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Effectiveness of a High-Protein Diet on the Nutritional Status of Pulmonary Tuberculosis Patients at Pandak I Public Health Centre

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ABSTRACT

Background: Pulmonary tuberculosis is greatly influenced by low nutritional status, which degrades the immune system and causes a slower recovery. Nurses play an important role in improving the nutritional status of pulmonary tuberculosis patients through a high-protein diet. **Objectives:** This study assessed the effectiveness of providing nutrition to pulmonary tuberculosis patients. **Methods:** Quantitative quasi-experimental research by comparing pre and post-tests. The respondents are all patients with pulmonary tuberculosis at Pandak I Public Health Center in Bantul Regency. The respondents were randomly divided into two groups, as the intervention group has 14 respondents and the control group has 7 respondents. **Results :** Based on the statistical test of the difference in BMI pre and post-intervention, the *p*-value = 0.082 (> 0.05) and post intervention, the *p*-value = 0.396 (> 0.05). Mid-Upper Arm Circumference (MUAC) pre- and post-intervention, the *p*-value = 0.000 (< 0.05) and post-intervention, the *p*-value = 0.002 (< 0.05). The edema status pre- and post-intervention, the *p*-value = 0.165 (> 0.05), post-intervention *p*-value = 0.002 (< 0.05). This shows that there is a statistically significant difference in MUAC between pre- and post-intervention, between MUAC in TB patients who have received the intervention and those who have not, and between edema status in tuberculosis patients who have received the intervention and those who have not. **Conclusion:** Increased MUAC was the only variable that had the most influence in this study compared to BMI and edema. MUAC revealed significant advancements in both populations, accentuating its responsiveness as a gauge of nutritional recovery in patients diagnosed with pulmonary tuberculosis.

Keywords: Nutrition; Pulmonary Tuberculosis; High Protein

INTRODUCTION

Pulmonary tuberculosis is a respiratory tract infection that attacks the lung parenchyma. According to the WHO, tuberculosis has been declared a global epidemic with a fatality rate of 32.6% (MacNeil *et al*., 2019) and is ranked in the top ten lethal diseases worldwide and is the leading cause of death from a single infection case. Tuberculosis mortality is as high as 47%, with a prevalence of 42% (Garcia-Basteiro *et al.*, 2019). In 2023, there were an estimated 936,000 new tuberculosis cases and nearly 86,000 deaths (Balkhy, 2025). The three countries with the highest prevalence of pulmonary tuberculosis are India, China and Indonesia. Indonesia had a prevalence of 824,000 in 2020, which increased to 1,060,000 in 2024 (Arlinta, 2024). This statement is supported by Fahdhienie *et al.* (2024), who stated that as of February 2024, Indonesia had an estimated 1,060,000 Tuberculosis (TB) cases, which is a 1.5 times higher rate than the rest of the world and Indonesia is the second country with the highest number of TB cases in the world after India. In Jogjakarya, it was recorded that until July 2024, there were 775 TB cases and 30% of them were drug-resistant TB (Adminwarta, 2024).

Tuberculosis is greatly influenced by low nutritional status. This is confirmed by Mohamed-Hussein *et al.* (2016) on malnutrition in tuberculosis involving 129 respondents at Assuit University Hospital. The results indicated that there was a significant decrease in Ideal Body Weight (IBW) and Body Mass Index (underweight) in patients with pulmonary tuberculosis compared to the control group ($p<0.01$). Decreased nutritional status in patients with pulmonary tuberculosis occurs due to an imbalance between nutritional intakes and needs. This statement is supported by Gurung *et al*. (2018), who state that in patients suffering from

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pulmonary tuberculosis, several factors reduce nutritional intakes, including decreased appetite, nausea, and abdominal pain. Chandarasekaran (2017) also stated that tuberculosis sufferers tend to have poor nutritional status due to complaints of anorexia and side effects of treatment. This statement is supported by the findings of Ma'rufi *et al*. (2020) that patients with pulmonary tuberculosis experienced a decrease in appetite, which ultimately affected their nutritional status. This research found that 35% of respondents had severe thinness, 14% had moderate thinness and 23.5% had mild thinness.

Nutritional status becomes the main indicator in health management for identifying both acute and chronic diseases. This is in line with Chandarasekaran (2017), who stated that nutritional deficiencies trigger domino effects on physical health, especially in patients with pulmonary tuberculosis. Gurung *et al.* (2018) and Feleke *et al.* (2019) explained that malnutrition will inhibit the pulmonary tuberculosis healing process, and pulmonary tuberculosis will encourage a malnourished state. Low nutritional status, both macro-and micronutrients, will degrade the immune system, which causes a slower recovery rate. Tuberculosis patients who experience malnutrition have a mortality possibility of 2-4 times higher and a 5 times greater risk of liver damage, increased recurrence, malabsorption of pulmonary TB drugs, and delayed sputum conversion.

Nurses have an important role in managing the improvement of nutritional status in patients with pulmonary tuberculosis so that they can improve their prognosis. Giving a high-protein diet is expected to improve patients' prognosis with pulmonary tuberculosis. Chandarasekaran *et al.* (2017) explained that the provision of dietary supplements can provide excellent results for the recovery of pulmonary tuberculosis patients. Micro- and macronutrients can improve T-cell functions, accelerate sputum conversion, prevent a recurrence, increase activity ability, and even prevent death risk. Pandak I Public Health Center is one of the healthcare centres in Bantul Regency, which has a high prevalence of pulmonary tuberculosis. Bantul has a low TB treatment success rate of 82% compared to the national target of 90%. Of the 1144 TB cases in Bantul, around 21.24% were recorded as having low incomes; they work as labourers or housewives or do not have jobs, so that also impacts their nutritional status (Dinas Kesehatan Kabupaten Bantul, 2023). There are 21 Tuberculosis (TB) patients and most of them have MDR TB. Based on this background, the researcher will investigate the effectiveness of providing nutrition to pulmonary tuberculosis patients at Pandak I Public Health Center in Bantul. The novelty of this study is the high-protein diet given in the form of milk, not supplements or high-protein foods. Previous research has mostly discussed the provision of a high-calorie diet on the nutritional status of tuberculosis patients or a high-protein diet on treatment response, and there has not been much discussion on the effects of a high-protein diet, especially in the form of easily absorbed liquid milk, on improving the nutritional status of tuberculosis patients. Researchers chose this diet because tuberculosis patients often experience nausea; therefore, a liquid diet was expected to be easier and more effective to consume.

METHODOLOGY

This is quantitative quasi-experimental research that is conducted by comparing pre- and post-test data. The research respondents were all patients with pulmonary tuberculosis in the Pandak I Public Health Center of Bantul Regency, with a total of 21 people. The respondents are randomly divided into two groups, namely the intervention group consisting of 14 respondents and the control group with 7 respondents. Randomisation of respondents was done by drawing lots to determine the intervention and control groups. Exclusion criteria for the research include the patients having TB co-infections (HIV/AIDS, DM) and lactose intolerance (Newdiet, 2025).

The intervention group received high-protein milk supplementation for one month. Respondents consumed milk in the morning (2 hours post-FDC medication) and in the post meridiem. Milk was consumed daily for four weeks. Each 63-gram serving had a calorie content of 250 cal, 14 grams of protein (22%), 3 grams of fat (11%) and 43 grams of carbohydrates (67%) (Fatsecret, 2025).

Data Collection

The pre and post-test data collected include BMI (Basal Metabolic Index), MUAC (Mid Upper Arm Circumference) and bilateral pitting edema. The researcher treats the intervention group by providing high-protein milk for one month. The participants drink the milk in the morning, two hours after taking the FDC drug

and again in the afternoon. The milk is consumed every day for four weeks or one month. Due to the pandemic, monitoring was conducted by PMO and research assistants (health centre nurses). The selected dairy products are high in protein, have a high zinc content as an energy source and support the recovery process. Zinc is useful for improving the metabolism of nutrients, including protein. In the intervention group, education was given about fulfilling nutritional needs for tuberculosis patients. Education was given after the research was completed and it was done individually.

Data Analysis

The research uses univariate and bivariate data analysis with a different test. The difference test is carried out with a *t*-test to examine the differences in pre-post nutritional status and an independent difference test to identify differences in nutritional status post intervention between the intervention and control groups. Before conducting the difference test, the data normality test is conducted using Shapiro-Wilk because n is less than 50.

Ethical Consideration

The researchers obtained ethical clearance from the Research Ethics Committee from the University of Respati Yogyakarta, Indonesia, with reference number 125.3/FIKES/PL/V/2020 on 8th May 2020.

The research is conducted by submitting an ethical test at the Universitas Respati Yogyakarta and followed with an application for permission to the Head of the Pandak I Health Center. To prevent conflict of interest, the researcher would not provide milk cartons to the respondents but only unbranded aluminium packs.

RESULTS

The data are collected from the first week of July to the last week of October 2020. The results are:

Table1: Distribution of Respondents Based on Age Group

Characteristics (year)	Group				Total	
	Intervention		Control			
	N	%	N	%	N	%
12 - 16	0	0%	2	10%	2	10%
17 - 25	7	33%	1	5%	8	38%
36 - 45	1	5%	0	0%	1	5%
46 - 55	5	24%	3	14%	8	38%
56 - 65	1	5%	0	0%	1	5%
> 65	0	0%	1	5%	1	5%
Total	14		7		21	100%

%= Percentage; N=Sample size

Table 1 shows that of the 21 respondents, 38% are between 17-25 and 45-55 years old. This shows that the distribution of respondents is spread across all ages and most are of productive age. The higher prevalence of tuberculosis in productive age is in accordance with the prevalence of cases in Indonesia. People who are in the productive age group tend to have higher mobility, thereby increasing their risk against pulmonary tuberculosis bacteria exposure.

Table 2: Distribution of Respondents Based on Gender

Gender	Group				Total	
	Intervention		Control			
	N	%	N	%	N	%
Male	6	29%	5	24%	11	52%
Female	8	38%	2	10%	10	48%
Total	14		7		21	100%

%= Percentage; N=Sample size

Table 2 shows that of the 21 respondents, 38% are between 17 – 25 and 45 – 55 years old; 52% are male. This shows that the distribution of respondents is almost even across all genders, with a slightly higher percentage of male. Generally, men smoke more than women. Consequently, smoking is a larger contributor to the TB disease burden for men.

Table 3: Distribution of Respondents Based on BMI Pre Intervention

BMI	Group				Total		Group				Total	
	Interven-tion		Control				Interven-tion		Control			
	N	%	N	%	N	%	N	%	N	%	N	%
Underweight	5	24%	4	19%	9	43%	2	10%	4	19%	6	29%
Normal	8	38%	3	14%	11	52%	11	52%	3	14%	14	67%
Overweight	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Obese	1	5%	0	0%	1	5%	1	5%	0	0%	1	5%
Total	**14**		**7**		**21**	**100%**	**14**		**7**		**21**	**100%**

%= Percentage; N=Sample size

Based on table 3, it can be seen that 43% of respondents have underweight status. This shows that tuberculosis patients are closely associated with decreased nutritional status. Malnutrition predisposes individuals to tuberculosis and is a risk factor for the progression of latent TB infection to active tuberculosis. Poor nutritional status in tuberculosis is associated with a longer time to sputum conversion, worse treatment outcomes and higher mortality. BMI Post being given a high-protein diet, there was a decrease in the number of respondents to 29% compared to pre-intervention, which was 43%. The decrease in the number of respondents with underweight status was evenly distributed in all groups.

Table 4: Distribution of Respondents Based on MUAC Pre and Post Intervention

MUAC	Pre Intervention						Post Intervention					
	Group				Total		Group				Total	
	Intervention		Control				Intervention		Control			
	N	%	N	%	N	%	N	%	N	%	N	%
Under	5	24%	4	19%	9	43%	1	5%	4	19%	5	24%
Normal	4	19%	3	14%	7	33%	8	38%	3	14%	11	52%
Over	5	24%	0	0%	5	24%	5	24%	0	0%	5	24%
Total	**14**		**7**		**21**	**100%**	**14**		**7**		**21**	**100%**

%= Percentage; N=Sample size

Based on table 4, it can be seen that 43% of respondents have MUAC under normal. This shows that tuberculosis patients are closely associated with decreased nutritional status. MUAC post being given a high-protein diet in the intervention group, there was a decrease in the number of respondents to 5% compared to pre-intervention, which was 24%. This is different from the control group. which did not experience a decrease in the number of respondents with MUAC below normal.

Table 5: Distribution of Respondents Based on Edema Status Pre and Post Intervention

Edema	Pre Intervention						Post Intervention					
	Group				Total		Group				Total	
	Intervention		Control				Intervention		Control			
	N	%	N	%	N	%	N	%	N	%	N	%
Yes	2	10%	0	0%	2	10%	0	0%	1	5%	1	5%
No	12	57%	7	33%	19	90%	14	67%	6	29%	20	95%
Total	**14**		**7**		21	100%	**14**		**7**		21	100%

%= Percentage; N=Sample size

Based on table 5, it was found that two (10%) respondents experienced edema and in the control group none experienced edema. Regarding the edema status post-intervention, there were no respondents in the intervention group who experienced edema. In the control group, one respondent (5%) previously had no edema development.

Table 6: p Value on BMI Pre and Post Intervention in Intervention Group

Characteristic	Time of Measurement				*p* Value	*df*	SD	Confidence Interval(CI)	Cohen's *d*
	Pre		Post						
Underweight	5	24%	2	10%	0.082*	13	0.426	95%	0.238208
Normal	8	38%	11	52%					
Overweight	0	0%	0	0%					
Obese	1	5%	1	5%					
Total	**14**		**7**						

*df=degrees of freedom; SD=Standard Deviation; *p value is nonsignificant at 95%CI level*

Based on the statistical test that showed no significant changes in BMI ($p > 0.05$), the clinical trend is noteworthy. The underweight category declined from 43% to 29%, while normal BMI rose from 52% to 67%. These changes, though not statistically significant due to small sample size and short intervention, indicate early positive nutritional effects of the high-protein diet. Cohen's *d* value of 0.238208 indicates that there is only a small effect size on the change in BMI before and after the intervention (Table 6).

Table 7: Independent T-Test between Intervention Group and Control Group

Characteristic	Group				*p* Value	*df*	Confidence Interval(CI)	Cohen's *d*
	Intervention		Control					
Underweight	2	10%	4	19%	0.396*	19	95%	1.004393
Normal	11	52%	3	14%				
Overweight	0	0%	0	0%				
Obese	1	5%	0	0%				
Total	**14**		**7**					

*df=degrees of freedom; *p value is nonsignificant at 95%CI level*

Based on the table 7, post intervention, the *p*-value = 0.396 (>0.05). Statistically, it can be concluded that there is no significant difference between BMI in TB patients who have received the intervention and those who have not. Cohen's d score of 1.004393 indicates that there is a large effect size on the change in BMI between the intervention and control group.

Table 8 : p Value on MUAC Pre and Post Intervention in Intervention Group

Characteristic	Time of Measurement				*p* Value	*df*	SD	Confidence Interval(CI)	Cohen's *d*
	Pre		Post						
Under	5	24%	1	5%	0.000*	13	0.1008	95%	0.05102
Normal	4	19%	8	38%					
Over	5	24%	5	24%					
Total	**14**		**7**						

*df=degrees of freedom; *p value is nonsignificant at 95%CI level*

Based on the statistical test of the difference in MUAC pre - and post-intervention in the intervention group, the *p*-value = 0.000 (< 0.05). This shows that there is a statistically significant difference in MUAC between pre-and post-intervention. Cohen's d value of 0.05102 indicates that there is a very small effect size on the change in MUAC before and after the intervention in the intervention group (Table 8).

Table 9: p Value of MUAC between Intervention and Control Group Based on Independent Test

Characteristic	Group				*p* Value	*df*	Confidence Interval(CI)	Cohen's d
	Intervention		Control					
Under	1	5%	4	19%	0.002*	19	95%	0.202587
Normal	8	38%	3	14%				
Over	5	24%	0	0%				
Total	**14**		**7**					

*df=degrees of freedom; *p value is nonsignificant at 95%CI level*

Based on the table 9, post intervention is conducted, and the *p*-value = 0.002 (< 0.05). Statistically, it can be concluded that there is a significant difference between MUAC in TB patients who have received the intervention and those who have not. Cohen's d score of 0.202587 indicates that there is a small effect size on the change in MUAC between the intervention and control group.

Table 10 : p Value of Respondents Based on Edema Status Pre and Post Intervention in Intervention Group

Characteristic	Time of Measurement				*p* Value	*df*	SD	Confidence Interval(CI)	Cohen's d
	Pre		Post						
Edema	0	0%	0	0%	0.165*	13	0.363	95%	0.716844
No significant amount of edema	14	67%	14	67%					
Total	**14**		**7**						

*df=degrees of freedom; *p value is nonsignificant at 95%CI level*

For edema status, results differ depending on the test applied. Within the intervention group (Table 10), the change from pre- to post intervention was not significant ($p = 0.165$). However, the between-group comparison (Table 10) after the intervention showed a significant difference ($p = 0.16$). This means that although improvements within the intervention group alone were not statistically strong, the intervention group still showed a clear protective advantage compared to the control group. Cohen's *d* value of 0.716844 represents a medium effect size on the change in edema status before and after the intervention.

Table 11 : p Value of Edema Status Respondents Based on Independent Test between Intervention Group and Control Group

Characteristic	Group				*p* Value	*df*	Confidence Interval (CI)	Cohen's *d*
	Intervention		Control					
Edema	0	0%	1	5%	0.052378*	19	95%	0.052378
No significant amount of edema	14	67%	6	29%				
Total	**14**		**7**					

*df=degrees of freedom; *p value is nonsignificant at 95%CI level*

Based on the statistical test post-intervention is conducted, p-value < 0.05. Statistically, it can be concluded that there is a significant difference between edema status in TB patients who have received the intervention and those who have not. Cohen's d score of 0.052378 indicates that there is a very small effect size on the change in edema status between the intervention and control groups.

DISCUSSION

Most respondents were young adults (17-25 years) and middle-aged (45-55 years), with only a minority older (>65 years). This age distribution indicates that adults generally have better metabolic functions, but older individuals tend to have reduced nutritional status as a result of metabolic changes related to age (Mondoni *et al*., 2020). In addition, the study found a similar proportion of male and female patients, who may benefit from a better immune response due to hormonal factors (Ortona *et al*., 2019), which may contribute to a more optimal recovery if well maintained. Prolonged disease requires increased protein intake to support recovery, as prolonged TB exacerbates the protein depletion that is critical for recovery (Bernstein *et al*., 2015).

As regards nutrition, the intervention with a high-protein diet showed a trend in improvements in body weight, although these were not statistically significant. The proportion of obese patients fell from 43 to 29%, while the proportion of normal BMI patients rose from 52 to 67 percent (Bray *et al*., 2012). These changes indicate an early positive effect of a high-protein diet, although the short duration and small size of the study may limit the statistical power (Chandarasekaran *et al.*, 2017).

MUAC

MUAC demonstrated statistically significant improvement within the intervention group and compared with the control ($p = 0.000$ within the intervention group, $p = 0.002$ between groups). This supports the idea that MUAC is a more sensitive measure of dietary adjustment than BMI, particularly in the case of short-term interventions in patients with tuberculosis. Protein supplementation is likely to have contributed to the increase in muscle and fat mass, as reflected by the significant changes in MUAC values (Kesari & Noel, 2023 ; Carbone & Pasiakos, 2019).

Edema

The study also examined edema status, with results varying according to the statistical test applied. No significant change in edema was observed within the intervention group ($p = 0.165$), but a significant difference was observed when comparing the intervention group with the control group after treatment ($p = 0.16$). This suggests that a high-protein diet had a protective effect on oedema (Thompson *et al*., 2024), probably because it had a role in increasing plasma protein levels and oncotic pressure (Kabthymer *et al*., 2020). In patients with tuberculosis who are malnourished, protein deficiency leads to a decrease in plasma protein, which exacerbates the edema. Increased albumin levels due to protein intake may reduce swelling by

improving fluid retention in the blood vessels. This statement is also strengthened by Lent-Schochet and Jialal (2023) about the physiology of edema that albumin is the most abundant plasma protein.

Health Education

Nutritional interventions are essential to managing the nutritional status of TB patients. The findings highlight the need for health education on the need for protein in order to improve nutrition (Gumelar & Tangpukdee, 2022). In addition, socioeconomic factors such as household income and access to nutritious food are key factors in the management of TB-related malnutrition. Families with higher socioeconomic status are more likely to be able to afford nutritious food, while those with lower income face greater difficulties in maintaining adequate nutrition (Kumar & Paswan, 2021; Bemena *et al.*, 2025).

This study aligns with Sagala *et al*., 2024 systematic review of the positive effect of nutrition on the nutritional status of TB patients. Sustainable nutrition interventions may improve long-term recovery and reduce recidivism. This analysis is consistent with Moon's statement that protein has an important role in healing chronic diseases and ultimately has an impact on weight loss (Moon & Koh, 2020). Malnutrition not only damages the quality of life but also affects the compliance and effectiveness of TB treatments, as poor nutrition may impair the body's ability to metabolise medicines and heal properly.

Limitations

This study has a small sample. Nutritional status is also measured based on three components only, not using a body composition analyser because the price of the device is expensive. Observation of adherence to intervention is also based on patient statements only, not observed directly. This study was conducted in one place only, so the results cannot be generalised in general.

CONCLUSION

This study concluded that a high-protein diet can improve nutritional status based on Mid-Upper Arm Circumference (MUAC) but not Body Mass Index (BMI) and edema measurements. Liquid diets are more easily digested by the intestines, help increase muscle mass, increase intravascular protein levels and improve colloid osmotic pressure. Improvements in BMI were not observed due to the longer duration and higher calorie content. Therefore, a high-protein liquid diet should be incorporated into the diet of pulmonary tuberculosis patients to improve their nutritional status. Future research is expected to identify the most effective duration of high-protein diet administration to improve the nutritional status of tuberculosis patients. Similar experimental studies in larger community samples were also recommended to provide stronger evidence of their effectiveness.

Recommendation

This research recommends cooperation with the government to provide a high-protein diet to pulmonary TB patients, continuous monitoring of the nutritional status of pulmonary TB patients, and dietary supervision by the health centre officers. The researchers acknowledge that the main limitation of the study is the small sample size. Future studies should include a larger sample size to ensure more reliable results.

The intervention did not result in statistically significant changes in BMI ($p > 0.05$) so it is recommended to extend the duration of the intervention or explore additional dietary modifications to address BMI changes. This study also has limitations by not reviewing external variables, so it is recommended to include these variables in future studies.

Conflict of Interest

The author declares that there are no conflicts of interest.

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REFERENCES

Adminwarta, (2024, August 22). Pemkot Yogya targetkan 2026 Zero TB [Yogyakarta City Government targets Zero TB by 2026]. *Portal Berita Pemerintah Kota Yogyakarta*. https://warta.jogjakota.go.id/detail/index/35256

Arlinta, D. (2024, February 8). Estimasi kasus TBC di Indonesia naik jadi lebih dari 1 juta kasus [Estimated TB cases in Indonesia have increased to more than 1 million cases]. *kompas.id*. https://www.kompas.id/baca/english/2024/02/07/en-estimasi-kasus-tbc-di-indonesia-naik-jadi-lebih-dari-1-juta-kasus

Balkhy, H. (2025). World TB Day 2025. World Health Organization. https://www.emro.who.int/world-tb-day/2025/index.html

Bemena, B. M. S., Totoshina, A., Feno, D. R., & Rakotoarivelo, R. A. (2025). New branch and definitions against emerging infectious diseases. *Academia Medicine and Health, 2*(1). https://doi.org/10.20935/acadmed7470

Bernstein, A. M., Golubic, M., & Roizen, M. F. (2015). The impact of protein on chronic disease risk should be considered in studies of weight loss. *The American Journal of Clinical Nutrition, 101*(5), 1097–1098. https://doi.org/10.3945/ajcn.114.105189

Bray, G. A., Smith, S. R., Xie, H., Rood, J., Martin, C. K., Most, M., Brock, C., Mancuso, S., & Redman, L. M. (2012). Effect of dietary protein content on weight gain, energy expenditure, and body composition during overeating: A randomized controlled trial. *JAMA, 307*(1), 47-55. https://doi.org/10.1001/jama.2011.1918

Carbone, J. W., & Pasiakos, S. M. (2019). Dietary protein and muscle mass: Translating science to application and health benefit. *Nutrients, 11*(5), 1136. https://doi.org/10.3390/nu11051136

Chandarasekaran, P., Saravanan, N., Bethunaickan, R., & Tripathy, S. (2017). Malnutrition: Modulator of immune responses in tuberculosis. *Frontiers in Immunology, 8*, 1316. https://doi.org/10.3389/fimmu.2017.01316

Dinas Kesehatan Kabupaten Bantul (2023, November 24). *Dinkes Bantul bersama Sinergi Sehat Indonesia terus berupaya tekan angka penularan TBC*. Kabupaten Bantul. [The Bantul Health Office, together with Sinergi Sehat Indonesia, continues its efforts to reduce the number of TB infections. Bantul Regency]. https://bantulkab.go.id/berita/detail/6179/dinkes-bantul-bersama-sinergi-sehat-indonesia-terus-berupaya-tekan-angka-penularan-tuberculosisc.html

Fahdhienie, F., Mudatsir, M., Abidin, T. F., & Nurjannah, N. (2024). Risk factors of pulmonary tuberculosis in Indonesia: A case-control study in a high disease prevalence region. *Narra J, 4*(2), e943. https://doi.org/10.52225/narra.v4i2.943

Fatsecret. (2025, April 23). Kalori dalam Kalbe Peptisol dan Fakta Gizi [Calories in Kalbe Peptisol and Nutrition Facts]. *Fatsecret*. https://www.fatsecret.co.id/kalori-gizi/kalbe/peptisol/1-porsi

Feleke, B. E., Feleke, T. E., & Biadglegne, F. (2019). Nutritional status of tuberculosis patients, a comparative cross-sectional study. *BMC Pulmonary Medicine, 19*(1), 182. https://doi.org/10.1186/s12890-019-0953-0

Garcia-Basteiro, A. L., Hurtado, J. C., Castillo, P., Fernandes, F., Navarro, M., Lovane, L., Casas, I., Quintó, L., Jordao, D., Ismail, M. R., Lorenzoni, C., Carrilho, C., Sanz, A., Rakislova, N., Mira, A., Alvarez-Martínez, M. J., Cossa, A., Cobelens, F., Mandomando, I., Vila, J., Martínez, M. J. (2019). Unmasking the hidden tuberculosis mortality burden in a large post mortem study in Maputo Central Hospital, Mozambique. *The European Respiratory Journal, 54*(3), 1900312. https://doi.org/10.1183/13993003.00312-2019

Gumelar, W. R., & Tangpukdee, J. (2022). The effect of nutrition education based on local foods on mothers' knowledge and anthropometry of malnutrition children aged 6 to 21 months. *The Malaysian Journal of Nursing, 14*(01), 53–58. https://doi.org/10.31674/mjn.2022.v14i01.008

Gurung, L. M., Bhatt, L. D., Karmacharya, I., & Yadav, D. K. (2018). Dietary practice and nutritional status of tuberculosis patients in Pokhara: A cross sectional study. *Frontiers in Nutrition, 5*, 63. https://doi.org/

10.3389/fnut.2018.00063

Kabthymer, R. H., Yacob, T., & Tenkolu, G. (2020). Determinants of nutritional edema among under-five children with severe acute malnutrition admitted to health facilities at Gedeo Zone: Unmatched case–control study. *Nutrition and Dietary Supplements, 12*, 49–56. https://doi.org/10.2147/NDS.S238403

Kesari, A., & Noel, J. Y. (2023, April 10). *Nutritional assessment*. StatPearls - NCBI Bookshelf. https://www.ncbi.nlm.nih.gov/books/NBK580496/

Kumar, R., & Paswan, B. (2021). Changes in socio-economic inequality in nutritional status among children in EAG states, India. *Public Health Nutrition, 24*(6), 1304–1317. https://doi.org/10.1017/S1368980021000343

Kusumawardhani, N. E., & Hadiani, N. N. F. (2025). Albumin levels pre therapy and clinicopathological parameters of lung cancer patients. *Majalah Biomorfologi, 35*(1), 29–39. https://doi.org/10.20473/mbiom.v35i1.2025.29-39

Lent-Schochet, D., & Jialal, I. (2023, May 1). *Physiology, edema*. StatPearls - NCBI Bookshelf.

Ma'rufi, I., Ali, K., Jati, S. K., Sukmawati, A., Ardiansyah, K., & Ningtyias, F. W. (2020). Improvement of nutritional status among tuberculosis patients by Channa striata supplementation: A true experimental study in Indonesia. *BioMed Research International*, 2020, 1–9. https://doi.org/10.1155/2020/7491702

MacNeil, A., Glaziou, P., Sismanidis, C., Maloney, S., & Floyd, K. (2019). Global epidemiology of tuberculosis and progress toward achieving global targets — 2017. *MMWR Morbidity and Mortality Weekly Report, 68*(11), 263–266. https://doi.org/10.155 85/mmwr.mm6811a3

Mohamed-Hussein, A. A. R., Salama, S. A., Khalil, M. A., & Eid, S. A. (2016). Malnutrition in tuberculosis: Value of fat-free mass and creatinine-height index. *The Egyptian Journal of Bronchology, 10*(1), 58–63. https://doi.org/10.4103/1687-8426.176790

Mondoni, M., Centanni, S., & Sotgiu, G. (2020). New perspectives on difficult-to-treat tuberculosis based on old therapeutic approaches. *International Journal of Infectious Diseases, 92*, S91–S99. https://doi.org/10.1016/j.ijid.2020.02.039

Moon, J., & Koh, G. (2020). Clinical evidence and mechanisms of high-protein diet-induced weight loss. *Journal of Obesity & Metabolic Syndrome, 29*(3), 166–173. https://doi.org/10.7570/jomes20028

Newdiet (2025, April 22). *Contraindications of the high-protein diet NEWDIET|NEWDIET*. https://www.newdiet.ch/en/about-method/contraindications-of-the-high-protein-diet-newdiet/

Ockenga, J., Fuhse, K., Chatterjee, S., Malykh, R., Rippin, H., Pirlich, M., Yedilbayeva, A., Wickramasinghe, K., Barazzoni, R. (2023). Tuberculosis and malnutrition: The European perspective. *Clinical Nutrition, 42*(4), 486–492. https://doi.org/10.1016/j.clnu.2023.01.016

Ortona, E., Pierdominici, M., & Rider, V. (2019). Editorial: Sex hormones and gender differences in immune responses. *Frontiers in Immunology, 10*, 1076. https://doi.org/10.3389/fimmu.2019.01076

Sagala, A. B. M., Rekawati, E., & Nursasi, A. Y. (2024). The effect of nutritional management in the nutritional status of patients with pulmonary tuberculosis: A systematic review literature. *Indonesian Journal of Global Health Research, 6*(3), 1161-1172. https://doi.org/10.37287/ijghr.v6i3.3085

Scallan, J., Huxley, V., & Korthuis, R. J. (2010). Pathophysiology of edema formation. In Capillary fluid exchange: Regulation, functions, and pathology (Chapter 4). *Morgan & Claypool Life Sciences*. https://www.ncbi.nlm.nih.gov/books/NBK53445/

Thompson, A. D., Shea, M. J., & Howlett, J. G. (2024, August). Edema. MSD Manual, Professional Version. https://www.msdmanuals.com/professional/cardiovascular-disorders/symptoms-of-cardiovascular-disorders/edema