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Prevalence, risk factors, and glycaemic control of type 2 diabetes mellitus in eastern Sudan: a community-based study

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Abstract

Background: Diabetes mellitus (DM) constitutes a global health threat and burden, especially in developing countries. We conducted a cross-sectional study in Gadarif in eastern Sudan to evaluate the prevalence and glycaemic control of patients with type 2 diabetes mellitus (T2DM).

Methods: We performed a cross-sectional community-based study. Data on blood glucose levels, and anthropometric, demographic and clinical history data were obtained.

Results: Six hundred Sudanese adults with a mean (SD) age of 44.9 (16.5) years were enrolled. More than two-thirds (70.3%) of the study participants were women. The prevalence of T2DM, newly diagnosed T2DM and uncontrolled T2DM was 20.8%, 10.0% and 80.0%, respectively. Logistic regression analysis showed no significant association between education, marital status, body mass index, waist circumference and DM. However older age (AOR = 4.88, 95% CI = 3.09–7.70) and a family history of DM (AOR = 2.58, 95% CI = 1.59–4.20) were associated with T2DM.

Conclusion: The prevalence of T2DM is high among the Sudanese population, especially in older people and those with a family history of DM. The high prevalence of uncontrolled DM in this setting is another hidden burden.

Keywords: diabetes, glycaemic control, prevalence, Sudan

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Introduction

Chronic noncommunicable diseases are a large health problem worldwide. World Health Organization (WHO) data suggest that noncommunicable diseases are thought to be the second leading cause of death in Africa. In 2011, the broad category of noncommunicable diseases, such as stroke, hypertension and diabetes mellitus (DM), accounted for one-third of 9.5 million deaths and one-quarter of 675.4 million disability-adjusted life years.[1] The spectrum of chronic complications related to DM is extended to include microvascular complications – nephropathy, neuropathy and retinopathy – and chronic macrovascular complications – coronary artery disease, peripheral artery disease, stroke, diabetic encephalopathy and diabetic foot. Furthermore, it has also been associated with increased risk of cancer, physical and cognitive disability, tuberculosis and depression.[2]

DM is a large problem worldwide. A total of 424.9 million adults have been estimated to have had DM, and this is estimated to rise to 628.6 million patients.[2] The WHO eastern Mediterranean region has the highest prevalence of DM in the world. Seven countries in this region have a high prevalence of DM and a further seven countries (including Sudan) have a medium prevalence (9–12%) of DM.[3] Type 2 diabetes mellitus (T2DM) is the major type of DM, accounting for approximately 90% of all cases.[4] The estimated

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prevalence of DM in Africa in 2017 was 3.3%, and Sudan was among the countries that had a prevalence of DM of more than 12%.[2]

Various risk factors for diabetes have been reported, such as urban residence, obesity and male sex.[2,5–9] Moreover, increasing age, a family history of diabetes and hypertension are risk factors for DM.[10–13] DM is associated with acute complications, such as diabetic keto-acidosis, a hyperglycaemic state, hypoglycaemia, thrombosis and electrolyte disturbance. Therefore, premature morbidity, mortality, reduced life expectancy and the financial burden of DM result in a public health problem.[14] DM is responsible for 10.7% of global all-cause mortality among people aged between 20 and 70 years.[2] Africa had the highest rate (77.0%) of people who died from DM before the age of 60 years in the International Diabetes Federation regions in 2017.[2]

While there are several published studies on DM in African countries,[15–18] there are few published data on DM in Sudan, particularly the eastern part of Sudan.[19,20] Moreover, most studies on DM in Sudan were health facility studies. Investigation of the epidemiology of DM is urgently required for health planners and practising physicians. Therefore, the current study was conducted to investigate the prevalence and risk factors for DM and to assess glycaemic control of pre-existing DM in Gadarif in eastern Sudan.

Materials and methods

Study area

Gadarif is one of the 18 states of Sudan and has an area of 75,263 km^2. The estimated population of the state is 1,348,378 people, with an annual growth rate of 3.7%; the population is 25% urban and 73.7% rural.[21] It has vast land suitable for agriculture, and it is home to the largest projects for rain-fed agriculture in Sudan. The mosaic of population includes all Sudanese tribes from all different regions of Sudan and many dwellers of foreign origin who are attracted by the agriculture and pastoral activities.[21]

Method

A multistage sampling study was conducted in Gadarif, eastern Sudan. Initially, four localities (the lowest administrative units in Sudan) were selected from 11 localities within Gadarif by simple random sampling. The total sample size of 600 participants was distributed to the four localities according to size allocation of the localities. Finally, all the agreed adults (>18 years of age) Sudanese subjects from the household were then chosen using a lottery method irrespective of symptoms or signs. When a selected house was not inhabited or the inhabitants refused to participate, the next house was selected. Trained medical officers interviewed the participants during the period January to May 2018. All eligible participants were invited to participate in the study. After providing informed consent, the WHO three-level stepwise-approach questionnaire was used for data collection.[22] This questionnaire was used to collect demographic and behavioural information, physical measurements, including anthropometric measurements, blood pressure and biochemical test results for noncommunicable disease surveillance. All adults (age ⩾18 years, men and women) with T2DM were enrolled. All participants were Sudanese; those aged <18 years, those with type 1 DM, pregnant women, patients with haemoglobinopathy, those who were acutely ill, debilitated patients and those with any chronic disease that may alter haemoglobin A1c (HbA1c) levels (e.g. end-stage renal disease) were excluded. The questionnaire was used to collect sociodemographic characteristics: age, sex, education (less than secondary level or equal or higher than secondary level), employment (employed or nonemployed), marital status (married, divorced or unmarried), alcohol consumption (one or more drink in the past month), smoking (smokers were those who smoked >100 cigarettes in their lives and reported any smoking in the past year) and comorbidities (hypertension). The questionnaire was also used to determine the duration of DM and whether DM was diagnosed previously, the symptoms of diabetes and the family history.

The participants' weight and height were measured using standard procedures, and body mass index (BMI) was computed using the equation: weight (kg)/height (m^2).

Blood pressure was measured using a standard mercury sphygmomanometer after resting for at least 10 min in the sitting position, and the arm was maintained at the level of the heart. With an appropriate-size cuff, the mean of two (at an interval of 1–2 min) blood pressure readings was calculated. If the difference between the two readings was >5 mmHg, measurements were taken again until a stable reading was achieved. A sample size of 600 Sudanese adults was determined to be required. This sample size was based on previous studies[13,23] in which 19.1% of participants were expected to have DM and 71.7% would be uncontrolled to detect a difference of 5% at $\alpha = 0.05$ with a power of 80%. We assumed that 10% of the participants might not respond or have incomplete data.

Blood glucose measurement

A total of 3 ml of venous blood was drawn from any participant after full explanation of the procedure and technique. The blood was then adequately disinfected by alcohol swab in a vacuum blood collection tube containing EDTA. Random blood glucose levels were immediately tested from a sample using a glucometer (Accu-Check Active; Roche Diagnostics, Germany). The sample was transferred to a modern diagnostic laboratory to measure HbA1c levels using an Ichroma machine (Republic of Korea).

DM and glycaemic control were defined as recommended by the American Diabetes Association for nonpregnant adults and the International Diabetes Federation[2,24] as follows: random plasma glucose levels of ⩾200 mg/dl (11.1 mmol/L) in a patient with classic symptoms of hyperglycaemia or hyperglycaemic crisis. HbA1c level of 6.5% or higher should be a primary diagnostic criterion. Glycaemic control status for known cases was defined depending on the HbA1c target of <7.0%. Accordingly, HbA1c levels of ⩾7.0% were defined as poor glycaemic control.

Statistical analysis

Data were entered into a computer using SPSS for Windows (version 20.0). The Chi-square test was used to compare proportions between participants with no DM and those who were diagnosed as having DM. Continuous parametric and nonparametric data were compared by the *t* test and Mann–Whitney *U* test, respectively, between the two groups (nondiabetic and diabetic). Logistic regression analyses were performed with DM as the dependent variable. Independent variables (age, sex, marital status, education, BMI and waist circumference) were entered into the model if their univariate *p* was <0.20. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated and a *p* value of <0.05 was considered significant.

Ethics

The study received ethical approval from the Ethics Committee at the Faculty of Medicine, University of Gadarif, Sudan (reference number: 2017/13). Written informed consent was obtained from each participant before taking part in the research.

Results

General characteristics

A total of 600 Sudanese adults [mean (SD) age: 44.9 (16.5) years] were enrolled. A total of 422 (70.3%) respondents were women and 178 (29.7%) were men. Of the 600 enrolled individuals, 425 (70.8%), 132 (22.0%) and 43(7.2%) were married, unmarried and divorced/widowed, respectively. Approximately two-fifths (43.7%) of the individuals had less than secondary-level education. Fifteen and two respondents were smokers and alcoholics, respectively. A total of 118 (19.7%) and 174 (29.0%) respondents had a first-degree family history of DM and hypertension, respectively. Forty-four (7.3%), 201 (33.5%), 159 (26.5%) and 196 (32.7%) respondents were underweight, normal BMI, overweight and obese, respectively.

Of the enrolled 600 individuals, 65 (10.8%) were diagnosed with DM previously and 60 (10.0%) were newly diagnosed with DM. Therefore, in this survey, 125 (20.8%) individuals had DM. Half ($n = 33$, 50.7%) of the individuals who were known as having DM were not on medication at the time of the survey. Moreover, the majority ($n = 52$, 80.0%) of the respondents who were diagnosed as being diabetic had uncontrolled DM.

There is no significant difference in sex ($p = 0.381$) or alcohol consumption ($p = 1.00$) between individuals with DM and individuals without DM. Patients with DM were older, had a lower level of education, were married, were smokers and had a family history of diabetes (Table 1). While there was no significant difference in the median (interquartile) BMI ($p = 0.073$), the median (interquartile) age and waist circumference were significantly

Table 1. Comparing the number (proportions) of the sociodemographic characteristics between diabetic and nondiabetic participants in eastern Sudan.

Variable		Diabetes ($n=125$)	Non-diabetic ($n=475$)	p
Age	Below the mean (44.9 years)	31 (24.8)	289 (60.8)	<0.001
	Above or equal to the mean (44.9 years)	94 (75.2)	186 (39.2)	
Gender	Males	41 (32.8)	137 (28.8)	0.381
	Females	84 (67.2)	338 (71.2)	
Education	Less than secondary level	70 (60.0)	192 (40.4)	0.002
	Secondary level or higher	55 (44.0)	283 (59.6)	
Marital status	Married	99 (79.2)	326 (68.6)	0.004
	Unmarried	14 (11.2)	118 (24.8)	
	Divorced/widowed	12 (9.6)	31 (6.5)	
Family history of diabetes	Yes	39 (31.2)	79 (16.6)	0.001
	No	86 (68.8)	396 (83.4)	
Smoking	Yes	8 (6.4)	7 (1.5)	0.005
	No	117 (93.6)	468 (98.5)	
Alcohol	Yes	0 (0)	2 (0.4)	1.000
	No	125 (100.0)	473 (99.6)	
Body mass index groups	Underweight	5 (4.0)	39 (8.2)	0.435
	Normal weight	42 (33.6)	159 (33.5)	
	Overweight	34 (27.2)	125 (26.3)	
	Obese	44 (100.0)	152 (35.2)	

Table 2. Comparing the median interquartile of the age, body mass index and waist circumference between diabetic and nondiabetic participants in eastern Sudan.

Variable	Diabetes ($n=125$)	Non-diabetic ($n=475$)	p
Age (years)	55 (44.5–65)	38.0 (30.0–53.0)	<0.001
Body mass index (kg/m^2)	27.3 (23.9–31.6)	26.4 (22.3–31.6)	0.074
Waist circumference (cm)	95.0 (82.0–111.0)	88.0 (80.0–100.0)	0.003

higher in individuals with DM than in those without DM ($p=0.003$) (Table 2).

Logistic regression analysis showed no significant associations between education, marital status, BMI, waist circumference and DM. However, older age (adjusted OR = 4.88, 95% CI = 3.09–7.70, $p<0.001$) and a family history of DM (adjusted OR = 2.58, 95% CI = 1.59–4.20, $p<0.001$) were associated with DM (Table 3).

Discussion

The current survey showed that 20.8% of the respondents had DM. This is consistent with the recent reported prevalence of DM in North

Table 3. Logistic regression of the factors associated with diabetes in eastern Sudan.

Variable		OR	95% CI	*p*
Age	Below the mean (44.9 years)	Reference		<0.001
	Above or equal to the mean (44.9 years)*	4.88	3.09–7.70	
Education	Secondary level or higher	Reference		0.351
	Less than secondary level	1.23	0.79–1.93	
Marital status	Married	Reference		
	Unmarried	0.62	0.32–1.21	0.169
	Divorced/widow	0.91	0.43–1.93	0.813
Family history of diabetes*	No	Reference		<0.001
	Yes	2.58	1.59–4.20	
Body mass index (as continuous variable)		1.00	0.97–1.04	0.747
Waist circumference (continuous variable)		1.00	0.99–1.021	0.153

*Adjusted.

Sudan (18.7% and 19.1%).[13,25] A much lower prevalence (8.9%) of DM has been recently reported in Egypt[26] and in Ethiopia (6.5%). Recently, Arugu and Maduka reported a low prevalence of DM (8.0%) and newly diagnosed DM (1.9%) in Nigeria.[27] The prevalence of DM (20.8%) in the current study is higher than the global estimated prevalence (8.8%) of DM. According to the 2017 International Diabetes Federation report, Sudan was among countries that had a prevalence of DM of ⩾12%.[2] This increase in the prevalence of DM could be explained by increased life expectancy with improved medication, lifestyle changes, improve awareness and early detection of DM. The last three justifications mentioned might also explain the higher percentage (33%) of patients below 45 years with DM.

In the current study, the prevalence (10%) of undiagnosed DM was higher compared with that (2.6%) reported in River Nile State, North Sudan, by Noor and colleagues.[28] Notably, these researchers[28] enrolled patients aged ⩾35 years, while we enrolled adults aged ⩾18 years. However, our rate of undiagnosed DM is much lower compared with the estimated global prevalence (37.6–69.2%) of undiagnosed DM.[2] Our results should be cautiously compared with the results of other studies because of the differences in the methods and the criteria used for diagnosing DM in the different studies.

Our study showed a significant association between DM and older age and a family history of DM. A previous report from North Sudan showed that older age was a risk factor for DM.[28] Similarly, Elmadhoun and colleagues reported that older age and a family history of DM were significantly associated with DM in North Sudan.[13] Moreover, recently, Arugu and Maduka reported significant associations between older age and a family history of DM with DM in another African country (Nigeria).[27] However, age was not associated with DM in neighbouring Ethiopia.[29] The association between DM and a family history of DM has been observed in India.[30,31] Generally, the association between a family history of DM and DM suggests shared genetic or environmental factors in the aetiology of DM.[32]

Our study and the previous study in Sudan[28] showed no association between sex and DM. A similar observation was reported by Song and colleagues.[33] However, many reports have shown that men had a higher risk for developing DM.[2,34,35] This discrepancy among studies might be explained by the synergistic effects of the observed combination of obesity and a parental history of DM among men.[35] Interestingly, 70.3%

of the enrolled participants in the current study were women. Of course, bias cannot be ruled out. The availability of men outside their homes at the time of the survey could have resulted in this bias.

Although we did not show any association between marital status and DM, divorced respondents and widows had a high risk for DM.[36,37] In our study, obesity was not associated with DM. Different concepts have been reported for obesity and DM, such as general obesity,[8] BMI,[30,38] the duration of obesity and body fat distribution[7] and waist circumference for men and BMI for women.[5,31] However, a controversial suggestion has been that obesity protects against DM because of the presence of anti-diabetogenic effects of fat tissues in some obese patients,[39] or genetic factors.[40] A similar outcome was documented in some clinical trials.[41–43] There was no association between education and DM in our study. Another similar study in Africa (Ghana) has suggested a strong association of university or college education or wealth status with higher prevalence of DM. This is to be expected in most parts of Africa, where a good education and increased wealth is associated with the adoption of a Western lifestyle, thereby increasing the likelihood of diabetes.[44]

There were only two respondents who consumed alcohol in our study. Perhaps alcohol is not a socially common habit in Sudan, especially among women. The risk of developing DM is related to the amount of alcohol consumption, and moderate consumption presents is well tolerated.[45]

The prevalence of uncontrolled DM was 80.0% in our study, which is consistent with recent reports from Sudan (71.7–85%)[19,23,46] and some African countries (78.2–86.4%).[47–49] Our study showed that half of the individuals who were diagnosed as having DM were not on medication at the time of the survey. Lack of medicines, cultural beliefs and lack of healthcare professionals could explain the higher prevalence of uncontrolled DM obtained in our study.

Thus, our results enable healthcare professionals to have a better insight into the epidemiology of DM. Moreover our results can be applied to settings (inside Sudan and other African countries) other than that in which they were originally tested.

A limitation of this study is that some factors, such as socioeconomic status, physical exercise, type of food and the lipid profile, were not assessed. Moreover, only two tests were used for diagnosing DM.

Conclusion

The prevalence of T2DM and uncontrolled DM is high among the Sudanese population. Therefore, efforts to minimize the burden and shape the future of DM in Sudan are highly recommended. Old age and a family history of DM in the first degree are strong predictors for developing the disease.

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Author contributions

SMO, IRM and IA contributed to the design and implementation of the research, and wrote the main manuscript text. IRM, AE and IA prepared the analysis of the results. SMO and AE contributed to the design, implementation of the research and acquisition of data. All contributors reviewed the manuscript.

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Conflict of interest statement

The authors declare that there is no conflict of interest.

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