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Correlation Between Leukocyte Count and Erythrocyte Sedimentation Rate in Pulmonary Tuberculosis Patients at Suai Referral Hospital, Timor Leste

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Abstract
Background: Human Tuberculosis (TB) is an infectious disease caused by Mycobacterium tuberculosis. TB causes serious health problems for about 10 million people each year and is one of the most common causes of death worldwide. The incidence of TB in Indonesia is 354 per 100,000 population, while in Timor-Leste the incidence has stagnated at 498 per 100,000 population. An active TB process may be indicated by an increase in leukocytes and LEDs, whereas an improvement is shown by a decrease in LEDs and normal lecocyte counts. *Objectives*: This study aimed to determine the correlation between leukocyte count and erythrocyte sedimentation rate (ESR) in pulmonary TB patients at Suai Referral Hospital, Timor-Leste. *Materials and Methods*: This was an observational analytic study with a cross-sectional approach, conducted from April to June 2023, using medical laboratory records. The study population consisted of pulmonary TB patients who underwent laboratory testing, with a total sampling of 50 patients. Data on leukocyte counts measured using an automated Hematology Analyzer and ESR determined by the Westergren method were tested for normality using the Shapiro-Wilk test, followed by Spearman's rank correlation test. *Results*: The mean leukocyte count was 11.15 ± 5.24 /mm^3 and the mean ESR was 63.30 ± 35.71 mm/hour. The correlation test between leukocyte count and ESR showed r = 0.124 (p = 0.392), indicating no significant correlation. *Conclusions*: There is no significant correlation between leukocyte count and ESR in pulmonary TB patients at Suai Referral Hospital, Timor-Leste.

Keywords
Erythrocyte sedimentation rate, Leukocyte count, Pulmonary tuberculosis.

1. Introduction

According to WHO (2022), an estimated 10.6 million people were diagnosed with Tuberculosis (TB) worldwide in 2021, an increase from 10 million in 2020. Of these, 6.4 million (60.3%) were detected and treated, while 4.2 million (39.7%) remained undiagnosed and unreported. Indonesia ranks second after India in TB burden, followed by China, the Philippines, Pakistan, Nigeria, Bangladesh,

and the Democratic Republic of Congo. TB incidence in Indonesia is 354 per 100,000 population. Timor-Leste has reported a stable TB incidence of 498 per 100,000 population in recent years, with a slight decline to 486 per 100,000 in 2021. Two other encouraging developments in Timor-Leste are a 91% success rate in TB treatment and a 32% increase in testing coverage using quick diagnostic at diagnosis. In contrast, testing coverage reached 11% and the treatment success rate was 88% in 2019 (NTP TL, 2020).

Tuberculosis (TB) is an infectious disease caused by *Mycobacterium tuberculosis*. Despite advances in treatment and detection, TB remains a major global health problem, causing serious health impacts in around 10 million people annually and ranking among the leading causes of death worldwide (Samhatul & Bambang, 2018). Pulmonary tuberculosis (commonly referred to as pulmonary TB) primarily affects the respiratory system (Srihartini, 2018). Transmission occurs through airborne droplets when an infected person expels the bacteria, for example, through coughing. An estimated one-quarter of the global population is infected with TB, but only a fraction develops active disease. About 90% of new TB cases each year occur in adults, with higher prevalence in males compared to females. TB primarily affects the lungs but can also affect other parts of the body. By modifying normal hematopoiesis, tuberculosis causes significant abnormalities in bone marrow and peripheral blood. The condition worsens when co-infected with HIV due to compromised immunity (Menia et al., 2022).

TB not only affects the lungs but also the bone marrow, leading to hematological abnormalities. Hematological parameters such as hemoglobin, packed cell volume, erythrocyte count, platelet count, leukocyte count, and ESR can aid in diagnosis, prognosis, and monitoring of treatment (Chowdhury & Chakraborty, 2017). The most common hematologic findings are mild anemia, leukocytosis, and thrombocytosis with a slightly elevated ESR (Menia et al., 2022). Numerous laboratory abnormalities, low serum albumin levels, hyponatremia, aberrant liver function, and hypocalcemia, can be brought on by tuberculosis (Han et al., 2024).

Common TB symptoms include hemoptysis, chronic cough lasting more than two weeks, weight loss, fever, night sweats, fatigue, and elevated ESR (Pratiwi et al., 2019). ESR is a routine hematological test to assess inflammation and monitor disease progression or therapeutic response (Sofyanita, 2021; Rohini et al., 2016). Pulmonary TB subjects' ESR values were statistically significantly ($p<0.001$) higher than those of normal controls, increasing by almost 15 times. ESR is a well-established standard investigation for tuberculosis (Rohini et al., 2016).

In TB, leukocytosis and elevated ESR are often observed, particularly in newly infected or untreated individuals (Chairani & Novita, 2019). In newly diagnosed TB patients, it was found that the average ESR was high (~63.6 mm/h) and the prevalence of leukocytosis was about ~45.9% (Farhadian et al., 2024). While an increased ESR reflects active lesions or progression, a decrease indicates improvement. However, some studies found no significant correlation between lymphocyte count and ESR (Sofyanita, 2021).

Study found a relationship between the rate of blood precipitation and the quantity of lymphocytes. Similar research revealed that TB patients had much higher levels of leukocytes, absolute neutrophils, and platelets, as well as significantly higher LED values, as compared to healthy controls (Sofyanita, 2021). Hematological parameter evaluation in patients with paru tuberculosis show there is a high ESR in98% of TBC cases and leukositosis is found in 53% of TBC cases. Leukocytes are useful for part of the immune system to fight infection. In TB patients, leukocyte counts often increase in response to bacterial infections. Changes in leukocyte count can vary depending on the stage of infection and the individual's body's reaction to treatment (Safitri et al., 2024). In order to further evaluate supportive care and other therapeutic alternatives that may improve the course of treatment, it becomes imperative to determine immunological and hematological parameters (Rohini et al., 2016). The purpose of this study is to examine the relationship between leukocyte count and erythrocyte sedimentation rate in pulmonary TB patients at Suai Referral Hospital, Timor-Leste, given the significance of leukocytosis and elevated ESR as potential indicators of active pulmonary tuberculosis.

2. Materials and Methods

2.1. Study Design and Data Source

This study was designed as an observational analytic study with a cross-sectional approach. The research relied on secondary data obtained from the clinical laboratory records of Suai Referral Hospital, Timor-Leste. The records consisted of routine hematological test results from adult patients diagnosed with pulmonary tuberculosis. Using secondary data allowed the researchers to analyze existing laboratory results without direct patient intervention, making the study more efficient and minimizing ethical risks.

2.2. Study Population and Sampling

The population included adult pulmonary tuberculosis patients, both male and female, regardless of whether they were newly diagnosed or undergoing treatment, who underwent hematology testing

at Suai Referral Hospital between January and June 2023. A total of 50 patients' records were included, selected through a total sampling technique, meaning all eligible cases within the study period were analyzed.

2.3. Variables and Laboratory Parameters

The independent variable in this study was leukocyte count, measured using an automated Hematology Analyzer (Mindray BC-3000). The dependent variable was erythrocyte sedimentation rate (ESR), determined by the Westergren method, performed manually using venous blood collected in EDTA tubes.

2.4. Data Processing and Analysis

The laboratory data were extracted from patient records and tabulated for statistical analysis. Data analysis began with a normality test using the Shapiro-Wilk method to assess the distribution of variables. Since leukocyte count data were not normally distributed, the correlation between leukocyte counts and erythrocyte sedimentation rate (ESR) was analyzed using Spearman's rank correlation test. Descriptive statistics were presented as mean ± standard deviation, while inferential results were reported using correlation coefficients (r) and p-values to determine statistical significance.

3. Results and Discussion

3.1. Descriptive Findings

This study analyzed secondary laboratory records from 50 patients diagnosed with pulmonary tuberculosis at Suai Referral Hospital, Timor-Leste. The mean leukocyte count among the study population was 11.15 ± 5.24 × 10^3/μl, which is above the normal reference range (4,000–11,000/μl), indicating the presence of leukocytosis in many patients. Meanwhile, the mean erythrocyte sedimentation rate (ESR) was 63.30 ± 35.71 mm/hour, which is markedly higher than the normal reference values (<10 mm/hour in men and <15 mm/hour in women). These findings suggest that most patients with pulmonary TB in this cohort exhibited signs of systemic inflammation.

Table 1. Leukocyte count and ESR in pulmonary TB patients.

Variable	Mean ± SD	Minimum	Maximum
Leukocyte count (×10^3/μl)	11.15 ± 5.24	4.20	22.30
ESR (mm/hour)	63.30 ± 35.71	12.00	120.00

3.2. Statistical Analysis

Normality testing using the Shapiro-Wilk method showed that leukocyte count data were not normally distributed ($p < 0.05$), while ESR data followed a normal distribution. Since at least one variable was non-normally distributed, Spearman's rank correlation test was applied. The analysis yielded a correlation coefficient of $r = 0.124$ with a p-value of 0.392. This result indicates a very weak, statistically non-significant correlation between leukocyte count and ESR in pulmonary tuberculosis patients. Thus, although both parameters tended to be elevated in the study population, they did not demonstrate a meaningful linear relationship.

Table 2. Normality test of Leukocyte count and ESR (Shapiro-Wilk)

Variable	Statistic	p-value	Distribution
Leukocyte count	0.926	0.021	Not normal
ESR	0.968	0.214	Normal

Table 3. Correlation between leukocyte count and ESR (Spearman's rank)

Variables	r (Correlation Coefficient)	p-value	Interpretation
Leukocyte count vs. ESR	0.124	0.392	Very weak, not significant

3.3. Discussion

Suai Referral Hospital, located in Covalima District, Timor-Leste, reports between 500 and 2000 suspected TB cases monthly, with 5–30 confirmed cases across all age groups in both outpatients and inpatients. Most patients present for medical evaluation after experiencing clinical symptoms of TB for one to two months. Leukocyte count and ESR (erythrocyte sedimentation rate) examinations are routinely requested by clinicians for suspected TB cases. At Suai Referral Hospital, leukocyte counts are measured using an automated hematology analyzer, whereas ESR is determined manually with the Westergren method. In this study, 50 outpatient records were analyzed. The mean leukocyte count was $11.15 \pm 5.24 \times 10^3/\mu l$, while the mean ESR was 63.30 ± 35.7 mm/hour. Correlation analysis showed no significant association between leukocyte count and ESR ($r = 0.124$; $p = 0.392$). Leukocyte counts typically respond more rapidly to infectious stimuli, reflecting an immediate mobilization of the immune system. In contrast, changes in ESR occur more slowly, as

they depend on the hepatic synthesis of acute-phase proteins—such as fibrinogen and globulins—and subsequent alterations in plasma composition.

Consequently, leukocyte levels may already be elevated while ESR remains within the normal range, or conversely, ESR may stay high even after leukocyte counts have normalized, particularly in subacute or chronic phases of infection. Moreover, hematological characteristics (including leukocyte count) can be affected by co-infection of TB patients with other metabolic and another infectious diseases, such as diabetes, myocardial infarction (MI), HIV, and HCV (Javed et al., 2018) which caused variations in laboratory results including ESR. The limitations of this study, which did not include data on the existence of conditions/comorbidities in pulmonary tuberculosis cases, may explain discrepancies in ESR levels and leukocyte counts. Other studies have seen that ESR was higher than that of non-DM PTB patients, but PTB-DM patients had lower levels of neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), monocyte-to-lymphocyte ratio (MLR), system immune inflammation index (SII), and system inflammation response index (SIRI) (all $p<0.05$), describing different immune responses (He et al., 2025). Other studies in children with PTB demonstrated a substantial relationship between the degree of anemia and large increases in the levels of inflammatory markers, demonstrating that anemia also impacts leukocyte count and ESR (Han et al., 2024). Furthermore, ESR generally decreased after anti TB treatment, but did not show a strong direct correlation with the number of bacteria or the clinical condition of the patient.

The decrease in ESR values and other inflammatory parameters has their own dynamics, as does the leukocyte response (Safitri et al., 2024). However, this study showed that leukocyte count and ESR do not correlate significantly, implying that these measurements represent different aspects of host response and disease development in pulmonary tuberculosis. Another study showed that the number of cytokines, including IL-1β, IL-6, and IL-8 as pro-inflammatory marker is affected by the host's ethnic/genetic background and M. tuberculosis strain type. This shows that the host-strain M.tb combination can affect the leukocyte count and ESR (Nahid et al., 2018).

Leukocytes are nucleated blood cells that play a central role in host defense by preventing the entry of foreign antigens through phagocytosis and immune activation. Normal leukocyte counts range from 4,000–10,000/μl. Leukocyte count elevation also reflects the host immune response to Mycobacterium tuberculosis. Once the pathogen enters the body, immune activation results in increased leukocyte production as part of the inflammatory defense mechanism. Leukocyte count and ESR are widely used as supportive parameters for evaluating disease status and prognosis. ESR is especially popular in resource-limited settings due to its simplicity, speed, and affordability.

Elevated ESR values in pulmonary TB are associated with the systemic inflammatory response, driven by increased fibrinogen and globulin levels during the acute-phase reaction. ESR typically remains normal in mild localized or acute infections but rises markedly in chronic infections such as tuberculosis, as well as in arthritis, rheumatic fever, and nephritis (Kasih & Sulastina, 2019).

Conditions that have comorbidities, such as DM, can cause higher ESR, possibly as a result of additional metabolic and inflammatory stress. However, the ratio of leukocytes to leukocytes may not increase significantly (He et al., 2025).Immmunopathological variables in pulmonary TB patients show increased ESR and signs of immunosuppression and T cell hyporesponsiveness. These variables may explain why high leukocytes are not necessarily associated with high ESR (Ahor et al., 2024). Except ESR and Leukocyte count, Neutrophil Lymphocyte Ratio (NLR) and Red Cell Distribution Width (RDW) levels can be utilized as indicators of inflammation to assess the severity of the disease and aid in the clinical management of TB patients (Abakay et al., 2016).

CRP levels and RDW levels were positively correlated. Infection and inflammation caused by Mycobacterium TB may be linked to high RDW levels (KOÇ & GULLU, 2022). Systemic inflammation has been caused by pulmonary tuberculosis (PTB) is typically characterized by elevations in the levels of acute phase proteins, including C-reactive protein (CRP), apha-2 macroglobulin (a2M), haptoglobin (Hp) and serum amyloid P (SAP) (Kumar et al., 2021). The WHO also conditionally recommends screening for tuberculosis with C-reactive protein (CRP) in people with HIV (Bosman et al., 2024). In the groups receiving therapy for tuberculosis, CRP displayed the biggest early and baseline changes. In the total group receiving TB treatment, the median percent CRP reduction at week two (interquartile range [IQR]) was 62.7% (19.7% to 85.1%). The median percent CRP change (IQR) in the group not receiving TB treatment did not change substantially (Wilson et al., 2018). Eight intriguing candidate protein biomarkers have been identified as non-sputum diagnostic markers for tuberculosis (TB): IFN-γ (Interferon-gamma), LIF (Leukemia Inhibitory Factor), uPA (Urokinase-type Plasminogen Activator), CSF-1 (Colony Stimulating Factor 1), SCF (Stem Cell Factor), SIRT2 (Sirtuin 2), 4E-BP1 (Eukaryotic Translation Initiation Factor 4E-Binding Protein 1), and GDNF (Glial Cell Line-Derived Neurotrophic Factor) (Ayalew et al., 2024).

4. Conclusions

According to the findings of this study, leukocyte count and ESR in pulmonary tuberculosis patients at Suai Referral Hospital in Timor-Leste do not significantly correlate. Numerous laboratory tests,

such as CRP as an assessment and prognosis marker for tuberculosis (TB) and potential protein biomarkers as non-sputum diagnostic markers, are promising for further research.

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Author Contributions: EJOL: conceptualization, resources, data curation, formal analysis, writing; EI: supervision, review & editing; LSG: methodology, supervision, review & editing, validation.

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