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Prevalence of chronic diabetic complications and associated risk factors among follow-up diabetic patients: estimates from a referral national diabetes center in Yemen

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Abstract

Background Emergence and progression of diabetic complications are associated with several risk factors. Identifying these risk factors related to diabetes helps avoid such complications and develop preventive measures to protect patients and improve their quality of life. This study aimed to estimate the prevalence of chronic complications among Yemeni diabetic patients and investigate the associations between these complications, sociodemographic characteristics, and diabetic risk factors.

Methods This cross-sectional study was conducted at the National Diabetic Referral Center in Sana'a, Yemen, from September 1 to October 30, 2023. Of the 228 respondents, 222 were considered valid for analysis. Data for this study were collected using the World Health Organization (WHO) STEPS Surveillance questionnaire and a simple physical assessment. IBM SPSS version 24.0 was utilized to manage and analyze the data. Descriptive statistics were used to determine the prevalence of diabetes complications. The chi-square test and binary logistic regression were used to determine the associations and risk factors. A *p*-value of less than 0.05 was used to determine statistical significance.

Results Diabetes-related complications were reported by 62.6% of respondents, with females having a greater risk of diabetic foot, nephropathy, and retinopathy, while males had an increased risk of neuropathy complications. Unemployment, obesity, non-adherence to diabetes regimens, uncontrolled hypertension, longer duration of type 1 diabetes (T1DM), and irregular physician check-ups were identified as key predictors of diabetes-related complications. Administration of statins as lipid-lowering medications was associated with a reduced risk of coronary artery disease (CAD) or ischemic stroke complications.

Conclusion Chronic complications related to diabetes were common among patients in Yemen. Factors such as unemployment, obesity, non-adherence to diabetes regimens, uncontrolled hypertension, longer duration of T1DM, and irregular physician check-ups were identified as key predictors of these complications. Implementation of the WHO non-communicable disease package is strongly recommended. This package comprises comprehensive

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measures aimed at detecting, treating, preventing, and controlling diabetic complications and ultimately improving the overall management of diabetes in Yemen.

Clinical trial number Not applicable.

Keywords Diabetes mellitus, Prevalence, Complications, Associated factors, Yemen

Introduction

The incidence of diabetes mellitus (DM) has steadily increased in both developed and developing nations [1]. Diabetes, with its substantial life-threatening consequences, has become one of the world's most serious health issues [2]. DM currently affects 463 million people aged between 18 and 99 years, and the number is expected to exceed 700 million by 2045 [3, 4]. Diabetes has become more prevalent in the Arab world over the last two decades, with the prevalence expected to nearly double by 2035, possibly owing to unhealthy food choices and lifestyle changes [5].

Yemen has 366,000 cases of type 2 diabetes mellitus (T2DM), with an estimated 447,000 undiagnosed cases; the prevalence of diabetes mellitus is 8.45% [6]. This figure may be underestimated because of limited access to health services, the high cost of diabetes diagnosis and treatment, and the lack of research capacity in Yemen, all of which are obstacles to understanding the scope of the country's DM problem [7].

Importantly, even people who have been diagnosed are frequently mismanaged because of healthcare professionals' lack of resources, knowledge, and skills [6]. Diabetes is a high-cost disease to treat, especially if it is uncontrolled, owing to its chronic nature, serious consequences, and the necessary control measures that affect not only the patient, but also the family and the healthcare system [8]. Patients with diabetes are at a higher risk of developing subsequent health problems that result in severe morbidity, diminished life expectancy, and elevated direct and indirect costs [9]. Uncontrolled diabetes can cause significant damage to various organs [10]. Damage to blood vessels and nerves is one of the most serious consequences of diabetes [11].

Modifiable risk factors such as physical inactivity, obesity, overweight, untreated high blood pressure, high cholesterol and/or triglycerides, smoking, unhealthy foods, stress, poor patient well-being, and insufficient sleep play a significant role in increasing the risk of diabetes mellitus and its chronic complications [12]. As a result, effective diabetes control and management necessitate the examination of multiple lifestyle risk factors rather than just one.

Chronic complications of diabetes cause serious morbidity and mortality worldwide. In a study conducted among diabetic patients in Morocco, the findings indicated that chronic complications of T2DM lead to increased morbidity and mortality globally. The primary risk factors associated with these complications included prolonged duration of diabetes, insulin use, insufficient physical activity, hypertension, hypolipidemia drugs, elevated serum creatinine levels, and high levels of LDL-C [13]. Likewise, the results of studies conducted in Sudan and Egypt, which aimed to estimate diabetes complications, revealed a high prevalence rate of chronic diabetic complications, especially among individuals with poor control and a longer duration of diabetes [14, 15].

Diabetes-related complications must be detected early to avoid disability and death [16]. However, data on the prevalence of chronic diabetic complications and associated risk factors have not been well documented in Yemen [7, 17]. Given the serious consequences of these complications for the patient, family, and health-care system, quantifying the problem, and exploring the associated risk factors would aid in a greater understanding of diabetic management, improving patient quality of life, and reducing the significant diabetes burden [18]. The current study aimed to estimate the prevalence of chronic complications among Yemeni diabetic patients and to investigate the associations between chronic complications and patients' sociodemographic characteristics and diabetic risk factors.

Methods

Study design, setting, and time frame

Across-sectional study was conducted at the referral national diabetic center in Sana'a, Yemen, from September 1 to October 30, 2023. This design allows for the assessment of relationships between variables at a single time point, providing a thorough overview of participant characteristics and valuable insights regarding prevalence and associations. The diabetes center is located at the Al Thaw rah Modern General Hospital in Sana'a City, Yemen. This center is a referral National Diabetes Center, serving nearly 8,640 diabetic patients from all governorates across the country each year.

Participants

Both male and female patients with diabetes, aged 18–65 years, from rural ($n=67$) and urban ($n=155$) areas in Yemen were recruited for this study. Systematic random sampling was employed to select the participants. According to data from the national diabetic center in Sana'a, Yemen, 1440 diabetic patients were recorded over

a two-month period. Dividing this total by 228 gives a sampling interval of 6. Subsequently, a random number generator was utilized to establish a starting point between 1 and 6, ensuring an unbiased selection process. The generated number was 5, initiating the interview process with patient number five. Interviews continued with every fifth patient based on their check-up sequence until the required 228 patients were recruited for the study. A total of 228 participants were eligible to participate.

Sample size estimation

The sample size for this study was calculated via the single-population proportion formula under the following assumptions: a prevalence of diabetic complications of 16% [19] 95% confidence level and a 5% margin of error. The sample size was calculated as follows:

$$n = \frac{\left(Z_{\alpha/2}\right)^2 p\,(1-p)}{d^2}$$

where n = the required sample, Zα/2 = 1.96, $p = 0.16$, d = 0.05.

$$n = \frac{(1.96)^2 0.16\,(1-0.16)}{(0.05)^2} = 207$$

Considering a 10% nonresponse rate, 207 + 21 = 228.

Data collection instruments

The WHO STEPS Surveillance questionnaire was adapted for use in this study [20]. The questionnaire was divided into three sections, the first of which addressed the respondents' sociodemographic information such as gender, age, place of residence, marital status, occupation, educational level, and monthly income. Section (2) addresses chronic diabetic complications. Section (3) concentrated on the key risk factors. Weight, height, and blood pressure were measured using well-calibrated, high-quality equipment that was regularly checked for accuracy.

Data collection

Data were collected from both primary and secondary sources. Primary data were gathered through face-to-face interviews conducted by a trained research team, using a questionnaire to collect sociodemographic information such as age, education, residence, occupation, marital status, and family income. Additionally, healthcare professionals measured patients' weight and height to calculate Body Mass Index (BMI). Patients were classified as underweight (BMI < 18.5 kg/m²), normal weight (BMI 18.5–24.9 kg/m²), overweight (BMI 25.0–29.9 kg/m²), or obese (BMI ≥ 30 kg/m²). Family income levels were self-reported and categorized into low, moderate, and high-income groups.

Secondary data on diabetic complications and associated risk factors were retrieved from the diabetic health center's system. These data were validated by endocrinology specialists and consultants. IT staff extracted relevant information from electronic health records into a Microsoft Excel spreadsheet. The data were then cleaned, coded, and imported into SPSS software for analysis.

Validity and reliability

The updated questionnaire underwent cross-cultural adaptation and translation by two experienced bilingual translators (fluent in Arabic and English) to maintain consistency in meaning and measurements. Two experts validated the content, resulting in modifications to some words based on their suggestions, without adding or removing any items. Their suggestions were taken into consideration. The questionnaire was pilot-tested with 20 diabetic patients who were not part of the study sample. The reliability of the questionnaire items was evaluated using Cronbach's alpha, showing an acceptable value of 0.84. Furthermore, two fieldwork validators were recruited to ensure that the measuring instruments were accurate and precise before they were utilized.

Data analysis

The Statistical Package for Social Sciences (IBM SPSS) version 24.0 was used to manage and analyze the collected data. Descriptive statistics were used to determine the prevalence of diabetes complications. The associations between predictor variables and each chronic diabetic complication were initially examined using the chi-square test, followed by multiple binary logistic regression. The chi-square test was chosen because it is frequently used for assessing associations between categorical data. After identifying significant associations through the chi-square test, the significant factors were included in a multiple binary logistic regression model using the enter method. The model's prerequisites were met before conducting the analysis. A p-value of less than 0.05 was used to determine statistical significance.

Ethical considerations

The study was approved by the Al Razi University Human Research Ethics Committee (Ref: RU/ 070/FOMS/2021) before it began. Permission from the National Diabetes Center to extract the patient's relevant data from the electronic system was obtained. All eligible patients who visited the National Diabetes Center during the study period provided informed consent. They were also informed that their participation was entirely voluntary, that anonymity would be maintained, and that they could withdraw at any time.

Results

Prevalence of chronic DM complications among the respondents

According to our data, 62.6% of respondents reported one or more macro/micro diabetic complications. The macrovascular complication represents 40 (18%), with the highest prevalence being CAD at 37 (16.7%), whereas the microvascular complication represents 136 (61.3%), with the highest prevalence being retinopathy at 75 (33.8%) and diabetic foot at 73 (32.9%). Table 1 provides further details.

The association between respondents' sociodemographic data and chronic DM complications

Our study revealed associations between sociodemographic characteristics and certain macrovascular and microvascular complications of DM. The findings indicate that respondents aged > 40 years were more likely to develop retinopathy. Illiterate patients had macrovascular complications (PAD), while both illiterate and primary school-educated patients had statistical significance for all microvascular complications except neuropathy. The place of residence was most significantly associated with macrovascular complications including strokes and PAD. Unemployed respondents had a higher prevalence of retinal complications than employed ones. Similarly, respondents with high incomes were more likely to develop ischemic stroke and PAD than those with low and middle incomes. Obese patients have a greater likelihood of developing CAD, ischemic stroke, PAD, retinopathy, neuropathy, and diabetic foot. Further details are provided in Table 2.

The association between risk factors and chronic DM complications

This study identified significant associations ($p < 0.05$) between risk factors and macrovascular and microvascular complications of DM. Patients with uncontrolled HbA1c levels (HbA1c > 7%), those who did not adhere to their treatment regimen, and those who did not have regular follow-ups with physicians were at a higher risk of both macrovascular and microvascular complications of diabetes. Similarly, family history of DM is associated with increased rates of retinopathy and diabetic foot complications. Uncontrolled blood pressure is associated with CAD, ischemic stroke, PAD, retinopathy, nephropathy, and diabetic foot complications. This type of DM is associated with CAD, stroke, PAD, neuropathy, and diabetic foot complications. The history of DM for more than 10 years has been associated with CAD, ischemic stroke, PAD, retinopathy, nephropathy, and diabetic foot complications. Furthermore, non-use of lipid-reducing drugs was associated with ischemic stroke and PAD complications. Table 3 presents detailed information.

Results of multiple binary logistic regression analysis

Multiple binary logistic regression was used to identify factors contributing to diabetes-related macro- and microvascular complications. Males were less likely than females to experience nephropathy. Illiterate patients had a significantly greater chance of developing nephropathy and diabetic foot complications. Patients with low incomes were significantly less likely to have an ischemic stroke, however both low- and middle-income patients had a significantly lower risk of PAD. Unemployed respondents exhibited significantly higher likelihood of experiencing retinopathy than employed respondents. Obese respondents were significantly more likely to develop all macrovascular complications, along with one microvascular complication (neuropathy), compared to non-obese respondents. Patients who did not adhere to diabetes mellitus treatments were significantly more prone to developing all macro/micro-vascular complications, except for diabetic foot. Patients with no family history of DM were significantly less likely to develop retinopathy complication. Uncontrolled hypertensive respondents were significantly more likely to develop all macro/micro-vascular complications, except for neuropathy. Respondents with T1DM were significantly more likely to develop CAD and diabetic foot complications than those with T2DM, with odds ratios of 3.11 and 3.88 times, respectively. Furthermore, those who had diabetes for < 10 years were significantly less likely to develop CAD, ischemic stroke, PAD, retinopathy, and neuropathy, while 10-≤20 were significantly less likely to develop retinopathy and neuropathy than those who had diabetes for more than > 20 years. Moreover, patients with irregular physician follow-up were significantly more likely to develop retinopathy, along with all micro-vascular complications. Finally, our findings revealed that the use of a lipid-lowering drug (statin) significantly reduced the

Table 1 Prevalence of chronic DM complications among the respondents

	Overall	DM Complication *n* (%)						
		Macrovascular Complication (18%)			Microvascular Complication (61.3%)			
		CAD	Stroke	PAD	Retinopathy	Nephropathy	Neuropathy	Diabetic Foot
Yes	139 (62.6)	37(16.7)	23(10.4)	22(9.9)	75(33.8)	59(26.6)	54(24.3)	73(32.9)
No	83 (37.4)	185(83.3)	199(89.6)	200(90.1)	147(66.2)	163(73.4)	168(75.7)	149(67.1)

- CAD: Coronary artery disease; PAD: Peripheral arterial disease; DM: diabetes mellitus

Table 2 The association between respondents' sociodemographic data and chronic DM complications

Demographic characteristic	Overall *n*(%)	DM Complications						
		Macro-vascular Complications			Microvascular Complications			
		CAD	Stroke	PAD	Retinopathy	Nephropathy	Neuropathy	Diabetic Foot
Sex								
Male	151(68.0)	25(16.6)	15(9.9)	15(9.9)	49(32.5)	34(22.5)	38(25.2)	48(31.8)
Female	71(32.0)	12(16.9)	8(11.3)	7(9.9)	26(36.6)	25(35.2)	16(22.5)	25(35.2)
p-value		0.949	0.761	0.986	0.540	**0.046**	0.670	0.613
Age group (years)								
≤ 20	9(4.1)	0(0.0)	0(0.0)	0(0.0)	6(66.7)	0(0.0)	0(0.0)	2(22.2)
21–40	32(14.4)	4(12.5)	2(6.1)	1(3.0)	7(21.9)	9(28.1)	10(31.3)	9(38.1)
> 40	181(81.5)	33(18.2)	21(11.7)	21(11.7)	62(34.3)	50(27.6)	44(24.3)	62(34.3)
p-value		0.248	0.363	0.186	**0.041**	0.183	0.155	0.623
Educational Level								
Illiterate	75(33.8)	18(24.0)	13(17.3)	14(18.7)	37(49.3)	27(36.0)	22(29.3)	33(44.0)
Primary School	89(40.1)	13(14.6)	8(9.0)	6(6.7)	25(28.1)	20(22.5)	23(25.8)	25(28.1)
Secondary School	30(13.5)	3(10.0)	2(6.7)	1(3.3)	8(26.7)	10(33.3)	6(20.0)	11(36.7)
University and above	28(12.6)	3(10.7)	0(0.0)	1(3.6)	5(17.9)	2(7.1)	3(10.7)	4(14.3)
p-value		0.183	0.051	**0.017**	**0.004**	**0.016**	0.235	**0.021**
Place of Residence								
Urban	154(69.4)	23(14.9)	11(7.1)	11(7.1)	50(32.5)	38(24.7)	34(21.1)	46(29.9)
Rural	68(30.6)	14(20.6)	12(17.6)	11(16.2)	25(36.8)	21(30.9)	20(29.4)	27(39.7)
p-value		0.297	**0.018**	**0.038**	0.533	0.335	0.240	0.150
Occupation								
Employee	114(51.4)	20(17.5)	13(11.4)	11(9.6)	27(23.7)	26(22.8)	26(22.8)	37(32.5)
Unemployed	108(48.6)	17(15.7)	10(9.3)	11(10.2)	48(44.4)	33(30.6)	28(25.9)	35(33.3)
p-value		0.719	0.600	0.894	**0.001**	0.191	0.6588	0.889
Marital Status								
Married	196(88.3)	33(16.8)	22(11.2)	21(10.7)	67(34.2)	53(27.0)	48(24.5)	67(34.2)
Unmarried	26(11.7)	4(15.4)	1(3.8)	1(3.8)	8(30.8)	6(23.1)	6(23.1)	6(23.1)
p-value		0.852	0.246	0.271	0.729	0.667	0.875	0.257
Family-income								
Low-income	180(81.1)	30(16.7)	17(9.4)	16(8.9)	65(36.1)	49(27.2)	44(24.4)	63(35.0)
Middle-income	34(15.3)	4(11.8)	3(8.8)	3(8.8)	8(23.5)	8(23.5)	6(17.6)	9(26.5)
High-income	8(3.6)	3(37.5)	3(37.5)	3(37.5)	2(25.0)	2(25.0)	4(50.0)	1(12.5)
p-value		0.214	**0.037**	**0.029**	0.315	0.900	0.158	0.286
BMI Categories								
Non-Obese	157(70.7)	19(12.1)	9(5.7)	9(5.7)	45(287)	40(25.2)	28(17.8)	45(28.7)
Obese	65(29.3)	18(27.7)	14(21.5)	13(20.0)	30(46.2)	19(29.2)	26(40.0)	27(43.1)
p-value		**0.005**	**< 0.001**	**0.001**	**0.012**	0.565	**< 0.001**	**0.037**

- CAD: Coronary artery disease; PAD: Peripheral arterial disease; DM: diabetes mellitus; BMI: Body mass index

incidence of ischemic stroke and PAD complications. Further details are presented in Table 4.

Discussion

This study aimed to assess the prevalence of chronic diabetes complications and identify the contributing factors among patients with diabetes attending the Referral National Diabetes Center in Yemen. The findings indicated that 62.6% of respondents had experienced one or more chronic diabetes-related complications. The high rate of diabetes-related complications in Yemen can be attributed to catastrophic war and its consequences, including infrastructure destruction and healthcare system collapse. This has resulted in limited access to the necessary medical treatment, lack of health education, and insufficient follow-up care, all of which may lead to an increased risk of these complications. Such a high rate can also be attributed to insufficient patient knowledge and a lack of health education initiatives and diabetic-related programs [21]. Our findings are higher than previous results reported in the country in 2010, which were 25.4% [22]. Our findings are also higher than those reported in neighboring countries such as Saudi Arabia and Ethiopia, at 39.2% and 29.4%, respectively [23, 24]. However, our findings are lower than those of the United Arab Emirates (83.5%) [25]. The discrepancy in the

Table 3 The association between risk factors and chronic DM complications

Risk factors	Overall *n*(%)	DM Complications						
		Macro-vascular Complications			Microvascular Complications			
		CAD	Stroke	PAD	Retinopathy	Nephropathy	Neuropathy	Diabetic Foot
HbA1c Categories								
Control DM (HbA1c ≤ 7%)	135(60.8)	17(12.6)	9(6.7)	9(6.7)	37(27.4)	28(2.7)	26(19.3)	37(27.4)
Uncontrol DM (HbA1c > 7%)	67(30.2)	20(23.0)	14(16.1)	13(14.9)	38(43.7)	31(35.6)	28(32.2)	36(41.4)
p-value		**0.042**	**0.024**	**0.044**	**0.012**	**0.014**	**0.028**	**0.031**
Adherence to DM treatment								
Yes	92(41.1)	6(6.5)	3(1.9)	4(4.3)	13(14.1)	7(6.5)	9(9.8)	23(25.0)
No	130(58.6)	31(23.8)	20(15.4)	18(13.8)	62(47.7)	52(45.6)	45(34.6)	50(38.5)
p-value		**< 0.001**	**0.003**	**0.020**	**< 0.001**	**< 0.001**	**< 0.001**	**0.035**
Family History of DM								
Yes	104(46.8)	20(19.2)	13(12.5)	9(8.7)	44(42.3)	32(30.8)	30(28.8)	43(41.3)
No	118(53.2)	17(14.4)	10(8.5)	13(10.9)	31(26.3)	27(22.9)	24(20.3)	30(25.4)
p-value		0.336	0.326	0.557	**0.012**	0.184	0.140	**0.012**
BP Control								
Yes	133(53.2)	16(12.0)	6(4.5)	4(3.0)	38(28.6)	29(21.8)	34(25.6)	53(39.8)
No	89(40.1)	21(23.6)	17(19.1)	18(20.2)	28(41.6)	30(33.7)	20(22.5)	20(22.5)
p-value		**0.023**	**< 0.001**	**< 0.001**	**0.045**	**0.049**	0.599	**0.007**
Type of DM								
Type I	81(36.5)	24(29.6)	16(19.8)	15(18.5)	33(40.7)	27(33.3)	28(34.6)	43(53.1)
Type II	141(63.5)	13(9.2)	7(5.0)	7(5.0)	42(29.8)	32(22.7)	26(18.4)	30(21.3)
p-value		**< 0.001**	**< 0.001**	**0.001**	0.097	0.084	**0.007**	**< 0.001**
Duration of DM (years)								
< 10	72(32.4)	6(8.3)	3(4.2)	3(4.2)	27(37.5)	16(22.2)	15(20.8)	20(27.8)
10–20	117(52.7)	19(16.2)	12(10.3)	11(9.4)	28(23.9)	28(23.9)	25(21.4)	33(28.2)
> 20	33(14.9)	12(36.4)	8(24.2)	8(24.2)	20(60.6)	15(45.5)	14(42.4)	20(60.6)
p-value		**0.002**	**0.007**	**0.006**	**< 0.001**	**.028**	**0.032**	**0.001**
Regular follow-up with physician								
Yes	126(56.8)	13(10.3)	6(4.8)	5(4.0)	21(16.7)	19(15.1)	17(13.5)	29(23.0)
No	93(43.2)	24(25.0)	17(17.7)	17(17.7)	54(56.3)	40(41.7)	37(38.5)	44(45.8)
p-value		**0.004**	**0.002**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**0.006**
Lipid Lowering Medication								
Yes	155(69.8)	24(15.5)	11(7.1)	10(6.5)	47(30.3)	39(25.2)	33(21.3)	50(32.3)
No	67(30.2)	13(19.4)	12(17.9)	12(17.9)	28(41.8)	20(29.9)	21(31.3)	23(34.3)
p-value		0.472	**0.015**	**0.009**	0.097	0.468	0.109	0.763

- CAD: Coronary artery disease; PAD: Peripheral arterial disease; DM: Diabetes mellitus; HbA1c: Hemoglobin A1c; BP: Blood pressure

prevalence rate of complications could be attributed to differences in the study samples, particularly in the case of a study conducted in the United Arab Emirates, which only included patients with T2DM. Additionally, this difference could be related to the efficient, accessible, and affordable healthcare in the UAE, facilitating early detection and reporting of complications.

It is worth noting that despite the high prevalence of diabetes in Saudi Arabia [26], Yemen exhibits a significantly higher prevalence of diabetes-related complications. The difference can be attributed to the availability of free healthcare, insured care, and enhanced treatment options. Moreover, access to newer medications and evidence-based care is more widespread in Saudi Arabia. This reinforces our earlier statement that prevalence can be attributed to devastating conflicts and their subsequent impact. Consequently, there is an urgent need to improve the healthcare infrastructure, ensure adequate provision of medical care, and prioritize health education programs for patients with diabetes in Yemen.

Concerning the sociodemographic characteristics of the respondents and their relationship to both diabetes-related macro- and microvascular complications, the findings of this study are consistent with those of previous studies, highlighting the association between the sociodemographic characteristics of diabetic patients and the development of diabetes-related macro- and microvascular complications [27, 28]. Factors such as uncontrolled blood sugar levels, urban residence, low-income status, non-adherence to medication, unhealthy diet, lack of physical activity, longer duration of T2DM, absence of cholesterol-lowering medications, and unemployment

Table 4 Multiple binary logistic regression analysis of risk factors associated with chronic DM complications

Risk factors	Odds ratio (95% CI)						
	Macrovascular Complication			Microvascular Complication			
	CAD	Ischemic Strok	PAD	Retinopathy	Nephropathy	Neuropathy	Diabetic Foot
Sex							
Male					0.43(0.20-0.91)*		
Female	reference						
Age group (years)							
≤ 20				4.55(0.64-31.92)			
21–40				0.39(0.11 – 1.30)			
> 40	reference						
Educational Level							
Illiterate			1.43(0.13-16.25)	2.03(0.48-8.55)	5.86(1.06–32.27)*		4.18(1.13–15.47)*
Primary School			1.45(0.12-18.06)	1.03(0.25-4.23)	4.96(0.88-27.98)		1.89(0.52-6.92)
Secondary School			0.28(0.01-9.32)	0.97(0.19 – 4.9)	0.85(1.13–47.10)		0.78(0.91-16.61)
University and above	reference						
Place of Residence							
Urban		0.37(0.09-1.43)	0.47(0.11-1.98)				
Rural	reference						
Family income							
Low income		0.07(0.01-0.64)*	0.07(0.01-0.66)*				
Middle income		0.06(0.00-1.10)	0.04(0.00-0.87)*				
High income	reference						
Occupation							
Unemployed				2.97(1.27–6.93)*			
Employed	reference						
BMI Categories							
Obese	2.88(1.22–6.85)*	4.84(1.39–16.89)*	3.67(1.02–13.18)*	2.86(1.23–6.66)*		2.60(1.23–5.46)*	1.73(0.85-3.54)
Non-Obese	reference						
HbA1c							
Uncontrol (> 7%)	1.53(0.66-3.58)	1.94(0.23-3.78)	2.78(0.19-3.28)	1.23(0.55 – 2.70)	1.65(0.79-3.44)	1.26(0.63-2.53)	1.21(0.60-2.45)
Control (≤ 7%)	reference						
Adherence to DM treat							
No	5.60(1.96–16.02)**	12.10(2.34–62.48)**	7.80(1.61–37.81)*	7.60(3.00-19.22)**	8.26(3.22–21.21)**	4.79(2.20-10.39)**	1.32(0.65-2.69)
Yes	reference						
Family History of DM							
No				0.32(0.14-0.72)**			0.54(0.28-1.05)
Yes	reference						
Bp Control							
No	2.88(1.23–6.76)*	7.62(2.01–28.84)**	13.69(2.81–66.82)**	2.36(1.05–5.25)*	2.54(1.19–5.44)*		3.66(1.71–7.83)**
Yes	reference						
Type of DM							
Type I	3.11(1.33–7.28)**	3.57(0.96-13.23)	3.59(0.88-14.64)			1.09(0.52-2.25)	3.88(1.95–7.75)**
Type II	reference						
Duration of DM (years)							
< 10	0.20(0.06-0.74)*	0.08(0.01-0.67)*	0.10(0.01-0.88)*	0.28(0.08-0.91)*	0.26(0.09-0.75)*	0.46(0.16-1.28)	0.48(0.17-1.32)
10-≤20	0.50(0.17-1.43)	0.48(0.11-2.18)	0.51(0.10-2.59)	0.15(0.04-0.45)**	0.41(0.15-1.09)	0.20(0.07-0.53)**	0.44(0.17-1.14)

Table 4 (continued)

Risk factors	Odds ratio (95% CI)						
	Macrovascular Complication			Microvascular Complication			
	CAD	Ischemic Strok	PAD	Retinopathy	Nephropathy	Neuropathy	Diabetic Foot
> 20	reference						
Follow-up with physician							
No	1.56(0.68 – 3.60)	1.49(0.42-5.35)	1.93(0.50-7.52)	4.63(2.14–10.01)*	2.51(1.20–5.25)*	2.66(1.30–5.44)**	2.30(1.13–4.68)*
Yes	reference						
Lipid Lowering Medication							
No		3.18(0.86-11.70)*	3.23(0.84-12.40)*				
Yes	reference						

-* Significant at < 0.05

-** Significant at < 0.001

- CAD: Coronary artery disease; PAD: Peripheral arterial disease; DM: Diabetes mellitus; BMI: Body mass index; BP: Blood pressure

are associated with at least one of the diabetes-related macro- and microvascular complications [1, 27, 29, 30]. The findings are similar to those of previous studies conducted in Morocco, Sudan, and Egypt, which identified key risk factors for microvascular and macrovascular complications related to diabetes. These factors include poor glucose control, longer diabetes duration, inadequate physical activity, and uncontrolled hypertension. These findings highlight the importance of investigating these risk factors, particularly those that can be modified to enhance diabetes management, improve patients' quality of life, and alleviate the burden on patients, families, and the healthcare system. These findings support the notion that a comprehensive understanding of risk factors associated with diabetes is crucial for improving diabetes management. Similarly, the current study found that those living in rural areas are more likely to get macrovascular complications including stroke and PAD. This disparity could be attributed to unequal access to healthcare services, varying levels of health literacy, or differences in socioeconomic status. These findings emphasize the necessity for public policies that prioritize the reduction of health disparities, advocate for equity among all populations, and implement targeted interventions for high-risk groups.

Another notable finding in this study was that, except for neuropathy (which had a slightly higher prevalence in males) and PAD (which had an equal prevalence), all diabetes-related macro- and microvascular complications were more prevalent in female with diabetes than in males. This could be attributed to differences in the composition of the recruited sample, which included a greater number of females than males. This finding may also be related to cultural and lifestyle factors. In Yemeni culture, males often have greater opportunities to engage in physical activity because of their daily work responsibilities as well as their active social engagement. These factors can potentially contribute to a lower risk of diabetes-related complications in males compared than in females. The disparities in macro/microvascular complications between males and females could also be attributed to healthcare access and biological factors. For instance, estrogen levels in women can affect vascular health and immune responses, potentially influencing complication rates. Additionally, in Yemen, women have less access to healthcare services compared to men, increasing their susceptibility to diabetes-related complications. According to previous studies, diabetic retinopathy is more prevalent in females [31, 32]. In contrast, Arambewela et al. [30], found that men have a higher prevalence of vascular complications than women do. The discrepancy in findings could be attributed to differences in the proportion of females in the study sample, which was larger than that in the current study.

Importantly, the outcomes of the multiple binary logistic regression analysis revealed that males were less likely than females to experience nephropathy. This is congruent with the findings of Fan Zhang et al. [33], who found a higher prevalence of diabetic nephropathy among female participants than males. The variation could be attributed to disparities in healthcare-seeking behavior, comorbidities, or adherence to treatment regimens between men and women. Likewise, illiterate patients were significantly more likely to develop nephropathy and diabetic foot complications, possibly due to limited knowledge of diabetic self-care practices and challenges in maintaining controlled blood sugar levels. These findings align with previous study indicating that individuals with lower educational levels are at a heightened risk of developing diabetes and its associated complications [34]. Furthermore, patients with low to middle incomes, as well as those who are unemployed, were found to be at a higher risk of developing diabetes-related complications. This could be attributed to various factors, such as disparities in access to healthcare, availability of health insurance coverage, differences in lifestyle choices, and

variations in social and economic circumstances. This finding is similar to the finding reported in a study conducted by Berhe, Mselle, and Gebru in 2023, which found that patients with government employment had a decreased likelihood of developing chronic diabetes complications [35]. According to a meta-analysis, there is a notable correlation between unemployment and an increased risk of prediabetes, T2DM, and related complications [36]. This could be due to the fact that low to middle incomes and unemployed people frequently have financial constraints, limiting their abilities to purchase healthcare, transportation, nutritional food, and leisure activities. Likewise, non-obese respondents had a lower likelihood of developing CAD, retinopathy, and neuropathy than obese respondents. This highlights the importance of weight management for improving glycemic control and preventing diabetic complications. Furthermore, non-obese diabetics may benefit from better lifestyles, including well-balanced diets and regular physical activity, thereby lowering the risk of CAD, retinopathy, and neuropathy. This finding is consistent with studies conducted in several countries, including Tanzania [37], southern Benin [38], and Sudan [39].

Furthermore, diabetic respondents with uncontrolled hypertension were more likely to develop macro/microvascular complications than those with controlled hypertension. Diabetes and hypertension are widely recognized risk factors for CAD. Consequently, patients with diabetes and uncontrolled hypertension have a significantly higher risk of developing CAD than those without. This finding is consistent with earlier studies that highlighted the association between diabetes, uncontrolled hypertension, and CAD, and recommended an effective care strategy for patients with diabetes, uncontrolled hypertension, and CAD [24, 40].

Additional predictors identified in this study included the type and duration of diabetes as well as regular physician visits. The findings indicated that patients with T2 DM who had diabetes for 5–10 years and maintained regular physician follow-up had a lower risk of developing complications such as retinopathy, nephropathy, neuropathy, CAD, ischemic stroke, PAD, and diabetic foot complications. In contrast, patients with T1DM who had diabetes for > 15 years and did not have regular physician follow-up had a higher likelihood of experiencing these complications. This could be due to the persistently high blood sugar levels, which can cause significant organ damage. The findings emphasize the need to take preventative steps, such as regular check-ups, consultation with doctors, and following a healthy diet and lifestyle. These precautions could effectively prevent or delay the onset of DM-related complications. The findings of the present study are consistent with the findings of several studies that highlighted the relationship between risk factors and the progress of diabetes-related complications [24, 41–43]. The findings of these studies support our earlier suggestions of controlling risk factors, specifically modifiable risk factors, to prevent or delay diabetes-related complications. Similarly, the use of a lipid-lowering drug (statin) reduces the incidence of PAD and ischemic stroke complications. This finding is supported by several studies that found that statin use was associated with a lower risk of PAD and ischemic stroke complications in patients [44–46]. Nevertheless, additional studies are required to investigate when healthcare providers determine the initiation and escalation of statin dosages. Specifically, it is necessary to determine whether the decision is based on lipid profile values or guided by the occurrence of the disease, as indicated by established guidelines.

Conclusion and recommendations

Chronic complications related to diabetes are common among patients in Yemen. Factors such as unemployment, obesity, non-adherence to diabetes regimens, uncontrolled hypertension, longer duration of T1DM, and irregular physician check-ups were identified as key predictors of these complications. Implementation of the WHO non-communicable disease package is strongly recommended. This package comprises comprehensive measures aimed at detecting, treating, preventing, and controlling diabetic complications and ultimately improving the overall management of diabetes in Yemen.

Limitations of the study

This study has several limitations that were beyond the author's control. First, as a cross-sectional study, it did not provide insights into the cause-and-effect relationship between chronic diabetes-related complications and the associated factors examined. Second, HbA1c values were obtained from patients' records rather than assessed at the time of the study. The diagnosis of microvascular and macrovascular complications was based on patients' electronic records. Another limitation is that this study did not evaluate the severity or outcomes of chronic complications.

Abbreviations

DM	Diabetes mellitus
T1DM	Type 1 diabetes mellitus
T2DM	Type 2 diabetes mellitus
CAD	Coronary artery disease
PAD	Peripheral arterial disease
WHO	World Health Organization
IBM SPSS	Statistical Package for Social Sciences

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Author contributions
GGA confirmed the sole responsibility for the following tasks: conceptualizing and designing the study, collecting data, analyzing and interpreting the results, and writing and approving the final manuscript.

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Data availability
The dataset related to this study is available from the corresponding author upon request.

Declarations

Ethics approval and consent to participate
The study was approved by the Al Razi University Human Research Ethics Committee (Ref: RU/ 070/FOMS/2021) before it began. All eligible patients who visited the National Diabetes Center during the study period provided informed consent. They were also informed that their participation was entirely voluntary, that anonymity would be maintained, and that they could withdraw at any time.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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