ORIGINAL RESEARCH

Illness Perceptions, HbA1c, And Adherence In Type 2 Diabetes In Saudi Arabia

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Purpose: Little is known about predictors of adherence to diabetes medication in Saudi Arabia. This study aimed to investigate whether illness perceptions, beliefs about medicine, and God locus of health control beliefs were associated with adherence to medication and glycaemic control (HbA1c) in Saudi patients with type 2 diabetes (T2D).

Patients and methods: A convenience sample of 115 adults with T2D were recruited from a diabetes outpatient clinic. Validated self-reported measures of adherence to medication, illness perceptions, beliefs about medicine, and God locus of health control were administered. Patients' most recent HbA1c levels were extracted from medical records. Multivariable logistic and linear regressions were used to examine the association between illness perceptions, beliefs about medicine and adherence to medication and HbA1c.

Results: More than two thirds of patients (69%) reported poor adherence to medication. All illness perceptions domains, beliefs about medicine, and God locus of health control beliefs were associated with adherence. Multivariable logistic regression revealed that older age (OR= 3.76, p= 0.023), worse consequences perceptions (OR= 0.21, p= 0.011), worse illness identity (OR= 0.23, p= 0.010), and greater illness coherence (OR= 3.24, p= 0.022) were independent predictors of adherence. Two thirds of patients (67%) had suboptimal HbA1c; and perceptions of a cyclical timeline and lower insulin effectiveness were associated with higher HbA1c. In multiple linear regression, perceptions of a cyclical timeline (β= 0.19, p= 0.040) were an independent significant predictor of HbA1c.

Conclusion: In Saudi Arabia, patients' perceptions of T2D, beliefs about medicine, and God locus of control beliefs are associated with adherence. These results inform the development of interventions based on the Common-Sense Model (CSM) to encourage improved adherence and glycaemic control among Saudi patients with T2D. Further research with larger and more diverse samples is warranted to expand the generalizability of these findings.

Keywords: type 2 diabetes, adherence, glycaemic control, illness perceptions, Saudi Arabia

Introduction

Diabetes Mellitus is a chronic condition that affects approximately 425 million people worldwide, 79% of whom live in low-and middle-income countries. This estimate is projected to increase to 629 million by 2045.[1] Type 2 diabetes (T2D), the most common type of diabetes, is emerging as an epidemic in Saudi Arabia, affecting a large proportion of the population.[2] There has been an 8% increase in the prevalence of diabetes over the past 10 years and currently 18.5% of the Saudi population is affected by diabetes.[1]

Self-management of T2D is crucial in order to minimize the risk of developing complications and improve overall health outcomes.[1] Self-management behaviours

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include taking medications regularly, following a healthy diet, being physical active, blood glucose self-monitoring, foot care and smoking cessation, with an overall goal of achieving and maintaining balanced glycaemic control (HbA1c < 7%).[1] There are serious consequences of non-adherence to diabetes medication, including suboptimal glycaemic control,[3] increased mortality and hospitalization.[4] Considerable evidence indicates that non-adherence to diabetes medication and other self-management behaviours among patients with T2D is common,[5] with less than 50% of patients achieving glycaemic control.[6] It is well recognized that non-adherence is a multifaceted problem, influenced by a wide range of factors including demographic, personal, social, religious, cultural, condition, treatment and health system related factors.[7,8]

Research based on the Common-Sense Model (CSM)[9,10] has highlighted the role that illness perceptions play in determining health outcomes across a wide range of chronic illnesses.[11,12] The CSM proposes that individuals' mental representations of illness influence their coping behaviours. More specifically, cognitive representations of illness include perceptions about the illness' identity, timeline, consequences, controllability, and cause, whereas emotional representations include emotions in response to the illness. According to the CSM, these representations shape and guide self-management behaviours (e.g. adherence to medication),[9] which in turn affect health outcomes.

Horne and colleagues extended the CSM to integrate patients' beliefs about treatment and showed that these beliefs affect adherence to treatment regimens.[13–15] This extension of the CSM became known as the Necessity-Concerns Framework (NCF). This framework postulates that individuals undertake a cost-benefit analysis, where beliefs about the necessity of medicine are weighed against beliefs concerning potential adverse effects. Individuals who perceive medicines as necessary and have fewer concerns about adverse effects are more likely to adhere to treatment.[16]

Considerable evidence shows that illness perceptions are associated with adherence to diabetes medication and glycaemic control in patients with T2D. Lower perceptions of consequences, emotional distress, illness identity and higher perceptions of personal control were associated with adherence to diabetes medication in several studies.[17] Furthermore, greater perceptions of personal control were associated with lower HbA1c levels, whereas higher perceptions of treatment control and illness identity were associated with higher HbA1c levels.[18] A meta-analysis

found that greater perceptions of consequences, illness identity, cyclical timeline, emotional distress, and concerns about diabetes were all significantly correlated with higher HbA1c levels.[19] On the other hand, stronger perceptions of personal control over diabetes showed a significant correlation with lower HbA1c levels.

Beliefs about medicine have also been found to affect adherence to diabetes medication in patients with T2D, but not glycaemic control. A meta-analysis found that higher perceptions of necessity and fewer concerns about medicine-related adverse effects were associated with adherence to medicine across a number of long-term conditions including diabetes.[16] However, necessity and concerns beliefs about medicine did not predict glycaemic control.[20,21]

Research has shown differences between ethnic groups in how people perceive diabetes, which supports the idea that illness perceptions are influenced by cultural contexts.[22,23] For example, Tongan patients reported shorter and more cyclical perceptions of illness timeline, more emotional reactions to diabetes, and lower perceptions of treatment control than New Zealand Europeans, all of which were associated with non-adherence to diabetes medication in this group.[22] Pacific Island patients perceived T2D to have more severe consequences, attributed more symptoms to their T2D, and reported greater emotional responses than New Zealand European and South Asian patients.[23]

Around the time that the Common-Sense Model was being developed, research was being conducted into multidimensional locus of health control beliefs and their influence on self-care behaviours.[24,25] Locus of control beliefs include beliefs in self-control over health (internal locus), beliefs in chance health outcomes, and beliefs that powerful others can control health.[24] Locus of health control beliefs have been shown to influence adherence to treatment regimens and glycaemic control in patients with diabetes.[26] For example, high internal locus of health control beliefs were associated with better adherence to self-management behaviours[27] and better glycaemic control in patients with diabetes.[28] God Locus of Health Control (GLHC), is a particularly important construct given the dominance of religious beliefs in Saudi Arabia. GLHC refers to the extent to which individuals believe that God is in control of their health.[29] Available research indicates that patients with high GLHC beliefs are less likely to adhere to their treatment regimen.[30–32]

Non-adherence to diabetes medication is a major concern, especially in Saudi Arabia, where the prevalence of diabetes is high and continues to increase dramatically.[2] Non-adherence to diabetes medication is highly prevalent among Saudi patients, with reports of non-adherence ranging from 38% to 57%.[33–36] Less than 50% of Saudi patients achieve optimal glycaemic control.[37,38] It is important that research is conducted into modifiable factors associated with non-adherence so that interventions can be implemented to increase adherence to diabetes medication in this population.

Although studies have shown that illness perceptions and beliefs about medicine are associated with adherence in T2D in Western countries,[16,17,39] only six studies (two studies on illness perceptions, and four studies on beliefs about medicine), have been conducted in the Middle East region using the CSM. In Libya, lower perceptions of treatment control and higher perceptions of illness identity were significant predictors of non-adherence to diabetes medication among patients with T2D.[40] In Iran, longer perceptions of chronic timeline predicted adherence to diabetes medication.[41] Research on beliefs about medicine and adherence has been conducted in Saudi Arabia,[34] Iraq,[21] and Palestine[42] and findings were consistent with previous work.[16] Further research is needed to explore the associations between illness perceptions, medication beliefs, and adherence in Saudi Arabia, including God locus of health control beliefs, given the dominance of religious beliefs in the region.[32]

It is important to study GLHC and NCF beliefs alongside illness perceptions in this population, because they expand the scope of the CSM and may provide further insights into links between patients' beliefs and adherence. The aim of this study was to investigate whether illness perceptions, beliefs about medicine, and God locus of health control beliefs were associated with adherence to diabetes medication and glycaemic control in Saudi patients with T2D. We hypothesized that non-adherence to diabetes medication would be associated with greater consequences perceptions, lower personal and treatment control perceptions, shorter timeline perceptions, greater cyclical timeline perceptions, higher illness identity perceptions, higher concern perceptions, lower coherence perceptions, stronger emotional responses, lower beliefs about the necessity of medicine, higher concerns about medicine, and greater God locus of health control beliefs. We hypothesized that suboptimal glycaemic control would be associated with greater consequences perceptions, lower

personal control perceptions, greater cyclical timeline perceptions, higher illness identity perceptions, greater concerns, stronger emotional responses, and greater God locus of health control beliefs. Perceptions of treatment control, timeline (acute/chronic), coherence, necessity and concerns beliefs about medicine were hypothesized to be unrelated to glycaemic control.

Materials And Methods
Participants And Sampling
The study sample consisted of Saudi patients with T2D attending a diabetes outpatient clinic. Participants were recruited using a convenience sampling technique. Inclusion criteria were 18 years of age or older, a confirmed diagnosis of T2D for at least one year, and taking oral medications and/or insulin. Patients who were pregnant, ill on the day of recruitment, or not taking any medications for T2D were excluded. The sample size was calculated using G*Power software.[43] In the literature, associations between illness perceptions, adherence to medication, and HbA1c range between 0.60 and −0.26 respectively.[23,44] Using the lower correlation (r= −0.26) with 80% power and 0.05 alpha,[45] 113 participants were required.

Design And Setting
A cross-sectional design was employed. This study was conducted at a diabetes outpatient clinic in Najran, Saudi Arabia. The clinic offers various services including clinician consultations, health education, medication dispensing, foot and vision screening. The clinic is also responsible for treating and monitoring patients with diabetes in inpatient units.

Measures
The questionnaire collected information regarding the patients' age, sex, marital status, educational status, employment status, and monthly income. The questionnaire included questions related to smartphone ownership, access to Internet, use of apps to manage T2D, and patients' preferences for a future possible intervention (online, face-to-face or group sessions). Other self-report measures were included as detailed below.

Adherence To Medication
Participants' adherence to diabetes medications was measured using the Arabic version of Medication Adherence Report Scale (MARS-5).[15,46] The MARS-5 contains five

items that ask about the frequency with which participants did not adhere to their medication. The first item is concerned with forgetfulness (unintentional non-adherence), whereas, the other 4 items are concerned with changing doses, stopping doses, skipping doses, and taking less medication than instructed (intentional non-adherence). The MARS-5 is scored using a five-point Likert scale ranging from "1= always" to "5= never". The total score ranges between 5 and 25, with higher scores indicating higher self-reported adherence. The MARS-5 was originally developed for and validated in patients with asthma, but also has been used in other long-term conditions including diabetes.[44,47,48] The MARS-5 has been translated into other languages including Arabic.[49] In this study, internal consistency for the MARS-5 was 0.84.

A clear cut-off point to define non-adherence has not yet been defined, with some studies using a score of ≤ 24 to indicate non-adherence,[47] while other studies used a score of > 20 to indicate adherence.[48] In this study, scores on the MARS-5 showed a skewed distribution, and hence were dichotomized. Consistent with previous research with Arabic-speaking populations,[49] patients with a score of ≥ 24 were considered adherent in this study.

Illness Perceptions

The Arabic version of the Brief Illness Perception Questionnaire (B-IPQ) was used to assess participants' illness perceptions.[18] The B-IPQ consists of nine-items that assess cognitive and emotional perceptions of illness: consequences, timeline, (acute/chronic), personal control, treatment control, illness identity, concern, coherence, and emotional response. The first eight items are scored using a 10-point scale, with higher scores indicating stronger perceptions. The final item is an open-ended question which asks participants to list the three most likely causes of T2D. Responses to this question were categorized into 4 groups (psychosocial factors, behavioural factors, hereditary factors, and God's will). The B-IPQ has been widely used across a number of illnesses and different ethnic groups.[11] The original, as well as the Arabic version of the B-IPQ have demonstrated good psychometric properties.[11,18,50]

Six additional questions were added to the B-IPQ, extending the item list from 9 to 15. A single item about how patients perceive the cyclical timeline of their T2D was added (How much does your illness vary from day to day?) scored using a 10-point scale, where 0= very stable and 10= very changeable. The remaining five additional

questions asked patients about their perceptions of the effectiveness of self-management behaviours (diet, exercise, weight management, oral medication and insulin treatment).[17] Format and scoring of these additional questions were similar to the original B-IPQ items.

Beliefs About Medicine

Beliefs about medicine were assessed using the Arabic version of the Beliefs about Medicines Questionnaire-Specific (BMQ-Specific).[46] It includes two subscales, which evaluate patients' perceptions of the necessity of medicine in controlling their illness (Necessity-Specific) and concerns about potential adverse effects of medicine (Concerns-Specific). Each subscale consists of 5 items and is scored on a 5-point Likert scale. High scores on the Necessity-Specific subscale indicate that the patient perceives their medicine as necessary, whereas, high scores on the Concerns-Specific subscale indicate that the patient is concerned about potential adverse effects. The original, as well as the Arabic version of the BMQ have demonstrated good psychometric properties.[46,49] In the current study, both subscales demonstrated good internal consistency (α=0.88 for Necessity-Specific; and α=0.77 for Concerns-Specific).

God Locus Of Health Control

The God Locus of Health Control (GLHC) is a self-report, unidimensional scale that assesses the extent to which individuals believe that God has control over their health.[29] The GLHC consists of 6-items scored on a 6-point Likert scale (1= strongly disagree to 6= strongly agree). Item scores are summed to give a total score ranging between 6 and 36, with higher total scores indicating a greater belief that God has control over one's health. The original, as well as the Arabic version of the GLHC have demonstrated adequate reliability and validity.[29,31] The GLHC exhibited excellent internal consistency in the present study (α=0.97). Responses on the GLHC were positively skewed and hence scores were dichotomized into two categories (a score of 36 indicates that God is in total control and a score of ≤ 35 indicates that God is somewhat in control).

Clinical Data

Information regarding BMI, duration of diabetes, type and number of prescribed medications, number of comorbid conditions, number of diabetes-related complications, and patients' most recent HbA1c levels were extracted from medical records. HbA1c levels of ≥ 8% indicated

suboptimal glycaemic control in patients with T2D and increase the risk of diabetes-related complications and serious comorbid conditions.[51]

Data Collection

The first author approached and screened potential participants for eligibility at the diabetes outpatient clinic waiting areas. Patients who were eligible and provided written informed consent were asked to complete the questionnaires while waiting for their appointments. Participants who were old or unable to read the questionnaire independently were assisted by the first author. Data collection occurred between 18th of Feb and 18th of March 2019. Patients received no compensation for participation. This study was approved by the Saudi Ministry of Health, King Fahad Medical City (IRB 18-353E). Ethics approval was also ratified by the University of Auckland Human Participants Ethics Committee. This study complied with the Declaration of Helsinki.

Statistical Analysis

Kolmogorov–Smirnov and Levene's tests were used to inspect the normality and homogeneity of variance of the data. Non-parametric tests were used when distributions did not meet parametric assumptions. Correlation analyses (Spearman's rho and point biserial coefficients), logistic regression, chi square, and ANOVA were used to examine the relationships between variables. Logistic regression and hierarchical multiple linear regression were used to examine predictors of adherence to diabetes medication and HbA1c respectively. In all tests, statistical significance was set at $p < 0.05$ (two-tailed). When data were missing for one or two items, scores were imputed using the mean score, however, when data was missing for a whole scale, scores were excluded from analysis. Data analysis was conducted using the IBM SPSS Statistics version 25.[52]

Results

Descriptive Statistics

A total of 173 patients were approached and screened for eligibility. Forty-six patients did not meet the inclusion criteria (22 patients had type 1 diabetes; 8 patients were too ill, 6 patients had T2D for less than a year, 3 patients were pregnant, and 7 patients were not taking diabetes medication). Of the 127 patients who were eligible, 115 participants agreed to participate (91% response rate).

All participants were Muslim Saudi nationals, with a mean age of 56 years (SD 12.43). The majority of the sample were male (58%) and married (72%). Less than one third of the sample had tertiary education (24%), were employed (28%), and earned 5000 Saudi Riyal (≈ 1333 USD) or less a month (21%). The mean BMI was 30.94 (SD 5.05), with the majority of patients either overweight (32%) or obese (56%). Most patients were non-smokers (78%).

The mean time since diagnosis was 10.33 years (SD 7.60). More than half of patients (56%) were prescribed both oral medications and insulin. There were significant comorbidities, including dyslipidaemia, hypothyroidism, and hypertension. Diabetes-related complications were also common among patients, including coronary heart disease, retinopathy, and nephropathy. The mean HbA1c was 8.72% (SD 1.37), with 67% of patients exhibiting suboptimal glycaemic control (HbA1c > 8%).

Less than half of patients (47%) reported that they owned a smartphone, had frequent access to the Internet (37%), often used apps (38%), and none of the patients had used apps to help them manage their T2D. In addition, the majority of patients reported that they would prefer a face-to-face intervention (89%) delivered in Arabic language, compared to group-based (5%) and online-based intervention (7%).

Table 1 shows the mean scores for illness perceptions, beliefs about medicine, GLHC, and medication adherence. Based on the cut off point for the MARS-5, adherence to diabetes medication was suboptimal for 69% of patients.

Bivariate Relationships With Adherence To Medication And HbA1c

None of the demographic or clinical variables showed significant correlations with adherence ($p > 0.05$). Illness perception domains, beliefs about medicine and the belief that God is in less control were all associated with adherence to diabetes medication (see Table 2).

Females exhibited higher HbA1c levels (mean 9.05%, SD 1.41) than males did (mean 8.48%, SD 1.31) ($p= 0.027$). The number of comorbid conditions was also associated with HbA1c $F (2, 112) = 3.250$, $p= 0.042$. Tukey HSD post-hoc analysis indicated that patients with one comorbid condition exhibited significantly higher HbA1c than patients with no comorbidities (mean difference: 0.72, $p= 0.034$, 95% CI: 0.04, 1.40). The differences in HbA1c between patients with one comorbid condition and those with two or more comorbid

Table I Means And Standard Deviations For Study Variables

Variable	Mean (SD) Or N (%)	Range	n
MARS-5			
Forgetting medication	3.83 (1.17)	1-5	115
Altering dose	3.77 (1.00)	1-5	115
Stopping medication	4.37 (0.78)	1-5	115
Skipping dose	4.57 (0.80)	1-5	115
Taking less than instructed	3.96 (1.02)	1-5	115
MARS-5 total score	20.50 (3.75)	5-25	115
B-IPQ			
Consequences	6.95 (2.36)	0-10	115
Timeline (acute/chronic)	9.07 (1.05)	0-10	115
Personal control	5.49 (2.21)	0-10	115
Treatment control	6.69 (2.53)	0-10	115
Identity	6.95 (1.58)	0-10	115
Concerns	6.87 (2.53)	0-10	115
Coherence	3.68 (2.26)	0-10	115
Emotional response	6.13 (1.73)	0-10	115
Timeline (cyclical)	8.30 (1.65)	0-10	115
Oral medication effectiveness	6.88 (2.20)	0-10	115
Insulin effectiveness	6.85 (1.99)	0-10	62
Diet effectiveness	3.96 (2.74)	0-10	115
Weight management effectiveness	3.98 (2.77)	0-10	115
Physical activity effectiveness	5.60 (2.59)	0-10	115
Perceived causes of T2D			72
Psychosocial factors	3 (4%)		
Behavioural factors	46 (64%)		
Hereditary factors	44 (61%)		
God's will	19 (26%)		
BMQ			
Necessity-Specific	17.54 (4.43)	5-25	114
Concerns-Specific	19.97 (3.52)	5-25	114
GLHC			
GLHC total score	33.55 (4.48)	6-36	105

Abbreviations: MARS-5, Medication Adherence Report Scale; B-IPQ, Brief Illness Perception Questionnaire; BMQ, Beliefs about Medicines Questionnaire; GLHC, God Locus of Health Control; SD, Standard Deviation.

conditions (mean difference: 0.42, p= 0.425, 95% CI: −0.38, 1.21) and between patients with no comorbidities and those with two or more comorbid conditions (mean difference: −0.30, p= 0.662, 95% CI: −1.13, 0.53) were not statistically significant. HbA1c showed a positive association with perceptions of cyclical timeline (r= 0.20, p= 0.033) and negative association with perceptions of insulin effectiveness (r= −0.26, p= 0.044).

The majority of patients perceived their T2D was caused by behavioural factors (64%), followed by hereditary factors (61%), God's will (26%), and psychosocial factors (4%). Patients in the adherent group were more

likely to perceive behaviour as a cause (χ^2=10.65, df= 1, p= 0.001), less likely to perceive hereditary factors as a cause (χ^2=8.79, df= 1, p= 0.003), and less likely to perceive God's will as a cause of their T2D (χ^2=4.62, df= 1, p= 0.032) than those who were non-adherent. In addition, patients in the adherent group were more likely to endorse psychosocial factors as a cause of T2D than those who were non-adherent as assessed by Fisher's exact test (χ^2=5.54, df= 1, p= 0.044).

There were no statistically significant differences in HbA1c between patients who listed psychosocial factors as a cause (mean HbA1c 8.90, SD 1.47) and those who did not (mean 8.54, SD 1.36), [$F (1, 70) = 0.198$, p= 0.658]. There were also no significant differences in HbA1c between those who endorsed behavioural factors (mean 8.52, SD 1.34) and those who did not (mean 8.62, SD 1.41), [$F (1, 70) = 0.095$, p= 0.758]. Those who cited hereditary factors had similar HbA1c levels (mean 8.64, SD 1.36) to those who did not (mean 8.43, SD 1.36), [$F (1, 70) = 0.384$, p= 0.537]. Finally, patients who endorsed God's will had similar HbA1c levels (mean 8.63, SD 1.45) to those who did not (mean 8.53, SD 1.34), [$F (1, 70) = 0.077$, p= 0.782].

Predictors Of Adherence To Diabetes Medication And HbA1c

Binary logistic regression analyses revealed that all the independent variables from Table 2 remained significant predictors of adherence after controlling for demographic covariates (age, sex and education) ($p < 0.05$). Analysis of inter-item correlations revealed high inter-correlations between the predictors. Collinearity statistics confirmed this observation for several predictors including perceptions of personal control, cyclical timeline, oral medication effectiveness, insulin effectiveness, diet effectiveness, weight management effectiveness, physical activity effectiveness, and GLHC beliefs (VIF > 10 & tolerance statistics < 0.2). Therefore, several predictors were dropped from the regression model, while retaining the essential predictors in this study as recommended by Leech and colleagues.[53]

A multivariable binomial logistic regression analysis was conducted to examine associations with adherence to diabetes medication. The analysis initially adjusted for age, sex, and education (model 1) as these variables have been associated with adherence in previous studies.[33,40,54] In model 2, variables that were associated with adherence to diabetes medication were added; perceptions of consequences, timeline (acute/chronic), treatment control, illness identity, coherence,

Table 2 Relationships Between Adherence To Medication And Study Variables Using Binary Logistic Regression

Variable	B	S.E.	Sig.	Lower 95% CI	Upper 95% CI
B-IPQ					
Consequences	−0.83	0.15	0.000	0.32	0.59
Timeline (acute/chronic)	−0.61	0.20	0.002	0.37	0.81
Personal control	0.72	0.15	0.000	1.55	2.73
Treatment control	0.57	0.12	0.000	1.40	2.20
Identity	−1.15	0.22	0.000	0.21	0.49
Concerns	−0.52	0.11	0.000	0.48	0.74
Coherence	0.52	0.12	0.000	1.34	2.13
Emotional response	−0.56	0.15	0.000	0.43	0.77
Timeline (cyclical)	−0.38	0.13	0.004	0.53	0.89
Oral medication effectiveness	0.76	0.14	0.000	1.61	2.83
Insulin effectiveness	0.73	0.21	0.000	1.38	3.10
Diet effectiveness	0.36	0.09	0.000	1.19	1.71
Weight management effectiveness	0.33	0.09	0.000	1.18	1.65
Physical activity effectiveness	0.40	0.11	0.000	1.21	1.83
BMQ					
Necessity-Specific	0.33	0.07	0.000	1.22	1.58
Concerns-Specific	−0.27	0.07	0.000	0.67	0.87
GLHC					
God is in less control	1.10	0.45	0.015	1.23	7.30

Abbreviations: B, Beta; SE, Standard Error; Sig, Significance; CI, Confidence Interval.

emotional response, and beliefs about necessity and concerns of medicine. All the IVFs were well below 10 and tolerance statistics were all above 0.02, suggesting that there was no collinearity within the data (IVF < 1; tolerance > 0.3).

Model 1 was not significant (χ^2= 1.79, df= 5, p= 0.877); model 2 was significant (χ^2= 80.55, df= 8, p < 0.001). Of the predictor variables, age, perceptions of consequences, illness identity and coherence were significant individual predictors of adherence to diabetes medication (see Table 3). Greater perceptions of consequences and illness identity were associated with a reduction in the likelihood of optimal adherence to diabetes medication, whereas older age and greater perceptions of coherence were associated with an increased likelihood of optimal adherence to diabetes medication.

Simple linear regression analyses showed that only perception of cyclical timeline, but not perceived insulin effectiveness, was a significant independent predictor of HbA1c (β= 0.22, p= 0.016) after controlling for demographic covariates (age, sex, education). In the hierarchical multiple linear regression, the model initially adjusted for age, sex and education (Model 1) based on previous literature.[37,55] Model 1 was not significant (F (5, 109) = 1.37, p= 0.242, R^2 = 0.06). In Model 2, perception of cyclical timeline was

added. Model 2 was significant (F (1, 108) = 4.31, p= 0.040, R^2 = 0.10) explaining an additional 4% of the total variance in HbA1c (see Table 4, model 2). Perceptions of cyclical timeline independently predicted HbA1c when controlling for known covariates (β= 0.19, p= 0.040, 95% CI: 0.01, 0.52).

Discussion

This was the first study to investigate whether illness perceptions, beliefs about medicine, and God locus of health control beliefs were associated with adherence to diabetes medication and glycaemic control among Saudi patients with T2D. There were two main findings: illness perceptions, beliefs about medicine, and God locus of health control were associated with adherence to diabetes medication, and only illness perceptions (perceptions of cyclical timeline and insulin effectiveness) were associated with glycaemic control.

Approximately two thirds of patients reported non-adherence to diabetes medication and had suboptimal glycaemic control. These rates are consistent with earlier research on Saudi patients with diabetes.[33,34,36,38] None of the demographic and clinical variables showed any association with adherence to diabetes medication. A recent systematic

Table 3 Logistic Regression With Adherence To Medication As The Dependent Variable (n= 114)

Predictor	Model 1			Model 2		
	B (SE)	OR	95% CI	B (SE)	OR	95% CI
Age	−0.14 (0.30)	0.87	0.49, 1.56	0.13* (0.58)	3.76	1.21, 11.76
Sex (Male)	0.11 (0.43)	1.12	0.48, 2.63	0.26 (0.78)	1.30	0.28, 5.98
Education (Ref group: tertiary education)						
Illiterate	0.83 (0.83)	2.30	0.45, 11.75	0.88 (1.36)	2.40	0.17, 34.41
Read & write only	0.06 (0.67)	1.06	0.28, 3.96	−0.94 (1.09)	0.39	0.05, 3.34
High school	0.28 (0.65)	1.32	0.37, 4.68	0.27 (1.13)	1.31	0.14, 12.04
B-IPQ						
Consequences				−1.55* (0.61)	0.21	0.06, 0.71
Chronic timeline				−0.55 (0.37)	0.57	0.28, 1.19
Treatment control				0.04 (0.48)	1.04	0.41, 2.62
Illness identity				−1.47* (0.57)	0.23	0.07, 0.71
Coherence				1.18* (0.51)	3.24	1.18, 8.88
Emotional response				0.98 (0.54)	2.66	0.92, 7.68
BMQ						
Necessity-specific				0.37 (0.51)	1.45	0.53, 3.94
Concerns-specific				−0.09 (0.49)	0.91	0.35, 2.36

Notes: Hosmer & Lemeshow R^2 was 0.995 (model 1) and 0.844 (model 2). Nagelkerke R^2 was 0.022 (model 1) and 0.722 (model 2). *$P < 0.05$.
Abbreviations: B, Beta; SE, Standard Error; OR, Odds Ratio; CI, Confidence Interval.

Table 4 Hierarchical Linear Regression With HbA1c As The Dependent Variable (n= 115)

Predictor	Model 1			Model 2		
	B (SE)	β	95% CI	B (SE)	β	95% CI
Age	−0.09 (0.19)	−0.07	−0.46, 0.28	−0.11 (0.18)	−0.08	−0.48, 0.25
Sex (Male)	0.58* (0.27)	0.21	0.04, 1.11	0.47 (0.27)	0.17	−0.07, 1.01
Education (Ref group: tertiary education)						
Illiterate	−0.06 (0.73)	−0.02	−1.10, 0.99	−0.04 (0.52)	−0.01	−1.07, 0.99
Read & write only	0.06 (0.42)	0.02	−0.76, 0.88	0.10 (0.41)	0.03	−0.71, 0.91
High school	0.32 (0.41)	0.10	−0.49, 1.12	0.30 (0.40)	0.09	−0.49, 1.09
B-IPQ						
Cyclical timeline				0.27* (0.13)	0.19	0.01, 0.52

Note: *$P < 0.05$.
Abbreviations: B, Unstandardized coefficient; SE, Standard error; β, Standardized beta coefficients.

review of factors associated with medication adherence among patients with diabetes in the Middle East found mixed evidence for the associations between demographic, clinical variables and adherence to medication.[54] This inconsistency in the literature may be due to methodological variations across studies in terms of study design, sample size, population under investigation, measurement tools, and statistical analyses.

All the illness perceptions showed significant bivariate relationships with adherence in the hypothesized directions, which supports previous findings.[17,22,23,40] These relationships remained significant when each independent variable was examined separately controlling for the demographic covariates. Of the illness perception domains, three illness perceptions remained independent predictors of adherence in the fully adjusted model. Greater perceptions of consequences and illness identity were associated with a reduction in the likelihood of optimal adherence, whereas greater coherence was associated with an increased likelihood of optimal adherence. Consistent with our findings, earlier

research has shown that greater perceptions of consequences,[44] illness identity,[40] and lower coherence[39] were significant predictors of non-adherence to diabetes medication among patients with T2D.

There is mixed evidence for the association between perceptions of coherence and adherence. Some earlier studies failed to find a significant relationship.[22,40] Coherence perceptions may be more relevant to other self-management behaviours, such as foot care among patients with diabetes.[56]

Behavioural and psychosocial causal beliefs were associated with adherence to medication, whereas perceiving hereditary factors and God's will as the cause of diabetes were associated with non-adherence to medication. This finding is in line previous research showing that perceived external causes of T2D including God's will and environmental pollution were associated with non-adherence to diabetes medication.[22]

Although perceptions of cyclical timeline and insulin effectiveness were associated with glycaemic control in the bivariate analysis, only perceptions of cyclical timeline were significant independent predictors of glycaemic control adjusting for the demographic covariates. Patients who perceived the course of T2D as unstable were significantly more likely to exhibit suboptimal glycaemic control, which supports previous research. In a meta-analytical review, perception of cyclical timeline was found to have the largest correlation with glycaemic control.[19]

Beliefs about necessity and concerns about medicine were significantly correlated with adherence. Earlier studies in the Middle East region have found similar results.[34,42] In these studies, patients who perceived medication as necessary for controlling diabetes and had fewer concerns about medicine reported optimal adherence. A meta-analytical review of beliefs about medicine concluded that higher perceptions of necessity of medicine and fewer concerns about medicine were associated with optimal adherence to medicine across a number of long-term conditions including diabetes.[16] In this study, beliefs about medicine did not show significant correlation with glycaemic control, which is also in line with previous research.[20,21]

Consistent with other research,[31,32] religious beliefs were associated with how patients managed their T2D. The majority of our sample believed that God was in total control of their health and illness. This belief was associated with worse adherence to diabetes medication in the bivariate analysis. Patients who scored high on the GLHC scale were less likely to adhere to diabetes

medication. This finding supports previous research with asthma patients.[30] Stronger GLHC beliefs may discourage patients from taking active control in managing their illness and following their treatment regimen. No association was found between religious beliefs and HbA1c, which may be because HbA1c levels are not solely dependent on adherence. Although God-centred locus of control is indeed consistent with the Islamic faith,[57] Islamic teachings at the same time encourage individuals to look after their health and wellbeing.

The results of this study provide support for the utility of considering patients' illness perceptions, beliefs about the necessity and concerns about medication, as well as GLHC beliefs in patients with T2D in Saudi Arabia. They suggest that studies using typical measures of illness perceptions based on the CSM, may benefit by including measures of closely related concepts that lie within the model's wider bounds. These results provide a framework to develop future interventions targeting maladaptive illness and treatment perceptions to improve adherence and glycaemic control in this population.

Strengths And Limitations

This study used valid and reliable measures, although many were self-reported. Self-reported measures of adherence tend to overestimate adherence levels.[58] Patients may be inaccurate at estimating their adherence to medication over time or patients may be reluctant to admit to non-adherence because they know they are being observed or wanting to avoid disapproval from their physicians. Nevertheless, previous research has shown that self-report measures of adherence demonstrate moderate to high correlations with more objective measures such as electronic monitoring devices.[59] A strength was the inclusion of analysis of causal perceptions. Previous research on illness perceptions in diabetes and other conditions has often omitted the B-IPQ item on causal beliefs.[11] A limitation is the cross-sectional design meaning that causal inferences cannot be made. A second limitation is that our findings may not be generalisable to all Saudi patients with T2D given that participants were recruited from a single diabetes outpatient clinic using convenience sampling.

Future research in Saudi Arabia could also develop and test interventions to change illness perceptions to improve adherence and glycaemic control in patients with T2D, as has been shown in New Zealand[60] and Ireland.[61] Such interventions should be tailored to meet the patients' needs and preferences expressed in this research, including local language and face to face sessions.

Conclusion

Amongst the study participants, illness perceptions and treatment beliefs were consistently associated with adherence to medication, but less consistently with glycaemic control. These findings expand the existing literature on the importance of patients' perceptions of illness and treatment in relation to coping behaviours and health outcomes to the Saudi population. The study also paves the way for interventions based on the CSM to be developed in order to enhance adherence among Saudi patients with T2D. Further research with larger and more diverse samples is warranted to extend the generalisability of these results.

Abbreviations

T2D, type 2 diabetes; CSM, common sense model; NCF, necessity-concerns framework; GLHC, God locus of health control; MARS-5, medication adherence report scale; B-IPQ, brief illness perception questionnaire; BMQ, beliefs about medicines questionnaire.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Disclosure

The authors report no conflicts of interest in this work.

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