Introduction: Advanced stages of change (SOC) are usually associated with lower glycated hemoglobin (HbA1c) scores in patients with type 2 diabetes mellitus (T2DM). Additionally, these patients’ adherence to antidiabetic medications is crucial to achieve controlled HbA1c scores. The purpose of this study was to determine the relationship between SOC and HbA1c as well as between medication adherence and HbA1c in patients with T2DM in a primary healthcare setting in Qatar. Materials and Methods: A cross-sectional observational study was conducted in patients with T2DM at the noncommunicable diseases clinics at Mesaimeer Healthcare Center and West Bay Health Care Center. Medication adherence was assessed using the Morisky Medication Adherence Scale (MMAS-8), whereas a two-item SOC questionnaire was used to measure the SOC. HbA1c values were obtained from the electronic database at the clinic. Spearman rank correlations were performed, with the significance level set at α < 0.05. Results: A total of 387 patients were included in the analysis. More than 75% of them reported that they were in the maintenance stage, and 35.4% of them had a controlled diabetes status. There was no significant correlation between SOC and HbA1c or between medication adherence and HbA1c. Conclusions: There was no relationship between SOC and HbA1c or between medication adherence and HbA1c in patients with T2DM, indicating that in this study, self-reported measures are not associated with the HbA1c scores of patients.

Keywords: Diabetes mellitus, glycated hemoglobin, medication adherence, stages of change, transtheoretical model

INTRODUCTION

Diabetes mellitus (DM) is a worldwide health problem, and its prevalence has increased tremendously over the past few years.[1] In 2012, DM was the cause of 1.5 million deaths, 80% of which occurred in low- and middle-income countries.[2] There are currently 37 million people with type 2 diabetes (T2DM) in the Middle East and North Africa alone.[3] Focusing particularly on Qatar, 13.5% of the adult population has T2DM.[4] Patients with T2DM need to self-manage their disease to achieve better clinical outcomes such as a reduction in glycated hemoglobin (HbA1c) and better health-related quality of life (HR-QOL). Self-management of diabetes requires patients to perform several activities daily. Specifically, patients must follow a healthy diet, exercise regularly, and adhere to their medication regimen. A reported reduction in HbA1c will never occur if patients are not able to self-manage their diabetes.

Even though the treatment of T2DM has advanced tremendously over the past few years, many patients...
still fail to obtain the desired reduction in HbA1c, and consequently, have poorer HR-QOL. They are unable to improve their HR-QOL because health-care professionals depend solely on the biomedical model in which patients are passive recipients of the doctor’s instructions related to their medical conditions. However, according to the World Health Organization (WHO), health is “a complete state of physical, mental, and social wellbeing, and not merely the absence of disease or infirmity.” Given that the biomedical model only aims to improve the physical well-being of patients, interventions began to incorporate socio-behavioral models along with the biomedical model to improve patient health based on the WHO definition. One of the commonly used socio-behavioral models is the transtheoretical model (TTM), which is also known as the stages of change (SOC) model. The TTM consists of the following five stages:

1. Precontemplation: Patients in this stage do not intend to change their undesirable behavior within the next 6 months.
2. Contemplation: Patients in this stage begin to become aware that they have a problem with their behavior and plan to change within the next 6 months.
3. Preparation: Patients in this stage plan to change their behavior within the next month.
4. Action: Patients in this stage have actively changed their behavior for approximately 6 months.
5. Maintenance: Patients in this stage have been adhering to their new desired behavior for more than 6 months.

Furthermore, 10 processes of change need to be applied to help patients to progress through the SOC, with certain processes being more relevant to a specific stage of change than others.

Adhering to prescribed antidiabetic medications is necessary to self-manage T2DM, as patients with the disease will never be able to achieve controlled HbA1c if they do not stick to their medication regimen. Good health-related outcomes will not occur if the patient is not taking his/her medications consistently. The WHO suggests that if medication adherence increased for chronic conditions such as diabetes, health outcomes would improve significantly, and the health economic burden would decrease. Another common reason for uncontrolled T2DM is that health-care professionals in most institutions still use the biomedical model when treating patients, even though it has failed to improve their clinical outcomes and HR-QOL. Given that the biomedical model alone did improve medication adherence, and nonadherence to medications is considered to be a behavioral problem, health-care professionals started to use behavioral models to test their abilities to improve adherence to medications.

Several previous studies were conducted to test the relationship between SOC and HbA1c. For example, among patients with T2DM in a primary care setting, it was reported that advancement in SOC relating to diet led to better glucose control and higher levels of continuity of care with primary care providers. Another study compared HbA1c values of patients in a TTM intervention group with those of patients in a control group who were receiving usual care. There was a significant reduction in HbA1c in the intervention group compared to that in the other group following the TTM intervention. Three other studies supported the effectiveness of the TTM intervention in encouraging patients to consume a healthier diet and exercise more regularly, which subsequently led to a significant reduction in HbA1c.

Some studies stated that there is a direct relationship between medication adherence and HbA1c, where higher adherence is associated with a reduction in HbA1c. In fact, one study suggested that for each 10% increase in medication adherence, HbA1c decreases by 0.16%, even after controlling for demographic characteristics and disease duration. The study also highlighted that African Americans had poorer medication adherence and higher HbA1c compared to whites. Better medication adherence was also found to be associated with lower HbA1c, even after controlling for age, gender, race, body mass index, diabetes duration, and diabetes therapy. In addition, a review reported that most studies involving patients with T2DM showed an association between medication adherence and HbA1c, regardless of which tool was used to measure adherence. Interestingly, the association was not always apparent in low-income populations.

The objective of this study was to determine whether there is an association between SOC and HbA1c as well as between medication adherence and HbA1c in patients with T2DM in primary health-care clinics in Qatar.

**Materials and Methods**

This was a cross-sectional observational study involving adult patients with T2DM in Qatar. The research study was approved by the Primary Healthcare Corporation and Qatar University’s Institutional Review Board. All the recruited participants were given a consent form.

The recruitment of participants from Mesaimeer Healthcare Center and West Bay Health Care Center began on February 7, 2016 and ended on April 28, 2016, around a 3-month period to get enough samples for the
study. All the participants were recruited during their regularly scheduled visits, and none was requested for any follow-up for the research. The inclusion criteria for the study were adult patients (1) who had a confirmed T2DM diagnosis (HbA1c ≥6.5%, fasting plasma glucose ≥126 mg/dL, and/or 2-h plasma glucose ≥200 mg/dL) and (2) who were prescribed oral antidiabetics and/or insulin. The exclusion criteria were patients who were (1) younger than 18 years; (2) pregnant women, as they could have gestational diabetes; (3) mentally incompetent, as mental defects might affect the ability to understand the questionnaires correctly; and (4) receiving only non-pharmacologic therapy (i.e., lifestyle modifications).

A two-item SOC questionnaire to assess the SOC regarding medication adherence and the Morisky Medication Adherence Scale-8 (MMAS-8) to measure medication adherence were both administered to every participant who was recruited as a part of the study sample. HbA1c values were extracted from each patient’s electronic health record that was available in the electronic database. On the basis of the American Diabetes Association guidelines, the patients were later categorized into two groups: controlled diabetes status (if the patient had an HbA1c value ≤7.0%) and uncontrolled diabetes status (if the patient had an HbA1c value >7.0%). Patients who were visiting the noncommunicable diseases (NCD) clinic at the centers were asked to complete the SOC and MMAS-8 questionnaires. Information about each patient’s medication start date, dose, and frequency, as well as the number of total prescribed medications along with the date of the first visit to the NCD clinic, was extracted from the paper-based medical record. Participants were also asked about the date of their diabetes diagnosis, as it was not available in the paper-based record or electronic database. All the data were entered into the data collection form by the researcher.

All the analyses were performed using SPSS software, version 22.0 (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp.). Descriptive analyses were conducted to determine the SOC, medication adherence scores, and diabetes status of the patients with T2DM. Spearman $\rho$ correlation was performed to determine the relationship between SOC and HbA1c as well as medication adherence and HbA1c, with the significance level set at $\alpha < 0.05$.

**RESULTS**

In total, 387 patients participated in the study. Specifically, 337 adult patients with T2DM were recruited from Mesaimeer Health Care Center, whereas 50 patients were recruited from West Bay Health Care Center. The mean age (±SD) of the participants was 54.3 ± 10.2 years. There were more male participants than female participants (63% vs. 37%) and more non-Qatars than Qataris (84.8% vs. 15.2%). Additionally, there were more Arab participants than Asian participants and participants of other races (51.9%, 44.2%, and 3.9%, respectively). Table 1 presents the demographic characteristics of the recruited participants.

Of the 387 participants who were recruited for the study, 137 (35.4%) had controlled diabetes and 250 (64.6%) had uncontrolled diabetes, as they had an HbA1c value of more than 7.0%. The median HbA1c value of the participants was 7.5% (interquartile range = 2.2). In addition, 118 (30.5%) participants were diagnosed with diabetes fewer than 5 years ago, whereas 117 (30.2%) were diagnosed 5–9 years ago. Most of the participants had other chronic conditions. Specifically, 77.3% of them had dyslipidemia and 66.4% had hypertension. Only 5.7% of the participants did not have any

| Characteristic | Frequency (%) | Mean ± SD |
|----------------|--------------|-----------|
| Age (years), mean ± SD | 54.29 ± 10.20 |
| Age (years) | | |
| Younger than 45 | 69 (17.8) | |
| 45–54 | 117 (30.2) | |
| 55–65 | 153 (39.5) | |
| Older than 65 | 48 (12.4) | |
| Sex | | |
| Male | 244 (63) | |
| Female | 143 (37) | |
| Nationality | | |
| Qatari | 59 (15.2) | |
| Non-Qatari | 328 (84.8) | |
| Race | | |
| Arab | 201 (51.9) | |
| Asian | 171 (44.2) | |
| Others | 15 (3.9) | |
| Marital status | | |
| Single | 13 (3.4) | |
| Married | 366 (94.6) | |
| Divorced | 1 (0.3) | |
| Widowed | 7 (1.7) | |
| Educational attainment | | |
| Postgraduate | 15 (3.9) | |
| Bachelor | 193 (49.9) | |
| Less than bachelor | 179 (46.3) | |
| Occupation | | |
| Professional | 88 (22.7) | |
| Managerial | 32 (8.3) | |
| Assistants and helpers | 142 (36.7) | |
| Unemployed | 100 (25.8) | |
| Retired | 25 (6.5) | |
chronic conditions other than diabetes. Additionally, 208 (53.7%) participants were taking five or more medications. Table 2 presents all the relevant clinical characteristics of the recruited participants.

It was found that 297 (76.7%) participants were in the maintenance stage and 57 (14.7%) participants were in the preparation stage. In terms of medication adherence, the mean score on the MMAS-8 scale, which ranged from 0 to 8, was 6.88 ± 1.62. According to the scoring guidelines of the MMAS-8, the mean score indicated medium medication adherence. Moreover, 224 (57.8%) participants had high medication adherence related to their antidiabetic medications.

Table 3 provides details about the SOC and MMAS scores of all 387 participants. Correlation analyses were conducted to investigate the relationship between SOC and HbA1c as well as medication adherence and HbA1c. The results suggest that there was no significant correlation between SOC and HbA1c (r = −0.012, P > 0.05) or between medication adherence and HbA1c (r = −0.002, P > 0.05).

The correlations among demographic and clinical characteristics with HbA1c were determined. None of the demographic characteristics had a significant correlation with HbA1c, as given in Table 4. However, disease duration had a weak but significant correlation with HbA1c (r = 0.196, P < 0.001). Furthermore, the total number of prescribed medications had a significant correlation with HbA1c (r = 0.171, P < 0.001).

Table 5 presents the correlations between both disease duration and the total number of prescribed medications and HbA1c.

**Discussion**

The objective of the study was to determine if either SOC or adherence to antidiabetic medications could be used to predict HbA1c. In the study sample, no statistically significant relationship was found between...
SOC and HbA1c ($P > 0.05$). This result contradicts all the other studies that have investigated the relationship between SOC and HbA1c, which reported a significant negative relationship between SOC and HbA1c. For example, in a study of patients with T2DM, after comparing a control group with a group receiving a TTM intervention, SOC was found to be significantly better in helping patients to lower their HbA1c and led to better diabetes control.[11] Three other studies of patients with T2DM also reported that TTM led to a significant reduction in HbA1c.[12–14] All these studies determined that the SOC of patients with T2DM who were following a healthy diet plan or exercising regularly led to reductions in HbA1c. That is, when the TTM was used to identify the SOC of these patients in relation to their diet or exercise, a relationship was identified between the SOC and HbA1c. However, in our study, the SOC was related to the patients’ adherence to the prescribed medications and showed no statistically significant relationship with HbA1c. It is possible that, even though SOC might predict adherence, adherence to treatment among the individuals with T2DM in our study was not associated with HbA1c. Another possible explanation for our having found no association between SOC and HbA1c is a lack of continuity of care among patients with T2DM. A previous study found that continuity of care with a primary care provider who identified patients’ SOC relating to diet and exercise led to an improved SOC in terms of self-management behaviors and that continuity of primary health care was associated with better glucose control in a diabetic population.[10]

Contrary to previous studies, this study found no significant association between medication adherence and HbA1c ($P > 0.05$). Most previous studies reported a significant negative correlation between medication adherence and HbA1c. One study stated that for every 10% increase in medication adherence, HbA1c decreased by 0.16% ($P < 0.001$) in an impoverished population.[15] In that study, African American patients had higher HbA1c values than white patients, which led the authors to conclude that minority and impoverished groups had less control of their HbA1c. The results of our study suggest that Arabs have greater control of their HbA1c than Asians (21.2% vs. 12.4%; $P < 0.05$). Another potential explanation for the lack of an association between medication adherence and HbA1c is patients’ failure to attend appointments. A previous study found an association between medication adherence and HbA1c and provided evidence that every appointment that patients with T2DM attended was associated with a 0.12% decrease in HbA1c.[16] Moreover, a published systematic review concluded that there is an association between antidiabetic medications and HbA1c, regardless of the method used to assess medication adherence. However, this association was not always found in low-income populations.[17] This could be interpreted as supporting the results of our study, as almost half of the sample reported that their highest educational attainment was below a bachelor’s degree. Furthermore, 36.7% of the participants were employed as assistants and helpers who might have been expected to have a low income and possibly a low degree. However, if patients with T2DM who have a low income and high adherence to medications have no reduction in HbA1c, other factors that affect HbA1c need to be considered. It is possible that these patients are taking their antidiabetic medications regularly and consistently but consuming a diet that is high in sugar and other carbohydrates and not exercising regularly. That could be expected to result in a mean HbA1c that is higher than that observed in other populations who both follow a healthier diet and stick to an exercise regime.

**Limitations:** The study might be subject to social desirability bias, resulting in the misreporting of SOC and medication adherence scores. That would lead to the underestimation of the proportions of individuals in the early SOC and with low medication adherence. Self-reported measures generally tend to yield inflated adherence estimates or advanced SOC. Therefore, the actual adherence to prescribed medication was probably somewhat lower than we observed. Additionally, there might have been fewer patients who were actually at the action and maintenance stages. Another limitation is that the SOC that were determined only related to

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**Table 4: Spearman $\rho$ correlation of HbA1c with demographic characteristics**

| Characteristic       | Age    | Gender | Nationality | Ethnicity | Marital status | Education | Occupation |
|----------------------|--------|--------|-------------|-----------|----------------|-----------|------------|
| HbA1c                | $r = -0.08$ | $r = -0.05$ | $r = -0.05$ | $r = 0.06$ | $r = -0.03$ | $r = -0.09$ | $r = -0.01$ |
| Sig.                 | 0.12   | 0.30   | 0.36        | 0.20      | 0.59           | 0.06      | 0.83       |

**Table 5: Spearman rho correlation between diabetes duration, prescribed medications with HbA1c**

| Characteristic       | HbA1c     | $p$ values |
|----------------------|-----------|------------|
| Diabetes duration    | $r = 0.19$| 0.00 **    |
| Prescribed medications| $r = 0.17$| 0.001 **   |

**$\rho < 0.01$; $r =$ correlation coefficient**

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taking the antidiabetic medications as prescribed by the physician. The SOC related to following a healthy diet or exercising was not measured, even though both of them are factors that contribute to the self-management of T2DM.

CONCLUSION
The SOC of patients had no significant association with their HbA1c scores. In addition, identifying adherence scores using the MMAS-8 had no significant association with HbA1c scores, suggesting that self-reported measures such as the two-item SOC questionnaire and MMAS-8 cannot be used to assess HbA1c in patients with T2DM.

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Conflicts of interest
There are no conflicts of interest.

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