ORIGINAL ARTICLE

Zinc Intake and Appetite in Patients with Post-Tuberculosis Lung Disease at Persahabatan National Respiratory Referral Hospital, Jakarta

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ARTICLE INFO

Article history:
Received 20 May 2025
Received in revised form
30 July 2025
Accepted 25 August 2025
Available online 30 September 2025

Keywords:
Appetite,
Malnutrition,
Pulmonary disease,
Tuberculosis,
Zinc.

Cite this as:
Mahardhika L, Nurwidya F, Singal AM, *et al.* Zinc Intake and Appetite in Patients with Post-Tuberculosis Lung Disease at Persahabatan National Respiratory Referral Hospital, Jakarta. *J Respi* 2025; 11: 1-5.

ABSTRACT

Introduction: After completion of pulmonary tuberculosis (TB) treatment, some people may continue to experience respiratory issues that can progress into post-TB lung disease (PTLD). Individuals with PTLD exhibit suboptimal nutritional status. The loss of appetite is a significant factor influencing nutritional status. Zinc plays a role in hunger control. Lack of zinc reduces taste sensitivity and food intake. This study examined the relationship between zinc intake and appetite in patients with PTLD at Persahabatan National Respiratory Referral Hospital, Jakarta.
Methods: This cross-sectional study was conducted at Persahabatan National Respiratory Referral Hospital, Jakarta, from November 2024 to March 2025. Eighty-five adult patients with PTLD were included. Zinc intake was assessed by a semi-quantitative food frequency questionnaire (SQ-FFQ) and analyzed by NutriSurvey software. Appetite was measured using the visual analog scale (VAS) for appetite.
Results: A total of 85 subjects participated in the study, comprising 78.8% males and 21.2% females. The average daily zinc intake was 4.4 mg/day, and 92.9% of the subjects had zinc intake below the recommended dietary allowance (RDA). The average VAS appetite score was 70 mm. A significant positive correlation was found between zinc intake and appetite, indicating that a decrease in zinc intake might result in a reduced appetite (r=0.266, p=0.014).
Conclusion: Zinc intake is positively associated with appetite in patients with PTLD. Therefore, zinc intake monitoring is essential for supporting nutritional recovery and lung function in PTLD.

INTRODUCTION

Post-tuberculosis lung disease (PTLD) is a chronic pulmonary condition that occurs after the completion of tuberculosis (TB) treatment.[1] This condition may involve both functional and structural damage to the lungs. Clinically, it often presents as chronic airflow limitation. Radiological findings include the presence of lung cavities, fibrosis, bronchiectasis, pulmonary hypertension, and pleural thickening.[2] The clinical manifestations of PTLD can significantly affect quality of life, including socioeconomic status, psychological well-being, and functional capacity.[3] One of the factors that continues to influence the quality of life in patients with PTLD is their nutritional status and ability to maintain adequate food intake. Most individuals with PTLD experience weight loss and are often found to be undernourished.[4–6] One of the key factors affecting nutritional status is appetite, which directly influences dietary intake and overall nutritional adequacy.[7]

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Jurnal Respirasi (Journal of Respirology), p-ISSN: 2407-0831; e-ISSN: 2621-8372.
Accredited No. 79/E/KPT/2023; Available at https://e-journal.unair.ac.id/JR. DOI: 10.20473/jr.v11-I.3.2025.232-240

Post-tuberculosis lung disease develops from direct lung damage during TB infection and the host's immune response, involving granuloma formation, cytokine activation (e.g., tumor necrosis factor/TNF-α), transcription factors such as hypoxia-inducible factor (HIF), and the production of matrix metalloproteinases (MMPs).[3] The activation and enzymatic function of MMP require the presence of zinc ions (Zn^{2+}) as essential cofactors within their catalytic domain. Therefore, adequate zinc intake is vital for MMP activity, which plays a role in extracellular matrix degradation and tissue remodeling.[8] However, to date, no studies have clearly explained whether zinc intake decreases in response to MMP activation.

Zinc is a trace mineral that influences various physiological systems, including immune function, gene expression, enzymatic activity, tissue repair, and appetite regulation.[9] One of the critical roles of zinc related to nutritional status is its involvement in appetite control. Zinc affects appetite regulation through both peripheral and central mechanisms. Peripherally, it influences taste buds and the vagus nerve, whereas centrally, it modulates neuropeptides that regulate appetite at the hypothalamic level. Zinc deficiency has been associated with anorexia and reduced food intake.[10–13] However, studies specifically examining the relationship between zinc intake and appetite in patients with PTLD remain limited, despite this population being at high risk for both zinc deficiency and appetite loss.

This study examined the relationship between zinc intake and appetite in patients with PTLD. By identifying this association, this study aimed to highlight the importance of zinc as a modifiable factor in the nutritional rehabilitation of post-TB patients. The findings of this study may serve as a basis for developing more comprehensive nutritional interventions to improve appetite, enhance nutritional status, and accelerate recovery in patients with PTLD.

METHODS

Study Population

This cross-sectional study was conducted at Persahabatan National Respiratory Referral Hospital, Jakarta, from November 2024 to March 2025. It included 85 adult patients with PTLD diagnosed by pulmonologists who were recruited via accidental sampling from outpatient chronic obstructive pulmonary disease (COPD) and interstitial lung disease (ILD) clinics. Post-tuberculosis lung disease diagnosis was confirmed by medical records. Inclusion criteria were adults with post-TB treatment with lung damage. Exclusion criteria included pregnant/breastfeeding women and individuals taking zinc supplements. Participants were informed about the study before data collection, which included anthropometrics, socioeconomic factors, clinical symptoms, smoking history, dietary intake, and appetite, assessed using the visual analog scale (VAS).

Ethical Approval

This study received ethical approval from the Ethics Committee of Persahabatan National Respiratory Referral Hospital, Jakarta (No. 0220/KEPK-RSUPP/10/2024) and research permission from the same institution (No. DP.04.03/DSS.2/13241/2024).

Anthropometric Measurement

The anthropometric assessment consisted of two measurements. Body weight and height were each measured twice to validate the results.[14] Weight was measured with subjects wearing minimal clothing, and height was measured after removing footwear and headgear. Proper postural instructions were provided to ensure accurate measurements, in accordance with standard anthropometric procedures.[14] Body weight and height were measured using a calibrated SECA 876 scale and ShorrBoard (USA) by Southeast Asian Ministers of Education Organization Regional Center for Food and Nutrition (SEAMEO RECFON). Body mass index (BMI) was calculated and classified according to the World Health Organization (WHO) Asia-Pacific criteria: underweight (<18.5 kg/m²), normal (18.5–22.9), overweight (23.0–24.9), obese I (≥25.0), and obese II (≥30.0).[15]

Zinc Intake

The semi-quantitative food frequency questionnaire (SQ-FFQ) was used to assess zinc intake. The interviews were conducted using a food list that contained high-zinc foods, based on previously validated research conducted in the same geographic area.[16] The SQ-FFQ was used to assess the subjects' food intake over the past month. Independent subjects were interviewed directly, whereas caregivers assisted with physical or memory limitations. Portion sizes were estimated using the 2014 Food Photograph Book of the Ministry of Health of the Republic of Indonesia.[17] Nutrient intake was analyzed with NutriSurvey software. Daily zinc intake was classified by sex, with minimum requirements of 11 mg/day for males and 8 mg/day for females, based on the Indonesian Recommended Dietary Allowance (RDA).[18]

Appetite

Appetite assessment was conducted through interviews using a paper-based VAS for 100-mm appetite.[19] Participants were shown a 100-mm horizontal line, with marks to the right indicating stronger appetite and to the left indicating weaker appetite. Zero represented "no appetite" and 100 represented "very strong appetite." Participants were asked to mark their current appetite level on the line. Scores ≥50 mm were classified as good appetite, while scores <50 mm were considered poor.[20]

Data Analysis

Nominal and ordinal data are presented as frequencies (n, %). The ratio data were tested for normality using the Kolmogorov-Smirnov test. Normally distributed data (p>0.05) were presented as mean±standard deviation (SD), while non-normal data were presented as median (minimum/min-maximum/max). Bivariate analysis assessed the correlation between zinc intake and appetite using Pearson's test for normal data and Spearman's test for non-normal data. Variables with a significance (p<0.25) were subsequently subjected to additional examination. Categorical data were tested using the Chi-square test or Fisher's exact test (for non-normal data), to determine significance (p<0.05) and calculate odds ratios (OR). To analyze the numerical data, a Mann-Whitney U test was conducted to determine whether there was a significant difference between the two groups, with significance (p<0.05).

RESULTS

Study Population Characteristics

Table 1. Sociodemographic characteristics of the study population[a]

Variable	Mean/Median	N=85(%)
Age (years old)[b]	63 (33-84)	
Sex		
Male		67 (78.8)
Female		18 (21.2)
Education		
Elementary school		40 (47)
Middle school		36 (42.4)
High school/university		9 (10.6)
Brinkman Index		
Mild		23(27.1)
Moderate		0 (0)
Heavy		62 (72.9)
Body Mass Index	20.4 (13.3-33.8)	
Nutritional Status		
Underweight		29 (34.2)
Normal		26 (30.6)
Overweight		15 (17.6)
Obese I		15 (17.6)
Visual Analog Scale Appetite		
Good		74 (87.1)
Poor		11 (12.9)
Comorbidities		
Yes		49 (57.6)
No		36 (42.4)
Human Immunodeficiency Virus		
Positive		1 (1.2)
Negative		84 (98.8)
Diabetes Mellitus		
Yes		13 (15.3)
No		72 (84.7)
Anemia		
Yes		9 (10.6)
No		76 (89.4)
Hypertension		
Yes		32 (37.6)
No		53 (62.4)
Cardiovascular		
Yes		23 (27.1)
No		62 (72.9)

[a]Descriptive statistics; [b]Data were presented as mean±standard deviation if the distribution was normal and as median (minimum-maximum) if the data were not normally distributed

Table 1. Sociodemographic characteristics of the study population[a] (continued)

Variable	Mean/Median	N=85(%)
Symptoms		
Yes		67 (78.8)
No		18 (21.2)
Cough		
Yes		57 (68.2)
No		28 (31.8)
Dyspnea		
Yes		52 (61.2)
No		33 (38.8)
Wheezing		
Yes		25 (29.4)
No		60 (70.6)
Secondary infection		
Positive		43 (50.5)
Negative		6 (7.1)
Not examined		36 (42.4)
Zinc intake		
Male		
Adequate		3 (4.5)
Inadequate		64 (95.5)
Female		
Adequate		3 (16)
Inadequate		15 (84)
Income		
Low-income		54 (63.5)
Enough income		31 (36.5)

[a]Descriptive statistics

Table 2. Distribution of zinc intake and appetite[a]

Variable	Mean±SD/Median(Min-Max)
Zinc intake	4.4 (1.4-18)
Appetite (VAS appetite)	70 (10-100)

[a]Descriptive statistic
VAS: visual analog scale; SD: standard deviation; Min: minimun; Max: maximum

Table 3. Correlation between zinc intake and appetite[a]

Correlation Test	Appetite (VAS Appetite)[a]	
	r	p
Zinc intake	0.266	0.014*

[a]Bivariate analysis; *p<0.05 was considered statistically significant
VAS: visual analog scale

Table 4. Analysis of the relationship between appetite and other parameter[s]

Variable	Visual Analog Scale Appetite			Total	p-value	OR (95% CI)
	Mean/Median	Poor n(%)	Good n(%)			
Income						
Low-income		8(9.4)	46(54.2)	54(63.5)	0.739[c]	1.6(0.4-6.6)
Enough income		3(3.5)	28(32.9)	31(36.5)		
Age (years old)	63 (33-84)				0.039[m*]	
Sex						
Male		8 (9.5)	59(69.4)	67(78.8)	0.693	1.4(0.35-6.24)
Female		3(3.5)	15(17.6)	18(21.2)		
Symptom						
Yes		11(12.9)	56(65.9)	67(78.8)	0.169	7.5(0.42-134.1)
No		0(0)	18(21.2)	18(21.2)		
Cough						
Yes		9(10.6)	48(56.5)	57(67.1)	0.325	2.4(0.50-12.13)
No		2(2.4)	26(30.6)	28(32.9)		
Dyspnea						
Yes		9(10.6)	43(50.6)	52(61.2)	0.190	3.2(0.65-16.07)
No		2(2.4)	31(36.5)	33(38.8)		
Wheezing						
Yes		3(3.5)	22(25.9)	25(29.4)	1.000	0.8(0.21-3.65)
No		8(9.4)	52(61.2)	60(70.6)		
Comorbidities						
Yes		6(7.1)	43(50.6)	49(57.6)	1.000	1.1(0.32-4.13)
No		5(5.9)	31(36.5)	36(42.3)		
Diabetes Mellitus						
Yes		0(0)	13(15.3)	13(15.3)	0.272	0.2(0.01-3.57)
No		11(12.9)	61(71.8)	72(84.7)		

[a]Bivariate analysis; [m*]Mann-Whitney (p<0.05 was considered statistically significant); [c]Chi-square
OR: odds ratio; CI: confidence interval

Table 4. Analysis of the relationship between appetite and other parameter[s] (continued)

Variable	Visual Analog Scale Appetite			Total	p-value	OR (95% CI)
	Mean/Median	Poor n(%)	Good n(%)			
Hypertension						
Yes		6(7.1)	26(30.6)	32(37.6)	0.317	2.2(0.61-7.96)
No		5(5.9)	48(56.5)	53(62.4)		
Human Immunodeficiency Virus						
Positive		0(0)	1(1.2)	1(1.2)	0.649	2.1(0.81-55.5)
Negative		11(12.9)	73(85.9)	84(98.8)		
Anemia						
Yes		0(0)	9(10.6)	9(10.6)	0.479	0.3(0.01-6.43)
No		11(12.9)	65(76.5)	76(84.9)		
Cardiovascular						
Yes		4(4.7)	19(22.4)	23(27.1)	0.479	1.6(0.43-6.28)
No		7(8.2)	55(64.7)	62(72.9)		
Body Mass Index	20.4 (13.3-33.8)				0.521[m]	
Nutritional Status						
Underweight		4(4.7)	25(29.4)	29(34.1)	0.587	0.6(0.16-2.82)
Normal		5(5.9)	21(24.6)	26(30.5)		ref
Overweight		1(1.2)	14(16.5)	15(17.7)	0.294	0.3(0.32-2.84)
Obese I		1(1.2)	14(16.5)	15(17.7)	0.294	0.3(0.32-2.84)
Brinkman Index						
Severe		9(10.6)	53(62.3)	62(72.9)	0.482	1.7(0.35-8.95)
Moderate		0(0)	0(0)	0(0)	0.307	8.6(0.13-536)
Mild		2(2.4)	21(24.7)	23(27.1)		ref
Secondary Infection						
Positive		7(8.2)	36(42.4)	43(50.5)	0.298	2.1(0.51-8.96)
Negative		1(1.2)	5(5.9)	6(7)	0.528	2.2(0.18-25.5)
Not examined		3(3.5)	33(38.8)	36(42.5)		ref

[m]Mann-Whitney
OR: odds ratio; CI: confidence interval

DISCUSSION

Table 1 presents the demographic characteristics of the participants. The average age of the study subjects was 63 years old. This differs from another study conducted in Jakarta, Indonesia, where PTLP subjects had an average age of approximately 50 years old.[21] Similarly, a study conducted in Australia showed that patients with PTLD also tended to be younger, with an average age of around 45 years old.[22] However, a similar average age of 60 years old was reported in another study conducted in the United States (US) in 2020.[23] The risk of PTLD rises with age due to a decline in the immune system and diminished capacity for tissue repair. In comparison to younger individuals, the elderly exhibit a diminished immune response to lung pathogens and more pronounced structural lung alterations, resulting in reduced lung function.[24,25]

Most study subjects were males (78.8%). Similar findings were observed in several other studies. For instance, a study conducted in Australia reported that 61% of PTLD cases were males.[22] An Indonesian study conducted between 2019 and 2020 also found that most PTLD subjects were males (68%).[21] Another study conducted in Brazil in 2020 found that 52% of PTLD subjects were male.[23] Males are more likely to develop PTLD primarily because they have a higher incidence of smoking. Smoking tobacco exposes individuals to toxic substances that raise the likelihood of persistent respiratory conditions like bronchitis and emphysema. A study in China found that the extent of smoking varied widely, with males accounting for 53-75% of smokers, whereas females comprised only 2-12% of the smoking population.[26]

This study revealed that the highest proportion of subjects had only primary-level education (47%). This study aligns with a study conducted in Medan, Indonesia, where the majority of PTLD subjects (47%) generally had an education level at the senior high school.[27] Educational attainment influences an individual's ability to respond to disease, including the capacity to prevent the risk of infectious and metabolic diseases and to manage exposure to allergens that may trigger the recurrence of allergic conditions.[28] A study conducted in the United Kingdom (UK) found that the longer individuals remained in formal education, the greater their health knowledge, which in turn contributed to reduced mortality rates within the population.[29]

In this study, most of the subjects had a history of smoking, with the majority categorized as heavy smokers based on the Brinkman index (72.9%). A study conducted in Tanzania in 2021 found that 47% of respondents were smokers. However, the study did not specify the severity level of smoking behavior.[4] A history of smoking in patients with PTLD is associated with more frequent and severe clinical symptoms. Approximately 53% of smokers with PTLD experience intensified symptoms.[4] Cigarette smoke exposure during TB infection promotes macrophage polarization (M1 and M2), increases the production of MMP-9 and MMP-12, cytokine release, and alters key mechanisms of natural killer (NK) cell metabolism, contributing to the development of PTLD.[26]

The average BMI of the subjects in this study was 20.4 kg/m², with most subjects classified as underweight (34.1%). A study by Liu, *et al*. (2024) found a similar result, with an average BMI of 19.06 kg/m² and 48.68% of patients with PTLD being underweight.[5] Another study in Nigeria reported a slightly higher average BMI of 21.5 kg/m², with most patients in the normal category (54.2%).[6] A study conducted in Indonesia reported that patients with PTLD had a borderline BMI, with a mean value of 18.9 kg/m².[30] Notably, 54.7% of the patients were categorized as underweight.[30] In contrast to the study conducted in Yogyakarta, Indonesia, which found that most patients with PTLD had a BMI of 18.6, with 59.5% of the study subjects having a normal nutritional status.[31] Patients with PTLD with severe symptoms often experience difficulties in preparing their meals correctly. Inflammation not only boosts energy requirements and suppresses appetite. Elevated levels of TNF-α can lead to the depletion of fat-free mass (FFM) and alter the regulation of appetite-regulating hormones. Elevated interleukin (IL)-6 levels also diminish the impact of ghrelin.[32] However, this study did not determine whether the subjects were in the inflammatory phase or not, as no assessment of inflammatory markers was conducted.

A total of 57% of the subjects in this study had comorbidities. Only 1.2% of patients were human immunodeficiency virus (HIV)-positive. The majority of subjects did not have diabetes mellitus/DM (84.7%), and 10.6% were found to have anemia. Most subjects did not have hypertension (62.4%), and 27.1% had a history of heart disease. According to Rozaliyani, *et al*. (2020), in a study of PTLD patients in Jakarta, 13% of subjects had comorbid diabetes and 16% had hypertension.[21] Another study conducted in Australia in 2022 found that 5% of PTLD subjects had comorbid heart diseases.[22] Meanwhile, a 2021 study in Shenzhen showed that 15.25% of PTLD subjects experienced anemia.[5] Mpagama, *et al*. (2021) reported that 16% of PTLD patients in their study were HIV-positive.[4] Comorbidities, such as COPD, heart disease, and DM, may worsen the severity of lung damage in patients with PTLD. These conditions complicate clinical management and increase the risk of poor outcomes.[33]

In this study, 78.8% of subjects presented with clinical symptoms. The most common symptoms were cough (68.2%), shortness of breath (61.2%), and wheezing (29.4%). A study conducted in Malawi in 2019 found that 51.9% of subjects experienced shortness of breath, 43% had a cough, and 12.6% reported wheezing.[34] Another study conducted in Nigeria in 2019 on patients with PTLD found that 93.2% of subjects experienced a clinical symptom of cough, 69.5% reported shortness of breath, and 16.9% reported wheezing.[6] In another study conducted in Jakarta, Indonesia, 88% of the subjects reported having a cough, and 75% experienced shortness of breath.[30] Clinical symptoms impact quality of life in patients with PTLD. A Ugandan study emphasized improving health, physical capacity, nutrition, and social functioning as key treatment goals.[35] In this study, a further analysis was conducted to assess the relationship between appetite and clinical symptoms, and no significant association was found between the two (OR=7.5; 95% confidence interval (CI): 0.42-134.1; p=0.169).

In this study, 50.5% of subjects were found to have a positive secondary infection. A study conducted in Malawi in 2019 reported that 2.1% of subjects had positive results in the microbiological culture tests.[34] However, this study did not differentiate secondary infections according to whether they originated from bacterial or fungal cultures. Another study conducted in Jakarta, Indonesia, in 2020 found that 31% of PTLD subjects had positive results for secondary infections (fungal culture).[21] The presence of secondary infections can lead to structural changes in the lungs, persistent inflammation, increased susceptibility to bacterial and fungal colonization in the airways, and risk of impaired mucociliary function.[36]

Among the subjects, it was found that the majority (63.5%) had a monthly income below the provincial minimum wage. A systematic review of PTLD in several countries reported that 47.7% of patients with PTLD were from lower-middle-income countries, whereas 40.2% were from low-income countries.[1] This aligns with data from the National Statistics Agency, which indicates that most study participants were older adults.[37] This group generally had income levels below the minimum wage.[37] Low-income countries have limited healthcare access, leading to delayed diagnosis and more advanced lung damage. The people also face higher exposure to waste and live in areas with poor air quality and heavy pollution.[1]

The average zinc intake among study subjects was 4.4 mg/day, with the lowest intake recorded at 1.4 mg/day and the highest at 18 mg/day. Based on zinc adequacy, 4.5% of male subjects had adequate zinc intake, whereas 16% of female subjects met the recommended intake level. However, this study did not analyze the intake of other nutrients that may affect zinc absorption, such as phytic acid, casein, protein, and calcium.[38] A 2021 study conducted in Semarang, Indonesia, reported an average adult zinc intake of 5.1 mg/day, with males and females consuming 5.8 and 4.4 mg/day, respectively.[39] Zinc deficiency can delay growth, weaken immunity, and reduce appetite. It regulates appetite via the brain's central control center and helps maintain energy balance.[13,16,40]

Appetite assessment in this study was conducted using a 100 mm VAS for appetite. The average appetite score was 70 mm (range: 10-100 mm), with 87.1% of subjects classified as having good appetite. In contrast, a 2020 study in Bogor, Indonesia, involving 46 patients with multidrug-resistant (MDR)-TB, reported a median VAS score of 58.72 mm, with 63% experiencing poor appetite.[41] However, the study used a different cut-off point for categorizing appetite adequacy compared with this study. Several factors, including inflammation, changes in taste buds, and zinc intake, influence appetite. During inflammation, there is an increase in pro-inflammatory cytokines (TNF-α and IL-6), which can reduce appetite and FFM. This, in turn, leads to increased energy expenditure.[32]

The results of this study showed a weak correlation (r=0.266) with statistical significance (p=0.014) between zinc intake and appetite in patients with PTLD at Persahabatan National Respiratory Referral Hospital, Jakarta. No previous studies have specifically examined the relationship between zinc intake and appetite, particularly in adult patients with PTLD. This finding suggests that age is a significant factor influencing appetite. A statistically significant negative correlation (p=0.038) was observed between increasing age and decreased appetite. This finding is similar to a previous study, which reported that the aging process can lead to physiological and psychological changes that reduce the desire to eat.[42]

CONCLUSION

Most of the study subjects had inadequate zinc intake but maintained a good appetite. This study found a statistically significant relationship between zinc intake and appetite in patients with PTLD. It is also essential to educate patients on the importance of adequate nutrient intake, including both macro- and micronutrients, to maintain appetite and prevent malnutrition in those with PTLD. Additionally, it is essential to offer advice on easily accessible daily nutritional sources, appropriate food preparation methods, and nutrient combinations that can enhance or reduce intake.

LIMITATIONS OF THE STUDY

This study assessed zinc status based on dietary zinc intake using the SQ-FFQ interview method, which relied on participants' food consumption over the past month. However, this method is susceptible to recall bias, which may compromise the accuracy of the intake data. Therefore, the use of objective biomarkers is recommended for future studies. Additionally, this study did not assess other nutrients that may affect zinc absorption, such as phytic acid, casein, protein, and calcium. Appetite was evaluated using the VAS, which carries inherent limitations, including potential measurement and response bias due to its subjective nature. Furthermore, this study did not account for medications that may reduce appetite, nor did it include supporting information such as weight loss, changes in taste perception, or the frequency of receiving complete meals, all of which are important for improving the validity of appetite assessment.

Acknowledgments

The authors extend their appreciation to Persahabatan National Respiratory Referral Hospital, Jakarta, for obtaining the necessary permission and providing access to the facility, which enabled them to conduct their study from inception to completion.

Conflict of Interest

The authors declared there is no conflict of interest.

Funding Statement

This study did not receive any funding.

Authors' Contributions

Conceived and designed the study, collected, analyzed, and interpreted the data, and wrote the manuscript: LM. Provided guidance, contributed substantial intellectual content during the drafting process, and revised the manuscript: FN, AMS, KS, RI, SS. All authors contributed and approved the final version of the manuscript.

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