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Uncovering Early Risk Factors of Diabetic Peripheral Neuropathy: Insights from Primary Health Care Facilities

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Abstract

Diabetic Peripheral Neuropathy (DPN) is a progressive and frequently underdiagnosed complication of type 2 diabetes mellitus. Limited early screening based on clinical risk factors in primary healthcare settings in Indonesia contributes to delayed diagnosis, increasing the likelihood of advanced neuropathy, foot ulceration, and lower-limb amputation. This study aimed to analyse risk factors for DPN among individuals with T2DM. A quantitative cross-sectional study was conducted among 162 patients with T2DM in the Bogor Primary Healthcare area. The Michigan Neuropathy Screening Instrument (MNSI) was used to assess neuropathic symptoms, and a physical foot examination was performed. Data were analyzed using Chi-square tests and binary logistic regression. 75.3% of respondents showed signs of Neuropathy, with the most common symptoms being dry and cracked skin on the feet (93.1%), muscle cramps (75.9%), and numbness (74.1%). Bivariate analysis showed that age (p=0.004), duration of diabetes mellitus (p=0.030), and random blood sugar (p=0.000) were significantly associated with NPD. Logistic regression identified hyperglycemia (AOR=6.50; 95% CI = 2.65–15.85) and age ≥35 years (AOR=2.16; 95% CI 1.12–4.28) as independent predictors of NPD (Nagelkerke R^2=0.27). Peripheral Neuropathy was highly prevalent even among patients with a short diabetes duration and had not been clinically diagnosed previously.

Introduction

Diabetes mellitus (DM) continues to increase globally, with approximately 193 million cases remaining undiagnosed, the majority of which occur in developing countries. The IDF estimates that the number of people with DM will increase from 415 million in 2015 to 642 million in 2040 (Gebabo *et al.*, 2021). A similar trend is occurring in Indonesia, where the prevalence of DM increased from 6.9% in 2013 to 8.5% in 2018, with West Java accounting for 1.74% of cases, or approximately 570,611 cases (Riskesdas, 2018). If not optimally managed, DM can lead to microvascular complications such as diabetic Neuropathy, retinopathy, and nephropathy (Shiferaw *et al.*, 2020). Diabetic peripheral Neuropathy (DPN) is one of the most common complications, with a prevalence of 13–78%, and is a significant cause of disability, amputation, and decreased quality of life (Adi Pamungkas *et al.*, 2022; Gebabo *et al.*, 2021; Mathiyalagen *et al.*, 2021).

Globally, 60–70% of people with diabetes show signs of neuropathy (Adi Pamungkas *et al.*, 2022), and the prevalence of DPN can reach 35% even at the time of initial diagnosis of type 2 diabetes, indicating that Neuropathy develops subclinically (Kirthi *et al.*, 2021). In Southeast Asia, Indonesia has the highest prevalence at 58%, and data from Dr Cipto Mangunkusumo

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General Hospital show that Neuropathy accounts for 54% of DM complications, with 16.2% of patients experiencing foot ulcers that often result in amputation (Pamungkas *et al*., 2023). Factors such as poor glycemic control, obesity, dyslipidemia, advanced age, smoking, and a sedentary lifestyle are known to accelerate the progression of DPN (Ponirakis *et al*., 2022; Putri & Waluyo, 2020; Yang *et al*., 2025). The economic burden of DPN is also significant; for example, the cost of treating chronic leg ulcers exceeds 2.5 billion dollars in the United States (Adi Pamungkas *et al*., 2022).

Although diabetic Neuropathy has a significant impact on patients' quality of life, ranging from physical limitations and psychological distress to the social effects, early detection efforts in primary healthcare facilities are still far from optimal. Simple screening tools such as the Michigan Neuropathy Screening Instrument (MNSI), with 80% sensitivity and 95% specificity, have been recommended for use at the primary care level in Indonesia (Imamah *et al*., 2024; Martin, 2014; Mathiyalagen *et al*., 2021). This lack of screening implementation results in many cases going undetected in the early stages and only being diagnosed after severe complications, such as foot ulcers or amputations, have occurred (Hicks *et al*., 2021). This highlights the critical importance of strengthening preventive strategies and early detection of diabetic neuropathy to reduce the burden of complications and preserve patients' quality of life (Ardiyati & Ernawati, 2024).

This phenomenon illustrates what is known as *silent Neuropathy*, namely the progression of Neuropathy that patients or healthcare providers do not recognize until serious complications arise. Despite increasing global understanding of diabetic peripheral neuropathy, its early detection in real-world clinical settings, particularly in primary care, remains inadequate. Many patients are only diagnosed after neuropathy has progressed to painful, disabling, or limb-threatening stages, indicating a disconnect between available evidence and actual practice. Although several studies have examined neuropathy and its risk factors, most were conducted in controlled research settings or outside the Indonesian healthcare context, limiting their applicability to daily practice in local primary care facilities. This gap highlights the need for context-specific evidence to support routine screening and identify patients at risk before irreversible damage occurs. Strengthening early detection strategies is essential to prevent foot ulcers, disability, and costly amputations, and to shift diabetes care from reactive treatment toward proactive prevention.

Methods

This study used a quantitative cross-sectional design to identify factors associated with peripheral Neuropathy in patients with diabetes mellitus in primary health care in Bogor Regency. Data collection was conducted in August–October 2025 using a purposive sampling method, involving 162 respondents who met the inclusion criteria: patients diagnosed with diabetes mellitus who attended the Community Health Centre for treatment and were willing to participate in the study. Neuropathy screening was conducted using the Michigan Neuropathy Screening Instrument (MNSI), which consists of two parts: (1) a 15-item symptom questionnaire and (2) a structured clinical foot and sensory examination. The symptom questionnaire was described in terms of the percentage for each item. The clinical assessment included inspection for deformities, callus, dryness, fungal infection, and ulceration, followed by tests of vibration sensation (128 Hz tuning fork), ankle reflexes, and monofilament testing, scored according to the original scoring guidelines, with a cutoff ≥2.5 considered indicative of neuropathy.

A registered professional nurse performed all assessments. Before data collection, the assessor underwent refresher calibration training to ensure alignment with standardized MNSI procedures and reduce inter-observer variability. To minimize information and measurement bias, standardized written and verbal instructions were provided to participants, and the same equipment and examination sequence were used for all assessments. Data entry and scoring were cross-verified by a second researcher to ensure accuracy. Confidentiality was maintained throughout the study. In addition, demographic data, clinical status, and blood

glucose levels were collected through interviews, medical records, and direct examination. Data analysis was performed stepwise using the Chi-square test for bivariate analysis and binary logistic regression to determine independent predictors of Neuropathy with a significance level of α = 0.05. This study has received ethical approval (Number: UN.10/F.10/KP.01.1/KE.SP/10.08/014/2025, and written informed consent was obtained from all participants before participation.

Results And Discussion

Most respondents were in the 35–60 age group (56.2%), followed by those aged ≥60 years (29.6%), and only 14.2% were in the 15–34 age range. Women comprised the majority of the study sample (69.1%), while men accounted for 30.9%. The majority of participants had a diabetes duration of less than 5 years (71.6%), while 28.4% had suffered from diabetes for more than 5 years. Most respondents' random blood sugar levels were ≥200 mg/dL (66.7%), and the remainder (33.3%) were below 200 mg/dL. Based on nutritional status, 58% of respondents had a BMI <25, while 42% had a BMI ≥25, indicating a relatively high proportion of overweight and obesity.

Neuropathy examination results showed that the majority of respondents, 122 (75.3%), had peripheral neuropathy, while 40 (24.7%) showed no signs of Neuropathy. These findings suggest that neuropathy is a common complication in patients with diabetes mellitus in this study population.

Prevalence: Dry and cracked foot skin (93.1%) ranks highest. These symptoms indicate autonomic Neuropathy, which interferes with the regulation of sweating and peripheral circulation. Dominant sensory symptoms: Numbness, muscle cramps, and stabbing sensations showing significant involvement of the sensory nervous system, indicating an advanced stage of diabetic Neuropathy. Motor symptoms and ulcer risk: Calf pain when walking, and a history

Table 1. Characteristics Respondents (n = 162)

Characteristics	n = 162	%
Age (Year)		
15–34 years	23	14.2
35–60 years	91	56.2
≥60 years	48	29.6
Gender		
Male	50	30.9
Female	112	69.1
DM Time		
< 5 years	116	71.6
≥ 5 years	46	28.4
Random Blood Glucose		
<200 mg/ dL	54	33.3
≥200 mg/ dL	108	66.7
Body Mass Index (BMI)		
< 25	94	58
≥ 25	68	42

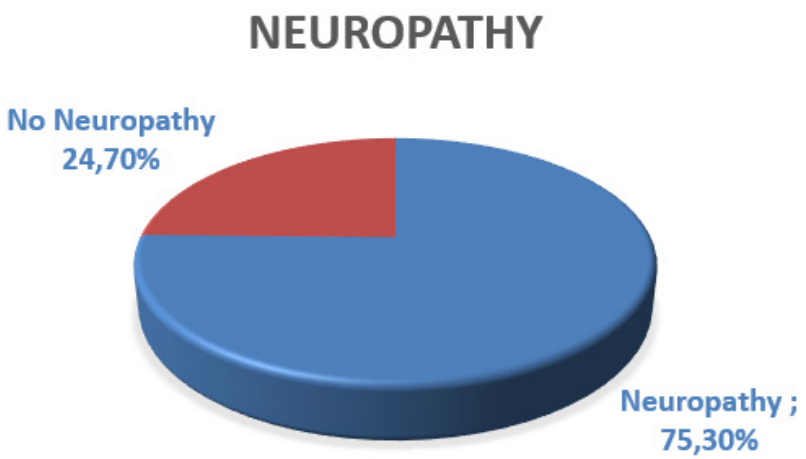

Figure 1. Prevalence Neuropathy (n = 162)

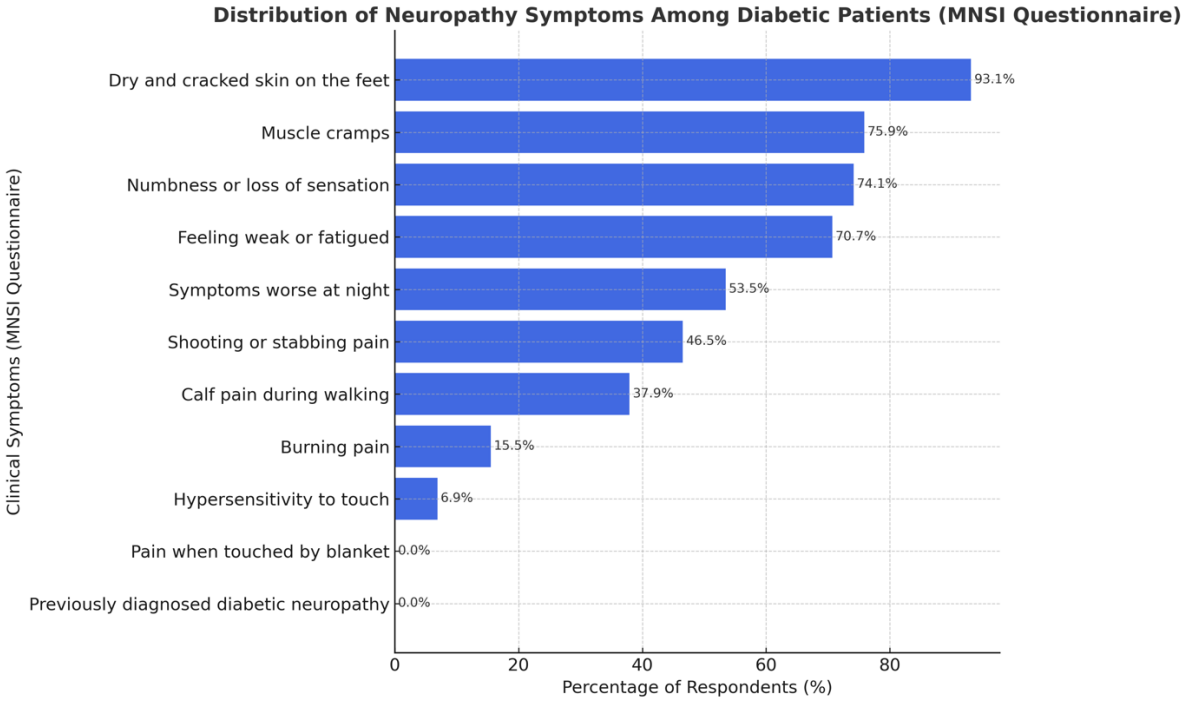

Figure 2. Symptoms of Clinical Neuropathy

of open wounds demonstrate the impact of Neuropathy on mobility and the risk of diabetic foot complications. Interestingly, although clinical findings clearly indicate the presence of Neuropathy, none of the respondents had previously been diagnosed with diabetic Neuropathy, as shown in the graph below.

The results of bivariate analysis using the Chi-Square test showed that age (p=0.004), duration of diabetes (p=0.030), and random blood glucose levels (p=0.030) had a significant relationship with the incidence of peripheral Neuropathy, indicating that increasing age, duration of exposure to hyperglycemia, and poor glycemic control contribute to the risk of Neuropathy. In contrast, no significant

Table 2. Analysis Bivariate (n = 162)

Variables	Neuropati Perifer Diabetic				*p-value*
	Yes		No		
	n	%	n	%	
Age (Year)					
15–34 years	14	8.62	9	5.55	0.004
35–60 years	70	43.20	21	12.92	
≥60 years	38	23.45	10	6.26	
Gender					
Male	42	25.92	8	4.93	0.087
Female	80	49.38	32	19.75	
DM Time					
< 5 years	82	50.61	34	20.98	0.030
≥ 5 years	40	24.69	6	3.70	
Random Blood Glucose					
<200 mg/ dL	31	19.13	23	14.19	0.000
≥200 mg/ dL	91	56.17	17	10.49	
Body Mass Index (BMI)					
< 25	70	43.20	24	14.81	0.771
≥ 25	52	32.09	16	9.87	

relationship was found between neuropathy and gender (p=0.174) or body mass index (p=0.778), indicating that these two variables were not differentiating factors for the incidence of Neuropathy in this study population. Based on the results of the bivariate analysis, variables with a p-value <0.25, namely age, duration of diabetes, and random blood glucose levels, were selected as candidates for further testing in a multivariate analysis using logistic regression. Gender and BMI were also included in the model due to theoretical considerations and their potential as confounding variables (confounders). Multivariate analysis was conducted to identify the independent factors most strongly influencing the incidence of peripheral Neuropathy, after controlling for other variables.

Binary logistic regression analysis showed that blood glucose levels and age were independently associated with diabetic peripheral neuropathy. The DM duration variable had a p-value of 0.332, indicating that DM duration did not have a significant effect on the incidence of neuropathy (p> 0.05). The Exp(B) value of 1.71 indicated that respondents with a longer DM duration had a greater risk of experiencing neuropathy. Still, this effect was not statistically significant, so it could not be generalized as a risk factor in this research model. Hyperglycemic patients (blood sugar ≥200 mg/dL) were 6.50 times more likely to experience neuropathy (95% CI = 2.65–15.85; p = 0.000), and respondents aged ≥35 years had a 2.16 times higher chance (95% CI 1.12–4.28; p = 0.023). The model showed good fit (Hosmer–Lemeshow p = 0.552) and explained 27% of the variance in neuropathy (Nagelkerke R^2 = 0.27). The prevalence of Neuropathy in this study reached 75.3%, significantly higher than the figures reported in general population studies (18–50%) (Yildirim, 2025; Andarge et al., 2025). This high figure may be explained by the population's predominance of patients with hyperglycemia (66.7%), a risk factor shown to increase nerve damage through non-enzymatic glycosylation, oxidative stress, and endothelial dysfunction (Asghar et al., 2023; Yang et al., 2025).

The clinical presentation of Neuropathy in this study also provides a relevant pattern. Dry and cracked feet were found in 93.1% of

Table 3. Binary Logistic Analysis

Variables	B	SE	Wald	p-value	AOR	95% CI
Age ≥35 years	0.77	0.34	5.18	0.023	2.16	1.12–4.28
Duration of diabetes ≥5 years	0.54	0.54	0.63	0.332	1.71	0.59–4.95
Blood sugar ≥200 mg/ dL	1.87	0.45	17.02	0.000	6.50	2.65–15.85
BMI ≥25 (overweight/obese)	0.32	0.48	0.46	0.085	1.37	0.53–3.52
Gender	0.79	0.49	2.58	0.108	0.451	0.17 – 1.19
Constant	–3.38	1.58	4.55	0.001	0.034	—

Model summary: Nagelkerke $R^2 = 0.271$; Hosmer–Lemeshow test $p = 0.552$ (model fit).

respondents, indicating autonomic Neuropathy affecting sweat production and peripheral tissue perfusion, a finding consistent with Rastogi et al. (2025). The combination of sensory symptoms such as numbness, paresthesias, and muscle cramps suggests involvement of the somatosensory nervous system, reflecting symmetric distal polyneuropathy, the most common form of Neuropathy in diabetic patients (Hanewinckel et al., 2016; Vileikyte, 2024). These manifestations indicate a combination of progressive autonomic and sensory Neuropathy, consistent with the characterization of DPN as a multifactorial condition involving axonal damage, demyelination, and microvascular disruption (Jasmine et al., 2021; Yang et al., 2025). Furthermore, the presence of motor symptoms and reports of difficulty walking suggest that some subjects have entered a clinically advanced phase of Neuropathy that increases the risk of foot ulcers and amputation.

The fact that none of the respondents in this study had ever received a diagnosis of neuropathy, despite having demonstrated clear clinical signs of neuropathy, indicates a significant gap in the early detection and management of Diabetes Mellitus complications in primary healthcare. This finding aligns with that of Houghton et al. (2025),who reported that foot screening in primary healthcare is still rarely performed, not standardized, and more often relies on annual or incidental screening rather than routine clinical practice. This situation underscores the importance of implementing structured screening instruments, such as the Michigan Neuropathy Screening Instrument (MNSI), which is effective at detecting neuropathy early, before it progresses to ulcerative complications. Furthermore, the results of this study are consistent with those of Hakim (2025), which showed that the health behaviour of DM patients is significantly influenced by the Health Belief Model constructs, including perceived susceptibility, perceived severity, perceived barriers, self-efficacy, and cues to action. Low perceptions of risks and benefits, coupled with personal and situational barriers and limited education and encouragement from healthcare professionals, contribute to suboptimal early detection of DM complications. In this context, the ineffectiveness of neuropathy screening in primary healthcare facilities is influenced not only by clinical factors and service systems but also by patient perceptions and health beliefs, as outlined in the Health Belief Model (Hakim., 2025).

Logistic regression analysis showed that age ≥60 years and hyperglycemia (≥200 mg/dL) were independent risk factors for Neuropathy. At the same time, diabetes duration, BMI, and gender did not show a statistically significant relationship. Age ≥60 years was associated with an increased risk of Neuropathy (AOR = 2.16), consistent with studies by Kebede et al. (2021) and Lin (2025), which showed that aging exacerbates neurodegeneration by increasing systemic inflammation, mitochondrial dysfunction, and decreasing neuroregeneration. These results also support the report by Li & Lu (2025), which emphasized that age is a strong predictor of neuropathic complications due to reduced nerve conduction velocity and increased oxidative stress with aging. Blood glucose levels ≥200 mg/dL increased the risk of NPD by 2.49 times in this study, consistent

with the results of Davalos et al. (2025) and Andarge et al. (2025), who showed a similar association in clinical populations. The hyperglycemia factor is also consistent with Shahid et al. (2025), who explained the role of non-enzymatic glycosylation in vascular damage and nerve dysfunction. Similarly, the association between disease duration ≥5 years and a 3.26-fold increased risk confirms that the progression of Neuropathy is cumulative. In many cases, it begins earlier, as shown in this study.

The duration of diabetes mellitus (DM) was not statistically significant in this study (p=0.332). This finding indicates that the duration of diabetes mellitus (DM) is not a crucial predictor of Neuropathy among the respondents in this study. This condition may be influenced by several factors, such as blood glucose control, medication adherence, age, lifestyle, and other comorbidities, which are more influential in the occurrence of Neuropathy than the duration of diabetes. This finding strengthens recent evidence that diabetic Neuropathy is not only related to the duration of diabetes but can occur earlier, especially in conditions of chronic, uncontrolled hyperglycemia (Hanewinckel et al., 2016; Pfannkuche et al., 2020). The results of this study indicate that diabetic peripheral Neuropathy (NPD) has emerged significantly in the early phase of the diabetes course, even when the majority of respondents had a disease duration of less than five years (71.6%). Consistent with the findings of Rastogi et al. (2025), this study confirms that early-onset Neuropathy is an increasingly common clinical phenomenon, especially in primary care settings in developing countries, where delayed diagnosis and poor metabolic control remain challenges (Kebede et al., 2021; Rastogi et al., 2025).

In this study, gender was not significantly associated with Neuropathy incidence, suggesting that gender is not an independent predictor of Neuropathy based on objective criteria, such as loss of sensation, impaired reflexes, and nerve conduction results. This finding supports the notion that gender differences are more evident in the subjective aspects of neuropathic pain or symptoms, rather than in the degree of objective nerve damage. This result contrasts with the study of Tao et al. (2025), which found women to be a risk factor for diabetic peripheral neuropathy with more intense neuropathic pain; this difference is likely due more to variability in pain perception and reporting than to the pathophysiology of Neuropathy itself, consistent with the findings of Abraham et al., (2018) who reported a higher prevalence of pain in women.

The results of this study indicate that BMI does not significantly influence the incidence of Neuropathy. Theoretically, obesity plays a role in the early phase of diabetes development through the mechanisms of insulin resistance and systemic inflammation. Still, once Neuropathy develops, chronic metabolic factors such as poor glycemic control, increased HbA1c, dyslipidemia, and oxidative stress become more dominant determinants than body weight status (Davalos et al., 2025). Several studies support this. Zhen et al. (2019) showed that although the obese group had a higher prevalence of Neuropathy than the normal weight group (66.62% vs. 46.99%), independent risk factors for Neuropathy were not solely determined by BMI, but were more related to hypertriglyceridemia in obese patients (OR 3.90; p=0.04) and the duration of diabetes. In the present study, this may be explained by patients' adherence to dietary management, driven by the belief that dietary control can stabilize blood glucose levels and prevent complications. Qualitative findings revealed that respondents were motivated to maintain dietary compliance due to unpleasant symptoms experienced during hyperglycemia, such as headaches, generalized weakness, and reduced comfort, which reinforced sustained dietary behaviors despite variations in BMI (Murodi et al., 2025).

From a patient experience perspective, these findings also have implications for quality of life. Research by Sionti et al. (2025) found that diabetes significantly affects physical function and social activities, with 93% of respondents reporting a decline in quality of life. In conjunction with these findings, the high prevalence of neuropathic symptoms such as burning, cramping, or pain during walking has the potential to exacerbate limitations

in daily activities, sleep disturbances, and psychological burden, as explained by Vileikyte (2024). These clinical impacts also contribute to increased healthcare costs, as patients with DPN, particularly those with chronic pain, tend to have more healthcare visits, medication consumption, wound care procedures, and even the risk of amputation (Wang et al., 2025).

Overall, these results are relevant to the current understanding of diabetic Neuropathy as a multifactorial disease characterized by oxidative stress, inflammation, insulin resistance, mitochondrial dysfunction, and microvascular damage (Yang et al., 2025). This study adds significant evidence that diabetic Neuropathy in the primary care population is not only common but also often undiagnosed. Neuropathy has clear clinical manifestations and is closely associated with poor metabolic control and modifiable risk factors. However, there is no definitive therapy that can halt the progression of Neuropathy, and management still focuses on symptom reduction and glycemic control. In the context of primary health care, early identification of Neuropathy is of great urgency. Houghton et al. (2025) emphasize the need for community-based screening models and for alternative approaches, such as self-screening and annual event-based screening programs (e.g., World Diabetes Day), to improve early detection and access to services.

The findings of this study indicate that limited implementation of diabetic neuropathy screening in primary healthcare facilities contributes to the low early detection of neuropathy in patients with diabetes mellitus. The development of artificial intelligence (AI) has been reported to have potential as an alternative for neuropathy screening with promising results, particularly through its ability to simultaneously integrate physiological and anatomical data to detect and classify neuropathy severity more accurately (Lians et al., 2025). However, the implementation of AI technology in primary healthcare still faces various obstacles, including limited infrastructure, costs, and human resource readiness. Therefore, a more realistic and sustainable approach currently is to optimize the use of simple and standardized screening instruments, such as the Michigan Neuropathy Screening Instrument (MNSI), which can bridge the need for early neuropathy detection with the limitations of the primary healthcare system.

This study has several limitations that should be considered when interpreting the results. First, the cross-sectional design did not allow researchers to determine a causal relationship between risk factors and the incidence of diabetic neuropathy; therefore, the relationship found was associative, not causal. Second, the study location was limited to a few community health centers within a single geographic region, so the results may not fully reflect the condition of the diabetes population at the national level. Studies with multi-regional or national coverage are needed to increase the generalizability of the findings. Third, this study only evaluated a few basic demographic and clinical variables as risk factors, namely age, sex, random blood glucose, and body mass index. Other important variables, such as diabetes duration, history of glycemic control (HbA1c), lifestyle, comorbidities, drug therapy, and metabolic factors, were not included in the analysis. Therefore, further studies with more comprehensive measurements of clinical variables are needed to provide a more complete picture of the determinants of neuropathy in diabetic patients.

Conclusion

The findings of this study have important implications for nursing practice, particularly in primary care. The identification that diabetic peripheral Neuropathy can appear even within the first five years of diagnosis underscores the need for early and ongoing screening, regardless of the duration of the disease. Nurses need to conduct systematic assessments using standardized instruments, such as the Michigan Neuropathy Screening Instrument (MNSI), as part of a routine annual examination or at every visit for diabetes patients, particularly for individuals with poor glycemic control, persistent hyperglycemia, advanced age, or longer duration of diabetes. Furthermore, the results of this study indicate that most respondents already have neuropathic pain with a significant level of functional

impairment. Hence, nurses need to integrate multidimensional pain management, including pharmacological, pain self-management education, and non-pharmacological approaches such as relaxation, foot exercises, and structured foot care. Furthermore, the impact of Neuropathy on quality of life and the burden of healthcare costs reinforces the urgency of the nurse's role in a holistic approach**.** Implementation of these evidence-based interventions may reduce late complications, lower amputation rates, improve quality of life, and increase efficiency in financing the national healthcare system. Further research using longitudinal or interventional designs is recommended to evaluate the causal relationship and effectiveness of neuropathy prevention measures.

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