



## Identifying the Risk Factors and the Prevalence of Poor Glycemic Control among Diabetic Outpatients in a Rural Region in Saudi Arabia

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### Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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### ABSTRACT

**Aim:** This cross-sectional study aimed to assess the prevalence of poor glycemic control and risk factors associated with it among diabetic patients in the central rural region of Saudi Arabia.

**Methods:** The study included a review of diabetic patients' medical record in King Khaled Hospital in Al-Kharj from the beginning of January 2019 to the end of June 2019. Poor glycemic control was defined as the current use of diabetic-lowering medication associated with HbA1c levels  $\geq 7\%$ . Multivariate analysis was done to identify the associated factors of poor glycemic control.

**Results:** Of 1,010 consecutive outpatients' diabetic patients were involved in the study sample, poor glycemic control presented in 496 (49.1%). Individuals who were at risk to have poor glycemic control those between 45 and 65 years with odds ratio (OR) of 1.927 (95% CI: 1.143–3.248), obese 1.496 (95% CI: 1.085–2.063) and diagnosed with asthma 2.062 (95% CI: 1.637–3.504).

**Conclusion:** The extent of poor glycemic control in the study sample was found high. Age, obesity, and having asthma are the most important factors of increased risk of poor glycemic control. Improving glycemic control would need rigorous efforts by addressing these factors.

**Keywords:** *Diabetes mellitus; glycemic control; prevalence; risk factors; diabetic patients; public health.*

## 1. INTRODUCTION

Diabetes mellitus (DM) is a main medical problem that has been rising more rapidly in the twenty-first century. Globally, it is affecting about 415 million adults and it is projected to affect 642 million in 2040 (uncertainty interval: 521–829 million), according to The International Diabetes Federation (IDF) [1]. It is sufficiently common to represent a public health concern in Saudi Arabia as well. Saudi Arabia is one of the nations with the highest DM prevalence regionally and internationally. It was estimated that the Saudi prevalence of DM is 14.4% and the estimated prevalence of DM among males and females is 14.7% and 13.8%, respectively [2]. Even more worrying perhaps, the prevalence of DM overall is anticipated to increase due to high socio-economic development, urbanization, and changes compounded by lifestyle and behavior patterns in the country, according to a report by the Saudi Arabian Ministry of Health [3].

DM created a great economic burden on the Saudi healthcare system. In 2014, the Saudi MOH spent an estimated \$4.4 billion on direct management of DM for Saudi citizens alone, which accounts for 17.5% of the MOH budget. Yearly, individuals with DM have average direct medical expenditures of nearly \$4,473 for DM care alone [4]. It is worth noting that these cost estimates do not account for indirect costs such as a decrease in productivity of the patient, caregivers, and families. Given the forecast future trends in diabetes prevalence, increased Saudi healthcare expenditure will also be imposed.

Poor glycemic control is highly correlated with chronic conditions related to the damaging effects of hyperglycemia, resulting in serious complications. The major long-term hyperglycemic complications involve the vasculature leading to both microvascular (small blood vessels damage) and macrovascular (arterial damage) complications. Thus, DM is connected with an increased risk of retinopathy, nephropathy, neuropathy, and cardiovascular

disease (CVD), which are common among diabetic patients [5].

To restrict and delay the complications of DM, good glycemic control and management are fundamental. A previous study has unambiguously revealed the benefits of meticulous glycemic control on complications of DM [6]. For example; risk reductions for macrovascular events and death were down by 7.0%, while microvascular events were down to 6.5% in patients with type 2 DM [6]. In that context, the American Diabetes Association (ADA) guidelines from 2016 recommended reaching ideal levels of glycemic control with hemoglobin A1c (HbA1c) of less than 7% [7]. Despite the great emphasis on tight glycemic control, a high number of patients remain poorly controlled. Studies from Saudi Arabia showed that the prevalence rates of poor glycemic control in different regions and time varied widely, ranging between 43.1% and 87.5% of patients [8-15]. However, the contributing factors for poor glycemic control are complex and multifactorial [16].

To date, studies conducted in Saudi Arabia were in hospitals in urban areas rather than in rural areas, which are often less developed and have lower quality health care services compared with the urban regions of Saudi Arabia [17]. It is noteworthy that 16.67% of the populations in Saudi Arabia are living in rural areas where the healthcare services, doctors, and other health professionals' characteristics and demographic characters differ from those of urban areas [18]. In addition, for downscaled healthcare services in rural areas, diabetic patients, particularly those with poorly controlled glucose levels, were facing an increased risk of life-threatening complications related to DM [19].

Because only little data is available on potential contributing factors accountable for glycemic control among diabetic individuals in rural areas, more information that lays a foundation for a comprehensive understanding of these risk factors is needed to help to scale the contextually tailored interventions to improve diabetic management and outcomes for people with DM

in this population. Improving glycemic control will help to reduce the risk of diabetic-related complications, reduce health care spending, and improve both quality and quantity of life. In the current study, we endeavored to evaluate the point prevalence rate of poor glycemic control and risk factors connected with it among the diabetic population living in the central rural region of Saudi Arabia with a large population.

## 2. METHODS

### 2.1 Study Designs and setting

The cross-sectional study design was performed to identify the prevalence rate and related risk factors of poor glycemic control among diabetic individuals attending the King Khaled Hospital and Prince Sultan Center for Health Care from the beginning of January 2019 to the end of June 2019. The hospital is located in the Al-Kharj governorate, which is a lightly populated small rural region in the central province of Saudi Arabia. King Khaled Hospital is operated by the Ministry of Health and provides services for ~12,560 inpatients, 147,443 outpatients, and 91,479 emergency cases each year.

### 2.2 Study Population

The population included males and females aged 26 years old and above who have been diagnosed with type 2 DM and were treated either with oral antidiabetic medications or insulin. To be eligible for this study, patients were required to have at least 12 months of therapy and continuous care at the time of data collection. Terminal patients, patients with cognitive impairments, pregnant women, patients with type 1 DM, and patients with no HbA1c in their medical records were excluded from the final dataset.

This research was reviewed and approved by the Ministry of Health's Institutional Review Board (IRB) number IRB00010471. Permissions from the Ministry of Health (MoH) as well as the hospital management were obtained to conduct this study. The present study was performed in accordance with the Declaration of Helsinki.

### 2.3 Definition of Poor Glycemic Control

Poor glycemic control was defined as current use of diabetic-lowering medication associated with HbA1c levels  $\geq 7\%$  on two separate occasions in accordance with the recommendations from the

ADA [7]. The records of HbA1c levels within the study period were used to determine the glycemic control status of the patient. HbA1c measurements that were obtained from urgent care visits were excluded from the analysis to rule out the chance of including transiently high glycemic levels resulting from acute illnesses.

### 2.4 Data Collection

Data were collected from patients' medical records by trained medical personnel. A patient's medical record consists of data of a patient's prior follow-up visits, including their HbA1c measurements, as well as the accurate list of a patient's medicines and other comorbidities. A well-designed and organized checklist was utilized to obtain and extract information from patients' medical records. Data covered demographic factors such as age and gender, and clinical-related factors such as data on comorbidities, complications of DM, and type of treatment.

### 2.5 Variable Definitions

The variable level of obesity was determined according to the body mass index (BMI). BMI was computed as weight (kg)/height ( $m^2$ ), and obesity was classified as *yes* when BMI is  $\geq 30$ , or *no* when BMI  $< 30$ , as per World Health Organization (WHO) weight classification [20]. Comorbidities were categorized as *yes* or *no* according to whether the patients have had any of the following co-morbidities: CVD (i.e. a diagnosis of angina, myocardial infarction, stroke, or heart failure), asthma (i.e. diagnoses of asthma), liver disease (i.e. diagnoses of cirrhosis, hepatitis, hepatic encephalopathy and liver steatosis), kidney disease (i.e. urinary albumin creatinine ratio (UACR)  $\geq 30$  mg/g and/or estimated glomerular filtration rate [eGFR]  $< 60$  mL/min/1.73  $m^2$ ), dyslipidemia (i.e. total cholesterol  $\geq 200$  mg/dl, triglycerides  $\geq 150$  mg/dl, LDL-C  $\geq 100$  mg/dL, or HDL-C  $\leq 40$  mg/dL in males and  $\leq 50$  mg/dL in females), and arthritis (i.e. diagnoses of arthritis). Because admission due to acute illnesses could potentially change laboratory test results, any lab results recorded during an acute admission were excluded.

### 2.6 Statistical Analysis

Obtained data were entered and analyzed using SAS version 9.4. Descriptive data were reported as frequencies, and percentages were used to examine the distribution of study variables

among patients whose glycemic control was considered poor ( $HbA1c \geq 7$ ) and patients whose glycemic control was considered good ( $HbA1c < 7$ ). Demographic information and clinical data of the study sample were processed as dichotomous or polychotomous variables. Chi-square test was utilized to evaluate the distribution of the groups with good glycemic control and poor glycemic control. Multivariate logistic regression was used with glycemic control status as the binary outcome measure (poor glycemic control / good glycemic control). The degree of correlation was shown as odds ratios (OR) with 95% confidence interval (95% CI) for each variable. Statistics were computed for patients with available (nonmissing) data. No imputation was performed for all tests, and a  $P$ -value less than 0.05 was considered to be statistically significant.

### 3. RESULTS

Table 1 displays patients, comorbidity, and complications and treatment characteristics according to their glucose control status. A total of 1,010 patients with DM were involved in the study. The majority (63.8%) of the study subjects were aged between 46 and 65 years. Female patients constituted 60.59% of the study population. A total of 49.76% of included patients were obese; 41.48% of patients were only on OAD therapy, while 29.71% were on insulin and 28.81% were on OAD + insulin.

The prevalence of poor glycemic control among the studied population was 50.89%. Subjects between 46 and 65 years were significantly higher among the poor glycemic control group ( $P < .0001$ ), and 57.17% of the patients with poor glycemic control were obese. Among comorbid disease, asthma was more prevalent among subjects with poor glycemic control ( $P = 0.0004$ ), whereas no significant difference has been seen regarding other comorbidities. When patients with no complications of DM were taken into account, poor glycemic control was significantly high in patients with nephropathy, retinopathy, and neuropathy.

According to the multivariable logistic regression model, only three variables (age, obesity, and having asthma) were noticed to be statistically significant determinants of poor glycemic control at  $p$ -value  $< 0.05$  (Table 2). Individuals between 45 and 65 years were found to be at greater risk of poor glycemic control compared to those aged

between 26 and 45 years (OR = 1.927, 95% CI: 1.143–3.248). Obese patients were more likely to experience poor glycemic control than their not-obese counterparts (OR = 1.496, 95% CI: 1.085–2.063). Patients with asthma were at higher risk of poor glycemic control compared to patients who were not asthmatic (OR = 2.062, 95% CI: 1.637–3.504).

### 4. DISCUSSION

Rigorous glycemic control is the principal goal for prevention of serious organ-related complications of DM [21]. The ADA suggested an HbA1c level of below 7% as a target for adequate glycemic control for most diabetic adults [7]. This study was carried out to measure the prevalence of poor glycemic control and find the risk factors correlated with it among diabetic patients in a central rural region of Saudi Arabia.

Our study reported a prevalence of 49.11% of poor glycemic control among the study sample. The reported prevalence rate in the current study was lower than values related to population in urban areas of Saudi Arabia [9-15] which can be attributed to the fact that disease is more prevalent in the urban areas than in the rural areas, 25.5% and 19.5%, respectively [22], except in those studies conducted in Riyadh, in which the prevalence rate was 43.1% [8]. However, the rates of poor glycemic control observed in this study seem unsatisfactory in comparison with the corresponding rates in some countries. A study conducted in two largely rural areas in central North Carolina showed that 36.4% of patients had poor glycemic control [23]. In addition to this, research conducted in the city of Calgary, Alberta, indicated that 5.6% of the total patients had poor status of glycemic control [24]. Likewise, another study conducted in a rural area in Southern India showed that poor glycemic control in diabetics was 42.6% [25].

Several of the poor glycemic control risk factors were found among the study population. We found a statistical correlation between age, that is, adults 46-65 years of age and poor glycemic control. Similar associations were noted in a study done in Singapore and another done in the Jimma zone, southwest Ethiopia [26,27]. Another study conducted in Tabuk, KSA concluded that age between 41 and 50 years was found to be the strongest predictor for poor glycemic control [11].

Table 1. Patients' characteristics and clinical aspects of the studied population (n = 1010)

Variable	Total, n	%	Glycemic control				P-value
			HbA1c<7		HbA1c ≥ 7		
			n	(%)	n	(%)	
Total	1010	100	514	50.89	496	49.11	
<b>Age group (years)</b>							<.0001
26-45	122	12.07	82	15.95	40	8.06	
46-65	652	64.56	300	58.37	352	70.97	
Older than 65	236	23.37	132	25.68	104	20.97	
<b>Gender</b>							0.4824
Female	612	60.59	306	59.53	306	61.69	
Male	398	39.41	208	40.47	190	38.31	
<b>Obesity</b>							<.0001
No	507	50.24	295	57.39	212	42.83	
Yes	502	49.76	219	42.61	283	57.17	
<b>Comorbidity</b>							
<b>Hypertension</b>							0.2315
No	458	45.44	243	47.28	215	43.52	
Yes	550	54.56	271	52.72	279	56.48	
<b>CVD</b>							0.3628
No	746	73.86	386	75.1	360	72.58	
Yes	264	26.14	128	24.9	136	27.42	
<b>Asthma</b>							0.0004
No	884	87.87	470	91.44	414	84.15	
Yes	122	12.13	44	8.56	78	15.85	
<b>Hypercholesterolemia</b>							0.3186
No	692	71.64	358	73.06	334	70.17	
Yes	274	28.36	132	26.94	142	29.83	
<b>Liver disease</b>							0.5463
No	902	89.31	462	89.88	440	88.71	
Yes	108	10.69	52	10.12	56	11.29	
<b>Anemia</b>							0.963
No	786	78.28	398	78.35	388	78.23	
Yes	218	21.72	110	21.65	108	21.77	
<b>Arthritis</b>							0.8162
No	708	70.01	362	70.43	346	69.76	
Yes	302	29.99	152	29.57	150	30.24	
<b>Type of treatment</b>							0.7198
OAD	419	41.48	218	42.41	201	40.52	
Only insulin	300	29.71	147	28.6	153	30.85	
OAD and insulin	291	28.81	149	28.99	142	28.63	
<b>Complications of diabetes</b>							
<b>Neuropathy</b>							<.0001
No	592	58.81	350	68.49	242	49.09	
Yes	412	41.19	161	31.51	251	50.91	
<b>Nephropathy</b>							<.0001
No	826	82.03	451	87.91	375	75.91	
Yes	181	17.97	62	12.09	119	24.09	
<b>Retinopathy</b>							0.0005
No	863	85.71	459	89.47	404	81.78	
Yes	144	14.29	54	10.53	90	18.22	

Abbreviations: CVD, cardiovascular disease; OAD: Oral Antidiabetic

**Table 2. Association of poor glycemic control with demographic and clinical characteristics using multivariate logistic regression**

Variable	OR	95 % CI		P-value
		Lower	Upper	
<b>Age group (years)</b>				
26-45	1			
46-65	1.927	1.143	3.248	0.0005
More than 65	1.036	0.574	1.87	0.1838
<b>Gender</b>				
Female	1			
Male	0.921	0.657	1.29	0.6307
<b>Obesity</b>				
No	1			
Yes	1.496	1.085	2.063	0.0141
<b>Comorbidity</b>				
<b>Hypertension</b>				
No	1			
Yes	1.238	0.895	1.712	0.1969
<b>CVD</b>				
No	1			
Yes	1.381	0.944	2.021	0.0961
<b>Asthma</b>				
No	1			
Yes	2.042	1.237	3.371	0.0052
<b>Hypercholesterolemia</b>				
No	1			
Yes	0.942	0.653	1.359	0.75
<b>Liver disease</b>				
No	1			
Yes	1.191	0.706	2.008	0.5118
<b>Anemia</b>				
No	1			
Yes	1.04	0.694	1.558	0.849
<b>Arthritis</b>				
No	1			
Yes	0.982	0.695	1.388	0.9187
<b>Type of treatment</b>				
OAD	1			
Only insulin	0.972	0.662	1.428	0.7759
OAD and insulin	1.046	0.711	1.541	0.7411

Abbreviations: OR, odds ratio; 95%CI, 95% confidence interval; CVD, cardiovascular disease; OAD: Oral Antidiabetic

Our results showed that obesity is the major contribution towards glycemic control in our study population with 57.1% of the poor glycemic control group being obese [25]. Similar findings were reported from Saudi Arabia [10], USA [28], Ethiopia [27], Turkey [29], India [30] and China [31]. Because people with impaired glucose levels and obesity are more prone for death from CVD and impaired insulin resistance [32], these results emphasize the need to embrace and foster new strategies for obesity management in this population to achieve the intended glycemic

level. This is particularly important given the fact that almost half of people with DM in the current study were in this category (49.7%).

Another concerning result of this analysis is that asthma was also a significant factor in poor glycemic control. This is supported by other published work in the USA [33]. Previous evidence demonstrated a high likelihood of developing a worse pulmonary function among people with DM than among nondiabetic controls [34]. In the same context, other studies found

that those with inadequate glucose control have impaired pulmonary function, compared to those with good glycemic control [35]. Given the cross-sectional nature of this study, it is difficult to derive causal relationships. A likely explanation of these observations is believed to be the result of glycosylation of proteins, such as lung connective tissue, and pulmonary microangiopathy or inflammatory changes in lungs resulting from hyperglycemia [36,37]. Hence, this remarkable finding highlights the importance of employing effective measures in the Saudi healthcare system to monitor the pulmonary function and avert our population from negative health impacts and later subsequent poor glycemic control.

Although our study included a larger sample size to ensure more accurate study results, the present paper still has several limitations that are worth considering. First, although the rural population is very homogeneous in Saudi Arabia, the rural data may differ from other rural areas and care should be taken in generalizing findings to other rural areas of Saudi Arabia. Second, we did not obtain information on lifestyle components (e.g., smoking and physical activity), which may influence glycemic control [38]. The third limitation is that data regarding individualized HbA1c targets of the study sample could not be obtained because it was not recorded in patients' medical records. Hence, an HbA1c threshold point of 7% was selected to categorize sufficient control, which is too strict for elderly who have had diabetes for a long time and those who have previous CVD [7].

These findings indicate a prompt action by the Ministry of Health would help diabetic patients achieve glycemic control in order to minimize the progression of disease and related costs and poor quality of life associated with long-term poor glycemic control [39]. Greater effort is crucial to evaluate the level of glycemic control among obese and asthmatic patients with DM and implement better approaches for achieving long-term glycemic control. Health education for patients was considered as the best choice to improve their self-care practices. It has been proven that DM-related self-care practices, such as diet control, being physically active, blood glucose monitoring, and medication adherence, can contribute to achieving the ideal glycemic control [40]. Besides the self-care practice, the Ministry of Health should initiate a proper screening protocol to detect and treat diabetic patients at risk of poor glycemic control.

## 5. CONCLUSION

Poor glycemic control among patients with DM, along with its many serious health problems, has been seen as a serious public health concern in both urban and rural areas. In this study, we found that the prevalence of poor glycemic control in a central rural region of Saudi Arabia is high compared with the corresponding rates in some countries. Therefore, it is necessary for the Ministry of Health to implement effective preventive procedures to improve glycemic control among people with DM living in rural areas.

## CONSENT AND ETHICAL APPROVAL

As per international standard or university standard guideline patients consent and ethical approval has been collected and preserved by the authors.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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