

**Original Article****Association Between Blood Glucose Levels and Leukocyte Counts in Patients with Diabetic Gangrene: A Cross-Sectional Study**

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**ABSTRACT**

**Background:** Diabetic gangrene is a severe complication of diabetes mellitus (DM) that often leads to amputation. DM increases susceptibility to infection by impairing leukocyte function. Although hyperglycemia is known to weaken innate immunity, its association with leukocyte count remains unclear, particularly in low- and middle-income country (LMIC) settings. This study aimed to assess the association between admission blood glucose levels and leukocyte counts in patients with diabetic gangrene.

**Methods:** This study utilized a retrospective cross-sectional design and was prepared in accordance with the STROBE guidelines. Secondary data were extracted from the medical records and laboratory reports of patients hospitalized at Kertosono Regional General Hospital in East Java, Indonesia, from January to December 2022. A purposive total sampling approach was applied. Inclusion criteria required an inpatient diagnosis of diabetes mellitus with diabetic gangrene, alongside the availability of both random blood glucose and total leukocyte count results for the same admission. Exclusion criteria eliminated records with missing or illegible key laboratory values, duplicate records, and records lacking diagnostic confirmation in the discharge summary. The independent variable assessed was admission random blood glucose (mg/dL), and the dependent variable was the total leukocyte count (cells/ $\mu$ L).

**Results:** From an initial pool of 50 records, a final sample of 38 medical records was selected for analysis. Spearman's rank correlation indicated that there was no significant association between random blood glucose levels and total leukocyte counts ( $r = -0.031$ ;  $p = 0.853$ ).

**Conclusion:** Admission blood glucose does not meaningfully track or correlate with total leukocyte count in patients presenting with diabetic gangrene. Clinically, this suggests that leukocyte count should not be used as a proxy or surrogate for acute glycemic status. Therefore, comprehensive infection severity assessments in these patients require integrating clinical evaluation with additional, more specific inflammatory indices.

**Keywords:** Blood Glucose; Leukocyte Count; Gangrene; Diabetic Gangrene; Diabetes Mellitus; Infection.

### Implications for Practice:

- **Healthcare Provider Training:** Medical professionals should receive training on traditional medicine. Clinicians should assess glycemic status and infection severity as complementary but distinct clinical parameters, rather than using total leukocyte count as a surrogate indicator of acute hyperglycemia in patients with diabetic gangrene.
- Health policies should support standardized multidisciplinary protocols that integrate clinical assessment with available inflammatory markers and wound evaluation to improve the management of diabetic gangrene.
- Midwifery education should strengthen competencies in diabetes-related wound assessment, infection recognition, and patient education, particularly for practice in Low- and Middle-Income Countries and other resource-constrained healthcare settings.

### Introduction

Diabetes mellitus (DM) is a growing global health challenge. The International Diabetes Federation estimated that 537 million people lived with the condition in 2021, a figure projected to reach 783 million by 2045 ([Rokom, 2024](#)). Indonesia faces a particularly steep trajectory, currently ranking fifth worldwide with 19.5 million reported cases ([Rokom, 2024](#)). One of the most devastating clinical outcomes of uncontrolled DM is diabetic gangrene, a condition characterized by severe tissue necrosis and infection, primarily in the extremities ([Smeltzer & Bare, 2017](#)). In Indonesia, the clinical burden of diabetic foot ulcers and gangrene is exceptionally high, with related mortality rates reaching 32% and lower-limb amputation rates approaching 30% ([Milasari, 2023](#)).

The high rate of severe infections in diabetic patients is firmly rooted in the physiological impact of chronic hyperglycemia on the innate immune system. Under normal conditions, polymorphonuclear leukocytes (white

blood cells) are the body's primary defense, identifying and destroying bacterial pathogens. However, when blood glucose levels remain abnormally high, this system begins to fail. Hyperglycemia actively inhibits leukocyte chemotaxis, their ability to migrate to the site of an injury and severely blunts their phagocytic capacity ([Lee et al., 2024](#); [Nuryani & Damayanti, 2022](#)). Consequently, when a minor foot injury occurs, the suppressed cellular immune response allows bacteria to multiply rapidly. This localized infection increases local metabolic demand, which, combined with diabetes-induced vascular damage, exacerbates tissue hypoxia ([Smeltzer & Bare, 2017](#)). The resulting oxygen deprivation accelerates tissue death, ultimately manifesting as clinical gangrene.

Managing these complex infections requires prompt assessment of both the patient's glycemic status and their systemic inflammatory response. In high-resource clinical environments, care teams can utilize advanced inflammatory biomarkers, such as C-reactive protein (CRP) or procalcitonin, to accurately gauge the severity of an infection ([Sharma et al., 2022](#); [Zhang et al., 2025](#)). However, in low- and middle-income country (LMIC) hospital settings, access to these advanced diagnostics is frequently limited by high costs and equipment availability. Clinicians in these environments must instead rely on basic, routine laboratories, random blood glucose, and total leukocyte count to make immediate triage, antibiotic, and surgical decisions.

While the physiological link between high blood sugar and weakened immunity is well established in laboratory settings, how this translates to acute clinical presentations remains a distinct gap in the literature. An elevated leukocyte count typically signals an active infection, yet it is unclear if acute spikes in blood glucose

directly drive proportional changes in total leukocyte numbers upon hospital admission. Current evidence is inconsistent; some studies suggest that acute hyperglycemia triggers a parallel inflammatory spike ([Gala et al., 2018](#)). While other studies argue that the inflammatory response in diabetic gangrene is multifactorial and does not directly correlate with blood sugar levels ([Almehmadi, 2020](#); [Darwis et al., 2020](#); [Qin & Deng, 2025](#); [Saleem et al., 2025](#)). Despite the heavy reliance on these two basic metrics in resource-constrained hospitals, their direct diagnostic relationship during acute gangrene admissions has not been adequately explored.

To address this practical clinical uncertainty, this study investigates the interplay between acute glycemic status and basic systemic inflammatory markers in a resource-limited setting. Specifically, the objective of this research is to determine if there is a statistically significant correlation between admission random blood glucose levels (measured in mg/dL) and total leukocyte counts (measured in cells/ $\mu$ L) among patients hospitalized with diabetic gangrene at Kertosono Regional General Hospital, East Java, Indonesia.

## Methods

### Study Design

This analytical observational study employed a retrospective cross-sectional design using secondary data obtained from hospital medical records. The study was conducted in accordance with the *Strengthening the Reporting of Observational Studies in Epidemiology* (STROBE) guideline for cross-sectional studies. Data were collected from the medical records of patients admitted to Kertosono Regional General Hospital, East Java, Indonesia, between January and December 2022.

The primary objective was to examine the association between admission random blood glucose levels and total leukocyte counts among patients diagnosed with diabetic gangrene. Random blood glucose level (mg/dL) was the independent variable, and total leukocyte count (cells/ $\mu$ L) was the dependent variable. Both laboratory parameters were obtained from the same hospital admission to ensure temporal consistency between exposure and outcome measurements.

### Participants

The study population comprised all hospitalized patients diagnosed with diabetes mellitus complicated by diabetic gangrene during the study period. A total sampling approach was adopted, whereby all eligible medical records were consecutively screened for inclusion to minimize selection bias.

Medical records were eligible if they met the following criteria: (1) a confirmed inpatient diagnosis of diabetes mellitus with diabetic gangrene documented in the discharge summary, and (2) availability of both admission random blood glucose and total leukocyte count results from the same hospitalization episode. Records were excluded if they contained incomplete or illegible laboratory data, represented duplicate admissions, or lacked confirmation of diabetic gangrene diagnosis.

Initially, 50 medical records were identified. After eligibility assessment, two records were excluded because of incomplete laboratory data, and ten records were removed because the final diagnosis did not confirm diabetic gangrene. Consequently, 38 medical records were included in the final analysis. As this investigation relied exclusively on retrospective secondary data, no participant attrition occurred after the selection process.

## Instruments

The study utilized routinely collected laboratory data extracted from hospital medical records. Admission random blood glucose concentration (mg/dL) and total leukocyte count (cells/ $\mu$ L) were measured by the hospital's accredited clinical laboratory as part of standard patient management. Laboratory analyses were performed according to institutional standard operating procedures using calibrated automated analyzers, with regular internal quality control and periodic instrument calibration to ensure measurement reliability.

For descriptive analyses, random blood glucose levels were categorized as  $>200$  mg/dL or  $\leq 200$  mg/dL, while leukocyte counts were classified as leukocytosis ( $>11,000$  cells/ $\mu$ L), normal, or leukopenia according to the hospital laboratory reference ranges. Continuous laboratory values were retained for correlation analysis to preserve statistical information and avoid unnecessary loss of precision.

## Data Collection

Data were collected retrospectively from paper-based and electronic medical records maintained by Kertosono Regional General Hospital. A standardized data extraction form was used to ensure consistency throughout the data collection process. Medical records were first screened against the predefined eligibility criteria before extraction of demographic characteristics and laboratory variables, including admission random blood glucose levels and total leukocyte counts. All extracted data were anonymized prior to analysis to protect patient confidentiality. To enhance data accuracy, a random sample of extracted records was independently verified against the original medical records, and any discrepancies were resolved through consensus among the

research team before the final analytical dataset was established.

## Data Analysis

Descriptive statistics were used to summarize participant characteristics and laboratory findings. Continuous variables are presented as mean  $\pm$  standard deviation or median with range, as appropriate, whereas categorical variables are reported as frequencies and percentages. Data normality was assessed using the Kolmogorov–Smirnov test. Because both continuous variables were non-normal, the association between admission random blood glucose levels and total leukocyte counts was evaluated using Spearman's rank correlation coefficient. Correlation strength was interpreted according to Cohen's conventional criteria. Statistical significance was established at a two-sided  $p < 0.05$ . All analyses were performed using IBM SPSS Statistics version 25.

## Ethical Considerations

The study received ethical approval from the Health Research Ethics Committee of Universitas Kadiri (Approval No. 042/13/XII/EC/KEP/UNIK/2021). It was conducted in accordance with the principles of the Declaration of Helsinki. As this investigation involved a retrospective analysis of de-identified secondary medical record data, the ethics committee waived the requirement for informed consent. Patient confidentiality was maintained throughout the study by removing all personal identifiers before data extraction and statistical analysis, and access to study data was restricted exclusively to the research team.

## Results

**Table 1** illustrates the demographic and clinical characteristics of the 38 patients included in the study. The mean age was  $57.53 \pm 10.25$  years (median, 56 years;

range, 42–79 years), and females accounted for a slightly higher proportion of the study population than males (60.5% vs. 39.5%). Most patients presented with random blood glucose levels exceeding 200 mg/dL (60.5%) and exhibited leukocytosis (>11,000 cells/ $\mu$ L) (78.9%). All documented cases of diabetic gangrene involved the foot, with no lesions reported in other anatomical locations.

**Table 1.** Participant Demographic and Clinical Characteristics (N = 38)

Characteristic	n (%)
<b>Age (years)</b>	
Mean $\pm$ SD	57.53 $\pm$ 10.25
Median (Range)	56 (42–79)
<b>Sex</b>	
Male	15 (39.5)
Female	23 (60.5)
<b>Random Blood Glucose</b>	
$\leq$ 200 mg/dL	15 (39.5)
>200 mg/dL	23 (60.5)
<b>Total Leukocyte Count</b>	
Leukopenia	1 (2.6)
Normal	7 (18.4)
Leukocytosis (>11,000 cells/ $\mu$ L)	30 (78.9)
<b>Gangrene Location</b>	
Foot (toes/forefoot/midfoot)	38 (100.0)
Lower leg	0 (0.0)
Other	0 (0.0)

**Table 2** presents the correlation analysis between admission random blood glucose levels and total leukocyte counts. Spearman's rank correlation demonstrated no statistically significant association between the two variables ( $r = -0.031$ ,  $p = 0.853$ ), indicating that admission glycemic status was not associated with total leukocyte count in patients with diabetic gangrene.

**Table 2.** Distribution of Leukocyte Count According to Admission Random Blood Glucose Category

Admission Random Blood Glucose	Leukocytosis n (%)	Normal n (%)	Leukopenia n (%)	Total n (%)
>200 mg/dL	18 (78.3)	4 (17.4)	1 (4.3)	23 (100)
$\leq$ 200 mg/dL	12 (80.0)	3 (20.0)	0 (0.0)	15 (100)
Spearman's correlation	$r = -0.031$			$p = 0.853$

## Discussion

The research results showed no association between Blood Glucose Levels and Leukocyte Counts in Diabetic Mellitus Patients with Gangrene at Kertosono Hospital in 2022 ( $p$ -value = 0.853). The results of this study are also supported by Tiana (2021), who reported no relationship between blood glucose and leukocyte count in diabetic foot patients. ( $p=0.428$ ) (Tiana et al., 2021). Another research study explored glycemic control as a possible aid to DFU healing but found no significant direct association between acute blood glucose levels and white blood cell count (Dissanayake et al., 2020)

There is no significant correlation between blood glucose levels and leukocyte levels in patients with gangrene, often due to the nature of the disease and the body's complex immune response. In related studies, elevated leukocyte counts are usually associated with common infections or systemic inflammation, while acute hyperglycemia or elevated blood glucose is more often associated with metabolic stress and is not always directly related to acute inflammatory reactions as measured by leukocytes. It means that although blood sugar levels may increase in patients with gangrene, it does not necessarily cause or correlate with significant changes in leukocyte levels (Almehmedi, 2020; Biadgo et al., 2016)

In patients with diabetic foot ulcers (DFUs), there is no significant relationship between leukocyte counts and changes in wound size, suggesting that leukocyte levels may not strongly correlate with wound progression ([Darwis et al., 2020](#)). Diabetic foot infections and ulcers involve complex interactions, in which leukocytes and glucose may not have a straightforward relationship. Instead, immune responses are more influenced by specific inflammatory markers and overall glycemic control over time ([Boulton et al., 2020](#)). Studies indicate the importance of the neutrophil-to-lymphocyte ratio (NLR) and haemoglobin levels in relation to diabetic foot prognosis and inflammation, but they do not show a consistent correlation specifically between blood glucose and total leukocyte count in diabetic foot patients ([Rezaei Shahrabi et al., 2023](#))

Some studies have shown that elevated leukocyte levels are more consistent in chronic infections or long-lasting inflammation, such as in patients with long-term uncontrolled type 2 diabetes mellitus. Gangrene can cause a local inflammatory response without a direct correlation with increased sugar levels at any time, mainly due to the influence of various factors, including differences in immune responses among individuals and varying levels of oxidative stress ([Almehmadi, 2020](#); [Biadgo et al., 2016](#)). Another study explains the differences in white blood cell distribution between diabetic and non-diabetic groups, noting increased leukocyte types in diabetic individuals but not necessarily correlating this with blood glucose levels directly ([Kadhim & Mohammed, 2021](#))

The relationship between blood sugar levels and leukocyte levels in diabetic patients with gangrene is complicated and tends to be indirect. Research shows that although leukocyte counts may increase in diabetic foot infections, they do not

necessarily correlate with blood sugar levels or the severity of gangrene.

#### Leukocyte Levels and Diabetic Foot Complications

Research by Darwis et al. (2020) found that changes in leukocyte count did not significantly correlate with wound area in patients with diabetic foot ulcers. It suggests that leukocyte levels do not directly reflect the severity of diabetic wound conditions ([Darwis et al., 2020](#)). Another study conducted by Stavchikov et al. (2023) showed that neutrophil and platelet levels were higher in patients with diabetic foot syndrome but did not show a direct correlation with blood sugar levels ([Stavchikov et al., 2023](#))

Leukocyte elevations in diabetic foot patients correlated with inflammatory responses rather than directly with blood glucose levels, suggesting that leukocyte counts might reflect infection or an inflammatory state in these cases rather than glycemic control ([Mohit et al., 2017](#)). Other studies emphasize the importance of ratios like the Neutrophil to Lymphocyte Ratio (NLR) and Platelet to Lymphocyte Ratio (PLR), which have shown stronger correlations with diabetic foot ulcer severity ([Gao & Yi, 2023](#); [Serban et al., 2024](#))

However, a direct correlation between blood glucose and total leukocyte (WBC) count is not consistently observed, as hyperglycemia may impair leukocyte function (e.g., chemotaxis, phagocytosis, immune signaling) without necessarily leading to a proportional rise in circulating leukocyte numbers ([Lee et al., 2024](#)). In diabetes-related foot conditions (including infected ulcers that clinically overlap with gangrene-spectrum presentations), the literature increasingly suggests that CRP is often more informative than WBC count alone for assessing infection severity: a systematic review/meta-analysis found CRP and other markers to outperform white cell count for diagnosing and grading

infected diabetic foot ulcers, and current international guidance emphasizes using laboratory markers only as adjuncts to clinical assessment ([Sharma et al., 2022](#)).

More recent cohort evidence also shows that CRP levels are independently associated with diabetic foot infection severity, reinforcing the idea that inflammatory burden may be detectable even when leukocyte counts change modestly ([Zhang et al., 2025](#)).

#### Blood Sugar Levels and Inflammation

Despite the inflammatory response triggered by high sugar levels, studies show inconsistent associations with leukocyte counts. For instance, changes in leukocyte counts were positively associated with glycemic changes, but the relationship was not uniformly observed across all studies ([Gala et al., 2018](#)).

Recent evidence continues to indicate that elevated blood glucose is closely intertwined with systemic inflammation, through mechanisms such as oxidative stress, cytokine upregulation, and dysregulated leukocyte trafficking ([Pezhman et al., 2021](#)).

In population-level data, inflammatory biomarkers like high-sensitivity C-reactive protein (hs-CRP) also tend to be higher in people meeting diabetes diagnostic criteria, supporting the broader link between worsening glycemic status and low-grade inflammation ([Tutuncu et al., 2016](#)).

At the same time, etiologic inference remains cautious: Mendelian randomization work has reported no clear causal role of WBC subtypes in type 2 diabetes or key glycemic traits, implying that observed associations in clinical datasets may reflect residual confounding or concurrent inflammatory comorbidity rather than a direct glucose–leukocyte count relationship. In addition, the ratio of neutrophils to lymphocytes was found to be a significant marker in predicting the outcome of diabetic foot syndrome,

although the direct relationship with blood sugar levels could not be clearly defined ([Serban et al., 2024](#)).

Another comprehensive analysis of immune profiles in diabetic patients categorized into subgroups based on insulin sensitivity and inflammatory markers found differences in leukocyte counts among diabetes types, with some subtypes presenting higher leukocyte levels due to increased inflammation rather than direct blood glucose correlation ([Ratter-Rieck et al., 2021](#)).

#### Chronic Hyperglycemia and Immune Dysfunction

Some studies also mention that chronic hyperglycemia may cause immune dysfunction that affects leukocyte function without affecting the number directly. Understanding how immune system dysfunction occurs during hyperglycemia could lead to new treatments and prevention for infectious diseases and comorbidities of type 2 diabetes, thereby improving the outcomes of infectious disease treatment in type 2 diabetes patients ([Berbudi et al., 2020](#)). Host factors like immune response as more critical than glucose control in affecting leukocyte activity during DFI episodes ([Maity et al., 2024](#)).

Hyperglycemia can alter leukocyte adhesion, migration, and phagocytic efficiency, potentially through mechanisms like increased oxidative stress and cytokine production, which lead to systemic inflammation and compromised immune responses. This chronic inflammatory environment is primarily responsible for immune dysfunction rather than an increase in leukocyte count itself ([Vasbinder et al., 2022](#)).

#### Implications and limitations

Scientifically, this study demonstrates that blood glucose levels on acute hospital admission are not a significant correlate of

total leukocyte count in diabetic gangrene, highlighting the need to differentiate between markers of metabolic control and inflammatory markers in clinical interpretation.

Major limitations include the small sample size (n = 38), limited availability of covariates (e.g., duration of diabetes, vascular status, antibiotic exposure, characteristics of the gangrenous wound, treatment received), and the use of secondary records, which may introduce measurement bias and variability. This study also assessed random blood glucose rather than long-term glycemic control (e.g., HbA1c), which may be more relevant to immune dysfunction. Future studies with larger sample sizes, standardized laboratory testing times, and additional biomarkers (NLR, CRP, procalcitonin) are recommended.

### Relevance to Practice

In everyday nursing and multidisciplinary care of diabetic gangrene, the findings support a balanced approach: while glycemic monitoring remains essential for overall management, total leukocyte count should be interpreted primarily as an infection/inflammation indicator rather than as a reflection of blood glucose status. Where feasible, incorporating differential counts (to calculate NLR) and other accessible inflammatory markers can improve triage and monitoring, especially in LMIC settings.

### Conclusion

Admission random blood glucose and total leukocyte count appear to reflect different aspects of the clinical condition in patients with diabetic gangrene. Therefore, total leukocyte count should not be used as a surrogate indicator of glycemic status, and infection assessment should rely on comprehensive clinical evaluation supported by appropriate inflammatory

markers. Further multicenter studies using larger populations and broader inflammatory and glycemic biomarkers are needed to improve understanding of the complex interactions between hyperglycemia, immune dysfunction, and diabetic gangrene.

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### CrediT Authorship Contributions Statement

**Satria Eureka Nurseskasatmata:** Conceptualization, Methodology, Investigation, Writing - Original Draft

**Wiwin Sulistyawati:** Software, Formal Analysis, Data Curation, Visualization

**Siska Christianingsih:** Investigation, Resources, Validation, Writing - Original Draft

**Caturia Sasti Sulistyana:** Methodology, Formal Analysis, Writing - Review & Editing

**Abdul Fauzi:** Data Curation, Project Administration, Investigation

**Indah Jayani:** Validation, Visualization, Writing - Review & Editing

**Arif Nurma Etika:** Conceptualization, Supervision, Funding Acquisition, Writing - Review & Editing

### Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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