Risk Management and Healthcare Policy

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ORIGINAL RESEARCH

Predictors of Foot Ulcers Among Diabetic Patients at a Tertiary Care Center, Egypt

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Background and Purpose: Diabetic foot ulcers (DFUs) markedly contribute to morbidity and mortality of diabetic patients. Hence, this study was conducted to investigate the predictors of foot ulcers among Egyptian diabetic patients.

Methods: A case-control study was conducted among 488 diabetic patients attending the inpatient departments and outpatient clinics at the National Diabetes Institute in Egypt. A pretested data collection sheet was designed to collect and record the following: socio-demographic data, diabetic history and lifestyle characteristics, recorded comorbidities, and the results of foot examination.

Results: Significant positive predictors of DFUs on multivariate logistic regression analysis included presence of three or more comorbidities; two or more diabetic complications; callus; and flatfoot. Significant protective (negative) predictors were management of diabetes by diet, oral hypoglycemic drugs (OHGs), and insulin; and intact vibration sense.

Conclusion: Significant positive predictors of DFUs on multivariate analysis were presence of three or more comorbidities, two or more diabetic complications, callus and flatfoot, while protective predictors were management of diabetes by diet, OHGs, and insulin; and intact vibration sense. Hence, close monitoring should be provided to diabetic patients with comorbidities and complications to reduce the risk of DFUs.

Keywords: diabetic foot ulcers, comorbidities, peripheral vascular disease, foot deformities

Introduction

Diabetes mellitus (DM) is a major public health problem worldwide and is considered one of the main global health emergencies of the 21st century.[1] The prevalence of DM is increasing in both developed and developing countries, recent estimates indicate that there were 463 million adults living with diabetes in 2019 which is projected to increase to 642 million in 2040.[2,3] In the Middle East and North Africa (MENA) region, the number of patients with diabetes is expected to increase from 34.6 million in 2013 to 67.9 million by 2035.[2] The International Diabetes Federation (IDF) classified Egypt among the top 10 countries in the world with the highest prevalence of diabetes, where about 9 million adults between 20 and 79 years of age were living with DM in 2019. The number of patients with DM in Egypt has increased rapidly from about 4.5 million in 2007 to 7.5 million in 2013, and is expected to increase to 13.1 million by 2035.[4]

There are multiple complications affecting diabetic patients, however, none are more debilitating than those involving the foot.[5] Diabetic foot ulcers (DFUs) markedly contribute to morbidity of diabetic patients; they prolong hospital stays and account for nearly 20% of all diabetes-related hospitalizations.[6] The lifetime risk of developing

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Received: 16 June 2021
Accepted: 22 August 2021
Published: 15 September 2021

foot ulcers among diabetic patients ranges from 19% up to 34%, and about 85% of all diabetic lower limb amputations (DLLA) are preceded by DFUs.[7,8] Mortality rate following DLLA because of foot ulcers ranges from 24.6% within 5 years to 45.4% within 10 years.[9] Beside morbidity and mortality, DFUs impose a huge socio-economic burden on the patients and their families.[10] Moreover, they have a significant effect on the patients' quality of life, being a major cause of depression and physical disability.[7]

The pooled global prevalence of DFUs was estimated to be 6.3% according to a systematic review involving more than 800,000 participants diagnosed with DM worldwide.[11] Moreover, results of the systematic review revealed a higher prevalence of DFUs in Africa (7.2%) than in Asia (5.5%) and Europe (3%).[11] According to studies conducted in Egypt, the prevalence of DFUs among diabetic patients ranges from 6.1% to 29.3%.[12,13]

As per the International Working Group on the Diabetic Foot (IWGDF) guidelines,[14] DFUs have a complicated etiology, to which several factors contribute including socio-demographic factors like age, gender, residence, and educational status;[15–17] clinical factors as duration and type of DM, poor glycemic control, increased body mass index (BMI), and foot deformities.[17,18] Comorbidities including peripheral vascular disease (PVD), retinopathy, nephropathy, and neuropathy are also associated with an increased risk of developing DFUs.[11,19] In addition, DFUs are also affected by life style factors such as smoking, alcohol intake, exercise, and habits of foot self-care practice.[17]

However, predictors of DFUs vary across different socioeconomic, cultural, and demographic factors. Therefore, investigating these factors worldwide is crucial to provide health care workers and policy makers with the needed information to prevent the devastating impact of DFUs.[19] In Egypt, few studies have assessed the factors associated with DFUs;[12,13] hence, this study was conducted to investigate the predictors of DFUs among Egyptian diabetic patients attending the National Diabetes Institute, Cairo, Egypt. The current study provides more in-depth estimate of the research problem in Egypt being conducted in a tertiary care facility like the "National Diabetes Institute" which serves as the most crucial endpoint for all referred diabetic cases from all over Egypt. Additionally, more study variables were investigated in the current work.

Methods

Study Design, Setting, and Participants

This case-control study was conducted over 8-months, from the beginning of October 2019 to the end of May 2020, to explore the predictors of foot ulcers among diabetic patients attending the inpatient departments and outpatient clinics of the National Diabetes Institute in Cairo, Egypt. This institute is a tertiary care facility serving at least 20,000 diabetic patients per month for follow up, with inpatients department of 120 beds to manage diabetes complications including surgery.

Inclusion criteria for the study population included patients diagnosed with type II diabetes according to the international standards [fasting blood glucose ≥ 7.0 mmol/l (126 mg/dl) or 2 hour postprandial plasma glucose ≥ 11.1mmol/l (200mg/dl)][20] and following a diabetic diet or anti-diabetic drug for at least one year, patients ≥ 18 years, and those who agreed to participate following personal approach. For the DFU cases, those with recently (incident) diagnosed DFU (one week to three months) were included, they were selected from both inpatient departments and outpatient clinics. A foot ulcer was diagnosed according to the International Consensus on Diabetic foot as full-thickness wound below the ankle in a diabetic patient, regardless of its duration.[21] Age and sex matched control group was recruited from the outpatient clinics and clinically confirmed free from any foot ulcer. Patients who were critically ill, mentally impaired or pregnant were excluded from the study.

Sample Size

The sample size was calculated by using the OpenEpi open source[22] considering two sided confidence interval of 95% and power of 80%, with proportion of cases exposed to DFU of at least 27% and controls of 15%, and the least Odds ratio of 2.0[22–24] with a ratio of control to cases of 2, the sample size required for cases was 146 and 302 for controls. An additional 10% increment was added to compensate for non-response, the final sample size was 160 cases and 332 controls. Selection of cases: all confirmed cases who developed and /or admitted having DFU were approached personally with the defined inclusion criteria. For the controls, a systematic sampling technique was employed for their selection from attendees of the outpatient clinics for follow up, where every 7th patient was selected till reaching the required sample

size. Controls were selected to match cases using frequency method in relation to sex and ±5 years range.

Study Tools and Data Collection Technique

1. Personal interview: Based on the available literature[15–17] a pretested data collection form composed of close-ended and multiple options questions was designed to collect and record the data as follows;
   - Socio-demographic characteristics including: Age, gender, residence, occupation, monthly income, and educational status.
   - Diabetic history including: Family history of diabetes, family history of DFUs, diabetes management and its duration, and diabetes diagnosis (incidental/screening/symptomatic).
   - The lifestyle characteristics: Smoking, alcohol intake, type of foot wear (slippers/sandals/covered shoe), history of exercising, duration, frequency and type of exercise.
2. Examination of patients records: Using a defined data compilation form to assess comorbidities among diabetic patients in relation to the diagnosis of DFUs (cardiac, visual, renal, dyslipidemia, hypertension); the number of comorbid conditions; diabetic complications including PVD, neuropathy, nephropathy, retinopathy, and cardiovascular complications; and the number of diabetic complications.
3. The results of foot examination of the study subjects by a consultant diabetologist and endocrinologist, including presence of healthy skin; foot deformities (callus, hammer / bunion / flatfoot / and claw toe); vibration sense (intact/impaired) over three sites; and also, position sense (intact/impaired).

Pilot Testing

The preliminary questionnaire used in the personal interview as well as the data compilation form were tested on 28 patients at the outpatient clinics to assess the comprehension, clarity and time required to complete the questionnaire. Accordingly, some questions were modified to be more concise and others were omitted to avoid repetition to end up with the final questionnaire form.

Ethical Considerations

The study participants received proper orientation about the objectives and expected outcomes of the current study, with emphasis on their right not to participate, and assuring the confidentiality of data. Individual report for each case and control was added to the patient's health record for reference. A written informed consent was obtained from the study subjects. Additionally, the contact number and e-mail address of the principal investigator were provided in case of any inquiries. The study procedures were carried out after approval of the Research Ethics Committee of the "National Institute of Diabetes and Endocrinology" (no. 201901012.05) and according to the ethical requirements of the Declaration of Helsinki.

Statistical Analysis

Out of 172 cases approached, 159 were included in the final data analysis (13 cases with incomplete health records), while of the 341 invited controls, 329 agreed to participate. Pre-coded data were entered and analyzed using the Statistical Package for Social Sciences (SPSS) software, version 21. Qualitative variables were displayed as numbers and percentages. Quantitative variables were presented as mean ± standard deviations (SD), and interquartile range (IQR). Univariate analysis was carried out by using Pearson's chi-square test to calculate the crude association between DFUs with the study independent variables. Mann–Whitney test was used for comparing non-parametric quantitative variables, while the Fisher-exact test was used for qualitative variables. Significant independent variables (predictors) at the univariate analysis were included in the final multivariate logistic regression model to outline the significant predictors of DFUs (dependent variable) among diabetic patients. The results of logistic regression analysis were presented as Odds Ratio (OR) and 95% Confidence Interval (CI). P values of ≤ 0.05 were considered statistically significant. Data will be available upon requesting from the investigators.

Results

Background Characteristics of the Studied Group in Relation to DFUs

A total of 488 diabetic patients were recruited for the current study. No significant age difference was found between cases (mean=54.7 + 8.6 years, IQR=50–60 years) and controls (mean=53.3± 9.8, IQR=48–60.5 years). Presence of DFUs was not significantly associated with gender, residence, occupation, and monthly income. A significantly higher percent of cases was illiterate compared to controls (OR=1.53, 95% CI=1.05–2.24, P<0.05).

Table 1 Socio-Demographics and Diabetic History of the Included Patients in Relation to the Diagnosis of Diabetic Foot Ulcer

Variables	Diabetics: No. (%)		Univariate Analysis Odds Ratio (95% C.I.)
	Foot Ulcer (n=159)	None (n=329)	
Age (years):			
Mean ±SD Median (IQR)	54.7±8.6 55(50–60)	53.3±9.8 53.0(48–60.5)	0.124†
Gender:			
Males Females	83(52.2) 76(47.8)	163(49.5) 166(50.5)	1.11(0.76–1.62) Ref.
Residence			
Urban Rural	141(88.7) 18(11.3)	283(86.0) 46(14.0)	1.27(0.71–2.23) Ref.
Occupational status:			
Governmental employees Self-employed Retired/non-working Housewives	11(6.9) 59(37.1) 27(17.0) 62(39.0)	21(6.4) 102(31.0) 58(17.6) 148(45.0)	1.10(0.51–2.32) 1.31(0.88–1.95) 0.96(0.58–1.59) Ref.
Monthly income (Egyptian pounds):			
<1000 1000–3000 >3000	111(69.8) 28(17.6) 20(12.5)	228(69.3) 72(21.9) 29(8.8)	1.02(0.68–1.55) 0.76(0.47–1.24) Ref.
Educational status:			
Illiterate/ read and write Primary/preparatory Secondary-technical diploma College or higher	81(50.9) 50(31.4) 21(13.2) 7(4.4)	133(40.4) 108(32.8) 69(20.9) 19(5.8)	1.53(1.05–2.24)* 0.94(0.62–1.41) 0.57(0.33–0.97)* Ref.
Marital status:			
Married Single Divorced/widowed	140(88.1) 11(6.9) 8(5.0)	290(88.1) 22(6.7) 17(5.2)	1.01(0.55–1.78) 1.04(0.50–2.20) Ref.
Family History of diabetes:	116(66.7)	229(69.6)	1.04(0.50–2.19)
Family history of diabetic foot ulcer	47(29.6)	65(19.8)	1.18(0.77–1.79)
Diabetes mellitus diagnosis:			
Incidental Screening Symptomatic	25(15.8) 8(5.0) 126(79.2)	40(12.2) 36(10.9) 253(76.9)	1.10(0.51–2.32) 1.35(0.79–2.31) Ref.
Diabetes management:			
Diet+ OHGs Diet+ OHGs +Insulin Diet + insulin	21(13.2) 15(9.4) 123(77.4)	125(38.0) 46(14.0) 158(48.0)	1.15(0.72–1.82) 0.25(0.15–0.41)** Ref.

(*Continued*)

Table 1 (Continued).

Variables	Diabetics: No. (%)		Univariate Analysis Odds Ratio (95% C.I.)
	Foot Ulcer (n=159)	None (n=329)	
Duration of diabetes treatment (years):			
Mean ±SD Median (IQR)	14.8±8.4 15.0(10–20)	10.2±8.1 10.0(6–15)	0.001†

Notes: *P<0.05; **P<0.001; †Mann Whitney test.
Abbreviations: IQR, interquartile range; OHG, oral hypoglycemic drugs; CI, confidence intervals.

Management of diabetes by diet, oral hypoglycemic drugs (OHGS), and insulin was less significantly associated with DFUs (9.4% vs. 14%, P <0.001) (Table 1).

Lifestyle Characteristics of the Studied Group in Relation to DFUs

A significantly higher percentage of cases were current smokers compared to controls, with no significant differences in type (cigarettes, shisha, both) and duration of smoking. As regards type of footwear, wearing covered shoes was less significantly associated with DFUs. Presence of DFUs was not significantly associated with history, duration and frequency of exercising. However, walking was significantly more frequent among cases (90.3% vs. 65.3%, P<0.05), while running was more frequent among controls (Table 2).

History of Recorded Comorbid Conditions Among Diabetic Patients in Relation to DFUs

Although none of the associated recorded comorbidities was significantly associated with DFUs, their number whether two (P<0.05) or three or more (P<0.001) was significantly associated with increased risk of DFUs. A significantly higher percent of cases suffered from PVD, peripheral neuropathy, and cardiovascular complications. Presence of two diabetic complications and three or more diabetic complications was significantly more common among cases (Table 3).

Results of Foot Examination of the Included Diabetic Patients in Relation to DFUs

A significantly higher percentage of cases (P<0.001) suffered from unhealthy skin, and dry/cracked skin. Foot deformities were more significantly present among cases as follows: callus (46.5% vs. 14.6%, P<0.001), bunion (20.1% vs. 10%, P<0.05), and flatfoot (32.7% vs. 15.2%, P<0.001). Impaired vibration and position senses were significantly (P<0.001) associated with DFUs (Table 4).

Predictors of DFUs Among the Included Diabetic Patients

The multivariate logistic regression model identified the possible predictors for DFUs as follows (Table 5): presence of three or more comorbidities (OR=1.76, 95% CI=1.13–2.51; P=0.021), two or more diabetic complications (OR=6.053, 95% CI=1.742–21.031; P=0.005), callus deformity (OR=5.200, 95% CI=2.318–11.666; P<0.001), and flatfoot (OR3.315, 95% CI=1.509–7.279; P=0.003). The significant protective predictors for DFUs in the current study included: management of diabetes by diet, OHGs, and insulin (OR=0.528, 95% CI=0.342–0.814; P=0.004); and intact vibration sense (OR=0.294, 95% CI=0.132–0.654; P=0.003).

Discussion

Screening to detect risk factors of DFUs is crucial, since most of them are modifiable.[15,25] Hence, this study was conducted to explore predictors of foot ulcers among Egyptian diabetic patients. Previous studies reported that socio-demographic factors like older age,[16,26] male gender,[15] and rural residency[17] were associated with a higher risk of DFUs. A possible justification is that older age affects wound healing in diabetic patients,[27] and that women adhere more to life style changes and health-seeking behavior associated with diabetes.[28] A higher risk of DFUs in rural areas was attributed to illiteracy and poor knowledge about diabetic foot-related complications, and to walking barefooted.[6] In the current study, none of the aforementioned factors was significantly associated with development of DFUs. Similarly, Al Kafrawy et al[29] and Atosona and Larbie[30] found that age

Table 2 Lifestyle Characteristics of the Included Patients in Relation to the Diagnosis of Diabetic Foot Ulcer

Variables	Diabetics: No. (%)		Univariate Analysis Odds Ratio (95% C.I.)
	Foot Ulcer (n=159)	None (n=329)	
Smoking			
Never	90(56.6)	203(61.7)	0.81(0.55–1.90)
Current smokers	58(36.5)	93(28.3)	1.46(1.01–2.18)*
Ex-smokers	11(6.9)	33(10.0)	Ref.
Types of smoking (current smokers)			
Cigarettes	29/58(50.0)	64/93(68.8)	0.93(0.65–0.150)
Shisha	14/58(24.1)	19/93(20.4)	1.57(0.76–3.22)
Both	15/58(25.9)	10/93(10.8)	Ref.
Duration: current smokers (years): Mean ±SD	24.7±11.7	20.7±13.5	0.001†
Duration: ex-smokers (years): Mean± SD	20.1±13.5	15.3±10.0	0.001†
History of alcohol intake:			
Yes	11(6.9)	20(6.1)	1.15(0.54–2.46)
No	148(93.1)	309(93.9)	Ref.
Duration: alcohol intake (years): Mean ±SD	8.3±10.5	7.9±11.7	0.704†
Type of footwear:			
Slippers	91(54.1)	172(51.9)	1.22(0.83–1.79)
Sandals	15(10.0)	17(5.2)	1.91(0.93–3.95)
Covered shoe	35(22.0)	113(34.3)	0.54(0.34–0.83)**
Sandals /covered shoe	15(9.4)	21(6.4)	1.53(0.76–3.05)
Slippers/sandals	7(4.4)	7(2.1)	Ref.
History of exercising:			
Yes	62(39.0)	124(37.7)	1.32(0.90–1.95)
No	97(62.0)	205(62.3)	Ref.
No. of Exercise/week:			
≤ 3 times	36/62 (58.0)	51/124 (41.1)	1.98(1.06–3.67)*
4 to 6 times	22/62(35.5)	57/124(46.0)	0.64(0.83–1.21)
Daily	4/62(6.5)	16/124 (12.9)	Ref.
Minutes of exercising (minutes/time):			
≤ 30 minutes	38/62 (61.3)	75/124(60.5)	1.58(0.83–3.02)
>30 minutes	24/62(38.7)	49/124(39.5)	Ref.
Types of exercise:			
Walking	56/62(90.4)	77/124(62.1)	5.69(2.27–14.25)*
Running	3/62(4.8)	27/124(21.8)	0.81(0.05–0.62)*‡
Football	2/62(3.2)	12/124(9.6)	Ref.
Walking + running	1/62(1.6)	8/124(6.5)	

Notes: *P<0.05; **P<0.001; †Mann Whitney test; ‡Fisher exact.

and gender, respectively, are not correlated with DFUs. Variation between studies could be due to different study population and methodology used. Illiteracy was significantly associated with a higher risk of DFUs in the present study, possibly because poor education levels limit the access to information about diabetes and its complications. Similar findings were reported by Cardoso et al.[31] In the current study, there was no significant association between the duration of diabetes and DFUs. In contrast, other studies stated that diabetes duration is a risk factor for developing complications especially neuropathy.[32,33] In this study, treatment modality in the form of diet, OHGs,

Table 3 History of Recorded Comorbid Conditions Among Diabetic Patients in Relation to the Diagnosis of Diabetic Foot Ulcer

Variables	Diabetics: No. (%)		Univariate Analysis Odds Ratio (95% C.I.)
	Foot Ulcer (n=159)	None (n=329)	
Cardiac (ischemic, failure, previous infarction):	32(20.1)	65(19.8)	1.02(0.69–1.64)
Duration (years): mean ±SD	5.6±5.5	5.2±9.0	0.0001
Visual (cataract, corneal opacity, etc.):	60(37.7)	120(36.5)	1.06(0.71–1.56)
Duration (years): mean ±SD	5.1±5.2	4.7±5.5	0.435
Renal (stones, nephritis, urinary infections):	16(10.1)	39(11.8)	0.83(0.45–1.54)
Duration (years): mean ±SD	5.9±5.2	4.4±3.0	0.008
Dyslipidemia (received treatment):	41(25.8)	97(29.5)	0.83(0.54–1.27)
Duration (years): mean ±SD	3.3±2.1	5.7±4.9	0.001
Hypertension (diagnosed/receiving treatment):	70(44.0)	161(48.9)	0.84(0.57–1.23)
Duration (years): mean ±SD	11.3±8.1	8.1±6.3	0.001
Comorbid others!:	11(6.9)	16(4.9)	1.45(0.66–3.21)
Number of morbid conditions:			
Two co-morbidities	38(23.9)	53(16.1)	1.64(1.02–2.61)*
Three or more co-morbidities	121(76.1)	201(61.1)	1.88(1.22–2.89)**
Diabetes complications:			
Peripheral vascular disease	13(8.1)	4(1.2)	7.20(2.40–26.02)*
Retinal problems	6(3.8)	7(2.1)	1.80(0.49–6.37)‡
Peripheral neuropathy	46(28.9)	61(20.9)	1.78(1.14–2.78)**
Cardiovascular complications	57(35.8)	89(27.1)	1.51(1.01–2.26)*
Renal disease (nephropathy)	5(3.1)	3(0.9)	3.52(0.67–22.94)‡
Multiplicity of diabetes complications:			
One	5(3.1)	15(4.6)	Ref.
Two	99(62.2)	155(47.1)	1.85(1.26–2.72)**
Three or more	20(12.6)	19(5.8)	2.34(1.21–4.53)*

Notes: !Includes: anemia, thyroid disease, gout, arthritis, hemolytic blood diseases, hepatitis C, fatty liver and liver cirrhosis; *P<0.05; **P<0.001; ‡Fisher Exact.

and insulin was a protective predictor of DFUs. A possible explanation is that insulin was added to OHGs for a better control of blood glucose levels and to prevent complications like diabetic foot.[34] In contrast, Atosona and Larbie (2019) reported that diet, insulin, and OHGs are not correlated with DFUs.[30] Moreover, Al-Rubeaan el al[32] and Banik et al[6] stated that insulin was associated with a significant risk of foot ulcers and amputations, and justified that insulin use was probably a result not a cause of uncontrolled blood glucose and occurrence of complications.[15]

Smoking is a major risk factor of PVD, one of the main causes of DFUs.[35] In the current study, smoking was significantly associated with DFUs, which was also supported by many studies.[29,36] In contrast, Coppini et al did not find any association between smoking and foot complications which may be due to biologic plausibility.[37] Previous research postulated that alcohol intake is linked with nerve damage which may predispose to foot ulcers and amputations;[30] however, no correlation was found between alcohol intake and DFUs in the present study and others as well.[38,39]

In the current study, wearing covered shoes was significantly less associated with DFUs (P<0.001), which suggests a protective effect of appropriate foot wear in diabetic patients as recommended by the IWGDF guidelines.[14] Similarly, Sriyani et al stated that wearing slippers as opposed to sandals and covered shoes increases the risk of foot ulcers by 3–4 folds.[40] About 38% only of the included participants in this study were practicing physical exercise; running was significantly more frequent among controls which could be explained by the fact that foot ulcers limited the physical activity of cases.

The role of dyslipidemia in the etiology of PVD, one of the major risk factors of DFUs, is inconsistent.[41] Hence, the current study like others did not find a significant association between dyslipidemia and DFUs.[30,42] Diabetic patients with severe PVD have a higher tendency

Table 4 Results of Foot Examination of the Included Diabetic Patients in Relation to the Presence of Diagnosed Foot Ulcer

Variables	Diabetics: No. (%)		Univariate Analysis Odds Ratio (95% C.I.)
	Foot Ulcer (n=159)	None (n=329)	
Healthy skin: No	78(49.1)	60(18.2)	4.32(2.84–6.56)**
Dry/cracked skin	95(59.7)	125(38.0)	2.42(1.65–3.57)**
Discolored skin	75(47.2)	272(82.7)	4.26(2.79–6.50)**
Foot deformities:			
Callus	74(46.5)	48(14.6)	5.10(3.29–7.88)**
Hammer /claw toe	47(29.6)	71(21.6)	1.52(1.00–2.34)
Bunion	32(20.1)	33(10.0)	2.26(1.33–3.83)*
Flatfoot	52(32.7)	50(15.2)	2.71(1.73–4.24)**
Claw toe	6(3.8)	4(1.2)	3.19(0.88–11.46)
Two or more deformities	27(16.9)	51(15.5)	1.11(0.67–1.86)
Vibration sense:			
Intact	29(18.2)	197(59.9)	Ref.
Impaired	130(81.8)	132(40.1)	6.69(4.23–10.59)**
Site:			
One	26/130(20)	37/132(28)	Ref.
Two	50/130(38.5)	63/132(47.7)	0.68(0.42–1.12)
Three sites	54/130(41.5)	32/132(24.3)	2.22(1.31–3.77)**
Position sense:			
Intact	48(30.2)	234(71.1)	Ref.
Impaired	111(69.8)	95(28.9)	5.69(3.76–8.62)**
Sites:			
One	12/111(10.8)	13/95(13.7)	Ref.
Two	48/111(43.2)	37/95(38.9)	1.19(0.68–2.10)
Three sites	51/111(46)	45/95(47.4)	1.02(0.68–1.76)

Notes: *P<0.05; **P<0.001.

Table 5 Multivariate Logistic Regression Model of the Possible Predictors for Diabetic Foot Ulcer Among the Included Sample

Independent Variables	B	Odds Ratio	95% Confidence Intervals		P value
			Lower	Upper	
Education (less than secondary)	0.163	1.177	0.496	2.793	0.712
Smoking (current)	−0.597	0.550	0.263	1.153	0.114
Footwear (covered)	−0.225	0.799	0.385	1.657	0.546
Three or more co-morbidities	0.864	1.76	1.13	2.51	0.021
Management (diet +OHGs +insulin)	−0.638	0.528	0.342	0.814	0.004
Duration of diabetes	−0.004	0.996	0.953	1.040	0.841
Diabetes Complications (two or more)	1.801	6.053	1.742	21.031	0.005
Cracked skin	0.313	1.367	0.632	2.959	0.427
Callus	1.649	5.200	2.318	11.666	0.000
Hammertoe	0.516	1.674	0.806	3.477	0.167
Flatfoot	1.198	3.315	1.509	7.279	0.003
Vibration sense (intact, 3 sites)	−1.226	0.294	0.132	0.654	0.003
Position sense (intact)	−0.783	0.457	0.134	1.558	0.211

Notes: Model % predicted=82.8%; Hosmer-Lemeshow Chi-square=17.211; P=0.028; Nagelkerke R^2=0.513.

of developing sudden ischemia due to arterial thrombosis, which in turn increases the risk of foot ulcers and amputations.[29] In the current study, PVD was a significant risk factor of DFUs, which was supported by another studies conducted in Egypt,[29] Canada,[43] and Italy.[44] Diabetic patients with neuropathy are also more liable to foot ulceration due to high pressure load and shearing forces.[29] Having peripheral neuropathy was significantly associated with DFUs in the present study, which was consistent with other studies done in Ethiopia,[17] Egypt,[45] and Jordan.[46]

Previous research indicated that foot deformities increase the risk of occurrence of foot ulcers directly by ulcer development and indirectly by increased plantar pressure.[43] In the present study, there was a significant association between foot deformities including callus, bunion, and flatfoot and DFUs. Similar findings were concluded by Al Kafrawy et al[29] and Yazdanpanah et al.[15]

Sensory peripheral neuropathy, one of the common complications of DM is associated with impairments of vibration sense and joint position sense. Impaired vibration sense is a risk factor of DFUs,[47] while impaired position sense increases the incidence of falls, soft tissue injuries and fractures.[48] In the current study, impaired vibration and position senses were significant risk factors of DFUs in the univariate analysis, while only intact vibration sense was a significant protective predictor in the multivariate logistic regression analysis. Similar findings were reported by Sriyani et al (2013) where there was a significant association between impairment of all three sensations (vibration, pressure, and position) and DFUs in the univariate analysis, however; only impairment of vibration and pressure senses were significant in the final logistic regression model.[40]

In the current study, significant positive predictors of DFUs on multivariate logistic regression analysis were presence of three or more comorbidities, two or more diabetic complications, callus and flatfoot. In a study conducted by Yazdanpanah et al, risk factors of DFUs on multivariate analysis were diabetes duration, educational level, marital status, smoking, glycemic control, retinopathy, nephropathy, and decreased peripheral pulses.[15]

Despite the current study provides valuable information for health care providers to implement preventive measures for DFUs, it has some limitations as follows; it adopted a case-control study design which does allow for establishing a cause-effect relationship. Moreover, it did not take into account some potential confounders like level of health services' provision and patients' compliance with foot care practices.

Conclusion and Recommendations

Significant positive predictors of DFUs on multivariate analysis were; presence of three or more comorbidities, two or more diabetic complications, callus and flatfoot, while protective predictors were management of diabetes by diet, OHGs, and insulin; and intact vibration sense. Hence, special care should be provided to diabetic patients with comorbidities and complications to reduce the risk of DFUs. In addition, health education should be provided to diabetic patients regarding risk factors of DFUs and foot care practices. The role of health care systems and policy makers should not be restricted to treatment of DFUs, but should also extend to taking effective measures for prevention.

Acknowledgments

The authors are thankful to all the physicians who helped in the data collection process. We would also like to thank all patients who participated in this study.

Disclosure

The authors report no conflicts of interest in this work. This research did not receive grant from any funding agency in the public, commercial, or not-for-profit sectors.

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