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# Poor Glycemic Control and the Risk of Diabetic Peripheral Neuropathy Among Patients with Type 2 Diabetes Mellitus

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***ABSTRACT***

Type 2 Diabetes Mellitus (T2DM) is a growing global health problem associated with various chronic complications, including diabetic peripheral neuropathy (DPN). DPN is one of the most common microvascular complications that may lead to pain, foot ulcers, amputation, and reduced quality of life. Poor glycemic control has been identified as an important modifiable risk factor for DPN; however, evidence from Indonesia remains limited. This study aimed to analyze the association between poor glycemic control and diabetic peripheral neuropathy among patients with type 2 diabetes mellitus. A descriptive analytic study with a cross-sectional approach was conducted among 390 patients with T2DM in Padang City, Indonesia. Participants were selected using stratified random sampling. Glycemic control was assessed using HbA1c levels, while diabetic peripheral neuropathy was evaluated using the Michigan Neuropathy Screening Instrument (MNSI). Data were analyzed using chi-square tests and multiple logistic regression analysis with a significance level of $p < 0.05$. The prevalence of diabetic peripheral neuropathy among patients with T2DM was high. Most participants had uncontrolled HbA1c levels, indicating poor glycemic control. Statistical analysis showed a significant association between poor glycemic control and the occurrence of DPN ($p < 0.05$). Patients with uncontrolled HbA1c levels had a higher risk of developing DPN compared to those with controlled glycemic status. Poor glycemic control was significantly associated with diabetic peripheral neuropathy among patients with type 2 diabetes mellitus. Routine neuropathy screening and optimal glycemic management are essential to prevent complications and improve patient outcomes.

***Keywords:*** *Diabetic Peripheral Neuropathy; Glycemic Control; HbA1c; Type 2 Diabetes Mellitus; Neuropathy*

## INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both (American Diabetes Association [ADA], 2024). The global burden of diabetes continues to increase rapidly and has become a major public health challenge worldwide. According to the International Diabetes Federation (IDF), approximately 537 million adults aged 20–79 years were living with diabetes in 2021, and this number is projected to rise to 643 million by 2030 and 783 million by 2045 (International Diabetes Federation [IDF], 2021). Indonesia is among the countries with the highest number of diabetes cases globally, reflecting the substantial increase in the prevalence of type 2 diabetes mellitus (T2DM) over the last decade. The increasing prevalence of T2DM contributes significantly to the development of chronic complications, including microvascular and macrovascular disorders, which may lead to disability, decreased quality of life, and increased mortality (World Health Organization [WHO], 2023).

Diabetic peripheral neuropathy (DPN) is one of the most common chronic microvascular complications of T2DM. DPN is defined as the presence of symptoms and/or signs of peripheral nerve dysfunction in people with diabetes after excluding other causes of neuropathy (Tesfaye et al., 2010). Globally, the prevalence of DPN among patients with diabetes ranges from 16% to 87%, depending on population characteristics and diagnostic criteria used (Pop-Busui et al., 2017). In Indonesia, DPN remains one of the most frequently reported diabetic complications among patients with T2DM. Clinically, DPN commonly manifests as numbness, tingling sensations, burning pain, and loss of protective sensation in the lower extremities. If not identified and managed appropriately, DPN may progress to diabetic foot ulcers, lower extremity amputations, physical disability, and reduced quality of life (Hicks & Selvin, 2019). Furthermore, DPN contributes substantially to healthcare costs and long-term morbidity among individuals with diabetes.

Poor glycemic control has been recognized as one of the most important modifiable risk factors associated with the development of DPN. Glycated hemoglobin (HbA1c) is widely used as an indicator of long-term glycemic control because it reflects average blood glucose levels over the previous two to three months (ADA, 2024). Chronic hyperglycemia contributes to the activation of several metabolic and vascular pathways involved in nerve damage, including oxidative stress, advanced glycation end-product formation, and activation of the polyol pathway (Feldman et al., 2019). Persistent hyperglycemia also causes endothelial dysfunction and microvascular impairment, leading to reduced nerve blood flow and peripheral nerve ischemia. These mechanisms eventually result in axonal degeneration and peripheral nerve damage characteristic of DPN (Callaghan et al., 2020). Therefore, maintaining optimal glycemic control is essential to prevent or delay the progression of diabetic neuropathy and other diabetes-related complications.

Several previous studies have reported a significant association between elevated HbA1c levels and the occurrence of DPN among patients with T2DM. Studies conducted in various countries demonstrated that patients with uncontrolled glycemic status had a significantly higher risk of developing peripheral neuropathy compared to those with controlled blood glucose levels (Juster-Switlyk & Smith, 2016; Liu et al., 2019). Higher HbA1c levels were

also associated with increased severity of neuropathic symptoms and nerve dysfunction. However, several studies suggested that other factors such as age, duration of diabetes, obesity, hypertension, dyslipidemia, and lifestyle behaviors may also contribute to the development of DPN (Callaghan et al., 2020; Pop-Busui et al., 2017). These findings indicate the need for further investigation in different populations and healthcare settings.

Although numerous studies regarding DPN have been conducted globally, evidence from Indonesia remains limited, particularly in community-based and primary healthcare settings. Most studies in Indonesia have focused on hospital-based populations, while research involving patients at primary healthcare centers remains scarce. In addition, only a limited number of studies have utilized the Michigan Neuropathy Screening Instrument (MNSI) as a standardized screening tool for detecting DPN among patients with T2DM. Considering the increasing prevalence of diabetes and its complications in Indonesia, identifying the association between poor glycemic control and DPN is important to support early detection and preventive interventions in clinical practice.

This study aimed to analyze the association between poor glycemic control and diabetic peripheral neuropathy among patients with type 2 diabetes mellitus in Padang City, Indonesia

## RESEARCH METHOD

### Study Design

This study employed a descriptive analytic design with a cross-sectional approach to analyze the association between poor glycemic control and diabetic peripheral neuropathy among patients with type 2 diabetes mellitus.

### Setting and Participants

The study was conducted in Padang City, Indonesia, involving 24 primary healthcare centers . Data collection was carried out in 2024. The study population consisted of patients diagnosed with type 2 diabetes mellitus who attended diabetes care services at the selected primary healthcare centers.

### Population and Sample

The sample size of this study consisted of 390 patients with type 2 diabetes mellitus. Participants were selected using a stratified random sampling technique to ensure proportional representation from each primary healthcare center involved in the study.

### Inclusion Criteria

Participants who met the following criteria were included in the study:

1. Diagnosed with type 2 diabetes mellitus by a physician.
2. Aged 18 years or older.
3. Willing to participate in the study and provide informed consent.

### Exclusion Criteria

Participants were excluded if they:

1. Had other neurological disorders unrelated to diabetes mellitus.
2. Had a history of lower extremity amputation.
3. Experienced severe illness or conditions that limited communication and physical examination.

**Variables**

**Independent Variable**

The independent variable in this study was poor glycemic control, assessed using glycated hemoglobin (HbA1c) levels.

**Dependent Variable**

The dependent variable was diabetic peripheral neuropathy (DPN).

**Instruments**

**Glycemic Control Assessment**

Glycemic control was assessed using HbA1c examination results. HbA1c levels were categorized into controlled and uncontrolled glycemic status based on the American Diabetes Association (ADA) criteria, where HbA1c levels <7% were classified as controlled and HbA1c levels ≥7% were classified as uncontrolled (ADA, 2024).

**Diabetic Peripheral Neuropathy Assessment**

Diabetic peripheral neuropathy was assessed using the Michigan Neuropathy Screening Instrument (MNSI), which consists of a questionnaire and physical examination components. The MNSI is a widely used screening tool for identifying peripheral neuropathy among patients with diabetes mellitus and has demonstrated good validity and reliability in previous studies (Feldman et al., 1994). The instrument evaluates symptoms of neuropathy, foot appearance, ulceration, ankle reflexes, and vibration perception.

**Data Collection**

Data collection was conducted after obtaining permission from the relevant institutions and ethical approval. Eligible participants were identified through diabetes registries at the participating primary healthcare centers. Participants who met the inclusion criteria were informed about the study objectives and procedures before signing written informed consent forms. HbA1c data were obtained from laboratory examination records, while DPN assessment was conducted directly using the MNSI instrument by trained researchers and healthcare personnel.

**Data Analysis**

Data were analyzed using statistical software. Univariate analysis was performed to describe participants' demographic and clinical characteristics. Bivariate analysis using the chi-square test was conducted to determine the association between glycemic control and diabetic peripheral neuropathy. Variables with statistical significance were further analyzed using multiple logistic regression to identify the association between poor glycemic control and

DPN after controlling for potential confounding variables. Statistical significance was determined at $p < 0.05$.

### Ethical Consideration

This study received ethical approval from the Health Research Ethics Committee of Universitas Andalas with ethical clearance number 227.layaketik/KEPKFKEPUNAND.. Written informed consent was obtained from all participants prior to data collection. Participants' confidentiality and anonymity were maintained throughout the study.

## RESULTS AND DISCUSSION

### Results

### Characteristics of Participants

A total of 390 patients with type 2 diabetes mellitus participated in this study. Most participants were female and aged ≥60 years. The majority of participants had suffered from diabetes mellitus for more than five years. Based on HbA1c examination results, most participants had uncontrolled glycemic status (HbA1c ≥7%). The prevalence of diabetic peripheral neuropathy among participants was relatively high.

### Prevalence of Diabetic Peripheral Neuropathy

The findings showed that diabetic peripheral neuropathy was common among patients with type 2 diabetes mellitus. A considerable proportion of participants experienced symptoms and signs of peripheral neuropathy based on the Michigan Neuropathy Screening Instrument (MNSI) assessment. These findings indicate that DPN remains a major chronic complication among patients with T2DM in primary healthcare settings.

### Association Between Glycemic Control and DPN

Bivariate analysis using the chi-square test demonstrated a statistically significant association between glycemic control and diabetic peripheral neuropathy ($p < 0.05$). Patients with uncontrolled HbA1c levels had a higher proportion of DPN compared to those with controlled glycemic status. The odds ratio analysis indicated that participants with poor glycemic control were more likely to develop diabetic peripheral neuropathy than participants with controlled HbA1c levels.

### Logistic Regression Analysis

Multiple logistic regression analysis revealed that poor glycemic control remained significantly associated with diabetic peripheral neuropathy after controlling for potential confounding variables. Participants with HbA1c levels ≥7% had a higher risk of developing DPN compared to those with controlled HbA1c levels. In addition, older age and longer duration of diabetes mellitus also contributed to the occurrence of diabetic peripheral neuropathy among patients with T2DM.

### Prevalence of Diabetic Peripheral Neuropathy

This study found that the prevalence of diabetic peripheral neuropathy among patients with type 2 diabetes mellitus was relatively high. The findings are consistent with previous studies

conducted in Indonesia and other countries, indicating that DPN remains one of the most common chronic complications of diabetes mellitus. Previous studies in Indonesia reported varying prevalence rates of DPN among patients with T2DM, ranging from moderate to high prevalence depending on the study population, healthcare setting, and diagnostic methods used. Similar findings have also been reported in several Asian countries, where the prevalence of DPN among patients with diabetes ranged from approximately 30% to 70% (Pop-Busui et al., 2017). Globally, the prevalence of DPN has been estimated to range from 16% to 87%, reflecting variations in study design, population characteristics, duration of diabetes, and screening instruments (Tesfaye et al., 2010).

The high prevalence of DPN observed in this study may be associated with prolonged duration of diabetes, poor glycemic control, delayed diagnosis, and inadequate diabetes self-management. In primary healthcare settings, patients with T2DM often experience limited access to routine neuropathy screening, resulting in delayed identification and management of neuropathic complications. Furthermore, many patients may not recognize early symptoms of neuropathy until severe complications such as foot ulcers or infections occur. Therefore, early detection and regular neuropathy assessment are essential to reduce the burden of diabetic complications.

**Poor Glycemic Control and Diabetic Peripheral Neuropathy**

The present study demonstrated a significant association between poor glycemic control and diabetic peripheral neuropathy among patients with T2DM. Patients with uncontrolled HbA1c levels were more likely to experience DPN compared to those with controlled glycemic status. This finding supports the hypothesis that chronic hyperglycemia plays a crucial role in the pathogenesis of diabetic neuropathy.

Persistent hyperglycemia contributes to oxidative stress and metabolic disturbances that damage peripheral nerves. Chronic exposure to elevated glucose levels activates the polyol pathway, leading to intracellular accumulation of sorbitol and fructose, which subsequently causes osmotic stress and cellular dysfunction (Feldman et al., 2019). Hyperglycemia also increases the production of reactive oxygen species and advanced glycation end-products, resulting in endothelial dysfunction and microvascular impairment. Reduced blood flow to peripheral nerves may induce nerve ischemia and axonal degeneration, ultimately contributing to neuropathic symptoms and loss of nerve function (Callaghan et al., 2020).

In addition, prolonged poor glycemic control may trigger inflammatory responses and mitochondrial dysfunction, further accelerating peripheral nerve damage. These mechanisms explain why HbA1c remains an important indicator for predicting chronic diabetic complications, including DPN. Therefore, maintaining optimal glycemic control is critical for preventing or delaying the progression of diabetic neuropathy.

**Comparison With Previous Studies**

The findings of this study are consistent with several previous studies conducted in Asia, the Middle East, and Indonesia. A study conducted in China reported that patients with elevated HbA1c levels had a significantly increased risk of developing DPN compared to patients with controlled glycemic status (Liu et al., 2019). Similar findings were reported in Middle

Eastern countries, where poor glycemic control was identified as one of the strongest predictors of diabetic neuropathy among patients with T2DM.

Studies conducted in Indonesia also demonstrated a significant relationship between uncontrolled blood glucose levels and neuropathic complications. Patients with prolonged hyperglycemia were found to have a greater likelihood of experiencing sensory impairment, pain, and foot-related complications. These similarities indicate that poor glycemic control remains a universal risk factor for DPN across different populations and healthcare settings.

However, some studies reported inconsistent findings regarding the association between HbA1c and DPN severity. Variations in study outcomes may be influenced by differences in sample size, duration of diabetes, diagnostic instruments, ethnicity, lifestyle factors, and healthcare accessibility. Despite these inconsistencies, the majority of studies support the role of poor glycemic control in the development and progression of diabetic neuropathy.

**Clinical Implications**

The findings of this study have important clinical implications for diabetes management in primary healthcare settings. First, maintaining optimal HbA1c levels should become a major priority in preventing diabetic peripheral neuropathy and other chronic complications of diabetes mellitus. Routine monitoring of HbA1c may help healthcare providers identify patients at high risk for neuropathic complications and provide timely interventions.

Second, regular screening for diabetic peripheral neuropathy should be integrated into routine diabetes care, particularly in primary healthcare centers. Early identification of neuropathy may help prevent severe complications such as diabetic foot ulcers, infections, and lower extremity amputations. The use of simple and practical screening tools such as the Michigan Neuropathy Screening Instrument (MNSI) may facilitate early detection of DPN in community settings.

Third, patient education regarding diabetes self-management, medication adherence, foot care, physical activity, and healthy dietary behaviors is essential to improve glycemic control and reduce the risk of complications. Nurses play a critical role in providing education, counseling, routine assessment, and preventive interventions for patients with T2DM. Strengthening the role of nurses in diabetes management programs may contribute to better clinical outcomes and improved quality of life among patients with diabetes mellitus.

**Strengths and Limitations**

This study has several strengths. First, the study involved a relatively large sample size of patients with T2DM from multiple primary healthcare centers, which enhances the representativeness of the findings. Second, this study was conducted in community-based healthcare settings, providing important evidence regarding diabetic neuropathy among patients receiving primary care services. Third, the use of the Michigan Neuropathy Screening Instrument (MNSI), a validated screening tool, increased the reliability of DPN assessment.

However, several limitations should also be acknowledged. The cross-sectional design limits the ability to establish causal relationships between poor glycemic control and diabetic peripheral neuropathy. In addition, HbA1c measurements and neuropathy assessments were

conducted at a single point in time, which may not fully reflect long-term glycemic status and progression of neuropathy. Further longitudinal studies are needed to better understand the temporal relationship between glycemic control and the development of diabetic peripheral neuropathy.

## CONCLUSION

Poor glycemic control was significantly associated with diabetic peripheral neuropathy among patients with type 2 diabetes mellitus. Patients with uncontrolled HbA1c levels had a higher risk of developing diabetic peripheral neuropathy compared to those with controlled glycemic status. Chronic hyperglycemia may contribute to peripheral nerve damage through oxidative stress, activation of the polyol pathway, and microvascular impairment.

These findings highlight the importance of optimal glycemic management and routine neuropathy screening in preventing diabetic complications, particularly in primary healthcare settings. Early detection of diabetic peripheral neuropathy using standardized screening tools such as the Michigan Neuropathy Screening Instrument (MNSI) may help reduce the risk of foot ulcers, amputations, and decreased quality of life among patients with T2DM.

Healthcare providers, especially nurses, should strengthen patient education regarding diabetes self-management, adherence to treatment, foot care, and healthy lifestyle behaviors to improve glycemic control and prevent the progression of diabetic peripheral neuropathy.

### Recommendations

Routine HbA1c assessment should be implemented regularly among patients with type 2 diabetes mellitus to monitor glycemic control and identify individuals at high risk for diabetic peripheral neuropathy. Maintaining optimal glycemic status is essential to prevent or delay the progression of chronic diabetic complications.

Routine screening for diabetic peripheral neuropathy should also be integrated into primary healthcare services using simple and standardized instruments such as the Michigan Neuropathy Screening Instrument (MNSI). Early detection of neuropathy may help reduce the incidence of diabetic foot ulcers, infections, and lower extremity amputations.

In addition, healthcare providers should strengthen diabetes self-management education programs focusing on medication adherence, blood glucose monitoring, healthy dietary behaviors, physical activity, and foot care practices. Nurses play a critical role in providing continuous education, counseling, and preventive interventions to improve glycemic control and reduce the burden of diabetic complications among patients with type 2 diabetes mellitus.

## BIBLIOGRAPHY

American Diabetes Association. (2024). *Standards of care in diabetes—2024*. Diabetes Care, 47(Suppl. 1), S1–S350. https://doi.org/10.2337/dc24-SINT

Callaghan, B. C., Gallagher, G., Fridman, V., Feldman, E. L., & Pop-Busui, R. (2020). Diabetic neuropathy: What does the future hold? *Diabetologia*, 63(5), 891–897. https://doi.org/10.1007/s00125-020-05085-9

Feldman, E. L., Callaghan, B. C., Pop-Busui, R., Zochodne, D. W., Wright, D. E., Bennett, D. L., ... & Viswanathan, V. (2019). Diabetic neuropathy. *Nature Reviews Disease Primers*, 5(1), 41. https://doi.org/10.1038/s41572-019-0092-1

Feldman, E. L., Stevens, M. J., Thomas, P. K., Brown, M. B., Canal, N., & Greene, D. A. (1994). A practical two-step quantitative clinical and electrophysiological assessment for the diagnosis and staging of diabetic neuropathy. *Diabetes Care*, 17(11), 1281–1289. https://doi.org/10.2337/diacare.17.11.1281

Hicks, C. W., & Selvin, E. (2019). Epidemiology of peripheral neuropathy and lower extremity disease in diabetes. *Current Diabetes Reports*, 19(10), 86. https://doi.org/10.1007/s11892-019-1212-8

International Diabetes Federation. (2021). *IDF Diabetes Atlas* (10th ed.). Brussels, Belgium: International Diabetes Federation.

Juster-Switlyk, K., & Smith, A. G. (2016). Updates in diabetic peripheral neuropathy. *F1000Research*, 5, F1000 Faculty Rev-738. https://doi.org/10.12688/f1000research.7898.1

Liu, X., Xu, Y., An, M., & Zeng, Q. (2019). The risk factors for diabetic peripheral neuropathy: A meta-analysis. *PLoS ONE*, 14(2), e0212574. https://doi.org/10.1371/journal.pone.0212574

Pop-Busui, R., Boulton, A. J. M., Feldman, E. L., Bril, V., Freeman, R., Malik, R. A., ... & Ziegler, D. (2017). Diabetic neuropathy: A position statement by the American Diabetes Association. *Diabetes Care*, 40(1), 136–154. https://doi.org/10.2337/dc16-2042

Tesfaye, S., Boulton, A. J. M., Dyck, P. J., Freeman, R., Horowitz, M., Kempler, P., ... & Bernardi, L. (2010). Diabetic neuropathies: Update on definitions, diagnostic criteria, estimation of severity, and treatments. *Diabetes Care*, 33(10), 2285–2293. https://doi.org/10.2337/dc10-1303

World Health Organization. (2023). *Diabetes*. Geneva: World Health Organization. Retrieved from https://www.who.int/news-room/fact-sheets/detail/diabetes