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Research Article

Association Between Smoking and Foot Ulcer among Patients with Diabetes Mellitus, Wad Medani, Sudan

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Abstract

Background: This study aimed to assess the relationship between smoking and diabetic foot ulcer (DFU) among adult diabetic patients presenting to Aldarga Diabetic Center, Wad Medani, Sudan in 2020.

Methods: This comprehensive study is based on primary data obtained via a longitudinal cross-section random sample of 400 patients with diabetes mellitus who presented to Aldarga Diabetic Health Center in Wad Medani Town, Gezira State, Sudan between September and December 2020. Data were collected using a structured questionnaire. The core questions included two main dimensions: sociodemographic variables and smoking. Data were analyzed using the SPSS software, v.20, using descriptive and inferential statistics, namely, frequency tables and graphs, showing the Chi-square test of the relationship between the dependent and the independent variables.

Results: Of the 400 participants, 96 were clearly diagnosed with foot ulcer giving a proportion of 33% in the sample. There was a statistically significant relationship between smoking and DFU. A Chi-square test was done to measure the relationship between smoking and foot ulcer, which was significant at $P = 0.043$.

Conclusion: Extensive awareness programs to control the negative effect of smoking in accelerating DFU and amputation are necessary.

Keywords: prevalence of diabetic foot ulcer, diabetic, diabetic food ulceration, smoking

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1. Introduction

A total of 12,089 diabetic cases were reported in Africa in 2010; this increased to 19,406.8 cases in 2019, which led to the prediction of the number for 2030 and 2045 as 28,629.4 and 47,133.7, respectively. According to the *International Diabetes Federation (IDF) Diabetes Atlas*, 9^{th} edition [1].

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> *Prevention of diabetic foot ulceration is critical in order to reduce the associated high morbidity and mortality rates, and the danger of amputation. It is essential to identify the "foot at risk," through careful inspection and physical examination of the foot followed by neuropathy and vascular tests*. [2]

Dubský *et al.*'s study showed

> *[...] a high recurrence rate of DFU during 3-year follow-up period in patients with a primarily healed ulcer, despite regular follow-up and patient education. We also found that the independent risk factors for ulcer recurrence were plantar location of the ulcer, the presence of underlying osteomyelitis, poor glycemic control and an elevated CRP at the time of diagnosis of the first foot ulcer. Knowing these risk factors may allow clinicians and health care systems to target heightened efforts at prevention of ulceration after healing to selected high-risk patients*. [3]

Furthermore, Al Busaidi *et al.* [4] stated that:

> *Diabetes is a chronic and costly disease; however, it can be prevented. The alarm of the rising tide of diabetes has not yet been successfully translated into action in the Middle East. The governments in the region need to devise more intense, broader policies and preventive measure programs based on local sociocultural practices to effectively combat the situation. Further improvements of the primary health care system and cross-governmental approaches are needed in the region to keep the growing epidemic of diabetes under control.*

1.1. Characteristics, prevalence, and outcomes of diabetic foot ulcers (DFUs) in Africa

Rigato and colleagues in a systemic review and meta-analysis reported as follows:

> *Fifty-five full-text papers and ten abstracts were retrieved, reporting data from 19 African countries on 56,173 diabetic patients. According to the data collected, the overall prevalence of foot ulcers was 13% and increased over time, especially since 2001. Approximately 15% of patients with foot lesions underwent major amputation and 14.2% died during hospitalization. In patients with diabetic ulcers, insulin therapy was uncommon and neuropathy was the most common predisposing factor, but the prevalence of*

> *peripheral arterial disease correlated with amputation rates. Amputation and mortality decreased over time, probably as result of the implementation of screening programs in the last ten years. Mortality was directly related to previous amputation*. [5]

Moreover, Elmadhoun and coworkers reported a high prevalence of diabetes mellitus (DM) and glucose intolerance in the urban population of the River Nile State (RNS) [6]. Another study conducted in the same region showed that the prevalence of DFU was 18.1% and that the risk of development of DFU is increased with the increase in the duration of diabetes, especially in those with DM for more than 10 years [7]. Additionally, another study [8] reported a strong relationship between smoking and foot ulcer, the results of the paper stated:

> *The role of smoking for wound healing in patients with diabetic foot has been unclear. This meta-analysis examined the relationship between cigarette smoking and diabetic foot wound healing. Observational studies for the association between smoking and diabetic foot wound healing of patients were systematically searched through PubMed and Wanfang Data, published up to June 2018. Healing rates of wounds were recognized as outcomes. Meta-analysis models were chosen by heterogeneity. A total of 3388 eligible studies were identified, of which 18 met all our inclusion criteria. In the smoking group, healing rate had an average of 62.1%, ranging from 20.0% to 89.6%; in the nonsmoking group, healing rate had an average of 71.5%, ranging from 40.2% to 93.8%. A significant association was found between smoking and the healing of diabetic foot. Our meta-analysis indicated that smoking had an overall negative effect on the wound healing of diabetic foot individuals. This study provides evidence for the harm of smoking to diabetic foot and may help reduce the medical and economic burden on poor healing of diabetic foot.*

Furthermore, Taha and Ball's [9] study on smoking in Africa showed that:

> *Cigarettes are heavily promoted in Africa. Smoking-related diseases have already made their appearance in Africa. The 2 most common types of cancer in the Natal Bantu are lung and esophageal tumors. Lung cancer in Natal men has increased 6-fold and in women about 5-fold over the past 11 years. As a result, tobacco companies have started to diversify and intensify promotion of cigarettes and the growth of tobacco in the 3rd world.*

DFU is one of the commonest complications of DM imputed to a number of morbidity and mortality cases in diabetic patients. Nowadays, the incidence of DFU is increasing due to the increased prevalence of diabetes. However, the risk factors of the problem are less or not studied in Gezira State, Sudan. Hence, this study was conducted to assess the determinants of DFU in relation to smoking among adult patients with diabetes attending Aldarga Diabetic Center, Wad Medani, Sudan in 2020.

2. Materials and Methods

A longitudinal, cross-sectional design was used to conduct the study among patients presenting at Aldarga Diabetic Health Center in Wad Medani Town, Gezira State, Sudan between September and December 2020. The center is located in the north of Wad Medani town, 186 km south of Khartoum, the capital of Sudan. It was opened as a specialized center for the central region of Sudan. Of the 400 participants who presented at the center, 96 had foot ulcer.

2.1. Sample size and sampling design

A random sampling method was used to select the sample of the study (total diabetic patients in 2020 reporting to the diabetic follow-up clinic). The simple random sampling equation for provisional sample size n^* was calculated using the following formula:

$n = (t^2 \times p \times q) / (d^2)$,

where: n^* = required sampling size; p = anticipated population proportion taken as 50% because it gives the maximum possible sample size. If we take the estimated prevalence rate of 0.15 for Sudan as p, the sample size will be 195, however, we preferred a larger sample; t = confidence level, taken as 95%; and d = absolute precision required on either side of anticipated proportion taken as 5%.

Next, the provisional sample was multiplied by a design effect of 2 to give the final sample n:

$n = (2^2 \times 50 \times 50) / (25) = 400$.

A total of 400 participants were successfully compassed by field data collection team. The total diabetic patients who reported to the center in 2020 were 40,507 classified by months with an average of 3376 diabetic patients per month.

The procedure used for selecting sampling units was twofold. First, we calculated the systematic sampling interval factor by dividing the number of diabetic patients during

the data collection period (November–December 2020) by the sample size, that is, N/n = 1823/400 = 4.55 ≅ 5. The sample unit number 5 was selected first. The rest of the sampling units were selected according to Kish selection procedure to cater for gender [10].

2.2. Data analysis

Descriptive statistics was initially undertaken to analyze the composition of the sample. Data were coded and entered into a computer using two of the latest versions of prepared packages of statistical analysis namely Statistical Package for Social Sciences (SPSS) v.24.0/25.0 for Windows. The programs were used in different stages of data processing to process the raw data obtained from the questionnaires. Quantitative analysis of the question responses obtained from the questionnaire were summarized, portrayed, and analyzed on a statistical basis in order to offer the researcher the opportunity to analyze the responses and identify whether the results are skewed [10].

The following statistical analyses were run:

1. A pilot study was conducted to establish content validity.
2. Face validity was established through the circulation of the questionnaire to 60 pilot respondents.
3. The summary results of the descriptive statistics were presented using tables and graphs.

2.3. Operational definitions

2.3.1. Diabetic foot

The International Working Group on Diabetic Foot (IWGDF) has defined the diabetic foot as infection, ulceration, or destruction of tissues of the foot of a person with currently or previously diagnosed DM, usually accompanied by neuropathy and/or peripheral arterial disease (PAD) in the lower extremity.

2.3.2. Diabetic foot ulcer (DFU)

DFUs are nondramatic lesions of the skin on the foot distal to malleoli of a person who has DM [11].

2.3.3. Diagnostic criteria for DM or measurement of DM

(i) Random plasma glucose value of ≥200 mg/dL (≥11.1 mmol/L) or (ii) fasting plasma glucose value of ≥126 mg/dL (≥7.0 mmol/L) or (iii) a 2-hr oral glucose tolerance test (GTT) value in venous plasma ≥200 mg/dL (≥11.1 mmol/L), or (iv) glycated hemoglobin (HbA1c) ≥6.5% (≥48 mmol/molHb) [12].

2.3.4. Smoking

> *The act of inhaling and exhaling the fumes of burning plant material. A variety of plant materials are smoked, including* marijuana *and* hashish*, but the act is most commonly associated with* tobacco *smoked in a* cigarette*,* cigar*, or* pipe*. Tobacco contains* nicotine*, an alkaloid that is addictive and can have both stimulating and tranquilizing psychoactive effects.* [13]

(i) Respondents' socioeconomic characteristics

The survey data were initially analyzed using frequency tables and descriptive statistics. Of the 400 sampled respondents, 55% were male and 44.5% were females living in predominantly extended (68%) families with the majority living in towns (56.8%). While only 8.5% reported high income level, 33.5% reported low income, and the majority were of medium income level (58%).

Table 1 shows the frequency distribution and descriptive statistics of the participant's socioeconomic characteristics. The youngest patient in the sample was 30 years of age and the oldest was 89. The age distribution classified in five years age group shows an expected pattern with sharp skewness to the right, where the majority are over the age of 50 years (79%) and more than half are >60 years of age. The mean age is 59.9 years with approximately similar median and mode indicating that the distribution is mesokurtic showing a confidence interval of 59.9 ± 1.31.

The majority of respondents were married (69.3%), 6.8% were single with abnormally nontypical high proportion of widows and divorcees (24%). The majority were either uneducated or had basic education (67.6), 20.3% had secondary education, and only 12.3% had a university degree. These tally very well with occupational classification, as 65.8% were either unemployed (38%), housewives (13.5%), or had unspecified jobs (14.3%). The general picture that can be drawn from the respondents' socioeconomic status is that diabetic patients reporting to Aldarga Center are mostly of low social class category.

(ii) Factors related to respondents' behavior

Table 1: Frequency distribution and descriptive statistics of major respondent's indicators.

Variable	N	Percentage (%)	Central tendency	Standard error of the mean
Age (yr)				
30–34	15	3.8		
35–39	10	2.5		
40–44	31	7.8	**Mean = 59.5**	**1.31**
45–49	28	7	**Median = 60**	
50–54	42	10.5	**Mode = 58**	
55–59	61	15.3	**Skewness = –0.222**	**–0.012**
60–64	48	12		
65–69	57	14.3	**Kurtosis = 0.555**	**0.243**
≥70	108	26.8		
Total	**400**	**100**		
Marital status				
Single	27	6.8	**Median = 2.0**	
Married	277	69.3	**Skewness = 0.976**	**0.122**
Widow	72	18	**Mode = 2.0**	
Divorced	24	6	**Kurtosis = 0.132**	**0.233**
Total	**400**	**100**		
Educational level				
Illiterate	34	8.5		
Khalwa	77	19.3	**Median = 3.0**	
Basic	159	39.8	**Skewness = 0.163**	**0.057**
Secondary	81	20.3	**Mode = 3.0**	
University	42	10.5	**Kurtosis = 0.232**	**0.223**
Postgraduate	7	1.8		
Total	**400**	**100**		
Occupation				
Professional	4	1		
Business	60	15	**Median = 8.0**	
Employee and uniform	38	9.6	**Skewness = 0.163**	**0.234**
Worker and farmer	35	8.8	**Mode = 9.0**	
Housewife	54	13.5	**Kurtosis = 0.232**	**0.122**
Unemployed and others	209	52.3		
Total	**400**	**100**		

Source: Researchers' own survey, 2020.

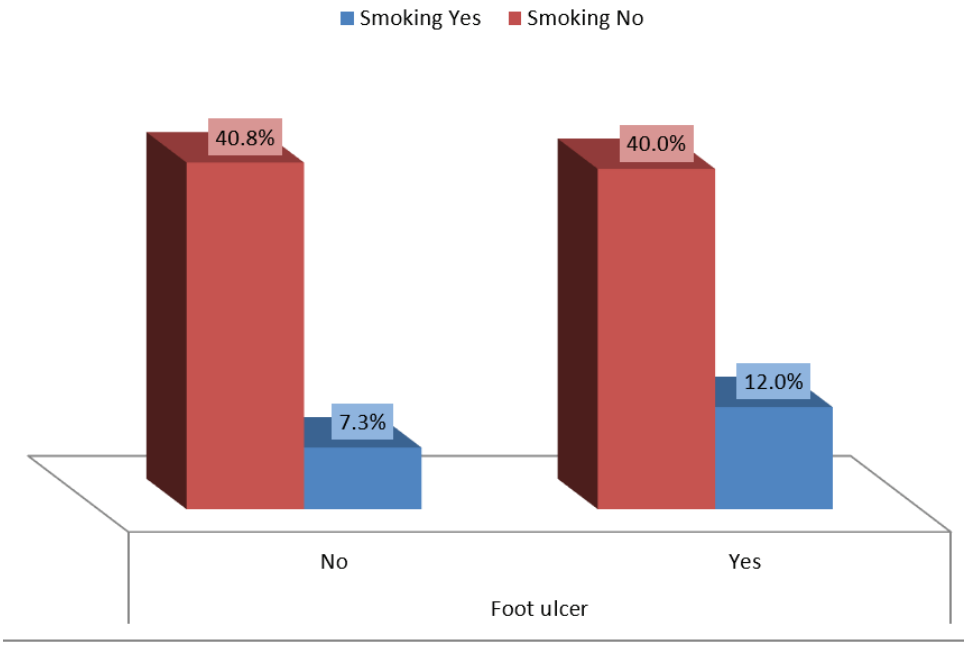

Figure 1: Relationship between smoking and diabetic foot ulcer.

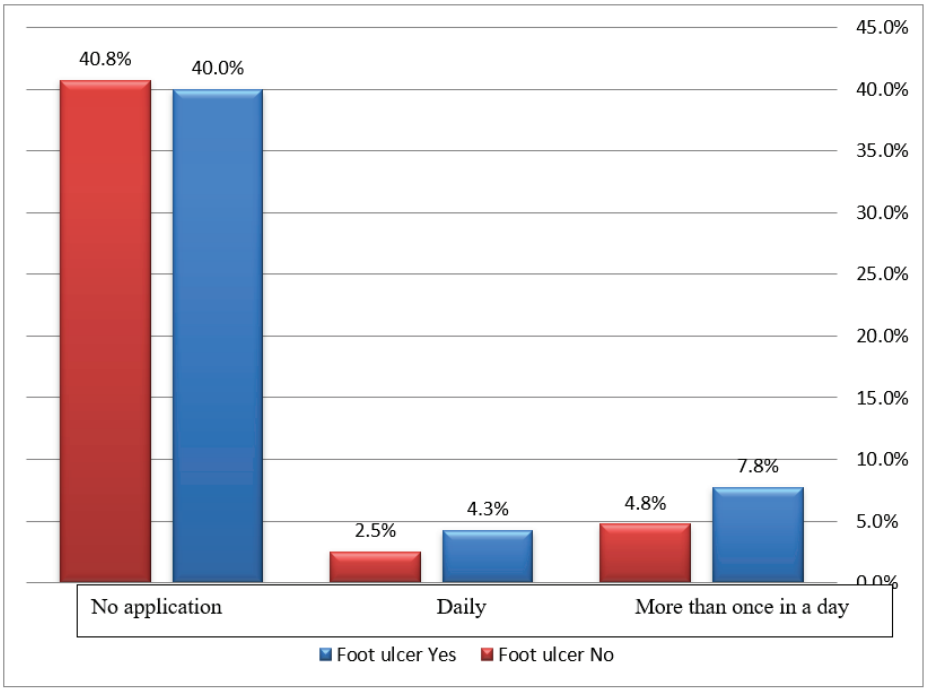

Figure 2: Relationship of diabetic foot ulcer with smoking frequency per day.

The majority of the respondents were nonsmokers and also nonalcoholic drinkers – 40.0% and 50.5%, respectively, and only 9.5% were snuffers. In addition, only 12% were smokers and about 4.3% of them smoked more than once daily (7.8%).

A Chi-square test was done to measure the relationship between smoking and foot ulcer, which was significant at *P*-value = 0.043.

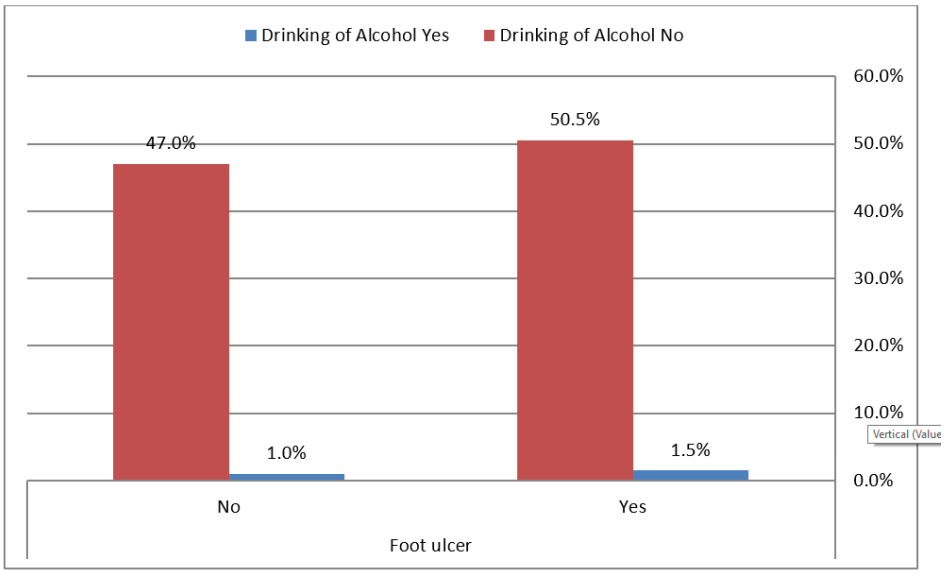

Figure 3: Relationship of diabetic foot ulcer with drinking of alcohol.

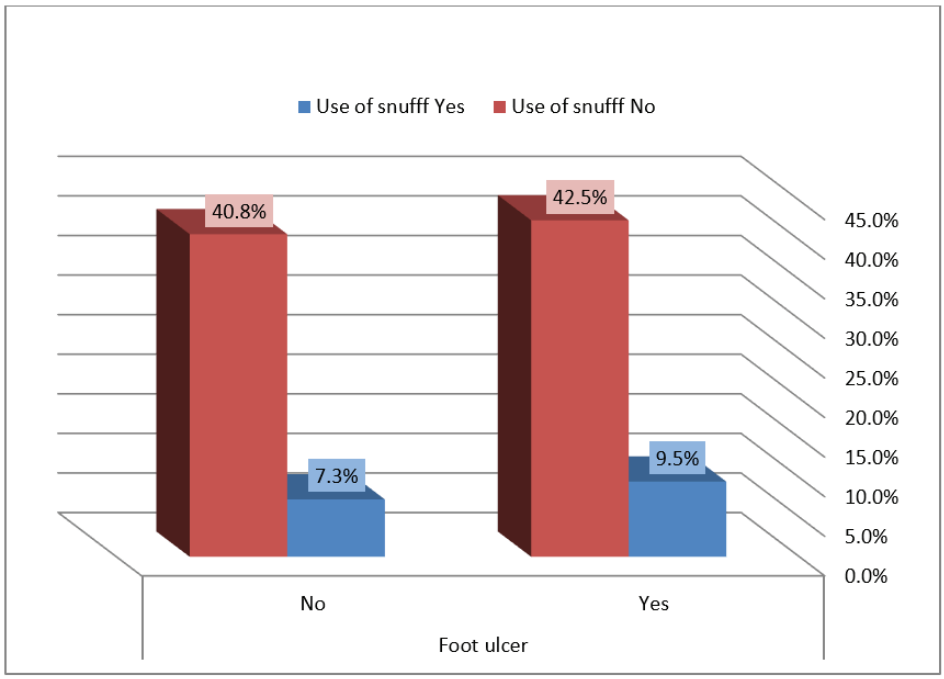

Figure 4: Relationship of diabetic foot ulcer with the use of snuff.

3. Results

3.1. Respondent's socioeconomic characteristics and association with smoking

The survey data were initially analyzed using frequency tables and descriptive statistics. Of the 400 sampled respondents, 55.5% were males and 44.5% were females living

TABLE 2: Chi-square test of the relationship between the dependent (foot ulcer) and independent variables (smoking).

Decision	DF	X2	SIG	Decision
Smoking	1	4.08	0.043	
Frequency of smoking per day	2	4.09	0.129	
Alcohol intake	1	0.263	0.608	
Use of snuff	1	0.717	0.397	

Source: Researchers' own data.

in predominantly extended (58%) families with the majority living in towns (56%). Only 8.5% reported high income level, 33.5% reported low income, and the majority were of medium income level (58%).

Table 3 shows the frequency distribution and descriptive statistics of the participant's socioeconomic characteristics. The youngest patient in the sample was 30 years old and the oldest was 89. The age distribution classified in five years age group shows an expected pattern with sharp skewness to the right, where the majority were >50 years (79%) and more than half >60 years of age. The mean age was 59.9 years with approximately similar median and mode indicating that the distribution is mesokurtic showing a confidence interval of 59.9 ± 1.31.

The majority of respondents were married (69.3%), 6.8% were single with abnormally nontypical high proportion of widows and divorcees (24%). The majority were either uneducated or had basic education (67.6), 20.3% had secondary education, and 12.3% were in the category of university and over. These tally very well with occupational classification as 65.8% were either unemployed (38%), housewives (13.5%), or had unspecified jobs (14.3%). The general picture that can be drawn from the respondent's socioeconomic status is that diabetic patients reporting to Aldarga center are of low social class category.

Additionally, 20% of the respondents smoked, which was significant at *p*-value = 0.043, where the drinking of alcohol was only 3% and snuffer was 17%.

4. Discussion

This study, to the best of our knowledge, could be the first to estimate the association between smoking and DFU in Gezira state, Sudan. Of the 400 DM participants included in this study, 96 had DFU, of which 12% were smokers, *P*-value = 0. .043The finding of this study is in line with the study of Xia *et al.* [14], who stated that:

Table 3: Frequency distribution and descriptive statistics of the participant's socioeconomic characteristics.

		Total	%	χ^2	P-value
Age of the respondents (yr)	30–39	25	6.2	20.81	0.035
	40–49	59	14.8		
	50–59	103	25.8		
	60–69	105	26.2		
	70–79	90	22.5		
	80–89	18	4.5		
Sex of the respondents	Male	222	55.5	1.682	0.116
	Female	178	44.5		
Residence of the respondents	Town	225	56	0	0.54
	Village	175	44		
Type of family	Nuclear	168	42	0.353	0.229
	Extended	232	58		
Income level	Low	134	33.5	0.736	0.612
	Medium	232	58		
	High	34	8.5		
Marital status	Single	27	6.8	0.451	0.93
	Married	277	69.2		
	Widow	72	18		
	Divorced	24	6		
Diabetic in the family	Yes	194	49	2.033	0.09
	No	206	51		
Type of work of the respondent	Professional/Busine	64	16	13.32	0.1
	Employee	35	8.8		
	Worker	15	3.7		
	Farmer	20	5		
	Uniform	3	0.8		
	Housewife	54	13.5		
	Other	57	14.2		
	Unemployed	152	38		
Educational level	Illiterate	34	8.5	7.496	0.186
	Khalwa/Madrasa	77	19.3		
	Basic	159	39.8		
	Secondary	81	20.2		
	University/Postgrad	49	12.2		
Smoking	Yes	77	20	4.08	0.043
	No	323	80		
Frequency of smoking per day	More than once in the day	50	13	4.09	0.129
	Daily	27	7		
	No application	323	80		
Drinking of alcohol	Yes	10	3	0.263	0.608
	No	390	97		
Use of snuff	Yes	67	17	0.717	0.397
	No	333	83		
Total		400			

> *At the end of this review, the current mainstream therapies for smoking cessation are also outlined. We believe that it is urgent for all diabetic patients to quit smoking so as to reduce their chances of developing foot ulcers and to improve the prognosis of diabetic foot ulcers*.

On the other hand, Pal and colleagues [15] showed that:

> *The diabetic patients who were smokers and/or chronic alcoholic underwent more amputations with concomitant longer hospital stay than the patients who had no addiction to these substances. The prognosis was worse in the subgroup of patients who were both smoker and chronic alcoholic. The study was done on 89 patients who were admitted in the surgical wards of the following teaching hospitals in India - KPC Medical College and Hospital as in our study those they had foot ulcer compared in those not had DFU were more smokers, snuffers and alcoholic's [12%, 7.3%,9.5%, 7.3%,1.5%, 1%] and as we know from medicine their effect on dealing wound healing and accelerating DFU.*

Moreover, public databases, including PubMed and Embase, were searched for articles published prior to February 29, 2016. Heterogeneity was assessed using the Cochran's Q statistic and the I2 statistic, and odds ratio (OR) and 95% confidence interval (CI) were calculated and pooled appropriately. Sensitivity analysis was performed to evaluate the stability of the results of the present meta-analysis which suggested that smoking is a notable risk factor for diabetic foot amputation. Liu *et al.* reported that smoking cessation appears to reduce the risk of diabetic foot amputation [15]. All studies showed a strong association between increased smoking and DFU. The effects of cigarette smoking on DFUs are clear from our study and other papers. Our study found that smoking had a negative effect in wound healing in foot ulcer cases. Hence, if the factors associated with DFU reduces such as quitting smoking, majority of our patients can be saved from DFU and disabilities arising thereof.

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Ethical Considerations

Before initiating the field survey, the objective of ethics in research was ensured by obtaining ethical clearance from the Director of Health Affairs in Wad Medani locality of Gezira State. A supportive formal letter was written to Aldarga Diabetic Center. Data collection was done after permissions were obtained from the center managers, and oral informed consent was obtained from the study participants to start data collection after assuring them of the ethical aspects regarding the confidentiality, privacy, and consent of the data.

Competing Interests

None declared.

Availability of Data and Material

All relevant data and methodological details pertaining to this study are available to any interested researchers upon reasonable request to corresponding author.

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