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Analysis of the Relationship between Neutrophil-Lymphocyte Ratio (NLR) Values and Body Mass Index in Tuberculosis Patients

Wahyu Nurfiyana*, A Zakaria Amien
Medical Laboratory Technology Department, Poltekkes Kemenkes Tanjung Karang, Bandar Lampung, Indonesia

Corresponding author: wnurfiyana@gmail.com

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ABSTRACT

Tuberculosis (TB) is a communicable infectious disease that remains a major public health problem, particularly in Indonesia. Low nutritional status can impair immune function and worsen the clinical course of TB. Body Mass Index (BMI) is commonly used to measure nutritional status. In contrast, the neutrophil–lymphocyte ratio (NLR) is a simple inflammatory biomarker reflecting the balance between innate and adaptive immune responses. This study aimed to analyze the relationship between NLR and BMI among TB patients undergoing treatment. This cross-sectional study involved 32 tuberculosis patients receiving treatment at Puskesmas Sukabumi, Bandar Lampung. NLR values were obtained from blood tests using a hematology analyzer and calculated as the neutrophil count divided by the lymphocyte count. BMI was determined from body weight and height measurements. Statistical analysis included Spearman's correlation test to examine the relationship between NLR and BMI, and a One-Way ANOVA to assess differences in NLR across BMI classifications. The results showed that the mean BMI was 20.4±3.0 kg/m^2, and the median NLR was 2.7. A significant negative correlation was found between BMI and NLR ($r = -0.379$; $p = 0.03$), indicating that lower BMI was associated with higher NLR. Significant differences in NLR were also observed among BMI categories ($p = 0.003$), with underweight subjects demonstrating the highest NLR values. These findings suggest a relationship between nutritional status and systemic inflammatory responses in TB patients. BMI and NLR may serve as simple indicators for assessing inflammatory status and monitoring treatment progress in tuberculosis patients.

INTRODUCTION

Tuberculosis (TB) is a communicable infectious disease caused by *Mycobacterium tuberculosis*. Transmission occurs through the air when individuals inhale droplets containing the bacteria. TB infection primarily affects the lungs but may also involve other organs. The disease is preventable and, in most cases, curable with appropriate treatment. In 2024, it is estimated that 10.7 million cases of TB globally resulted in 1.23 million deaths, which corresponds to a case fatality rate of 11.5%. TB is one of the top 10 causes of death worldwide and the leading cause of death from a single infectious agent (World Health Organization, 2025). Indonesia ranks second worldwide in terms of TB burden after India. According to data from the Indonesian Ministry of Health in 2023, TB cases in Indonesia were estimated at 969,000, with 821,341 cases detected and 147,686 cases remaining undiagnosed and unreported. The estimated number of TB cases in 2024 increased by approximately 13% compared with 2023, reaching 1,092,000 cases (Ministry of Health Republic Indonesia, 2023). However, despite the high burden of TB in Indonesia, there is still a lack of data from Indonesian primary care settings. Although several studies have explored factors related to TB severity and inflammatory response, evidence from primary health care facilities (Puskesmas) in Indonesia remains limited, even though these facilities serve as the main entry point for TB diagnosis and treatment.

Individuals with poor nutritional status may experience impaired immune function, thereby increasing their susceptibility to TB infection. One commonly used parameter to assess nutritional status is Body Mass Index (BMI), which classifies individuals as underweight, normal, or overweight (Regina et al., 2024). TB remains a significant global health threat and is among the leading causes of death worldwide. Several underlying diseases, lifestyle behaviors, and social determinants are known to contribute to TB development, with malnutrition being one of the most important risk factors for new TB cases. As BMI is widely used as an indicator of nutritional status, numerous studies have examined the relationship between underweight status and TB prevalence or incidence (Cho et al., 2022). Nutritional status, as reflected by BMI, may also influence systemic inflammatory responses, which can be evaluated through hematological parameters obtained from routine blood examinations (Uzun et al., 2025).

TB infection is characterized by an increase in neutrophil count and a decrease in lymphocyte count. During the early stage of infection, neutrophils increase as the first line of defense responsible for phagocytizing *Mycobacterium tuberculosis*. Conversely, lymphopenia may indicate active infection and disease progression. The immune system plays a crucial role in controlling TB infection, and the physiological immune response during inflammation is characterized by elevated neutrophil counts and reduced lymphocyte counts. T lymphocytes and macrophages are essential to TB pathogenesis, particularly through their roles in cell-mediated immunity (Mansyur et al., 2018). The neutrophil–lymphocyte ratio (NLR), calculated as the ratio of neutrophil to lymphocyte counts in peripheral blood, is a biomarker that integrates both innate immune responses mediated by neutrophils and adaptive immunity supported by lymphocytes (Song et al., 2021).

A study by Liu et al. (2022) demonstrated a significant negative correlation between NLR and BMI in TB patients (r= -0.2976; p= 0.0038), indicating that lower BMI is associated with higher NLR values (Liu et al., 2022). TB may lead to malnutrition, and malnutrition in turn can impair immune function, potentially resulting in elevated NLR levels (Bintanah et al., 2024). Previous studies have shown that TB patients with low BMI tend to have higher NLR values, suggesting that disease severity, often linked to malnutrition, may influence the inflammatory response reflected by NLR (Regina et al., 2024).

This study aims to evaluate NLR as an immunological parameter and BMI as an indicator of nutritional status, and to examine the relationship between these two variables in TB patients undergoing treatment. Given the high burden of TB in Indonesia and its strong association with nutritional status, which may reduce immunity, promote disease progression, and worsen patient prognosis, this study is urgently needed. Therefore, this research investigates the association between NLR and BMI among TB patients receiving treatment.

METHOD

This study employed an observational analytical design with a cross-sectional approach and was conducted in 2025 at Puskesmas Sukabumi, Bandar Lampung, Indonesia. The study population consisted of patients diagnosed with tuberculosis (TB) who were undergoing anti-tuberculosis treatment at the time of data collection. A total of 32 adult TB patients (≥18 years), both male and female, who met the inclusion criteria were recruited. Patients with conditions that could influence hematological parameters, including acute infections other than TB, autoimmune diseases, malignancies, or immunosuppressive drugs, were excluded. Demographic and anthropometric characteristics recorded included age, sex, body weight, and height.

Body weight was measured with a calibrated digital scale and reported in kilograms (kg), while height was measured with a microtoise and reported in meters (m). Body Mass Index (BMI) was determined by dividing body weight by the square of height (kg/m^2) and categorized according to the Asia-Pacific standards into underweight (<18.5 kg/m^2), normal (18.5-22.9 kg/m^2), overweight (23.0-24.9 kg/m^2), and obesity (≥25.0 kg/m^2).

Peripheral venous blood samples were obtained as part of routine laboratory examinations and analyzed using an automated hematology analyzer routinely employed at the primary health center or its referral laboratory. Absolute neutrophil and lymphocyte counts were recorded, and the neutrophil-lymphocyte ratio (NLR) was calculated by dividing the absolute neutrophil count

by the absolute lymphocyte count. NLR values were reported as median and range, and subsequently categorized into low (<2) and high (≥2) groups (Zahorec, 2021).

Data was analyzed using a statistical application. Descriptive analyses and measured parameters were presented as the mean±standard deviation (SD) for normally distributed data and as the median (minimum-maximum) for non-normally distributed data. The relationship between BMI and NLR was analyzed using Spearman's rank correlation test because the data were non-normal. Differences in NLR among BMI categories were analyzed using One-way analysis of variance (ANOVA) when the assumptions of homogeneity of variance were satisfied; otherwise, suitable nonparametric tests were utilized. A significant result was set at $p<0.05$. The Health Research Ethics Committee of Poltekkes Kemenkes Tanjungkarang approved this study (Ethical Approval No. 478/KEPK-TJK/X/2025). All participants were given a comprehensive overview of the study's objectives and procedures and provided written informed consent before participating.

RESULTS

The subjects in this study were 32 tuberculosis patients at the Sukabumi Primary Health Center in Bandar Lampung City, including 18 males and 14 females. The mean age of the subjects was 44.2 ± 15.8 years. The mean body weight was 53.7±8.2 kg, while the mean height was 1.62±0.09 m (Table 1).

Table1. Subject characteristics

Characterisics	n	%
Sex		
Male	18	56.25
Female	14	43.75
	mean	
Age (years)	44.2±15.8	
Body weight (kg)	53.7±8.2	
Height (m)	1.62±0.09	

Based on the analysis, the mean body mass index (BMI) of the study subjects was 20.4±3.0 kg/m^2. According to the Decree of the Minister of Health of the Republic of Indonesia on the National Clinical Practice Guidelines for Adult Obesity Management, the distribution of BMI classifications for the Asia-Pacific population in this study consisted of 8 underweight subjects, 18 normal-weight subjects, 4 overweight subjects, and 2 subjects with obesity class I (Table 2). The median neutrophil–lymphocyte ratio (NLR) among the study subjects was 2.7 (range: 1.22-14.25), with the normal reference range for NLR being 1-2 (Zahorec, 2021). The NLR values were further categorized into two groups: normal NLR (<2) and high NLR (≥2) (Table 3).

Table 2. Body Mass Index of subjects

Classification	BMI (kg/m^2)	n	%
Category IMT			
Underweight	< 18.5	8	25
Normal	18.5-22.9	18	56.3
Overweigth	23-24.9	4	12.5
Obesity class I	≥ 25.0	2	6.3
BMI (kg/m^2)	mean	20.4±3.0 kg/m^2	

Table 3. Neutrophil-Lymphocyte Ratio (NLR) Values

Classification	Results	
	n	%
Normal (NLR ≤2)	11	34.4
High (NLR >2)	21	65.6

Subsequent statistical analysis was performed to assess the correlation between BMI and NLR. Normality testing of the BMI variable indicated a non-normal distribution ($p < 0.05$); therefore, Spearman's correlation test was applied. The correlation analysis demonstrated a weak-to-moderate negative correlation between BMI and NLR, with a correlation coefficient (r) = -0.37 and a p value = 0.03 (Table 4).

Table 4. Correlation between BMI and NLR

Variables	n	r	p-value
BMI	32	-0.37	0.03
NLR			

Further statistical testing was conducted to evaluate differences in NLR across BMI classifications. Based on the parametric One-way ANOVA test, there was a significant difference in NLR values across BMI classification groups ($p = 0.003$) in Table 5).

Table 5. NLR values by BMI Classification

BMI Classification	n	NLR (mean±SD)	p-value
Underweight	8	6.1±3.9	
Normal	18	2.2±0.8	0.003
Overweight	4	2.8±0.6	
Obesity class I	2	3.1±2.7	

DISCUSSION

This study involved 32 tuberculosis patients undergoing treatment at Puskesmas Sukabumi, Bandar Lampung, with a higher proportion of male than female subjects. As this study was conducted in a primary healthcare setting (Puskesmas) in Bandar Lampung, the findings may reflect the characteristics of community-based TB patients who are commonly diagnosed and managed at the first level of healthcare services in Indonesia. The predominance of male subjects in this study is consistent with the 2024 Lampung Provincial Health Profile, which reported a higher incidence of tuberculosis among males compared to females (58.7% vs. 41.3%) (Lampung Provincial Government Health Service, 2024). This condition is presumed to be associated with behavioral factors such as smoking habits, which indirectly increase the risk of TB infection and disease progression in men (Ministry of Health Republic Indonesia, 2021) This finding is in line with Feldman et al. (2024), whose epidemiological study demonstrated that both active and passive smoking are independent risk factors for TB infection, with an increased odds ratio among smokers (OR = 1.35; 95% CI: 1.19–1.53) compared to non-smokers (Feldman et al., 2024). The mean age of the subjects in this study indicates that most were adults and in the productive age group. This finding is consistent with the 2022 report from the Indonesian Ministry of Health Tuberculosis Control Program, which showed that the majority of TB cases occurred in the productive age group of 15-54 years (60.1%) (Ministry of Health Republic Indonesia, 2023).

The findings indicated that the mean BMI of the subjects was 20.4 ± 3.0 kg/m^2, with a variation range from underweight to obesity class I. While the majority of participants were categorized as having a normal BMI, the proportion with a low BMI was nevertheless significant. This discovery signifies that nutritional deficiencies remain a significant concern among tuberculosis patients, even during their therapy. Rinawati (2021) reported that TB patients with underweight and normal BMI were more likely to suffer from severe side effects, especially gastrointestinal issues like nausea and vomiting. The incidence of tuberculosis is significantly affected by compromised immunological function, potentially arising from dietary deficiencies, particularly undernutrition. Nutritional imbalance, indicated by BMI, is believed to influence tuberculosis treatment outcomes (Rinawati, 2021). BMI reflects an individual's nutritional state, and when imbalanced, it can compromise immunological function, thereby reducing the effectiveness of TB treatment. Low BMI frequently suggests malnutrition, which can increase TB management difficulties in a variety of ways. Furthermore, individuals with low BMI may face

delayed wound healing, greater susceptibility to infection, and decreased ability to endure the physiological stress associated with tuberculosis and its treatment (Li et al., 2025).

In this study, the median NLR was 2.7 (range 1.22-14.25), indicating considerable variation in systemic inflammatory status among subjects. This wide range likely reflects differences in immune status, disease stage, and individual responses to *Mycobacterium tuberculosis* infection. In patients with TB, neutrophil counts typically increase, while lymphocyte counts tend to decrease. At the early stage of infection, neutrophils are recruited as part of the initial immune defense and actively phagocytose *Mycobacterium tuberculosis*. At the same time, a reduced lymphocyte count often indicates active infection and ongoing disease progression.

The immune system plays an essential role in controlling bacterial infection in TB. During inflammation, circulating leukocytes exhibit a characteristic response, with elevated neutrophils and reduced lymphocytes. T lymphocytes and macrophages contribute substantially to TB pathogenesis, particularly through cell-mediated immune mechanisms (Mansyur et al., 2018). In recent years, clinicians have increasingly used NLR as a marker of systemic inflammation. In TB, NLR reflects not only the inflammatory process but also shows potential as an indicator of disease severity and treatment response, supporting its relevance in routine clinical practice (Zahorec, 2021).

Correlation analysis revealed a significant negative correlation between NLR and BMI (r= -0.379; p= 0.03), indicating that lower BMI values were associated with higher NLR values. This finding is consistent with the study by Liu et al. (2022), which reported a significant negative correlation between NLR and BMI among TB patients (r= -0.2976; p = 0.0038), suggesting that lower BMI is associated with higher NLR values in TB patients (Liu et al., 2022). These results show that TB patients with lower BMI had higher systemic inflammation, as indicated by higher NLR scores. This association shows how closely linked a person's dietary state is to their immunological response in TB patients.

The neutrophil-to-lymphocyte ratio (NLR) is calculated as the ratio of neutrophil to lymphocyte counts. It serves as a biomarker integrating two components of the immune system: the innate immune response mediated by neutrophils and the adaptive immune response mediated by lymphocytes (Song et al., 2021). Neutrophils are among the earliest immune cells to infiltrate adipose tissue, releasing inflammatory mediators that promote macrophage recruitment and sustain chronic inflammation, thereby contributing to elevated NLR levels. Neutrophils exacerbate local and systemic inflammation by releasing pro-inflammatory mediators such as tumor necrosis factor-α (TNF-α) and interleukin-1β (IL-1β) (Uzun et al., 2025). In undernourished individuals (BMI <18.5 kg/m^2), several immune response pathways—including neutrophil activation (fMLP signaling), T-cell activation (CD28 signaling, PKC signaling, T-cell receptor signaling molecules), and pro-inflammatory cytokine signaling (IL-1 and IL-6) are upregulated, supporting increased inflammation in undernourished individuals (VanValkenburg et al., 2022).

Analysis of variations in NLR values according to BMI classification revealed considerable disparities among groups. The underweight cohort had the highest NLR values compared with the normal-weight and obese cohorts. This discovery suggests that tuberculosis patients with inadequate diet status experience heightened systemic inflammatory responses. This finding aligns with the study by Dragomir et al. (2021), which found elevated NLR values in underweight individuals relative to those with normal BMI and obesity (Dragomir et al., 2021). Conversely, the normal BMI group exhibited reduced NLR values, indicating a comparatively more balanced immune response. The elevated neutrophil-to-lymphocyte ratio (NLR) is mostly attributed to the pathophysiology of systemic inflammatory response syndrome, characterized by the suppression of neutrophil death, resulting in extended neutrophil longevity and enhanced innate immune function. At the same time, lymphocyte levels often decline due to stress-induced immunosuppression, promoting lymphocyte apoptosis (Lagunas-Rangel, 2025).

The limitations of this study include a relatively small sample size and the absence of additional inflammatory marker assessments. Data on potential confounding factors, such as ethnicity, dietary patterns, lifestyle, environmental conditions, and exposure-related factors, were unavailable; therefore, multivariate analysis could not be performed.

Overall, this study demonstrates that BMI and NLR are two simple yet interrelated parameters that reflect nutritional status and systemic inflammation in TB patients. The combined assessment of BMI and NLR has the potential to serve as an early screening tool to

identify TB patients at higher risk of severe inflammation and poor nutritional status who may require closer monitoring and more intensive interventions. Clinically, these findings support the importance of a multidisciplinary approach to TB management that not only focuses on bacterial eradication through anti-tuberculosis therapy but also emphasizes nutritional improvement and immunological monitoring. Thus, BMI and NLR may serve as complementary parameters in treatment monitoring and prognosis evaluation among TB patients.

CONCLUSION

This study reported a significant inverse relationship between body mass index (BMI) and the neutrophil-to-lymphocyte ratio (NLR) among tuberculosis patients undergoing treatment at Puskesmas Sukabumi, Bandar Lampung. Patients with lower BMI, particularly those classified as underweight, exhibited higher NLR levels, suggesting greater systemic inflammation. These findings suggest that poorer nutritional status is associated with an enhanced inflammatory response in tuberculosis patients during treatment. The results further show that NLR varies significantly across BMI classifications, with the highest NLR values observed in underweight patients and lower values in patients with normal BMI. This supports the role of NLR as a simple and accessible immunological marker that reflects inflammatory status in relation to nutritional condition in tuberculosis patients.

In conclusion, BMI and NLR are interrelated parameters that can provide complementary information regarding nutritional status and systemic inflammation in tuberculosis patients receiving therapy. Their combined assessment helps identify patients at higher risk of adverse inflammatory conditions who benefit from closer monitoring and targeted nutritional interventions. Further studies with larger sample sizes and longitudinal designs are recommended to confirm these findings and to evaluate the prognostic value of BMI and NLR in tuberculosis management.

AUTHOR'S DECLARATION

Authors' contributions and responsibilities

WN: writing, original draft, visualization, conceptualization; **AZA:** writing original draft (supporting), review.

Availability of data and materials

All data are available from the authors.

Competing interests

All authors have no competing interests.

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