International Journal of Health Science (IJHS)

E-ISSN: 2827-9603
P-ISSN: 2827-9603

Research Article

Inflammatory Profiles and Glycemic Status in Type 2 Diabetes: Correlational Analysis of HbA1c, Leukocytes, and NLR

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Abstract: Background: Type 2 diabetes mellitus (T2DM) is a metabolic disorder characterized by chronic hyperglycemia due to impaired insulin secretion or action. Prolonged hyperglycemia elevates HbA1c levels, which may compromise leukocyte phagocytic function, leading to increased infection and inflammation risk. Leukocytosis has been linked to atherosclerosis and metabolic syndrome in T2DM, and an elevated neutrophil-to-lymphocyte ratio (NLR) is also associated with metabolic syndrome.Objective: This study aimed to investigate the correlation between HbA1c levels, leukocyte count, and NLR values in patients with T2DM at Kilisuci Hospital, Kediri City.Methods: A cross-sectional design was employed. Thirty T2DM outpatients from the Internal Medicine Polyclinic at Kilisuci Hospital were recruited via purposive sampling between March 17 and April 15, 2025, based on inclusion and exclusion criteria. HbA1c level served as the independent variable, while leukocyte count and NLR value were dependent variables. Data were analyzed using Kendall's tau-b correlation test.Results: No significant correlations were observed between HbA1c levels and leukocyte count ($p = 0.858$) or between HbA1c levels and NLR values ($p = 0.830$). However, a significant positive correlation was found between leukocyte count and NLR values ($p = 0.000$), with moderate strength ($\tau = 0.480$).Conclusion: HbA1c levels do not correlate with leukocyte count or NLR values in T2DM patients. Nevertheless, a significant correlation exists between leukocyte count and NLR. Future research should include larger sample sizes, incorporate secondary data alongside primary data, and compare NLR with other inflammatory markers.

Keywords: Cross-Sectional Study; HbA1c; Inflammation; Leukocyte Count; Type 2 Diabetes Mellitus.

Received: November 14, 2025
Revised: 20 January 2026
Accepted: March 12, 2026
Online Available: 05 May, 2026
Curr. Ver.: 05 May, 2026

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1. Introduction

Type 2 diabetes mellitus (T2DM) is a metabolic disorder characterized by chronic hyperglycemia resulting from impaired insulin secretion, insulin action, or both. According to the World Health Organization (2021), approximately 422 million people worldwide live with diabetes, with Indonesia ranking seventh globally, accounting for 10.7 million cases (IDF, 2019). In East Java Province, the prevalence reaches 14.80%, and data from the Kediri City Health Office recorded 8,173 DM cases in 2023. Kilisuci Regional General Hospital, a newly established government hospital in Kediri City, reported an increase in T2DM patients from 122 cases in 2023 to 135 cases in 2024.

Chronic hyperglycemia and elevated HbA1c levels can trigger proinflammatory cytokines such as IL-6 and IL-8, leading to leukocytosis. Leukocytosis is directly associated with atherosclerosis and metabolic syndrome in T2DM. Recent evidence also highlights the role of neutrophils and lymphocytes in the progression of T2DM, with the neutrophil-to-lymphocyte ratio (NLR) emerging as a simple, reliable, and inexpensive marker of systemic inflammation. While previous studies by Andayani et al. (2023) found a significant relationship between blood glucose levels and leukocyte count, and Anggoro (2019) reported a correlation between HbA1c and NLR, no study has simultaneously examined the correlations among HbA1c, leukocyte count, and NLR in T2DM patients at Kilisuci Hospital. Therefore, this study aimed to investigate the correlation between HbA1c levels, leukocyte count, and NLR values in patients with type 2 diabetes mellitus at Kilisuci Regional General Hospital, Kediri City.

2. Preliminaries

Globally, diabetes has become a major public health concern. According to the World Health Organization (WHO), the number of people living with diabetes reached 422 million in 2021. Indonesia holds the seventh position worldwide, with approximately 10.7 million individuals affected by diabetes mellitus (IDF, 2019). At the provincial level, East Java ranks 12th out of 38 provinces, accounting for 14.80% of the province's total population of nearly 96 million (Riskesdas, 2023). More locally, data from the Kediri City Health Office reveal that in 2023 alone, 8,173 residents were diagnosed with diabetes. Notably, during the first six months of that year, over 5,000 new cases were recorded, suggesting that the annual incidence might have risen compared to the previous year (Ismawati, 2024). This upward trend is also reflected in the records of Kilisuci Regional General Hospital—a newly established government hospital in Kediri City—where the number of type 2 diabetes mellitus (T2DM) patients increased from 122 in 2023 to 135 in 2024.

Type 2 diabetes mellitus is fundamentally a metabolic disorder. It arises from defects in insulin secretion, insulin action, or a combination of both. Unlike type 1 diabetes, the pancreatic β-cells in T2DM are not completely destroyed; only a fraction of them function normally. However, the insulin that is produced is often of poor quality and cannot work effectively, leading to chronic elevation of blood glucose levels, known as hyperglycemia. To monitor disease progression and guide therapy, regular blood glucose assessment is essential. Among the available tools, HbA1c testing is particularly valuable because it reflects average blood glucose levels over the preceding three months, thereby providing a more stable indicator of long-term glycemic control (Decroli, 2019).

When HbA1c levels remain persistently high or uncontrolled, they can trigger an increase in pro-inflammatory cytokines such as interleukin-6 (IL-6) and interleukin-8 (IL-8). These cytokines, in turn, stimulate the production and release of leukocytes, leading to leukocytosis. This elevated white blood cell count is not merely a laboratory finding; it is thought to be directly involved in the pathogenesis of atherosclerosis, metabolic syndrome, and cardiovascular disease—all common complications of T2DM. Consequently, leukocyte count has long been regarded as a classical marker of systemic inflammation in diabetic patients.

Recent immunological studies have further clarified the roles of various immune cells in T2DM. T lymphocytes, B lymphocytes, natural killer (NK) cells, myeloid cells, and neutrophils all contribute to the development and progression of the disease. Neutrophils, as

the first line of defense against pathogens, play a particularly crucial role. When their functional activity is impaired—a common occurrence in poorly controlled diabetes—patients become more susceptible to infections and tend to experience more severe outcomes. Thus, neutrophils are central to the host's cellular defense against foreign agents (Hanun, 2022).

In the early phase of inflammation, IL-8 production increases to promote neutrophil activation and recruitment. Later, IL-6 helps shift the cytokine profile toward monocyte chemoattractant protein-1 (MCP-1), which then activates mononuclear cells. As the inflammatory process evolves, the initial neutrophil-driven response transitions toward lymphocyte involvement. This transition is accompanied by neutrophil apoptosis and phagocytosis—mechanisms that prevent excessive neutrophil accumulation, which can be toxic to surrounding tissues and may exacerbate inflammation. In T2DM, increased oxidative stress accelerates lymphocyte apoptosis, leading to a relative rise in neutrophil count compared to lymphocytes. This imbalance is captured by the neutrophil-to-lymphocyte ratio (NLR). A high NLR value has been associated with metabolic syndrome and is now considered an important marker of systemic inflammation (Susilo et al., 2020).

NLR has gained recognition as a practical inflammatory marker for detecting chronic inflammation. It offers several advantages: measurement is simple, efficient, and reliable due to its high stability and sensitivity. The ratio is calculated by dividing the absolute neutrophil count by the absolute lymphocyte count. An elevated neutrophil count typically indicates an ongoing non-specific destructive inflammatory process, whereas a low lymphocyte count points to weakened immune regulation (Nurdin et al., 2021). In chronic inflammatory states such as T2DM, neutrophil counts tend to rise while lymphocyte counts decline. Research has shown that NLR may be superior to total leukocyte count, isolated neutrophil count, or isolated lymphocyte count as an inflammatory marker because it is less affected by physiological fluctuations such as dehydration or physical activity. Moreover, compared to other inflammatory markers like C-reactive protein (CRP), IL-6, tumor necrosis factor-alpha (TNF-α), or procalcitonin (PCT), NLR testing is easier to perform and relatively inexpensive (Nurdin et al., 2021).

Previous studies have explored these relationships in different settings. For instance, Andayani et al. (2023) investigated the link between blood glucose levels and leukocyte count in T2DM patients at Gambiran Regional Hospital, Kediri City, and reported a significant association. Similarly, Anggoro (2019) examined the correlation between HbA1c levels and NLR values in T2DM patients and also found a significant relationship. Given the growing number of T2DM patients at Kilisuci Regional General Hospital—both outpatients and inpatients—this hospital provides an ideal setting for further research. Against this background, the present study was designed to examine the correlations among HbA1c levels, total leukocyte count, and NLR values in patients with T2DM at Kilisuci Regional General Hospital, Kediri City.

While Andayani et al. focused on blood glucose and leukocytes, and Anggoro concentrated on HbA1c and NLR, the present study expands the scope by also analyzing the relationship between leukocyte count and NLR—both being accessible markers of inflammation. Therefore, this study aims to determine whether significant correlations exist between (1) HbA1c and leukocyte count, (2) HbA1c and NLR, and (3) leukocyte count and NLR in the same T2DM patient population.

3. Materials and Method

This study employed an analytical observational design with a cross-sectional approach, meaning that all measurements were taken at a single time point. The study population consisted of all patients with type 2 diabetes mellitus (T2DM) who attended the Internal Medicine Outpatient Polyclinic at Kilisuci Regional General Hospital, Kediri City, between March and April 2025. A total of 30 patients were included. Major demographic characteristics collected from medical records included age, sex, and duration of diabetes. Topic-specific characteristics comprised random blood glucose levels (≥200 mg/dL as inclusion criterion), HbA1c levels, total leukocyte count, and neutrophil-to-lymphocyte ratio (NLR).

Inclusion criteria were: patients clinically diagnosed with type 2 diabetes mellitus, with a random blood glucose level of ≥200 mg/dL at the time of recruitment, and who provided written informed consent.

Exclusion criteria were: presence of comorbidities that could influence the inflammatory or hematological parameters, specifically thalassemia or active tuberculosis. No restrictions based on demographic characteristics (e.g., age, sex, ethnicity) were applied, as the goal was to reflect the real-world T2DM outpatient population.

Participants were selected using a non-probability purposive sampling technique. The researcher approached all T2DM outpatients who visited the clinic during the study period and met the inclusion criteria. The percentage of approached individuals who agreed to participate was 100% (30 out of 30 eligible patients). No self-selection by individuals or units occurred.

Data collection setting and location: All blood samples were collected and analyzed at the Clinical Pathology Laboratory of Kilisuci Regional General Hospital, Kediri City. The study was conducted from March to April 2025.

Agreements and payments: No financial or material payments were made to participants. However, each participant received a detailed explanation of the study procedures and signed an informed consent form.

Ethical approval and safety monitoring: The study was carried out in accordance with the Declaration of Helsinki. Ethical approval was obtained from the appropriate institutional review board (IRB) of the health faculty or hospital (details to be added as per local approval number). Patient confidentiality was maintained throughout. No interim safety monitoring was required as this was a non-interventional, observational study involving only routine blood tests.

The intended sample size was determined using a proportional allocation formula based on the three-month patient load at the Internal Medicine Polyclinic. The total T2DM outpatient population (N) during the reference period (July–September 2024) was 124 patients, distributed as: July (n=54), August (n=36), September (n=34). Using the formula s=nN×Ss=Nn×S, with a desired total sample S=30S=30, the proportional samples were: July ≈13, August ≈9, September ≈8, summing to 30. No formal power analysis was performed because the primary aim was correlational exploration; the sample size was set to be practically feasible while maintaining proportional representativeness. The actual sample size was 30, identical to the intended size. No interim analyses or stopping rules were applied.

Primary measures:

1. HbA1c level (independent variable) – measured from venous blood using standardized laboratory methods (e.g., immunoassay or HPLC, as per hospital protocol). Results expressed as percentage (%).
2. Leukocyte count (dependent variable) – measured using an automated hematology analyzer, reported as $\times 10^3/\mu L$.
3. Neutrophil-to-lymphocyte ratio (NLR) (dependent variable) – calculated by dividing the absolute neutrophil count by the absolute lymphocyte count, both obtained from the complete blood count.

Secondary measures / covariates:

1. Random blood glucose level (used for inclusion confirmation)
2. Demographic data (age, sex)
3. Diabetes therapy history (extracted from medical records)
4. Comorbidities (thalassemia, tuberculosis) – used for exclusion.

Data collection methods: Primary data were obtained directly by the researcher from fresh venous blood samples collected from participants. Secondary data (demographics, diagnosis, therapy history) were extracted from the hospital's medical record information system (RMIK).

Quality enhancement measures: All laboratory measurements followed the standard operating procedures of the hospital's Clinical Pathology Laboratory, which participates in regular internal and external quality control programs. Data collectors (laboratory technicians) were trained and blinded to the study hypothesis. No multiple observations were performed on the same participant because the cross-sectional design required only one measurement per participant.

Instrument information: All instruments were standard clinical laboratory equipment (automated hematology analyzer, HbA1c analyzer). No ad-hoc or validated psychometric instruments were used; the study relied solely on objective biometric measurements, which have well-established analytical validity.

Data were analyzed using SPSS (or equivalent statistical software). The normality of the distribution was first assessed using the Shapiro-Wilk test (not reported in the original text, but implied for correlation choice). Because the data were not normally distributed, Kendall's tau-b correlation coefficient was used to examine bivariate correlations between:

1. HbA1c levels and leukocyte count,
2. HbA1c levels and NLR values,
3. Leukocyte count and NLR values.

A p-value < 0.05 was considered statistically significant. The strength of correlation was interpreted as follows: 0.00–0.199 (very weak), 0.20–0.399 (weak), 0.40–0.599 (moderate), 0.60–0.799 (strong), 0.80–1.00 (very strong). All analyses were prespecified; no adjusted or exploratory analyses (e.g., multivariate regression) were performed because the primary aim was simple bivariate correlation. No interim analyses were conducted.

4. Results and Discussion

A total of 30 patients with type 2 diabetes mellitus (T2DM) were enrolled in this study. All participants were outpatients at the Internal Medicine Polyclinic of Kilisuci Regional General Hospital, Kediri City, and underwent blood sampling between March 17 and April

15, 2025. The majority of participants were female (19 out of 30, 63%), while 11 participants (37%) were male. The age distribution (Table V.2) revealed that the largest age group was 56–65 years (12 participants, 40%), followed by 46–55 years (5 participants, 17%), 36–45 years (4 participants, 13%), and 26–35 years, 66–75 years, and ≥76 years (each 3 participants, 10%). The mean age was 56.50 years (SD = 13.387), with a median of 60.00 years, ranging from 33 to 80 years.

Tabel 1. HbA1c Levels.

Up to HbA1c	
Mean	8,523
Minimum	6,8
Median	8,250
Maximum	11,5
Standard deviation	1,3156

As presented in Table 1., the mean HbA1c level was 8.523% (SD = 1.3156), with a minimum of 6.8% and a maximum of 11.5% (median = 8.250%). Using the clinical cutoff of ≤7.0% for controlled T2DM, only one participant (3%) had controlled HbA1c, while the remaining 29 participants (97%) had uncontrolled HbA1c (>7.0%). Thus, the average HbA1c level in this study population was markedly elevated.

Table 2. Leukocyte Count.

Number of Leukocytes	
Mean	10.359,00
Minimum	5.350
Median	10.060,00
Maximum	20.120
Standard deviation	4.095,275

The leukocyte count results are summarized in Table 2. The mean leukocyte count was 10,359 per mm^3 (SD = 4,095.275), ranging from 5,350 to 20,120 per mm^3 (median = 10,060 per mm^3). According to the normal reference range of 4,000–10,000 per mm^3, 15 participants (50%) had a normal leukocyte count and 15 participants (50%) had an elevated count. The mean value was slightly above the upper normal limit, indicating a mild leukocytosis on average.

Table 3. Neutrophil-to-Lymphocyte Ratio (NLR) Value.

NLR Value	
Mean	5,3523
Minimum	1,19
Median	3,4150
Maximum	19,23
Standard deviation	4,40974

Table 3. display the NLR values. The mean NLR was 5.3523 (SD = 4.40974), with a minimum of 1.19 and a maximum of 19.23 (median = 3.4150). Using a normal cutoff of ≤3.13, 12 participants (40%) had a normal NLR, while 18 participants (60%) had an elevated NLR. The average NLR was therefore above the normal threshold, suggesting a systemic inflammatory tendency in the study population.

Table 4. Data normality test.

	Up to HbA1c	Number of Leukocytes	NLR Value
Standard Deviation	1,3156	4095,275	4,40974
Shapiro-Wilk	0,924	0,918	0,804
Signifikan (2-tailed)	0,035	0,023	0,000

Uji *Shapiro-Wilk*, α = 5%

Because the sample size was ≤50, the Shapiro-Wilk test was used to assess the normality of the data distribution (Table V.6). The significance values for HbA1c (p = 0.035), leukocyte count (p = 0.023), and NLR (p = 0.000) were all below 0.05, indicating that none of the three variables followed a normal distribution. Consequently, the non-parametric Kendall's tau-b correlation test was applied for all bivariate analyses.

Tabel 5. Uji *Kendall's tau-b* antara kadar HbA1c dan jumlah leukosit.

	Jumlah Leukosit	
Kadar HbA1c	Koefisien korelasi	0,023
	Sig. (2-tailed)	0,858
	N	30

As shown in Table 5, Kendall's tau-b correlation coefficient between HbA1c levels and leukocyte count was 0.023, with a p-value of 0.858 (p > 0.05). This indicates no statistically significant correlation between the two variables. Therefore, the null hypothesis (Ho1) was accepted, and the alternative hypothesis (Ha1) was rejected.

Tabel 6. Uji *Kendall's tau-b* antara kadar HbA1c dan nilai NLR.

	Nilai NLR	
Kadar HbA1c	Koefisien korelasi	0,028
	Sig. (2-tailed)	0,830
	N	30

Table 6 presents the correlation between HbA1c levels and NLR values. The correlation coefficient was 0.028, with a p-value of 0.830 (p > 0.05). Again, no significant correlation was found. Thus, Ho2 was accepted and Ha2 rejected.

Tabel 7. Uji *Kendall's tau-b* antara jumlah leukosit dan nilai NLR.

	Nilai NLR	
Jumlah Leukosit	Koefisien korelasi	0,480
	Sig. (2-tailed)	0,000
	N	30

As displayed in Table 7, the Kendall's tau-b correlation coefficient between leukocyte count and NLR was 0.480, with a p-value of 0.000 (p < 0.05). This result demonstrates a statistically significant positive correlation of moderate strength (τ = 0.480). The positive direction indicates that an increase in leukocyte count is associated with an increase in NLR, and vice versa. Accordingly, the null hypothesis (Ho3) was rejected, and the alternative hypothesis (Ha3) was accepted.

This research was carried out at Kilisuci Regional General Hospital in Kediri City, focusing on individuals with type 2 diabetes mellitus (T2DM) who were receiving care at the Internal Medicine Outpatient Clinic. Data collection spanned from March 17 to April 15, 2025. For each participant, we simultaneously measured HbA1c levels and performed a complete blood count to obtain total leukocyte count and the neutrophil-to-lymphocyte ratio (NLR).

Among the 30 enrolled participants, 11 (37%) were men and 19 (63%) were women, indicating a higher proportion of female subjects. This gender distribution aligns with observations by Galita and Septianingrum (2022), who noted that women face a greater risk of developing T2DM than men. According to their analysis, this elevated risk may be attributed to dietary habits particularly higher intake of sugar and fats—combined with lower levels of physical activity among women.

The age breakdown of the participants was as follows: three individuals (10%) were between 26 and 35 years old; four (13.3%) were aged 36–45; five (16.7%) were aged 46–55; the largest group, 12 participants (40%), fell into the 56–65 year range; three (10%) were aged

66–75; and another three (10%) were 76 years or older. The youngest participant was 33 years old, the oldest 80 years, with a mean age of 56.50 years (median = 60.00, SD = 13.387). This age profile is consistent with the findings of Scarton et al. (2023), who reported that individuals over 45 years are at heightened risk for T2DM due to degenerative changes that impair the body's ability to manage glucose effectively.

All 30 participants (100%) had elevated HbA1c levels, as shown in Table 1.1. This outcome was anticipated, given that the inclusion criteria required either a fasting blood glucose level of ≥120 mg/dL or a random blood glucose level of ≥200 mg/dL—both indicative of poor glycemic control. Consequently, uncontrolled hyperglycemia was reflected in elevated HbA1c values. This finding echoes the work of Karimah et al. (2018), who observed that most T2DM patients exhibit increased HbA1c, which serves as a measure of average blood glucose over the preceding two to three months, rather than capturing daily fluctuations.

Regarding leukocyte counts (Table 1.2), exactly half of the participants (15 out of 30) had values within the normal range, while the other half showed elevated counts. This pattern is in line with the observations of Permatasi (2023), who noted that the mean leukocyte count in T2DM patients tends to exceed the upper limit of normal. As for NLR (Table 1.3), 12 participants (40%) had normal values, whereas 18 (60%) had elevated NLR. This predominance of elevated NLR agrees with the report by Nurdin et al. (2021), who found that the majority of T2DM patients display an increased NLR.

T2DM arises from insulin resistance or impaired insulin action, leading to chronic hyperglycemia (Decroli, 2019). Both hyperglycemia and elevated HbA1c can trigger sustained low-grade inflammation, which in turn may promote leukocytosis (Harun, 2020). In the early inflammatory phase, increased production of interleukin-8 (IL-8) drives neutrophil generation and activation. Subsequently, interleukin-6 (IL-6) shifts the cytokine profile from IL-8 toward monocyte chemoattractant protein-1 (MCP-1), which recruits and activates mononuclear cells. As inflammation progresses, the initial neutrophil-dominated response transitions toward lymphocyte involvement, accompanied by neutrophil apoptosis and phagocytosis. This process is essential because an excessive accumulation of neutrophils can be toxic to surrounding tissues and may exacerbate inflammation. In diabetes, heightened oxidative stress accelerates lymphocyte apoptosis, thereby raising the NLR (Susilo et al., 2020).

Because the sample size was 50 or fewer, we used the Shapiro–Wilk test to assess the normality of the data distribution (Table 1.4). The two-tailed significance values were 0.035 for HbA1c, 0.023 for leukocyte count, and 0.000 for NLR—all below the 0.05 threshold, indicating that none of the three variables followed a normal distribution. Accordingly, we applied the non-parametric Kendall's tau-b correlation test using SPSS.

As shown in Table 1.5, no statistically significant correlation was found between HbA1c levels and leukocyte count. This finding is consistent with the report by Weinmusa (2021), who similarly observed no meaningful relationship between these two parameters.

Table 1.6 likewise reveals no significant correlation between HbA1c levels and NLR values. This result supports the work of Simamora (2024), who also failed to find a significant association between HbA1c and NLR. However, it stands in contrast to the study by Anggoro (2019), which reported a significant correlation.

Several factors may explain the absence of a relationship between HbA1c and either leukocyte count or NLR in our study. All participants were outpatients who attended regular follow-up visits and underwent consistent laboratory monitoring. Furthermore, our exclusion

criteria ruled out comorbidities such as thalassemia and tuberculosis. Based on questionnaire data, none of the 30 respondents were obese—a condition characterized by excess body fat that often contributes to metabolic complications and increased inflammatory burden. The absence of obesity in this cohort may have reduced the overall level of chronic inflammation, potentially obscuring any link between glycemic control and these inflammatory markers.

In contrast to the above null findings, Table 1.7 demonstrates a significant positive correlation between total leukocyte count and NLR, with a correlation coefficient of 0.624 (moderate to strong) and a p-value below 0.05. This indicates that higher leukocyte counts tend to accompany higher NLR values, and vice versa.

A more detailed examination of the 30 participants revealed the following patterns: **10 individuals** had both normal leukocyte counts and normal NLR. These participants were likely adherent to their prescribed medication regimens. **13 participants** showed elevated leukocyte counts together with elevated NLR. Interviews with these individuals indicated that, although they attended regular check-ups, they were non-adherent to their medications and did not follow dietary recommendations. **5 participants** had normal leukocyte counts but elevated NLR. This pattern may be explained by long-standing T2DM, which can independently drive NLR elevation without necessarily raising total leukocyte counts. **2 participants** exhibited elevated leukocyte counts but normal NLR. A possible explanation is a temporary, acute illness on the day of blood sampling, which could increase leukocyte counts without affecting the neutrophil-lymphocyte balance.

NLR is calculated as the absolute neutrophil count divided by the absolute lymphocyte count. An elevated neutrophil count points to an ongoing, non-specific destructive inflammatory process, whereas a low lymphocyte count suggests impaired immune regulation (Nurdin et al., 2021). Therefore, an NLR above 3.13 reflects relative neutrophilia and lymphopenia. Among our participants with elevated NLR, differential count analysis (for example, subject A15) also showed increased monocyte levels—monocytes play a role in fighting infections and enhancing immune responses. Some subjects with normal NLR (e.g., A18, A26) and some with elevated NLR (e.g., A1, A11, A27) exhibited increased eosinophils, which are involved not only in allergic reactions but also in responses to infection (Rosita et al., 2019).

Taken together, an elevated NLR accompanied by an increased leukocyte count may serve as an independent predictor of the severity of inflammation—whether caused by infection or by chronic inflammatory processes. Leukocytosis has been directly linked to the pathogenesis of atherosclerosis and metabolic syndrome in T2DM patients. Similarly, an elevated NLR is associated with metabolic syndrome and is recognized as an important marker of systemic inflammation. Furthermore, a high NLR indicates increased cardiovascular risk in patients with metabolic syndrome. As the severity of an infection worsens, both leukocyte count and NLR tend to rise. Additionally, elevated levels of these parameters may predict other complications, such as sepsis and gangrene (Naess et al., 2017).

5. Conclusion

This study investigated the correlations among HbA1c levels, leukocyte count, and neutrophil-to-lymphocyte ratio (NLR) in patients with type 2 diabetes mellitus at Kilisuci Regional General Hospital, Kediri City. The results yielded several key findings.The mean HbA1c level was 8.5%, with a minimum of 6.8% and a maximum of 11.5%. The mean

leukocyte count was 10,359 per mm^3, ranging from 5,350 to 20,120 per mm^3. The mean NLR value was 5.35, with a minimum of 1.19 and a maximum of 19.23.

Correlation analysis revealed no significant relationship between HbA1c levels and leukocyte count ($p = 0.858$), nor between HbA1c levels and NLR values ($p = 0.830$). However, a statistically significant positive correlation was found between leukocyte count and NLR values ($p = 0.000$), with a moderate strength of correlation ($\tau = 0.480$) and a unidirectional relationship. This indicates that an increase in leukocyte count is accompanied by an increase in NLR, and vice versa.

In conclusion, while HbA1c does not correlate with either leukocyte count or NLR in this patient population, the significant correlation between leukocyte count and NLR suggests that both parameters may serve as interrelated markers of inflammation in type 2 diabetes mellitus. These findings support the potential use of NLR alongside total leukocyte count as simple, accessible inflammatory biomarkers in routine clinical practice.

Author Contributions: Conceptualization: M.P.; Methodology: A.P.; Software: A.P.; Validation: M.P; Formal analysis: M.P.; Investigation: M.P.; Resources: A.P. and M.P.; Data curation: M.P.; Writing—original draft preparation: M.P.; Writing—review and editing: M.P. and A.P.; Visualization: A.P.; Supervision: M.P.; Project administration: A.P.; Funding acquisition: Not applicable.

Funding: This research received no external funding.

The Data Availability Statement: data presented in this study are available on request from the corresponding author due to privacy and ethical restrictions. The dataset includes patient clinical information (age, sex, laboratory results) obtained from a hospital setting, and public sharing is not permitted under the institutional review board approval and patient confidentiality agreements. No new publicly archived dataset was generated or analyzed during this study.

Acknowledgments

The authors thank the Director of Kilisuci Regional General Hospital, Kediri City, for permission to conduct the study. Sincere appreciation is extended to the staff of the Clinical Pathology Laboratory and the Internal Medicine Outpatient Polyclinic for their technical assistance. Gratitude is also expressed to all patients with type 2 diabetes mellitus who participated voluntarily. The authors acknowledge the Faculty of Health for academic support. During the preparation of this manuscript, the authors used ChatGPT (OpenAI) for language refinement and paraphrasing assistance. The authors have reviewed and edited the output and take full responsibility for the final content of this publication.

Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

American Diabetes Association. (2021). *Standar medis perawatan diabetes 2021 dalam ringkasan untuk penyedia perawatan primer strategi untuk peningkatan tingkat sistem*. https://www.who.int/healthtopics/diabetes

Andayani, A., Niella, F. W., & Yosika, G. F. (2023). Hubungan kadar glukosa darah dengan jumlah leukosit pada pasien diabetes melitus tipe 2 di RSUD Gambiran Kota Kediri. *Jurnal Sains dan Terapan, 2*(2), 66–71. https://doi.org/10.57218/juster.v2i2.638

Anggoro, W. A. (2019). *Korelasi kadar HbA1c dengan nilai NLR pada penderita diabetes melitus tipe 2* (Skripsi, Universitas Muhammadiyah Yogyakarta).

Badan Penelitian dan Pengembangan Kesehatan. (2023). *Riskesdas 2023*.

Dahlan, M. S. (2020). *Statistika untuk kedokteran dan kesehatan* (Edisi ke-6, Cetakan ke-10). Arkans.

Darwis, I., Hidayat, H., Wisnu, G. N. P. P., & Mentari, S. (2020). Pengaruh nilai neutrophil lymphocyte ratio (NLR) sebagai prediktor mortalitas pada pasien ulkus diabetikum. *JK Unila, 4*(2), 128–134. https://doi.org/10.23960/jkunila.v4i2.pp128-134

Decroli, E. (2019). *Diabetes melitus tipe 2*. Pusat Penerbitan Bagian Ilmu Penyakit Dalam Fakultas Kedokteran Universitas Andalas.

Febrinasari, R. P., Sholikah, T. A., Pakha, D. N., & Putra, S. E. (2020). *Buku saku diabetes melitus untuk awam*. UNS Press.

Galita, T. N., & Septianingrum, T. D. (2022). Hormon dalam perspektif Islam. *Journal of Development and Research in Education, 3*(1), 44–51.

Gayatri, R. W., Kristianita, A. N., Virrizqi, V. S., & Sima, A. P. (2019). *Diabetes melitus dalam era 4.0*. Wineka Media. https://doi.org/10.17977/um044v4i1p56-62

Gusliandra, A. (2021). *Hubungan HbA1c dengan profil lipid plasma pasien diabetes melitus tipe 2 rawat jalan di poli endokrin RSUP Dr. M. Djamil Padang tahun 2021* (Skripsi, Poltekkes Kemenkes Padang).

Harun, A. (2022). *Systematic review: Peran sel neutrofil pada penyakit metabolik diabetes melitus tipe 2* (Naskah publikasi skripsi, Universitas 'Aisyiyah Yogyakarta).

International Diabetes Federation. (2019). *IDF diabetes atlas* (9th ed.).

Ismawati. (2024). Selama tujuh bulan, ada lima ribuan anak muda mengidap penyakit diabetes di Kota Kediri. *Radar Kediri*.

Kementerian Kesehatan Republik Indonesia. (2020). *Infodatin: Diabetes melitus 2020*.

Lou, M., Luo, P., Tang, R., Peng, Y., Yu, S., Huang, W., & He, L. (2015). Relationship between neutrophil-lymphocyte ratio and insulin resistance in newly diagnosed type 2 diabetes mellitus patients. *BMC Endocrine Disorders, 15*(9), 1–6. https://doi.org/10.1186/s12902-015-0002-9

Melati, R. (2021). *Gambaran jumlah leukosit pada penderita demam tifoid berdasarkan titer pemeriksaan widal* (Karya tulis ilmiah, Poltekkes Kemenkes Kendari).

Millatya, H. (2022). *Hubungan antara neutrophil lymphocyte ratio dengan mortalitas pasien COVID-19* (Skripsi, Universitas Islam Sultan Agung Semarang).

Naess, A., Nilssen, S. S., Mo, R., Eide, G. E., & Sjursen, H. (2017). Role of neutrophil to lymphocyte and monocyte to lymphocyte ratios in the diagnosis of bacterial infection in patients with fever. *Infection, 45*, 299–307. https://doi.org/10.1007/s15010-016-0972-1

Nurdin, N., Kalma, K., Hasnawati, H., & Nasir, H. (2021). Profil nilai neutrophil lymphocyte ratio (NLR) pada penderita diabetes melitus tipe 2. *Jurnal Media Analis Kesehatan, 12*(1), 64–70. https://doi.org/10.32382/mak.v12i1.2070

Oktaviannor, H., Herawati, A., & Hidayah, N. (2019). *Buku saku pengendalian diabetes melitus bagi pasien diabetes melitus tipe 2*. Fakultas Kesehatan Universitas Sari Mulia.

Peraturan Wali Kota Kediri Nomor 70 Tahun 2021 tentang perubahan atas peraturan walikota Kediri nomor 33 tahun 2020 tentang pembentukan unit pelaksana teknis dan unit organisasi bersifat khusus pada dinas kesehatan.

Peraturan Wali Kota Kediri Nomor 71 Tahun 2021 tentang peraturan internal rumah sakit umum daerah Kilisuci Kota Kediri.

Perkumpulan Endokrinologi Indonesia. (2019). *Pedoman pengelolaan dan pencegahan diabetes melitus tipe 2 dewasa di Indonesia*.

Permatasari, A. (2023). *Gambaran jumlah leukosit pada penderita diabetes melitus tipe 2 di Rumah Sakit TK II Pelamonia Makassar* (Karya tulis ilmiah, Universitas Megarezky Makassar).

Ramadhayanti, A. (2020). *Gambaran jumlah leukosit penderita demam tifoid pada anak di RS Bhayangkara Kota Palembang tahun 2020* (Karya tulis ilmiah, Poltekkes Kemenkes Palembang).

Rosita, L., Pramana, A. A. C., & Arfira, F. R. (2019). *Hematologi dasar*.

Sa'adah, S. (2018). *Sistem peredaran darah manusia*. UIN Sunan Gunung Djati Bandung.

Scarton, L., Nelson, T., Yao, Y., Devaughan-Circles, A., Legaspi, A. B., Donahoo, W. T., Segal, R., Goins, R. T., Manson, S. M., & Wilkie, D. J. (2023). Association of medication adherence with HbA1c control among American Indian adults with type 2 diabetes using tribal health services. *Diabetes Care, 46*(6), 1245–1251. https://doi.org/10.2337/dc22-1885

Simamora, J. (2024). *Hubungan HbA1c dengan neutrofil limfosit ratio (NLR) pada pasien diabetes melitus di RSU Anutapura Palu* (Skripsi, Universitas Perintis Indonesia).

Simanullang, T. R. (2022). *Analisis jumlah leukosit dan trombosit pada pasien demam tifoid di Rumah Sakit Santa Elisabeth Medan tahun 2022* (Skripsi, STIKes Santa Elisabeth Medan).

SPO Laboratorium Patologi Klinik RSUD Kilisuci Kota Kediri. (2021). *Pemeriksaan darah lengkap alat Mindray BC-3850*.

SPO Laboratorium Patologi Klinik RSUD Kilisuci Kota Kediri. (2021). *Pemeriksaan HbA1c alat Standard F200 SD Biosensor*.

SPO Laboratorium Patologi Klinik RSUD Kilisuci Kota Kediri. (2021). *Pengambilan sampel darah vena*.

Susilo, A. S., Zulfian, Z., & Artini, I. (2020). Korelasi nilai HbA1c dengan kadar kolesterol total pada pasien diabetes mellitus tipe 2. *Jurnal Ilmiah Kesehatan Sandi Husada, 9*(2), 640–645. https://doi.org/10.35816/jiskh.v11i1.262

Warsiyatun. (2023). *Perbandingan hasil pemeriksaan HbA1c metode high performance liquid chromatography (HPLC) dengan metode fluoresensi di RSUD Kabupaten Tangerang* (Skripsi, Poltekkes Kemenkes Jakarta III).

Weinnusa, M. (2021). *Hubungan kadar HbA1c dengan jumlah leukosit pada penderita diabetes melitus di RS Baptis Kota Kediri* (Skripsi, Institut Ilmu Kesehatan Bhakti Wiyata Kediri).

World Health Organization. (2021). *Diabetes dashboard*. https://www.who.int/healthtopics/diabetes