

## Exploring the connection between diabetes duration, HbA1c levels, and peripheral neuropathy in type 2 diabetes patients



Cut Husna<sup>1,\*</sup>, Aulia Akmal<sup>2</sup>, Hilman Syarif<sup>3</sup>, Sri Agustina<sup>4</sup>

<sup>1</sup>Department of Medical and Surgical Nursing, Faculty of Nursing, Universitas Syiah Kuala, Banda Aceh, Indonesia

<sup>2</sup>Faculty of Nursing, Universitas Syiah Kuala, Banda Aceh, Indonesia

<sup>3</sup>Department of Emergency Nursing, Faculty of Nursing, Universitas Syiah Kuala, Banda Aceh, Indonesia

<sup>4</sup>Department of Pediatric Nursing, Faculty of Nursing, Universitas Syiah Kuala, Banda Aceh, Indonesia

### ARTICLE INFO

#### Article history:

Received 1 January 2024

Received in revised form

18 April 2024

Accepted 19 April 2024

#### Keywords:

Duration of diabetes

HbA1c levels

Peripheral neuropathy

Diabetes mellitus

### ABSTRACT

Diabetes mellitus can lead to blood circulation problems, which include both large-scale (macrovascular) and small-scale (microvascular) issues. One specific small-scale problem is the loss of feeling in the feet (known as peripheral neuropathy), which can cause foot ulcers and greatly increase the risk of needing an amputation. The length of time someone has had diabetes and their HbA1c levels (a measure of blood sugar control over time) are linked to the risk of developing diabetic peripheral neuropathy (DPN) in individuals with diabetes. The purpose of this study was to investigate the relationship between how long someone has had type 2 diabetes mellitus (T2DM) and their HbA1c levels with the presence of DPN. We conducted a correlational study with a cross-sectional design. We specifically chose 154 outpatients with T2DM from a hospital clinic for this study. To collect data, we used forms that included demographic information, the Michigan Neuropathy Screening Instrument (MNSI), and the Michigan Diabetic Neuropathy Score (MDNS). We analyzed the data using chi-square tests. Our findings showed a significant link between DPN and both the duration of diabetes and abnormal HbA1c levels in individuals with T2DM, with statistical significance ( $p=0.001$ ) for both. We suggest that individuals with diabetes should manage their condition carefully to minimize the risk of complications from DPN. It is also recommended that hospitals regularly offer educational programs on neuropathy risks and prevention of severe complications to patients with T2DM.

© 2024 The Authors. Published by IASE. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

### 1. Introduction

Diabetes mellitus (DM) is a metabolic condition characterized by an increase in blood sugar levels as a result of defects in insulin secretion (Al-Rubeaan et al., 2015; Galicia-Garcia et al., 2020; Mou et al., 2024). DM is a non-communicable disease that affects 9% of the world's population today (American Diabetes Association, 2016). The number of diabetic patients in 2017 was 10.3 million people, and it is estimated that this number will increase to 16.7 million people in 2045 (Amour et al., 2019). DM is one of the biggest health problems in the world,

and Indonesia ranks third highest in Southeast Asia and seventh in the world (Syamsiah et al., 2021).

According to data from the Indonesian Hospital Association, over half of diabetic patients exhibit signs of neuropathy (Hébert et al., 2017). The Indonesian Basic Health Research (Riskesdas) reports that approximately 54% of Indonesians with diabetes mellitus suffer from neuropathy (IDF, 2017). Diabetic peripheral neuropathy (DPN) is the most frequent complication among diabetic patients, affecting about 50% of them. The incidence of DPN is rising, with reports from Africa indicating a prevalence of 46% (KKRI, 2020), and increases observed in Southeast Asia, including Malaysia (54.3%), the Philippines (58.0%), and Indonesia (58.0%) (Malik et al., 2020). Factors influencing DPN complications include patient age, duration of diabetes, HbA1c levels, and comorbidities such as hypertension, dyslipidemia, and history of foot ulcers (Mørkrid et al., 2010). Most cases of DPN are currently irreversible, making early detection and management of modifiable risk factors crucial,

\* Corresponding Author.

Email Address: [cuthusna@usk.ac.id](mailto:cuthusna@usk.ac.id) (C. Husna)

<https://doi.org/10.21833/ijaas.2024.04.025>

Corresponding author's ORCID profile:

<https://orcid.org/0000-0002-6283-4209>

2313-626X/© 2024 The Authors. Published by IASE.

This is an open access article under the CC BY-NC-ND license

(<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

particularly in low-income countries. Extended periods of uncontrolled diabetes are significant risk factors for the development of DPN in diabetics (Mythili et al., 2010).

Previous research has identified several risk factors for DPN, including age, duration of diabetes, glycemic control (indicated by high HbA1c levels), gender, medical history, and smoking status (Nisansala et al., 2022). This study aims to investigate the relationship between the duration of diabetes and HbA1c levels in type 2 diabetic patients and their association with diabetic peripheral neuropathy.

**2. Material and method**

This research was a correlational study conducted at an outpatient clinic in a referral hospital in Banda Aceh, Indonesia. To determine the sample size, a calculation was made with a significance level ( $\alpha$ ) of 0.05, a power of 0.80, and an effect size of 0.30. To accommodate potential non-responses, the sample size was increased by 10%, resulting in 154 participants selected through total sampling. The inclusion criteria for the sample were: 1) Patients with type 2 diabetes for at least one year, 2) Aged over 35 years, 3) Blood pressure below 180/100 mmHg, 4) Physically and mentally healthy, and 5) Able to communicate verbally.

Data collection involved three tools: demographic data, the Michigan Neuropathy Screening Instrument (MNSI) for screening dry, cracked skin, calluses, and deformities, and the Michigan Diabetic Neuropathy Score (MDNS) to evaluate autonomic, sensory, and motor nerve function. These instruments underwent validity and reliability tests, achieving a Cronbach's alpha of 0.703.

HbA1c scores were obtained from patients' laboratory results and medical records. Data were analyzed using univariate and bivariate analysis methods. Participation was voluntary, and all respondents provided written informed consent. The study received ethical approval from the Ethics Committee of the Faculty of Nursing, Universitas Syiah Kuala, Banda Aceh (approval no:

112004150722). Table 1 presents the demographic and clinical characteristics of type 2 diabetes mellitus (T2DM) patients. The data indicate that the majority of these patients are older than 65 years (55.8%), male (67.5%), and have had diabetes for more than five years (59.1%). Additionally, a significant portion of the patients have a history of comorbidity (79.9%), show abnormal HbA1c values (80.5%), and suffer from moderate levels of diabetic peripheral neuropathy (64.3%).

**3. Results**

The sociodemographic and clinical characteristics of the respondents in this study are shown in Table 1.

**Table 1:** Sociodemographic and clinical characteristics of respondents (n=154)

Characteristic	Frequency	Percentage
<b>Age</b>		
Young adult	11	7.1
Middle adult	57	37.0
Older adult	86	55.8
<b>Gender</b>		
Male	104	67.5
Female	50	32.5
<b>Long-suffering diabetic (year)</b>		
<1	13	8.4
1-5	50	32.5
>5	91	59.1
<b>History comorbidity</b>		
Yes	123	79.9
No	31	20.1
<b>HbA1c</b>		
Normal	30	19.5
Abnormal	124	80.5
<b>Diabetic peripheral neuropathy (DPN)</b>		
Low	55	35.7
Moderate	99	64.3

**3.1. The correlation between duration onset of diabetes and HbA1c with DPN**

The correlation between the duration of onset of T2DM patients and HbA1c with DPN is shown in Table 2. Table 2 indicates that there is a significant correlation between the duration of diabetes (p=0.001) and HbA1c levels (p=0.001) with the occurrence of DPN in T2DM patients in the hospital.

**Table 2:** The correlation duration onset of diabetes and HbA1c with DPN

Variables	Mild		Moderate		f	%	p-value
	f	%	f	%			
<b>Long-suffering DM (year)</b>							
<1	13	100	0	0	13	100	0.001
1-5	34	68	16	32.0	50	100	
>5	8	8.8	83	91.2	91	100	
<b>HbA1c score</b>							
Normal	26	86.7	4	13.3	30	100	0.001
Abnormal	29	23.4	95	64.3	124	100	

**4. Discussion**

Complications from diabetes may arise due to prolonged disease duration, particularly DPN. The risk of complications increases the longer an individual has diabetes. Research findings reveal that 35-40% of individuals with T2DM develop neuropathy after more than three years of managing

the disease, and this increases to 70% when the duration exceeds five years (Popescu et al., 2016). This study found that 64.3% of T2DM patients experienced moderate DPN, and 91.2% of those with a disease duration of over five years also had moderate DPN. Additionally, 64.3% of the cases showed abnormal HbA1c levels alongside moderate DPN. These findings support previous research

indicating a link between the duration of diabetes and the development of DPN, which typically occurs in individuals who have had diabetes for more than five years (Popescu et al., 2016). Furthermore, this study observed that 59.1% of T2DM patients with a disease duration exceeding five years exhibited moderate levels of DPN, underscoring a significant correlation between the duration of diabetes and the prevalence of DPN in T2DM patients.

The findings of this study align with previous research, which indicated that 64.6% of patients with long-term diabetic neuropathy had been diagnosed with diabetes for more than five years. Qureshi et al. (2017) noted that patients with a diabetes duration of five years or longer are 3.95 times more likely to develop DPN compared to those who have had diabetes for less than five years. Additionally, this study corroborates findings from Faizi and Kazmi (2017), who reported a significant relationship between the duration of diabetes and the occurrence of DPN, with an odds ratio (OR) of 1.010 and a 95% confidence interval (CI) ranging from 1.004 to 1.015, further emphasizing the impact of prolonged diabetes on the risk of developing DPN.

Another study also identified a significant relationship between DPN and the duration of diabetes. The prevalence of neuropathy escalates after five years following a diabetes diagnosis. Consequently, it is crucial to perform laboratory testing for the early detection of complications in diabetic patients. Early detection of DPN enables healthcare professionals and patients to start preventive measures and assess treatment options. This approach also improves education for patients on the importance of regular foot examinations (Shiferaw et al., 2020).

The prevalence of diabetic neuropathy escalates each year following a diabetes diagnosis, with an OR of 1.2 and a 95% CI ranging from 1.0 to 1.4. Specifically, after five years of diabetes diagnosis, the prevalence of diabetic neuropathy increases significantly, rising from 14.1% to 29.2% among patients who have had diabetes for 9 to 11 years (Tamer et al., 2006). Furthermore, recent findings indicate a significant positive correlation between the duration of type 2 diabetes and the severity of peripheral neuropathy in patients with type 2 diabetes ( $p=0.01$ ) (Tofure et al., 2021).

According to the findings of this study, the authors contend that having T2DM for more than five years poses a risk factor for neuropathy. The study demonstrates a correlation between an increased duration of diabetes and the occurrence of neuropathy, attributing this to chronic hyperglycemia, which heightens the risk of DPN complications. Prolonged exposure to high blood glucose levels can weaken and damage the walls of blood vessels, leading to traumas and injuries, especially in the lower extremities.

Furthermore, one of the methods used to monitor glucose control in T2DM patients is a measurement of HbA1c levels. With long-term monitoring of blood sugar regulation, evaluation could assess the

therapeutic efficacy of treatment. The relative glucose concentration to plasma in less than four weeks for 90 days is the HbA1c value. A number of diabetes complications, including neuropathy, have been associated with the development of glucose control as measured by HbA1c levels (Trisnawati, 2014).

DPN commonly occurs in patients with abnormal HbA1c levels. This study found that 80.5% of patients with DPN had abnormal HbA1c levels, and 64.3% of these patients exhibited moderate DPN. There is a demonstrated correlation between HbA1c levels and the occurrence of DPN in patients with T2DM. These findings are consistent with previous research, which indicated that patients with diabetic neuropathy had a 72.1% higher prevalence of abnormal HbA1c levels compared to those with normal levels, suggesting that blood glucose control is often inadequate in these patients (Qureshi et al., 2017). Similarly, Nugroho et al. (2016) found that the severity of DPN was significantly and positively correlated with HbA1c levels. Additionally, Shiferaw et al. (2020) reported a significant relationship between HbA1c levels and DPN. It has been noted that HbA1c levels are elevated in those with neuropathy, increasing approximately 10-15% for every 1% rise in HbA1c (Won et al., 2012).

In diabetic patients, measuring HbA1c levels is a method used to monitor glucose control. HbA1c assessment provides insight into long-term blood glucose regulation and evaluates the effectiveness of treatment. The HbA1c value reflects plasma glucose concentration over a period ranging from four weeks to three months. Effective blood sugar control, as indicated by HbA1c levels, is linked to the development of complications in diabetes, including neuropathy (Trisnawati, 2014). Furthermore, a significant correlation has been found between prolonged duration of diabetes, high HbA1c levels, and the occurrence of DPN in patients with diabetes mellitus.

On the other hand, several factors may confound the management of DPN, including blood glucose control, diet planning, physical activity, and diabetes medications or insulin therapy, all of which help regulate blood glucose levels. Implementing foot care strategies is also crucial in managing DPN. Effective blood glucose control can help prevent or delay the onset of further complications associated with T2DM, emphasizing the importance of early diagnosis, promotion, and prevention strategies to mitigate the adverse effects of DPN.

The findings from this research provide evidence-based insights for nursing practices, showing that prolonged periods of uncontrolled diabetes and high HbA1c levels are likely to lead to DPN. Therefore, these results can serve as a foundation for scientific literacy, highlighting the essential role of nurses or healthcare providers in clinical settings. They play a vital role in providing education and health promotion programs to diabetes patients to enhance adherence to therapy and proper management, thus

helping prevent complications such as DPN in patients with T2DM.

## 5. Conclusion

This study revealed that a prolonged duration of diabetes (over five years) and abnormal HbA1c levels in patients with T2DM are significantly correlated with DPN. Chronic high blood sugar can lead to microangiopathy, a disease that can damage blood vessel walls and cause nerve damage, particularly to peripheral nerves. This is evidenced by abnormally high HbA1c levels. Given these findings, it is crucial to implement effective self-management strategies in diabetic patients to reduce the risk of severe complications associated with DPN. Health workers play a vital role in providing feasible and beneficial education programs for diabetic patients to support their treatment and early detection of complications related to diabetes.

### 5.1. Limitations of study

This study specifically focuses on identifying how the duration of diabetes and HbA1c levels are associated with DPN, suggesting that other determinants or factors could be explored in future research. A review of the literature indicates that several factors may influence the incidence of DPN, including blood glucose control, diet planning, physical activity, diabetes medications or insulin therapy, and foot care. Therefore, it is essential for nurses to monitor and assess the impact of these factors on the occurrence of DPN in patients with T2DM.

### Acknowledgment

The researchers would like to extend their deepest gratitude to all participants who willingly engaged and fully contributed to this study and its data collection.

### Compliance with ethical standards

### Ethical consideration

The ethical clearance was approved by the Research Ethics Committee of the Faculty of Nursing, Universitas Syiah Kuala (approval number: 112004150722).

### Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### References

Al-Rubeaan K, Al Derwish M, Ouizi S, Youssef AM, Subhani SN, Ibrahim HM, and Alamri BN (2015). Diabetic foot complications and their risk factors from a large retrospective

cohort study. PLOS ONE, 10(5): e0124446.  
<https://doi.org/10.1371/journal.pone.0124446>  
PMid:25946144 PMCID:PMC4422657

American Diabetes Association (2016). Standards of medical care in diabetes—2016 abridged for primary care providers. Clinical Diabetes, 34(1): 3-21.  
<https://doi.org/10.2337/diaclin.34.1.3>  
PMid:26807004 PMCID:PMC4714725

Amour AA, Chamba N, Kayandabila J, Lyaruu IA, Marieke D, Shao ER, and Howlett W (2019). Prevalence, patterns, and factors associated with peripheral neuropathies among diabetic patients at tertiary Hospital in the Kilimanjaro Region: Descriptive cross-sectional study from north-eastern Tanzania. International Journal of Endocrinology, 2019: 5404781.  
<https://doi.org/10.1155/2019/5404781>  
PMid:31275374 PMCID:PMC6582881

Faizi N and Kazmi S (2017). Universal health coverage-There is more to it than meets the eye. Journal of Family Medicine and Primary Care, 6(1): 169-170.  
[https://doi.org/10.4103/jfmpc.jfmpc\\_13\\_17](https://doi.org/10.4103/jfmpc.jfmpc_13_17)  
PMid:29026777 PMCID:PMC5629889

Galicia-Garcia U, Benito-Vicente A, Jebari S, Larrea-Sebal A, Siddiqi H, Uribe KB, Ostolaza H, and Martín C (2020). Pathophysiology of type 2 diabetes mellitus. International Journal of Molecular Sciences, 21(17): 6275.  
<https://doi.org/10.3390/ijms21176275>  
PMid:32872570 PMCID:PMC7503727

Hébert HL, Veluchamy A, Torrance N, and Smith BH (2017). Risk factors for neuropathic pain in diabetes mellitus. Pain, 158(4): 560-568.  
<https://doi.org/10.1097/j.pain.0000000000000785>  
PMid:27941499 PMCID:PMC5359789

IDF (2017). IDF diabetes atlas. 8<sup>th</sup> Edition, International Diabetes Federation, Brussels, Belgium.

KKRI (2020). Tetap produktif, cegah, dan atasi Diabetes Melitus 2020. Pusat Data dan Informasi Kementerian Kesehatan RI, Kementerian Kesehatan Republik Indonesia (Ministry of Health), Jakarta, Indonesia.

Malik RA, Andag-Silva A, Dejthevaporn C, Hakim M, Koh JS, Pinzon R, and Wong KS (2020). Diagnosing peripheral neuropathy in South-East Asia: A focus on diabetic neuropathy. Journal of Diabetes Investigation, 11(5): 1097-1103.  
<https://doi.org/10.1111/jdi.13269>  
PMid:32268012 PMCID:PMC7477502

Mørkrid K, Ali L, and Hussain A (2010). Risk factors and prevalence of diabetic peripheral neuropathy: A study of type 2 diabetic outpatients in Bangladesh. International Journal of Diabetes in Developing Countries, 30(1): 11-17.  
<https://doi.org/10.4103/0973-3930.60004>  
PMid:20431800 PMCID:PMC2859278

Mou L, Wang TB, Wang X, and Pu Z (2024). Advancing diabetes treatment: The role of mesenchymal stem cells in islet transplantation. Frontiers in Immunology, 15: 1389134.  
<https://doi.org/10.3389/fimmu.2024.1389134>  
PMid:38605972 PMCID:PMC11007079

Mythili A, Kumar KD, Subrahmanyam KAV, Venkateswarlu K, and Butchi RG (2010). A comparative study of examination scores and quantitative sensory testing in diagnosis of diabetic polyneuropathy. International Journal of Diabetes in Developing Countries, 30(1): 43-48.  
<https://doi.org/10.4103/0973-3930.60007>  
PMid:20431806 PMCID:PMC2859284

Nisansala MN, Wimalasekera SW, and Amarasekara TD (2022). Peripheral neuropathy and impaired sensation of feet among patients with type 2 diabetes mellitus: A descriptive cross-sectional study. International Journal of Community Medicine and Public Health, 9(7): 2749-2757.  
<https://doi.org/10.18203/2394-6040.ijcmph20221734>



- Nugroho BAW, Adnyana IMO, and Samatra DPGP (2016). Gula darah tidak terkontrol sebagai faktor risiko gangguan fungsi kognitif pada penderita diabetes melitus tipe 2 usia dewasa menengah. *Medicina*, 47(1): 22-29.  
<https://doi.org/10.15562/medicina.v47i1.71>
- Popescu S, Timar B, Baderca F, Simu M, Diaconu L, Velea I, and Timar R (2016). Age as an independent factor for the development of neuropathy in diabetic patients. *Clinical Interventions in Aging*, 11: 313-318.  
<https://doi.org/10.2147/CIA.S97295>  
**PMid:27042031 PMCID:PMC4801151**
- Qureshi MS, Iqbal M, Zahoor S, Ali J, and Javed MU (2017). Ambulatory screening of diabetic neuropathy and predictors of its severity in outpatient settings. *Journal of Endocrinological Investigation*, 40: 425-430.  
<https://doi.org/10.1007/s40618-016-0581-y>  
**PMid:27848229**
- Shiferaw WS, Akalu TY, Work Y, and Aynalem YA (2020). Prevalence of diabetic peripheral neuropathy in Africa: A systematic review and meta-analysis. *BMC Endocrine Disorders*, 20: 49.  
<https://doi.org/10.1186/s12902-020-0534-5>  
**PMid:32293400 PMCID:PMC7158034**
- Syamsiah, Tombong AB, and Amin AN (2021). Long-standing type-2 diabetes mellitus is related to neuropathy incidence: A cross sectional study. *Comprehensive Health Care*, 5(1): 32-43.  
<https://doi.org/10.37362/jch.v5i1.575>
- Tamer A, Yildiz S, Yildiz N, Kanat M, Gunduz H, Tahtaci M, and Celebi H (2006). The prevalence of neuropathy and relationship with risk factors in diabetic patients: A single-center experience. *Medical Principles and Practice*, 15(3): 190-194.  
<https://doi.org/10.1159/000092180> **PMid:16651834**
- Tofure IR, Huwae LB, and Astuty E (2021). Karakteristik pasien penderita neuropati perifer diabetik di poliklinik saraf RSUD Dr. M. Haulussy Ambon Tahun 2016-2019. *Molucca Medica*, 14(2): 97-108.  
<https://doi.org/10.30598/molmed.2021.v14.i2.97>
- Trisnawati SY (2014). Diabetes melitus tipe 2 dengan kadar Hba1c tinggi sebagai faktor risiko neuropati diabetik perifer di rumah sakit umum Pusat Sanglah Denpasar. M.Sc. Thesis, Universitas Udayana, Denpasar, Indonesia.
- Won JC, Kwon HS, Kim CH, Lee JH, Park TS, Ko KS, and Cha BY (2012). Prevalence and clinical characteristics of diabetic peripheral neuropathy in hospital patients with type 2 diabetes in Korea. *Diabetic Medicine*, 29(9): e290-e296.  
<https://doi.org/10.1111/j.1464-5491.2012.03697.x>