not show statistically significant association with malnutrition. This finding is different from previous studies that showed bacterial positivity and drug-resistant TB as important predictors of malnutrition [9]. Another study reported a significant increase in undernutrition risk in drug resistant TB (AOR = 3.2, 95% CI: 1.0–11.8).

Strengths and limitations

This study provides context-specific evidence on malnutrition in TB Patients risk factors in Yemen using a cross-sectional design. Strengths include sociodemographic factors, dietary factors and life style factors. Limitations include potential bias from patients and caregiver-reported information, convenience sampling limiting generalizability, and the cross-sectional design cannot establish the causality.

Conclusion

The prevalence of malnutrition among tuberculosis patients in sana

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s nutritional status and treatment outcome.

Abbreviations

TB
Tuberculosis
PTB
Pulmonary tuberculosis
BMI
Body mass index
TB-MD
Tuberculosis with malnutrition disease
TB-HIV
Human immunodeficiency virus infection co-infection with tuberculosis

WHO
World health organizations
MDR-TB
Multidrug resistant tuberculosis
CORs
Crude odds ratios
AORs
Adjusted odds ratios
CIs
Confidence intervals

Declarations

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Authors' contributions:

A.F.A.A. (First author) conceived and designed the study, performed statistical analysis, and drafted the main manuscript text. F.M.A. (Supervisor) supervised the research process, provided critical guidance, and contributed to manuscript revision. N.A.A.A. data analysis review. G.I.A.H and L.S.S.A. were responsible of data entry. B.A.Y.A., A.M.S.A., A.K.A., A.K.A., S.A.M.A., S.A.Q.A., A.A.M.A.O., N.A.A.F. and A.W.E.H. were responsible of data collection.

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Availability of data and materials:

Yes, the manuscript contains third party material and obtained permissions are available on request by the Publisherand Data are available from the corresponding author on a reasonable request.

Clinical trial number:

Not applicable

Ethics approval and consent to participate:

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. The research protocol was approved by The Research Ethics Committee of the Faculty of Medical and Health sciences, AL-Razi University, Sana'a Yemen [Approval No: RU/04/FMHS/2022]. All participants provided informed consent prior to inclusion in the study.

Consent for publication:

Not applicable. This study does not contain any individual person's data in any form (including individual details, images, or videos).

Competing interests:

The authors declare that they have no competing interests as defined by BMC, or any other interests that could be perceived to influence the results and/or interpretation of this study.

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Figures

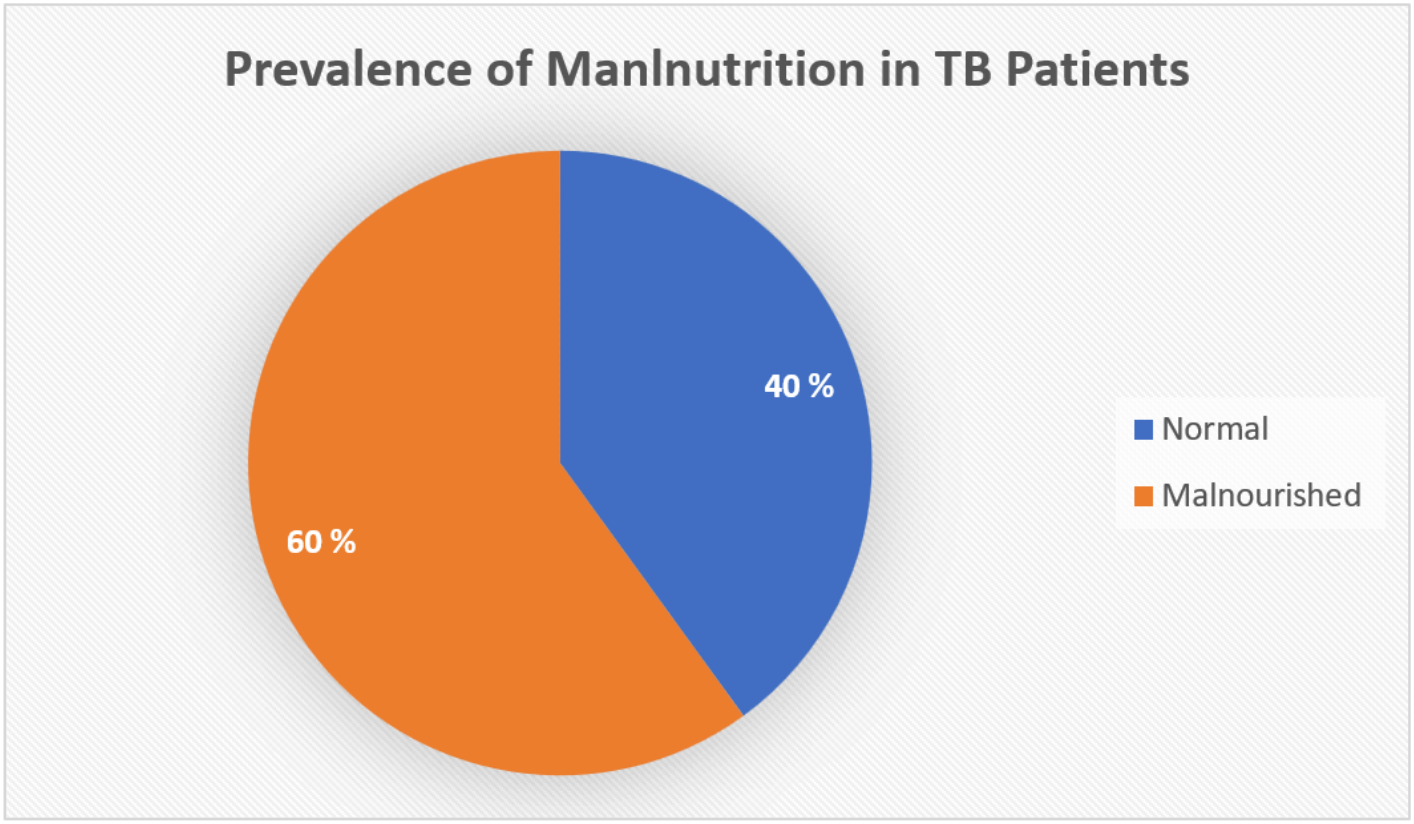


Figure 1

Prevalence of Malnutrition in Tuberculosis Patients *(N= 305)*