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ORIGINAL RESEARCH

The prevalence and determinants of poor glycemic control among adults with type 2 diabetes mellitus in Saudi Arabia

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Background: Although the prevalence of type 2 diabetes mellitus (T2DM) is rising sharply in Saudi Arabia, data on glycemic control, crucial to reducing diabetes mellitus complications, remain scarce. This study therefore investigated glycemic control status and the factors influencing poor glycemic control among adult T2DM patients in Saudi Arabia.

Methods: This cross-sectional study examined 423 T2DM patients at a diabetic center in Tabuk, Saudi Arabia between September 2016 and July 2017. Glycemic levels were measured via fasting blood glucose (FBG) levels, and "poor glycemic control" was defined as FBG >130 mg/dL. Poor glycemic control's risk factors were identified using a logistic regression.

Results: In the sample, 74.9% of the patients had poor blood glycemic control. Logistic regression revealed that T2DM patients had an increased chance of poorly controlled diabetes if they had family histories of diabetes (adjusted odds ratio [AOR] =7.38, 95% CI 4.09–13.31), longer diabetic durations (AOR =2.33, 95% CI 1.14–4.78 for 5–10 years and AOR =5.19, 95% CI 2.50–10.69 for >10 years), insufficient physical exercise (AOR =19.02, 95% CI 6.23–58.06), or were overweight (AOR =3.79, 95% CI 2.00–7.18), or obese (AOR =5.35, 95% CI 2.72–12.59).

Conclusion: A high proportion of the sampled patients had poor glycemic control, therefore, health care professionals should manage the associated risk factors to limit disease complications and improve the health of patients with diabetes.

Keywords: type 2 diabetes, glycemic control, Saudi Arabia

Introduction

Diabetes mellitus refers to a grouping of metabolic diseases involving prolonged hyperglycemia caused by the inadequate secretion of insulin, poor insulin action, or a combination of the two.[1] Diabetes is a globally chronic disease affecting 366 million people, a number which has been forecast to rise to 552 million by 2030.[2] It has various long-term complications which negatively impact the individuals' quality of life and potentially their lifespans, causing deleterious effects for both individuals and societies.[3] Diabetes complications are categorized as microvascular (nephropathy, neuropathy, retinopathy) or macrovascular (cardiovascular and cerebrovascular disease).[4] Diabetes management aims to delay the onset of disease complications, and to hinder its progression, mostly by improving glycemic control and controlling the risk of cardiovascular disease.[5,6]

Previous studies have provided evidence of the power of good glycemic control to restrict the microvascular and macrovascular complications of diabetes.[6–8] Despite that, between 40% and 60% of patients worldwide still have poorly controlled diabetes.[9–13]

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High glycemic control is difficult to achieve, and prior research has reported many factors as contributing to poor control among patients, including their age, gender, level of education, weight, smoking status, marital status, the duration of diabetes, the medications taken, and numerous other factors.[14–16] However, it has been proved difficult to confirm exactly which of these factors are most directly associated with poor glycemic control.[15] This is because the prior findings are inconsistent, and have also indicated that glycemic control and the factors influencing it vary across countries and between different ethnic groups.[17,18] There is, therefore, an obvious need for better understanding of the factors affecting glycemic control so that diabetes management can be improved.[19]

The International Diabetes Federation has confirmed that Saudi Arabia is among the global top 10 countries with the highest diabetes rates among adults aged between 20 and 79 years.[20] Further, the prevalence in Saudi Arabia has risen sharply in recent decades, from 7% in 1989 to 32% in 2009.[21] Despite this alarming trend, the factors linked to glycemic control among type 2 diabetes mellitus (T2DM) patients remain poorly understood.[22] This study therefore recruited a sample of adult T2DM patients in Saudi Arabia to evaluate their glycemic control status and its determinants.

Methods

Study design and participants

This cross-sectional observational study recruited a sample of adult outpatients attending a diabetes clinic at a diabetic center in Tabuk, the capital city of the Tabuk region of Saudi Arabia, between September 2016 and July 2017. Patients who have been diagnosed with diabetes are given referrals to this center by local hospitals and primary health care centers (PHCCs).

The size of the required sample was established according to the following assumptions: π=0.5 (there has been no prior estimate of the prevalence of poor glycemic control among type 2 diabetics in the Tabuk region); desired marginal error =0.05; and z (or 95% confidence level) =1.96. The ideal total sample size was therefore calculated as 385 patients. After allowing an additional 20% to account for nonrespondents, the final sample size was set at ~460 patients.

To be eligible to participate in the study, patients had to be at least 18 years old, to have received a confirmed diagnosis of T2DM, and to have received treatment as outpatients for a minimum of 1 year. Pregnant patients, patients suffering from diagnosed mental illness or psychological issues, and patients diagnosed with renal failure were excluded. All eligible patients were invited to participate in the study, and those who agreed were given a written informed consent form to sign. Ethical approval for the research was sought and obtained from the Committee of Research Ethics at the University of Tabuk in 2016.

Data collection

Data were collected during direct encounters between trained investigators and participating patients via a four-part questionnaire specially designed for the research, to ensure a high level of information accuracy. The first part of the questionnaire involved sociodemographic data on the participating patients' age, marital status, gender, residence, education level, employment status, and income. The second part concerned their clinical characteristics, including family histories of diabetes, the duration of disease, and self-reported comorbidities. The third part gathered lifestyle data on the patients' smoking status, whether they exercised regularly (ie, whether they were involved in at least 30 minutes of exercise per day, at least 3 days per week), and whether they followed a set dietary plan approved by dietitians (which restricted their intakes of sugar, salt, and fat). The fourth and final part had questions on the medications the patients were taking to manage their diabetes, and whether they self-monitored their blood glucose levels.

A pilot study was performed using 20 patients with T2DM to test the questionnaire and inform any necessary changes based on an assessment of their feedback. The pilot study established that the questionnaire required about 15 minutes to complete, and patients who participated in this study were removed from the final study sample.

The height and weight of each patient were measured while they wore lightweight clothing and no shoes. Their weight was measured to the nearest 0.5 kg and their height to the nearest 0.5 cm so that their body mass index (BMI) could be calculated using the formula of weight in kilograms divided by height in meters squared. Based on the calculated BMI, the patients were divided into categories reflecting the World Health Organization (WHO)'s definitions: normal range (BMI =18.5–24.9 kg/m^2), overweight (BMI =25–29.9 kg/m^2), and obese (BMI ≥30 kg/m^2).[23]

Data on the patients' fasting blood glucose (FBG) levels were taken either from their personal medical records, if it had been tested within 3 months prior to the research encounter and provided the patients were still taking the same medication when the encounter took place as they had been on at the time of the FBG test, or alternatively, they were tested during the period of study. Each patient's glycemic level was coded

as either poor or good. Poor glycemic control was defined in this study as an FBG level above 130 mg/dL.[24]

Statistical analyses

The data were analyzed using the SPSS program, version 23 (IBM Corporation, Armonk, NY, USA). Statistical significance was set at a *p*-value of <0.05. Data were expressed as counts (frequency, n) and proportions (%). A univariate logistic regression was performed to identify the factors associated with poor glycemic control in the study sample. Then, the variables highlighted as significant by the univariate logistic regression were included in a multivariate logistic regression, to identify associations between possible risk factors and poor diabetes control. The analysis also calculated the odds ratios and their 95% confidence intervals (CIs).

Results

A total of 460 T2DM patients were sent invitations to participate in the study, of whom 423 (92%) returned completed questionnaires.

The characteristics of the patients with T2DM are presented in Table 1, which shows that 233 (52.7%) were male; 278 (65.7%) were aged 30–49 years; 384 (90.8%) were married; 309 (73.0%) lived in an urban area; 395 (93.4%) had completed at least primary or higher education; 189 (44.7%) earned a middle-level income; and 278 (65.7%) were employed. Importantly, it also shows that almost three quarters of the patients (72.3%) were either overweight or obese.

The prevalence of poor glycemic control in this study sample of T2DM patients was 74.9%. The univariate logistic regression analysis results shown in Table 2 indicate a substantially greater risk of poor glycemic control among patients living in urban areas, with a family history of diabetes mellitus, who reported longer diabetic durations, who had insufficient physical exercise, who did not adhere to a diabetic dietary plan approved by a dietician, who failed to perform regular self-monitoring of their blood glucose, and who were overweight or obese.

An adjusted multivariate logistic analysis was carried out to establish the independent predictors of glycemic control for the study sample. In the present research, variables with a *p*-value of <0.05 in the univariate analysis were used in the multivariate analysis (Table 3). The results of the multivariate logistic analysis revealed that T2DM patients were more likely to have poorly controlled diabetes if they had a family history of diabetes mellitus (adjusted odds ratio [AOR] =7.38, 95% CI 4.09–13.31), had longer diabetic durations (AOR =2.33, 95% CI 1.14–4.78 for 5–10 years and AOR =5.19, 95% CI 2.50–10.69 for >10 years), did not undertake sufficient physical exercise (AOR =19.02, 95% CI 6.23–58.06), and/or were overweight (AOR =3.79, 95% CI 2.00–7.18) or obese (AOR =5.35, 95% CI 2.72–12.59).

Table 1 Sociodemographic characteristics of the study participants (n=423)

Variables	N	%
Gender		
Male	223	52.7
Female	200	47.3
Age group (years)		
<29	62	14.7
30–39	101	23.9
40–49	177	41.8
>50	83	19.6
Marital status		
Married	384	90.8
Unmarried	39	9.2
Type of residence		
Rural	114	27.0
Urban	309	73.0
Education level		
Tertiary	159	37.6
Secondary (grade 7–12)	161	38.1
Primary (grade 1–6)	75	17.7
Illiterate	28	6.6
Income status		
Low (<5000 SAR)	127	30.0
Middle (5000–15,000 SAR)	189	44.7
High (>15,000 SAR)	107	25.3
Employment status		
Employed	278	65.7
Unemployed	145	34.3
BMI (kg/m^2)		
Normal (<25)	117	27.7
Overweight (25–29.9)	215	50.8
Obese (≥30)	91	21.5

Abbreviations: BMI, body mass index; SAR, Saudi Arabian Riyal (≈$0.266).

Discussion

The results of the analyses indicated that 74.9% of the study sample of patients with T2DM suffered from poor glycemic control. The high prevalence of uncontrolled T2DM reported in this research is of concern, and is also broadly in line with prior studies in other regions of Saudi Arabia. A previous study reported that 67.7% of T2DM patients had poor glycemic control in Riyadh (the capital of Saudi Arabia).[25] A similar value, 67.9%, was found in Al Hasa (the eastern province), and 74% in Jazan (the southwestern province).[22,26] High prevalence of poor diabetes control has also been identified in other Middle Eastern contexts; for example, 65.0% in Oman, 65.1% in Jordan, 69% in the United Arab Emirates,

Table 2 Results of the univariate logistic regression analysis of factors associated with poor glycemic control (n=423)

Variables	Glycemic control status, n (%)		Unadjusted	
	Poor (n=317, 74.9%)	Good (n=106, 25.1%)	OR	95% CI
Gender				
Male	164 (73.5)	59 (26.5)	1	Ref
Female	153 (76.5)	47 (23.5)	1.17	0.75–1.82
Age group (years)				
<29	49 (79.0)	13 (21.0)	1	Ref
30–39	69 (68.3)	32 (31.7)	0.57	0.27–1.20
40–49	136 (76.8)	41 (23.2)	0.88	0.44–1.78
>50	63 (75.9)	20 (24.1)	0.84	0.38–1.85
Marital status				
Married	287 (74.7)	97 (25.3)	1	Ref
Unmarried	30 (76.9)	9 (23.1)	1.13	0.52–2.46
Type of residence				
Rural	73 (64.0)	41 (36.0)	1	Ref
Urban	244 (79.0)	65 (21.0)	2.11	1.32–3.37
Education level				
Tertiary	121 (76.1)	38 (23.9)	1	Ref
Secondary (grade 7–12)	114 (70.8)	47 (29.2)	1.44	0.51–4.06
Primary (grade 1–6)	59 (78.7)	16 (21.3)	1.16	0.60–2.25
Illiterate	23 (82.1)	5 (17.9)	0.76	0.46–1.25
Income status				
Low (<5000 SAR)	90 (70.9)	37 (29.1)	1	Ref
Middle (5000–15,000 SAR)	145 (76.7)	44 (23.3)	1.36	0.81–2.26
High (>15,000 SAR)	82 (76.6)	25 (23.4)	1.35	0.75–2.43
Employment status				
Employed	204 (73.4)	74 (26.6)	1	Ref
Unemployed	113 (77.9)	32 (22.1)	1.28	0.80–2.06
Family history of diabetes				
No	63 (48.1)	68 (51.9)	1	Ref
Yes	254 (87.0)	38 (13.0)	7.22	4.45–11.70
Diabetes duration (years)				
<5	106 (62.4)	64 (37.6)	1	Ref
5–10	92 (81.4)	21 (18.6)	2.65	1.50–4.67
>10	119 (85.0)	21 (15.0)	3.42	1.96–5.98
Comorbidity				
Diabetes mellitus only	111 (70.7)	46 (29.3)	1	Ref
Diabetes mellitus and comorbidity	206 (77.4)	60 (22.6)	1.42	0.91–2.23
Smoking status				
Smoker	62 (75.6)	20 (24.4)	1	Ref
Nonsmoker	255 (74.8)	86 (25.2)	0.96	0.55–1.68
Performs at least 30 min exercise 3 days per week				
No	221 (87.0)	33 (13.0)	5.09	3.16–8.20
Yes	96 (56.8)	73 (43.2)	1	Ref
On a dietary plan recommended by dietitians				
No	229 (82.7)	48 (17.3)	3.14	1.99–4.95
Yes	88 (60.3)	58 (39.7)	1	Ref
Diabetes treatment				
Diet and exercise	15 (65.2)	8 (34.8)	1	Ref
Oral antidiabetic agents only	156 (73.2)	57 (26.8)	1.46	0.59–3.63
Insulin only	99 (78.0)	28 (22.0)	1.89	0.73–4.90
Oral antidiabetic agents and insulin	47 (78.3)	13 (21.7)	1.93	0.67–5.54
Self-monitoring blood glucose				
No	241 (80.3)	59 (19.7)	2.53	1.60–4.01
Yes	76 (61.8)	47 (38.2)	1	Ref
BMI (kg/m^2)				
Normal (<25)	66 (56.4)	51 (43.6)	1	Ref
Overweight (25 to <30)	175 (81.4)	40 (18.6)	3.38	2.05–5.58
Obese (≥30)	76 (83.5)	15 (16.5)	3.92	2.02–7.60

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio; Ref, reference; SAR, Saudi Arabian Riyal (≈$0.266).

Table 3 Results of the multivariate logistic regression analysis of factors associated with poor glycemic control (n=423)

Variables	Adjusted	
	OR	95% CI
Type of residence		
Rural	1	Ref
Urban	1.61	0.87–3.01
Family history of diabetes		
No	1	Ref
Yes	7.38	4.09–13.31
Diabetes duration (years)		
<5	1	Ref
5–10	2.33	1.14–4.78
>10	5.19	2.50–10.69
Performs at least 30 min exercise 3 days per week		
No	19.02	6.23–58.06
Yes	1	Ref
On a dietary plan recommended by dietitians		
No	0.54	0.31–2.19
Yes	1	Ref
Self-monitoring blood glucose		
No	0.69	0.23–2.09
Yes	1	Ref
BMI (kg/m^2)		
Normal (<25)	1	Ref
Overweight (25 to <30)	3.79	2.00–7.18
Obese (≥30)	5.35	2.72–12.59

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio; Ref, reference.

and 78.8% in Kuwait.[27–30] The overall picture established by prior research is of a generally high prevalence of poor glycemic control, which is a matter of significant concern both in Saudi Arabia and more broadly across the Middle East because of the negative health implications for patients with poorly controlled T2DM.

Both modifiable and non-modifiable factors shape glycemic control's etiology and affect the extent of poor glycemic control in T2DM patients.[31] Further, glycemic control and the factors influencing it vary across countries and between ethnicities, making it vital to determine the factors causing poor glycemic control among Saudi T2DM patients.[17,18] This research has identified four variables which appear to be associated with glycemic control as an outcome: patients' family history, duration of diabetes, exercise levels, and weight status. Of these four factors, family history and diabetes duration are non-modifiable risk factors which raise the likelihood of poorly controlled diabetes; more specifically, a heightened risk emerges if a patient has a family history of diabetes, and/or has had the disease for a long time. The present findings are in line with those of prior studies.[19,22,25,28,31–34] A feasible explanation of why patients with a history of T2DM are at greater risk of having poor glycemic control is that the disease has inherent genetic risk factors which have the power to influence its duration and severity.[35] A longer T2DM duration is also associated with poor glycemic control, perhaps because of the progressive restriction of insulin secretion over time caused by B-cell failure which means that a patient's positive response to changes in diet, or oral agents, is less likely.[6]

The present investigation has also identified a significant association between low levels of physical activity and poor glycemic control, as poor glycemic control was observed to be less common among those undertaking regular physical exercise than in those taking part in infrequent activity. This result builds a consensus with prior research, which has also associated physical inactivity with high glucose levels.[28,36–38] Further, physical exercise has not only been reported to raise glycemic control, but also to boost a patient's insulin sensitivity and to repair some of the damage caused by diabetes-associated complications, such as impaired cardiovascular health, one of the most common complications.[39] Regrettably, a recent study of the barriers to successfully control T2DM in a Saudi Arabian context found low levels of physical activity to be extremely common.[40] For instance, a cross-sectional study with a sample of 450 Saudi participants who were attending PHCCs in Riyadh, the capital city of Saudi Arabia, found that 82% of the participants were physically inactive.[41] The obvious explanation for this remarkably high prevalence is that Saudi Arabia is a very hot country, so T2DM sufferers are discouraged from performing exercise outdoors.[22] Because physical inactivity (caused by a sedentary lifestyle) is a modifiable risk factor for poor diabetes control, further research investigating the barriers to exercise, including, for example, access to gym facilities in Saudi Arabia, would be useful in establishing how to raise levels of daily physical activity across the Saudi population.

Overweight and obesity is another important modifiable factor influencing poor glycemic control and diabetes risk.[42] Prior research has reported that the glycemic control of patients with T2DM generally deteriorates when they gain weight, and improves when they lose weight.[28,43–47] Furthermore, rapid and substantial weight loss such as that which can occur, for example, in association with gastric bypass surgery, has been found to cause partial or total T2DM remission.[48] The present research agrees with previous findings regarding the higher likelihood of poorly controlled T2DM among overweight or obese patients, possibly because these patients often have higher dietary intakes of food high in carbohydrates and a high glycemic index, thus enhancing their fat storage and making their glycemic

levels harder to control. Excessive storage of fat and high glucose levels due to carbohydrate overconsumption make good glycemic control difficult.[34] Unfortunately, WHO has reported that Gulf Arab countries, including Saudi Arabia, Kuwait, Bahrain, and the United Arab Emirates, are ranked among the top 10 countries globally for obesity.[49] A prior study has also found that between 80% and 90% of Saudi T2DM patients are obese.[40] Our results regarding the levels of overweight and obesity among diabetic patients are a little better, as approximately three quarters of the research patients with T2DM (72.3%) were in this category. This research therefore emphasizes the need to design strategies encouraging T2DM patients to make long-term lifestyle changes involving specific diet and exercise recommendations which can facilitate weight loss and raise their levels of glycemic control.

The present research has some inherent limitations. Firstly, the cross-sectional design of the study meant that it could not establish a cause-and-effect association between poor glycemic control and its influencing factors. Secondly, the self-reported responses to some items, such as approved diets and exercise plans, or smoking status, were subjective and may, therefore, have involved recall bias. Thirdly, the decision to use fasting blood glucose rather than HbA1c may have resulted in an underestimation of the prevalence of poor glycemic control in the sample, even though fasting blood glucose is reportedly more reliable than HbA1c according to prior research.[50] Finally, in this study, patients seen as potential participants were recruited using convenience sampling, which may have involved an element of selection bias.

Conclusion

This study has found an extremely high prevalence of poor glycemic control in its sample of T2DM patients, in line with the high levels previously reported by research in other Saudi Arabian regional contexts. It found that the most important factors influencing the development of poor glycemic control in this population were a family history of diabetes mellitus, longer diabetes duration, low level of physical exercise, and higher body weight. It is therefore vital that health care professionals focus on the risk factors associated with poor glycemic control in their health strategies, so that they can help to raise levels of glycemic control among diabetes patients across the country to reduce the impact of disease complications and improve the health of its patients. There is a need for prospective longitudinal research using large-scale samples to explore the barriers to controlling T2DM further among patients in Saudi Arabia.

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Author contributions

Riyadh A Alzaheb and Abdullah H Altemani designed this research. Abdullah H Altemani set the study protocol and performed the fieldwork and Riyadh A Alzaheb analyzed the data collected during the study. The two authors collaborated in interpreting the results and establishing the findings, and drafted, checked, finalized, and approved the manuscript together.

Disclosure

The authors report no conflicts of interest in this work.

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