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Factors associated with glycemic control among patients with type 2 diabetes: a cross-sectional study

W. AL-QEREM[1], A.S. JARAB[2], M. BADINJKI[1], A. HAMMAD[1], J. LING[3], F. ALASMARI[4]

[1]Department of Pharmacy, Al-Zaytoonah University of Jordan, Amman, Jordan
[2]Department of Clinical Pharmacy, Faculty of Pharmacy, Jordan University of Science and Technology, Irbid, Jordan
[3]Faculty of Health Sciences and Wellbeing, University of Sunderland, Sunderland, United Kingdom
[4]Department of Pharmacology and Toxicology, College of Pharmacy, King Saud University, Riyadh, Saudi Arabia

Abstract. – OBJECTIVE: Achieving glycemic control significantly improves the progression of the disease among diabetes mellitus patients although this is not achieved by many diabetics. The aim of the study is to explore the factors associated with glycemic control among patients with type 2 diabetes.

PATIENTS AND METHODS: In addition to sociodemographic variables, beliefs about medications and medication adherence were evaluated using the validated Beliefs about Medications Questionnaire and the 4-item medication adherence scale. A cut-off point of HbA1c% <7 was used as an indicator of glycemic control. Stepwise binary logistic regression was conducted to explore the variables associated with poor glycemic control.

RESULTS: A total of 287 patients participated in the study. More than half (58%) were found to have poor glycemic control. Females had significantly higher odds of having controlled diabetes (OR=2.28, *p*-value <0.01). Increasing necessity for diabetes medications was significantly associated with improved glycemic control (OR=2.75, *p*-value <0.01). Participants in low or moderate adherence groups had significantly higher odds of having uncontrolled diabetes.

CONCLUSIONS: Future diabetes management programs should focus on emphasizing medication necessity and improving medication adherence, particularly for male patients, with the aim of improving glycemic control and health outcomes among patients with type 2 diabetes.

Key Words:
Type 2 diabetes glycemic control, Medication adherence, BMQ.

Introduction

In 2019, the estimated worldwide prevalence of diabetes was 9.3%, which accounts for 463 million individuals[1]. In Jordan, prevalence of diabetes is even higher (12.9%)[2]. Moreover, patients with diabetes have 2-3-fold risk of mortality compared to the general population[3]. Diabetes mellitus has several complications that lead to the higher mortality rate and decreased quality of life. These complications include cardiovascular disease, chronic kidney disease, peripheral vascular disease, cerebrovascular disease, diabetic retinopathy, and diabetic neuropathy[4]. Around 90-95% of patients with diabetes have type 2 diabetes, and high prevalence of diabetes-related complications in these patients has been reported. For example, the prevalence of chronic kidney disease among patients with type 2 diabetes is 28.32%[5], cardiovascular disease is reported in 32%[6], and diabetic retinopathy is found in 19.4%[7]. Morbidity, mortality, and disease complications in patients with diabetes are all highly associated with glycemic control.

Glycosylated hemoglobin (HbA1c) is a reliable biomarker of diabetes prognosis and has a high correlation with the risk of long-term diabetes complications[8]. According to the United Kingdom Prospective Diabetes Study (UKPDS), a 1% reduction in HbA1c% is associated with 21% reduction in diabetes-related deaths, 14% reduction in myocardial infarction risk, and 37% reduction in microvascular complications[9]. However, systematic reviews[10] have revealed that less than half of those with diabetes achieve glycemic control based on HbA1c%.

Corresponding Author: Walid A. Al-Qerem, Ph.D; e-mail: waleed.qirim@zuj.edu.jo

Several factors have been associated with low glycemic control among patients with type 2 diabetes, including lack of education about the disease, polypharmacy, duration of diabetes[11], rural residence and lower education, among others[12]. Identification of the factors associated with poor glycemic control is important for the development of interventions to improve glycemic control and prevent target organ damage and other chronic complications arising from diabetes. The current study aimed to explore these factors to address them in future intervention programs.

Patients and Methods

Study Design and Subjects

The present cross-sectional study utilized the data from an earlier study which was conducted to explore the variables associated with medication adherence among patients with type 2 diabetes attending the National Center for Diabetes, Endocrinology and Genetics (NCDEG) in Amman, Jordan in the period from January through December 2020[13]. The patients were included in the study if they were 18 years of age or older, had been diagnosed with diabetes for at least one year, and were taking one or more anti-diabetes medication. Patients with cognitive impairment were excluded from the study. Out of 360 patients who matched the inclusion criteria, 287 (79.7%) agreed to participate and signed consent. Patients were assured that their participation was voluntary, and they had the right to withdraw from the study at any time and without penalty. The surveys were conducted in a private room at the outpatient clinic with an average duration of 15 minutes for each interview. Ethical approvals were obtained from NCDEG (Approval Number 1/2020) and Al-Zaytoonah University (Approval Number 22/23/2019-2020) ethical committees. The study was carried out following the Declaration of Helsinki ethics. The manuscript adhered to The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Study Instruments

Socio-Demographics and Disease Characteristics

Participants' socio-demographic data including age, sex, household monthly average income, and education level were collected using a customized questionnaire. The participants were classified based on their household monthly average income into a low-income group with an average monthly income of less than 1000 Jordanian Dinars (JOD) (equivalent to $1400) and a high-income group for those who earn 1000 JOD or more. This cut-off is the average monthly income for Jordan. Similarly, two groups based on education levels were created with those with a diploma degree or less placed in the low education group and those with bachelor's degree or higher placed in the highest education group. Participants' medical files in the NCDEG were used to obtain medical data, including disease duration, prescribed medications and dosage regimens, medication costs and other biomedical variables including systolic (SBP) and diastolic (DBP) blood pressure, glycosylated hemoglobin (HbA1c), lipid profile including total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C) and serum triglyceride (TG) and serum creatinine. HbA1c% cut-off point of 7% was used to classify the participants to controlled diabetes (HbA1c% < 7%) and uncontrolled diabetes (HbA1c% ≥ 7%)[14].

Beliefs About Medications Questionnaire

The validated Arabic Beliefs about Medications Questionnaire specific (BMQ-specific)[15] was used in the current study. BMQ-specific includes 10 items distributed into two scales. The first scale evaluated patients' beliefs about medications' necessity and the second one evaluated belief about medication concerns. Both scales consisted of five statements responded to using a 5-point Likert scale. The responses for the statements were 1: "Strongly disagree", 2: "Disagree", 3: "Not certain", 4: "Agree" and 5: "Strongly agree". The necessity and concerns scores were calculated as the mean of the responses of the statements to each scale.

The 4-Item Medication Adherence Scale

The validated Arabic version of the 4-item medication adherence scale was used to assess participants' adherence to their medications with "yes" or "no" responses. to calculate the adherence score, a "yes" response was granted one point and "no" was granted zero. Three groups of adherence level were created: high adherence for participants who scored zero, moderate adherence for participants who scored 1-2 points, and low adherence for those who scored 3-4 points (Figure 1).

Pilot Study

Thirty participants who met the inclusion criteria, were involved in the Arabic version questionnaires (socio-demographic sheet, 4-IMAS, and BMQ-specific) that was already previously validated. The participants agreed that all the questions presented in this study were comprehensible and clear. The data generated from this pilot study were excluded from the final analysis.

Sample Size Calculation

The equation used to compute the minimum required sample size to conduct binary regression is: required sample size = 50+8P, where P is the number of predictors. We aimed to assess 8 independent variables described in the regression model. Therefore, the minimum required sample size to conduct this study was 114.

Statistical Analysis

All data were analyzed using SPSS version 25 (SPSS Corp., Armonk, NY, USA). Frequencies and percentages were used to present categorical variables, while means and standard deviations (SD) were used to present continuous variables. Cronbach's alpha was computed to confirm internal consistency of the Necessity and Concerns statements and the results indicated high reliability (0.93 and 0.81, respectively). Stepwise binary logistic regression was conducted to evaluate variables associated with participants' glycemic control. The independent variables included in the model were diabetes duration, necessity score, concerns score, adherence level, age, household monthly average income, education, and number of medications. Because of the high significant correlation between total medication cost, medication frequency, and number of medications, only number of medications was included in the model.

Results

A total of 287 patients participated in the study. As shown in Table I, the sample mean age was 56 (±14). The majority of the participants had a high education level, and they were roughly equally divided with regard to sex and mean monthly income. The mean of diabetes duration was 6.04 (±3.52) years, and the mean number of medications

Table I. Socio-demographics and medical profile of the study participants (n=287).

	Frequency (%)	Mean (± SD)
Age		56 (± 14)
Sex		
Female	157 (54.7)	
Male	130 (45.3)	
Household monthly average income*		
≤ 1000 JD	123 (42.9)	
> 1000 JD	164 (57.1)	
Education level**		
Low education	222 (77.4)	
High education	65 (22.6)	
Diabetes duration		6.04 (± 3.52)
Number of medications		6.66 (± 3.36)
Frequency of taking medications per day		4.67 (± 2.29)
Diabetic medications	248 (86.4)	
Metformin	83 (28.9)	
DDP4- Inhibitor	89 (31.0)	
Sulfonylurea	13 (4.5)	
SGLT2 Inhibitor	105 (36.6	
Insulin	248 (86.4)	
Receiving Statin	113 (39.4)	
Lab tests		
HbA1c%		7.7 (± 1.8)
Creatinine		0.90 (± 0.46)
Triglycerides		178.35 (± 157.72)
Total cholesterol		161.87 (± 40.01)
LDL		104.02 (± 32.70)
HDL		46.48 (± 13.97)

*Jordanian dinars equivalent to $1400. Low education level included diploma or lower, high education level included bachelor's degree or higher. DDP4: Dipeptidyl peptidase-4, SGLT2: Sodium-Glucose Cotransporter.

was 6.66 (±3.36). The most common prescribed antidiabetic medication was metformin (86.4%) and the least was SGLT2 inhibitor (4.5%). Statins were the most prescribed non-antidiabetic medication (39.4%). The HbA1c% mean was 7.7 (±1.8), and the lipid profile tests means were as follows: TG 178.35 (±157.72), TC 161.87 (±40.01), LDL-C 104.02 (±32.70), and HDL-C 46.48 (±13.97). Mean diabetes medication cost was 28.58 (±28.90) JOD, equivalent to $40.20 (±$40.70), with a maximum cost of 160.64 JOD/month ($266.25).

Table II shows the means (±SD) for the BMQ-specific statements. The statement with the lowest mean in the necessity part was "My life would be impossible without my medicines" (3.46±0.92) while the statement with the highest mean was "Without my medicines I would become very ill" (3.61±0.85). For the concerns part, the statement with the lowest mean was "My medicines disrupt my life" (3.00±0.49) and the statement with highest mean was "Having to take medicines worries me" (3.16±0.61).

As shown in Figure 1, only 12.2% of the participants had low adherence, 46.7% had moderate adherence and 41.1% had high adherence.

A total of 168 (58.5%) participants did not achieve glycemic control (HbA1c < 7%). Stepwise binary logistic regression (forward: conditional) was conducted to assess the association between the participants glycemic control and different participants characteristics. As shown in Table III, females had significantly higher odds of having controlled blood glucose when compared to male patients (OR=2.28, *p*-value <0.01). Participants in low or moderate adherence groups had significantly higher odds of having uncontrolled blood glucose when compared to the participants in the high adherence group. Increasing necessity for diabetes medications was significantly associated with increased blood glucose control (OR=2.75, *p*-value <0.01).

Discussion

Less than half of the participants in this study (41.5%) achieved the target HbA1c of <7%. This is better than in studies conducted in Jordan (34.9%)[16], Palestine (20.3%)[17] and West Indies (15%)[18], but worse than that reported in another Jordanian study conducted in 2009 (56.1%)[19]. Studies that used higher HbA1c% targets also showed high percentages of poor glycemic control among the participants[8,9]. Comparing the current study's results to those that evaluated the degree of control in other diseases in Jordan shows that diabetes control is comparable to dyslipidemia control (39%)[20], and worse than hypertension control (44%)[21].

Conflicting results have been reported in studies that assessed the factors associated with diabetes control. Little information is available on the variables that strongly predict glycemic control in clinical settings. Sex was the only non-modifiable patient-related factor as male sex was significantly associated with decreased glycemic control. This contrasts with other studies in which males had significantly lower HbA1c% levels[10,11]. In the

Table II. Beliefs about Medicines Questionnaire (n=287).

	Strongly Agree/Agree Frequency (%)	Mean (±SD)
Necessity Statements		
My health, at present, depends on my medicines	166 (57.8)	3.52 (± 0.91)
My life would be impossible without my medicines	155 (54)	3.46 (± 0.92)
Without my medicines I would become very ill	174 (60.6)	3.61 (± 0.85)
My health in the future will depend on my medicines	172 (59.9)	3.56 (± 0.90)
My medicines protect me from becoming worse	172 (59.9)	3.60 (± 0.87)
Concern Statements		
Having to take medicines worries me	65 (22.6)	3.16 (± 0.61)
I sometimes worry about the long-term effects of my medicines	81 (28.2)	3.08 (± 0.75)
My medicines are a mystery to me	47 (16.4)	3.02 (± 0.64)
My medicines disrupt my life	26 (9.1)	3.00 (± 0.49)
I sometimes worry about becoming too dependent on my medicines	80 (27.9)	3.13 (± 0.72)
Beliefs about Medicines scores		
Necessity		3.55 (± 0.79)
Concerns		3.08 (± 0.49)

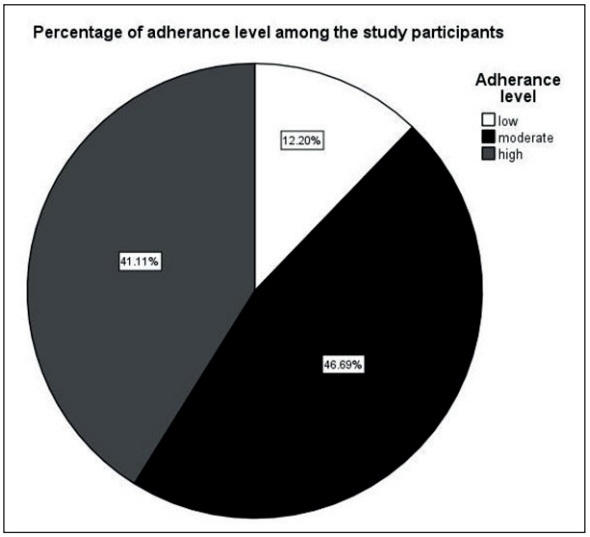

Figure 1. Percentage of adherence levels among the study participants.

present study, females reported better medication adherence which may have contributed to their improved glycemic control.

Consistent with findings from an earlier study in Jordan[24], medication adherence was significantly associated with improved glycemic control in the present study. Medication adherence was also associated with glycemic control in studies conducted in Indonesia[25], and the United States[26]. Likewise, poor medication adherence was associated with poor disease control in patients with hypertension[27], and dyslipidemia[20]. Several strategies have been effective at enhancing medication adherence. One of these strategies is a 30-minute consultation session which had a positive effect on patients' adherence to oral antidiabetic medications in the United Kingdom[28]. Other strategies that helped improve adherence include educational interventions conducted by healthcare providers, risk communication interventions, packaging and daily reminders[29].

Patients' perception of medication necessity was significantly associated with improved glycemic control in the present study, which is inconsistent with the results of studies conducted in Palestine[30], and the United States[31] where patients' beliefs about medication had no association with glycemic control. Several studies[32,33] found that positive patients' beliefs were associated with better adherence, and therefore, improved glycemic control. Future diabetes management interventions should focus on the benefits and minimize the concerns about receiving diabetes medications for patients with type 2 diabetes.

Limitations

One of the study limitations is selection bias as individuals who were interested in the study aims would be more likely to participate. Other limitations may include recall and social desirability biases as the study was based on data from self-report questionnaires. Lastly, the participants were recruited from only one center which affects the generalizability of the study findings; however, the NCDEG is the only specialized diabetes center in Jordan which has patients from across Jordan.

Conclusions

Glycemic control is crucial in diabetes management and for prevention of disease complications. Nevertheless, most of the current study participants did not achieve glycemic control. Future diabetes management programs should focus on improving medication adherence and beliefs about diabetes medications particularly for male patients, with the aim of improving glycemic control and health outcomes among patients with type 2 diabetes.

Table III. Multiple predictor analysis of variables associated with glycemic control (n =287).

	B	*p*-value	Odds ratio	Confidence interval of 95%	
				Lower	Upper
Sex					
Females compared to males	0.82	< 0.01	2.28	1.31	3.97
Adherence level					
Low adherence compared to high adherence	-1.27	0.04	0.28	0.08	0.96
Adherence level					
Moderate adherence compared to high adherence	-1.01	< 0.01	0.36	0.19	0.70
Necessity score	1.01	< 0.01	2.75	1.61	4.70

Conflict of Interest
The Authors declare that they have no conflict of interests.

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Availability of Data and Material
The datasets generated and analyzed during the current study are available at Mendeley repository, doi: 10.17632/v3s8hmht67.3.

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