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Factors influencing the severity of diabetic foot ulcers: a cross-sectional study

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Abstract

Background Diabetic foot ulcers (DFUs) are prevalent among individuals with poorly controlled diabetes, and severe cases can result in increased morbidity and a poor quality of life. This study aimed to identify the factors that affect the severity of DFUs, offering insights into potential interventions that could enhance patient outcomes.

Methodology A prospective cross-sectional study was conducted from August 2023 to March 2024 at Muhimbili National Hospital in Tanzania, involving 177 consecutively selected patients with DFUs. The primary outcome variable was the severity of DFUs, which was assessed using the Meggitt-Wagner severity score. Both socio-demographic and clinical characteristics were evaluated to determine their association with the outcome variable using multivariate ordinal logistic regression analysis.

Results The median age of the study participants was 60 years (IQR = 52–68), with a male-to-female ratio of 2 to 1. Notably, Wagner grades 4 and 5 accounted for 57.6% of the participants. Factors associated with increased severity of DFUs included age over 60 years (aOR = 1.83, 95% CI 1.05–3.23, $p = 0.035$) and poor adherence to diabetes medications (aOR = 2.62, 95% CI 1.36–5.09, $p = 0.004$). Conversely, having health insurance coverage was linked to better outcomes (aOR = 0.51, 95% CI 0.27–0.96, $p = 0.036$).

Conclusion The study highlights factors that can enhance comprehensive care for diabetic patients, especially elderly individuals. Key measures include implementing educational programs to encourage medication adherence, improving healthcare access, particularly for uninsured individuals, promoting insurance coverage, and making diabetes treatments more affordable.

Keywords Diabetic foot ulcer (DFU), Diabetes mellitus, Foot gangrene, Meggitt-Wagner

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Background

A recent report from the International Diabetes Federation estimates that approximately 537 million people worldwide are living with diabetes mellitus (DM), with this number projected to exceed 600 million by 2030, and around 80% of these cases are expected to occur in developing countries [1]. Tanzania has seen a significant rise in DM cases as well, with prevalence increasing from 2.8% in 2008 to 11% in 2011, posing a substantial challenge to its health sector [2, 3]. Among the frequent surgical complications associated with DM is diabetic foot ulcer (DFU), a condition that requires particular attention in managing diabetic patients.

Globally, DFUs are more commonly seen in individuals with Type 2 diabetes mellitus compared to those with Type 1 diabetes mellitus [4]. The World Health Organization reports that people with DM are ten times more likely to require lower-limb amputations due to DFUs than those without DM [5]. Among DFU patients, the likelihood of developing an ulcer on the contralateral lower limb within two years of the first occurrence increases by 50%, with a high recurrence rate within five years [6]. Additionally, DFUs affect 10 – 15% of individuals with DM over their lifetime, significantly raising hospital admission rates [7].

Diabetic feet are especially susceptible to infections, ulcerations, gangrene, joint deformities, and bone damage due to a combination of ischemia, neuropathy, and immune compromise [8]. Peripheral arterial disease and neuropathy commonly occur alongside diabetic foot, significantly contributing to its development. DFUs most frequently appear on the plantar surface of the foot, as this area bears the greatest weight and pressure during standing or walking [8, 9].

DFUs are generally treated through a multidisciplinary approach involving wound care, infection control, glycemic management, weight offloading, and, in severe cases, surgical interventions such as disarticulations and amputations. Consistent monitoring and follow-up with healthcare providers are crucial for effective healing and reducing the risk of complications [8]. Early intervention to address peripheral arterial insufficiency, along with strict glycemic control, is essential for preventing DFUs [10].

Numerous studies have examined factors associated with the occurrence of DFUs; however, few have concentrated on factors influencing their severity. Consequently, limited information is available regarding the determinants of DFU severity, particularly within our local context. This study, therefore, aims to identify the factors iinfluencing DFU severity. By recognizing these factors, we can enhance the understanding of DFU progression, potentially improve treatment strategies, and develop targeted interventions to manage and mitigate severe cases more effectively.

Methods

Study area and design

This cross-sectional study was conducted at Muhimbili National Hospital, a tertiary referral center in Dar es Salaam, Tanzania. The study took place across both the surgical and medical departments, encompassing inpatient and outpatient sections. Ethical clearance was obtained from Muhimbili University of Health and Allied Sciences, the university affiliated with the hospital.

Study population and sampling

The study included all patients aged 18 years or older who were diagnosed with DFUs and were receiving treatment at Muhimbili National Hospital between August 2023 and March 2024. A prospective consecutive sampling technique was applied, and the minimum sample size of 177 participants was determined using Cochran's formula (1963) [11].

Variables and data collection

The dependent variable in this study was the Meggitt-Wagner severity score for DFUs, which grades severity from 0 to 5: Grade 0 represents no open lesions or pre-ulcerative lesions; Grade 1 includes superficial ulcers affecting the skin and subcutaneous tissue; Grade 2 involves deep ulcers impacting ligaments, muscles, tendons, or joint capsules; Grade 3 is characterized by ulcers involving bones, with a deep abscess, osteomyelitis, or joint sepsis; Grade 4 includes gangrene or necrosis of part of the foot; and Grade 5 indicates gangrene extending throughout the entire foot [12].

Independent variables comprised socio-demographic factors such as age, gender, marital status, place of residence, education level, medical insurance status, alcohol use, and smoking. Clinical factors included DM duration, type of DM treatment, medication adherence, presence of hypertension, random blood glucose (RBG) levels on presentation, glycated hemoglobin levels (HbA1c), Body Mass Index (BMI), a history of prior DFU, and a history of DM associated lower limb amputation/disarticulation.

Data for this study were collected prospectively by a trained physician who used a standardized checklist to ensure accuracy and consistency. Relevant information was carefully extracted from each patient and their medical records, covering socio-demographic and clinical characteristics. To enhance the reliability of the Wagner grading for DFU severity, the physician performed repeated physical examinations in conjunction with reviewing the radiological reports, clarifying any uncertainties and confirming the assigned grade. This

approach helped ensure the accurate assessment of DFU severity for each participant.

Data processing and analysis

Data were collected and directly entered into Microsoft Excel for cleaning. The data were then imported into IBM SPSS software version 25 for analysis. Descriptive statistics were applied to summarize the independent and dependent variables, with results presented in frequency tables and percentages. The median and interquartile range were used since continuous data were not normally distributed.

For inferential analysis, univariate and multivariate ordinal logistic regression analyses were performed to examine the association between various factors and the severity of DFUs. Factors with a significance level of ≤ 0.2 (p-value) in the univariate analysis were included in the multivariable analysis to adjust for potential confounders, calculating adjusted odds ratios (OR). A p-value of ≤ 0.05 was considered statistically significant.

Table 1 Socio-demographic characteristics of the diabetic foot ulcer patients *N* = 177

Variable	Frequency (*n*)	Percent (%)
Age group (years)		
18–60	84	47.5
≥ 60	93	52.5
Median age in years (IQR)	60 (52, 68)	
Sex		
Male	117	66.1
Female	60	33.9
Marital status		
Married	134	75.7
Cohabiting	1	0.6
Single	13	7.3
Divorced	6	3.4
Widowed	23	13.0
Residence		
Dar es Salaam	123	69.5
Non-Dar es Salaam	54	30.5
Level of education		
No formal education	11	6.2
Primary education	79	44.6
Secondary education	41	23.2
College or University	46	26.0
Insurance coverage		
Yes	72	40.9
No	104	59.1
History of cigarette smoking		
Never	125	70.6
Past	52	29.4
Current	0	0.0
History of alcohol use		
Never	73	41.2
Past	96	54.2
Current	8	4.5

IQR – Interquartile range

Results

Socio-demographic characteristics

Table 1 summarizes the sociodemographic profile of the 177 study participants, with a median age of 60 years (IQR = 52–68), and over half (52.5%) were older than 60. The male-to-female ratio was 2:1, and most participants (76.3%) reported being in a formal or informal union. Fifty-nine percent lacked medical insurance, reflecting a significant gap in healthcare access. Education levels were generally high, with 96% having at least basic formal education. In terms of lifestyle, a majority had never smoked (70.6%), and 41.2% had no history of alcohol use.

Clinical characteristics

Table 2 summarizes data indicating that 48.0% of the patients had been diagnosed with DM for more than 10 years. A significant majority (69.0%) were on oral glycemic agents, while 29.4% relied on injectable insulin. However, a concerning 70.6% of the patients exhibited inconsistent adherence to their prescribed glycemic medications, whether insulin or oral treatments. Furthermore, 55.4% of the individuals had concurrent hypertension. Additionally, 36.4% of the patients had a history of DFU, with 67.7% of those experiencing recurrence in the same limb. Notably, upon presentation, 70.1% of the patients had high RBG levels, and 88.6% had elevated glycated hemoglobin (HbA1c ≥ 6.5%). According to their body mass index (BMI), 45.2% of the patients were classified as overweight, while 17.5% were categorized as obese.

Proportion of severity grading among DFU patients using the Wagner severity scale

Figure 1 illustrates the distribution of Wagner severity grades among participants, highlighting a varied range of severity levels. Grade 4 was the most prevalent, accounting for 30.5% of cases, followed closely by Grade 5 at 27.1%. Grades 2 and 3 exhibited similar proportions, each representing 13% of the participants. In contrast, Grade 1 and Grade 0 had lower proportions, at 12.4% and 4.0%, respectively.

Factors influencing DFU's severity

Table 3 summarizes the factors influencing the severity of DFUs. After controlling for confounders, significant influences included age, medical insurance status, and treatment adherence. Participants over 60 years old were 1.83 times more likely to present with a more severe form of DFU compared to those aged 18–60 years (aOR = 1.83, 95% CI 1.05–3.23, $P = 0.035$). Similarly, participants with poor medication adherence were 2.62 times more likely

Table 2 Clinical characteristics of the patients with diabetic foot ulcer $N = 177$

Variable	Frequency (*n*)	Percent (%)
Time since diagnosis of diabetes mellitus		
< 5 years	55	31.1
5–10 years	37	20.9
> 10 years	85	48.0
Type of treatment		
Injectable insulin	52	29.3
Oral glycemic drugs	122	69.0
None	3	1.7
Frequency of taking DM medications		
Regularly	52	29.4
Irregularly	122	70.6
Concurrently hypertensive		
Yes	98	55.4
No	79	44.6
History of diabetic foot ulcer		
Yes	64	36.4
No	113	63.6
Previously affected limb (*n* = 64)		
Ipsilateral	44	67.7
Contralateral	20	32.3
Previous ulcer resulted in amputation* (*n* = 64)		
Yes	53	82.8
No	11	17.2
Random blood glucose on presentation		
< 11.1	53	29.9
≥ 11.1	124	70.1
HbA1c levels (%)		
< 6.5	20	11.4
≥ 6.5	156	88.6
BMI category (in kg/m^2)		
Underweight (< 18.5)	2	1.1
Healthy weight (18.5–24.9)	64	36.2
Overweight (25.0–29.9)	80	45.2
Obese (≥ 30.0)	31	17.5

*Amputation includes Toe disarticulation and Mid-foot disarticulations

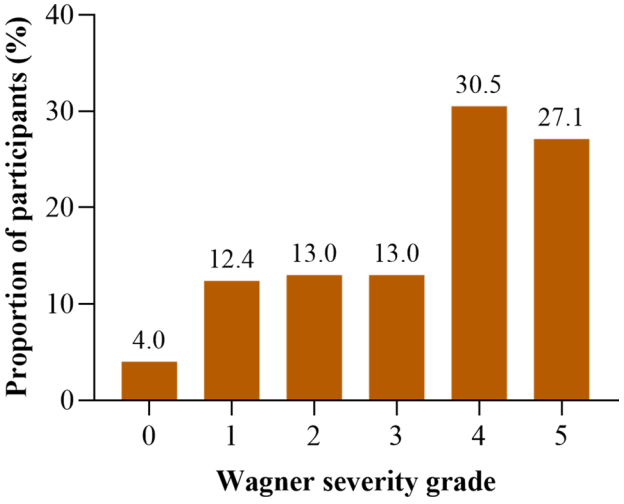

Fig. 1 Proportion of severity grading among DFU patients using the Wagner severity scale ($n = 177$)

to have severe DFUs than those who regularly took their glycemic medications (aOR = 2.62, 95% CI 1.36–5.09, $P = 0.004$). Conversely, patients with medical insurance had a reduced risk of experiencing severe forms of DFU (aOR = 0.51, 95% CI 0.27–0.96, $P = 0.036$).

Discussions

This study aimed to investigate the various sociodemographic and clinical factors that may affect the severity of DFUs in patients undergoing treatment. Most participants in our study had DFUs classified as above Wagner grade 3, which is consistent with the findings reported by Mir et al. in India [13]. In contrast, earlier studies by Mutonga et al. and Ghobadi et al. indicated that the majority of DFU patients were classified below Wagner grade 2 [12, 14]. The increased severity of ulcers in our setting and other lower-middle-income countries can be attributed to several factors, including poor health-seeking behaviors, the financial implications of treatment, and limited access to healthcare facilities.

Among the participants in our study, the majority (52.5%) were over the median age of 60 years. This finding aligns with other studies conducted in Indonesia and Uganda [9, 15]. Similarly, an Iranian study reported a mean age of participants at 53.13 ± 11.65 years [12]. Age ≥ 60 was associated with severe DFUs, consistent with findings from the Ugandan and Iranian studies [9, 12]. However, Syauta et al. reported no association between age and the severity of DFUs, contrasting with our results [15]. A plausible explanation for our findings is that older individuals are more susceptible to developing angiopathy compared to their younger counterparts, and this risk significantly increases among DFU patients [16]. According to Jeffcoate et al., DM impedes wound healing in DFU patients, exacerbating the effects of angiopathy [17].

The findings of our study reveal a significant link between health insurance coverage and the severity of DFUs. Alarmingly, only 40.9% of participants reported having medical insurance, highlighting a critical gap in access to care. While research on the impact of medical insurance on DFU severity is scarce, we suggest that having insurance may serve as an indicator of better financial stability, thereby influencing health-seeking behaviors and facilitating access to essential, often costly medications. In Tanzania, only 32% of the population had health insurance coverage in 2016, with the majority concentrated in urban areas [18]. Supporting this notion, a study from Taiwan demonstrated an alarming trend: as the incidence of diabetic foot ulcers rose over time, so too did the associated medical costs, underscoring the urgent

Table 3 Univariate and multivariate ordinal logistic regression analysis of the factors associated with the severity of the diabetic foot ulcer

Variable	Category	Univariate analysis			Multivariate analysis		
		cOR	95% CI	*p*-value	aOR	95% CI	*p*-value
Age (years)	> 60	1.97	1.16–3.38	**0.013**	1.83	1.05–3.23	**0.035**
	18–60	Ref					
Marital status	Union	1.92	1.02–3.62	**0.043**	1.90	0.98–3.71	0.059
	No-union	Ref					
Education	No formal	2.99	0.94–9.93	0.065	1.40	0.41–4.93	0.592
	Primary	1.92	1.00–3.71	0.050	0.95	0.43–2.10	0.893
	Secondary	1.78	0.84–3.81	0.134	1.09	0.46–2.56	0.846
	University	Ref					
Medical insurance	Yes	0.52	0.30–0.89	**0.018**	0.51	0.27–0.96	**0.036**
	No	Ref					
Cigarette smoking	Past smoker	1.53	0.86–2.75	0.149	1.39	0.76–2.56	0.294
	Never smoked	Ref					
Duration since diagnosis of DM (years)	< 5	0.92	0.50–1.71	0.802	1.09	0.57–2.10	1.791
	5–10	0.49	0.25–0.97	**0.042**	0.60	0.30–1.21	0.152
	> 10	Ref					
Treatment adherence	Irregularly	2.59	1.43–4.73	**0.002**	2.62	1.36–5.09	**0.004**
	Regularly	Ref					
HbA1c (%)	≥ 6.5	2.68	1.07–6.74	0.035	2.21	0.87–5.67	0.095
	< 6.5	Ref					

Key: cOR: crude Odds Ratio, aOR: adjusted Odds Ratio, Ref: Reference group, CI: Confidence Interval

need for improved access to healthcare for those at risk [19].

In our study, approximately 98% of participants were on some form of glycemic medication, whether oral glycemic agents or injectable insulin. Alarmingly, 70.6% of those taking glycemic medications reported poor adherence to their prescribed regimens. Our findings indicate that inadequate medication adherence is independently linked to severe forms of DFUs. Similar trends have been observed in studies conducted in India and Taiwan, where poor adherence not only exacerbated DFU severity but also led to increased medical and financial burdens, poor quality of life, and high mortality rates among affected individuals [20, 21]. Furthermore, 88.6% of DFU patients had an HbA1c level exceeding 6.5%. While our study did not find a direct association between poor glycemic control and DFU severity, it is noteworthy that a systematic review by Jalilian et al. [22] did report such an association.

This study design has several inherent limitations that warrant consideration. Conducting the research in a specialized center that primarily receives referrals may introduce selection bias, as patients referred to such facilities often represent more severe DFUs, which may not reflect the broader population of DFU patients. Consequently, the findings may lack generalizability to other healthcare settings. Additionally, the cross-sectional nature of the study limits the ability to establish causal relationships between the identified factors and DFU severity; while associations can be observed, the study cannot determine whether certain variables directly contribute to increased severity. Moreover, reliance on self-reported data regarding medication adherence may introduce recall bias. To mitigate these limitations, future research should adopt a multi-center approach to enhance sample representativeness and consider longitudinal designs that allow for monitoring DFU progression over time and evaluating the effectiveness of interventions on patient outcomes.

Conclusion and recommendations

The study revealed a significantly high prevalence of severe diabetic foot ulcers (Wagner grades 4 and 5) among participants. Additionally, advanced age and poor adherence to diabetes medications were correlated with greater severity of the condition. Conversely, health insurance coverage was associated with more favorable outcomes.

To address this issue, educational initiatives should promote consistent medication adherence, emphasizing its link to ulcer severity, while increasing access to healthcare services, especially for uninsured individuals. Additionally, strengthening healthcare systems by promoting insurance coverage and the affordability of diabetes treatments, will ensure comprehensive care. Establishing community health programs focusing on diabetes education and prevention can further reduce the incidence of severe DFUs.

Abbreviations

BMI Body Mass Index
DFUs Diabetic foot ulcers

DM	Diabetes Mellitus
HbA1C	Glycated hemoglobin levels
RBG	Random blood glucose

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12902-024-01785-0.

Supplementary Material 1

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Author contributions
The primary researcher, R.B, wrote the full-text paper and produced the manuscript. He has access to all of the study's data. D.K, L.S. and A.M. contributed to the study's conception and design as well as its statistical analysis and interpretation. M.U, G.M. and D.A. played administrative roles and offered material and technical support.

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Data availability
Data is provided within the manuscript.

Declarations

Ethical approval
The Muhimbili University of Health and Allied Sciences Institutional Review Board approved the study protocol (REF. No. DA.282/298/01.C/1766). The Muhimbili National Hospital Research and Consultancy approved the study protocol for data collection (REF. No. MNH/CRTCU/Perm/2023/459). Before taking part in the study, written informed consent was sought for all participants. The study was performed per the ethical standards laid by the 1964 Helsinki Declaration and its later amendments on comparable ethical standards.

Consent for publication
Not applicable.

Data collecting tool
We collected data for this study using an assisted-administered structured questionnaire through Google Forms.

Competing interests
The authors declare no competing interests.

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