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
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# Confirmatory Factor Analysis and Reliability of the Diabetes Treatment Satisfaction Questionnaire (DTSQ) for Arabic Speaking Patients with Type II Diabetes

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**Background:** Treatment satisfaction is an important indicator for treatment compliance and glycemic control. Although psychometric properties of the Diabetes Treatment Satisfaction Questionnaire have been confirmed in several languages, it remains unclear the extent to which the factorial structure of this tool is valid for Arabic speaking populations.

**Purpose:** This study set out to confirm the construct validity of the Arabic version of the Diabetes Treatment Satisfaction Questionnaire (DTSQ) by investigating the fit of published factor structures and the reliability of responses in patients diagnosed with type 2 diabetes.

**Methods:** Data were from a large cross-sectional study of 1002 patients with diabetes in Jordan. Confirmatory factor analysis was used to compare three different models of the 8-item questionnaire (one factor, two factors, three factors) across patients treated with insulin and patients treated with oral hypoglycaemic medications.

**Results:** Statistics covered the factorial validity and omega reliability coefficient ( $\Omega_w$ ) of the DTSQ. We were able to replicate the three different models of the 8-item Diabetes Treatment Satisfaction Questionnaire reported in previous studies, yet a two-factor model provided the best fit to the data in our sample with omega reliability coefficient ( $\Omega_w$ ) of the subscales above 0.70.

**Conclusion:** The finding suggests a cross-cultural invariance of the factor structure of the Arabic version of the Diabetes Treatment Satisfaction Questionnaire, as we were able to replicate the same factor structure using the Arabic translated version of the tool and using non-English speaking participants. Within known limitations and gaps in the literature, healthcare professionals working with Arabic speaking patients may find this tool useful for identification of high-risk patients and those in need for interventions to promote glycemic control.

**Keywords:** treatment satisfaction, factor analysis, diabetes, Arabic, reliability, validity

## Introduction

For the Arab world, diabetes is a devastating chronic illness with one of the highest incidences in the world.<sup>1,2</sup> The added cost of long-term diabetes care, shortages in medicines and services, and lengthy waiting times can make accessing necessary treatment a challenge for patients in the Middle East region.<sup>3,4</sup> Key to the management of diabetes according to the American Diabetes Association Standards of Medical Care in Diabetes<sup>5</sup> is glycemic control, and this underpins the prevention of

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acute and long-term complications. Maintaining glycemic control through a combination of medication and/or life-style remains challenging for many people living with type 2 diabetes<sup>6</sup> and linked to long-term complications.<sup>7,8</sup>

Now it is widely acknowledged that treatment satisfaction is an important indicator for treatment compliance; health professionals must take into consideration their patients' point of view of their treatment. Treatment satisfaction is conceptualized as the "confirmation of expectations for a patient, that is, the agreement between what the patients expects from the treatment and the results obtained".<sup>9</sup> It is suggested that improving treatment satisfaction is likely to improve health status<sup>10-12</sup> and treatment adherence in patients with diabetes.<sup>7,13,14</sup> With recent evidence of a clear relationship between depression and treatment satisfaction in type 2 diabetic patients;<sup>15</sup> the expectations and subsequent satisfaction with treatment may be an important determinant of patient wellbeing.<sup>8,16</sup> If improving treatment satisfaction in diabetic patients leads to improvement in glycemic control and patient's wellbeing, then treatment satisfaction should be targeted as an area of improvement in this population.

There are a number of instruments to measure patient-reported outcomes in diabetes, yet limited instruments are available for use in the Arabic language.<sup>17</sup> One instrument that has been specifically designed to measure patient satisfaction with diabetes medication and glucose control is the Diabetes Treatment Satisfaction Questionnaire Status, DTSQs.<sup>18</sup> The DTSQs instrument have been psychometrically tested in eight languages using baseline data from over 2,223 patients with type 1 or type 2 diabetes in the Hoechst Marion Roussel (HMR) multinational, random controlled trial.<sup>19</sup>

Overall, most available empirical research of the factorial structure of DTSQ has been exploratory in nature. Previous studies<sup>19-21</sup> used exploratory methods to evaluate the factor structure of the DTSQ and have supported a two-factor structure. It is suggested, however, that the factor structure of the DTSQ needs further evaluation for the Dutch and Finnish version of the scale.<sup>19</sup> In fact, when Bradley et al<sup>20</sup> presented the psychometric properties of the English and German version of the DTSQ, the main focus was to examine the DTSQ, diabetes treatment, and Ceiling effects. We were not able to find a specific empirical evidence on the goodness-of-fit index of the 8-items of DTSQ in the literature. Plowright et al<sup>19</sup> attempted to confirm the psychometric properties of the DTSQ in eight languages, including English, German,

Swedish, French, Danish, Norwegian, Dutch, and Finnish. However, this study was limited to short abstracts that give no information about how it was tested or how the fit of the different structures was computed. Therefore, it remains unclear the extent to which the factorial structure of the DTSQ is valid in other languages. Clearly, a good conceptualization of the factorial structure of the DTSQ is scarce in the literature; the dimensions identified by earlier studies<sup>19,20</sup> may be a starting point to build a more articulated theoretical framework.

The findings of DTSQ exploratory studies can be useful in the early stages of empirical enquiry where a theoretical underpinning or empirical evidence do not exist. Exploratory analysis of previous studies was helpful in hypothesizing the DTSQ construct, yet subsequent studies are needed to test the factorial structure of the DTSQ via confirmatory analytic technique. It remains unclear the extent to which the factorial structure of this tool is valid for other populations such as Arabic speaking patients. Moreover, despite encouraging evidence from Wilbur and Al Hammaq<sup>17</sup> regarding the utility of the existing Arabic DTQSs version in Qatar, the factor structure, and other features of the DTSQs are yet to be firmly established.

## Aims

The aim of the current study was to confirm the construct validity of the Arabic version of the Diabetes Treatment Satisfaction Questionnaire by investigating the fit between published factor structures and the reliability of responses in patients diagnosed with type 2 diabetes in Jordan, with particular attention to the similarity of responses from patients with insulin versus oral hypoglycemic treatment.

## Methods

### Participants and Procedure

Data were from a large cross-sectional study of 1002 patients with diabetes. The study was limited to patients older than 18 years of age, diagnosed with type 2 diabetes for at least 6 months prior to participation, and who were able to read and understand Arabic. Participants were recruited from a large, specialized national center for diabetes and endocrinology in Amman/Jordan. One author interviewed all participants to collect socio-demographic (eg, age, sex, education, marital status, Body Mass Index) and clinical variables (eg, duration of diabetes, type of treatment, comorbidity, glycemic control, exercise and

diet, and complications). Participants were then asked to complete the DTSQ.

## Instrument

Treatment satisfaction was assessed using the 8-item Diabetes Treatment Satisfaction Questionnaire.<sup>18,22</sup> The DTSQ consisted of two parts: 1) the treatment satisfaction (items 1, 4–8); and 2) the perceived frequency of hyperglycemia/hypoglycemia (items 2 and 3). Responses to treatment satisfaction used a 7-point Likert scale ranging from 0 “very dissatisfied” to 6 “very satisfied”.<sup>23</sup> The treatment satisfaction score is the sum of six of the items of the DTSQ for each respondent with a possible score of 0–36. This includes satisfaction with current treatment (item 1); treatment convenience (item 4); flexibility of treatment (item 5); understanding of diabetes (item 6); continuity of treatment (item 7); and recommending treatment to others with diabetes (item 8). The additional two items measure perceived frequency of hyperglycemia and hypoglycemia and use a seven-point scale (0–6) where a score of 0 indicates lack of hypo- or hyperglycemia and a score of 6 indicates a higher frequency.

## Ethical Consideration

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval to conduct the study was obtained from the ethics committee of the clinical setting (Ethical approval number MS/9/57 dated January 9, 2014). Approval to reproduce the existing Arabic version of the DTSQs for Israel and Saudi Arabia was granted by Dr. Bradley (Copyright holder) as part of another larger study on correlates of treatment satisfaction and wellbeing in type 2 diabetes.

## Statistical Analysis

A priori factorial structure existed for the subscales of the DTSQ, therefore, we proceeded to the confirmatory factorial analysis. This analysis was performed using (EQS V6.2) and was based on the factorial structure of prior psychometric work performed by Plowright et al.<sup>19</sup> According to Bradley et al,<sup>20</sup> the most common factor structures for the DTSQ show all six treatment satisfaction items loading on factor 1, while the Perceived Hyper- and Hypoglycemia items load together on factor 2 or separately on factors 1 and 2 or on 2 and 3.

First, descriptive statistics including univariate and multivariate analysis was conducted. Means, standard deviations (SD), skewness, and kurtosis for the

**Table 1** Socio-Demographic and Clinical Characteristics of Participants (n=1002)

Variables	Number	Percentage (%)
Age		88.5
≤60 years	885	
≥70 years	116	11.5
Gender		
Men	540	54
Women	462	46
Glycemic control		
HbA1c<7.0	350	35
HbA1c≥7.0	620	65
Type of treatment		
Oral	551	55
Insulin	451	45

participants treated with insulin and oral medication are presented in Table 1.

Second, to test the fit of published factor structure of the DTSQ subscales, three competitive models were tested. The first model was an 8-item factorial structure compromising one factor (Model 1). The second model tested a two-factor structure with all six treatment satisfaction items loading on factor one and the perceived hyper and hypoglycemia items load together on factor 2 (Model 2). The third model tested a three-factor structure with all six treatment satisfaction items loading in factor one, perceived hypoglycemia loading on factor two, and perceived hyperglycemia loading on factor three (Model 3).

The CFA were analyzed through the maximum estimation likelihood adjusted through Satorra-Bentler robust method; S-BX<sup>2</sup><sup>24</sup> to correct for heteroscedasticity and lack of normality. The goodness of fit S-BX<sup>2</sup> was used to assess the global fit of the model. A relatively good fit of the model was considered when two of the incremental and absolute fit indices such as CFI, RMSEA, and SRMR indicated a good fit. Hu and Bentler<sup>25</sup> considered a CFI higher than 0.95 a good fit of a model, while a value equal to or less than 0.06 of the RMSEA and 0.08 or less of the SRMR indicates a good fit of a model. The comparison of the nested models was based on  $\Delta$ S-BX<sup>2</sup><sup>26</sup> and  $\Delta$ CFI<sup>27</sup> where the model of the highest CFI and lowest AIC fit the best. The 90% confidence interval (90% CI) for RMSEA was computed and the factor loadings of the DTSQ items

were calculated for each model in the standardized solution.

The estimated parameters resulting from the confirmatory factorial analysis were used to compute the reliability of the subscales of the DTSQ suggested in models 2 and 3. The values of the weighted-omega reliability coefficient ( $\Omega_w$ ) were compared to the cut-off value of 0.70. Finally, given that the CFA have been estimated for two different groups of interest, measurement invariance was computed for each group.

## Results

### Sample Characteristics

In total, 1002 patients with a medical diagnosis of type 2 diabetes mellitus participated in this study (see Table 1). Gender was equally distributed; 540 males (54%) and 462 females (46%).

### Item Analysis and Factorial Structure of the DTSQ

Table 2 summarizes descriptive statistics for each item of the DTSQ.

The goodness-of fit indices of the confirmatory factor analysis conducted are shown in Table 3. The CFA conducted on the entire sample showed a weak model fit for the model 1 (S-B  $\chi^2=191.10$  (204),  $P>0.001$ , CFI=0.938,

TLI=0.913, RMSEA=0.092 (90% CI=0.081–0.105)). Model 2 showed a somewhat better fit in terms of a decreased chi-square value and decreased RMSEA value (S-B  $\chi^2=128.79$  (19),  $P<0.001$ , CFI=0.960, TLI=0.941, RMSEA=0.076 (90% CI=0.064–0.098)). However, the factorial structure of model 3 fitted relatively well too (S-B  $\chi^2=128.79$  (19),  $P<0.001$ , CFI=0.960, TLI=0.941, RMSEA=0.076 (90% CI=0.064–0.098)).

While the fit indices were relatively similar between models, we picked the model with the least AIC as the best model. Therefore, model 2 was regarded as the best model that presented better fit, in addition to an acceptable fit with the observed data. Standardized factor loadings by models and latent construct is presented in Figure 1. The two-factors construct (Model 2) was analyzed by constraining the covariance between the errors of items 2 and 3 to 0.7 – to ensure model identifiability. In the three-factors construct (Model 3), no significant gains from moving from two constructs to three constructs, the only advantage with the three constructs model is that the parameters were freely estimated, while we had to constrain the error covariance between the two items for one of the constructs in model 2. Factor correlations in model 2 (with standard errors) was  $-0.480$  (0.056), and for model 2 was  $-0.256$  (0.056);  $0.015$  (0.049), and  $0.235$  (0.091). Our results suggest the influence of the negative and

**Table 2** Univariate and Multivariate Descriptive Results for DTSQ

Item	Patients Treated with Insulin (N=451)				Patients Treated with Oral Hypoglycaemics Agents (N=551)			
	Mean	SD	Skewness	Kurtosis	Mean	SD	Skewness	Kurtosis
Satisfaction with current treatment	4.33	1.34	-0.84	0.73	4.56	1.23	-0.95	1.15
Perceived frequency of hyperglycemia	2.04	1.85	0.51	-0.88	1.25	1.57	1.11	0.23
Perceived frequency of hypoglycemia	1.83	1.67	0.75	-0.26	0.97	1.43	1.65	2.28
Treatment convenience	4.22	1.24	-0.79	1.09	4.47	1.29	-1.19	1.88
Flexibility of treatment	4.22	1.17	-0.51	0.38	4.46	1.17	-0.83	0.94
Understanding of diabetes	4.43	1.34	-1.15	1.25	4.59	1.29	-1.38	2.27
Recommending treatment to others with diabetes	3.32	2.44	-0.42	-1.53	3.80	2.28	-0.84	-0.93
Continuity of treatment	4.25	1.43	-1.13	1.23	4.61	1.30	-1.44	1.15

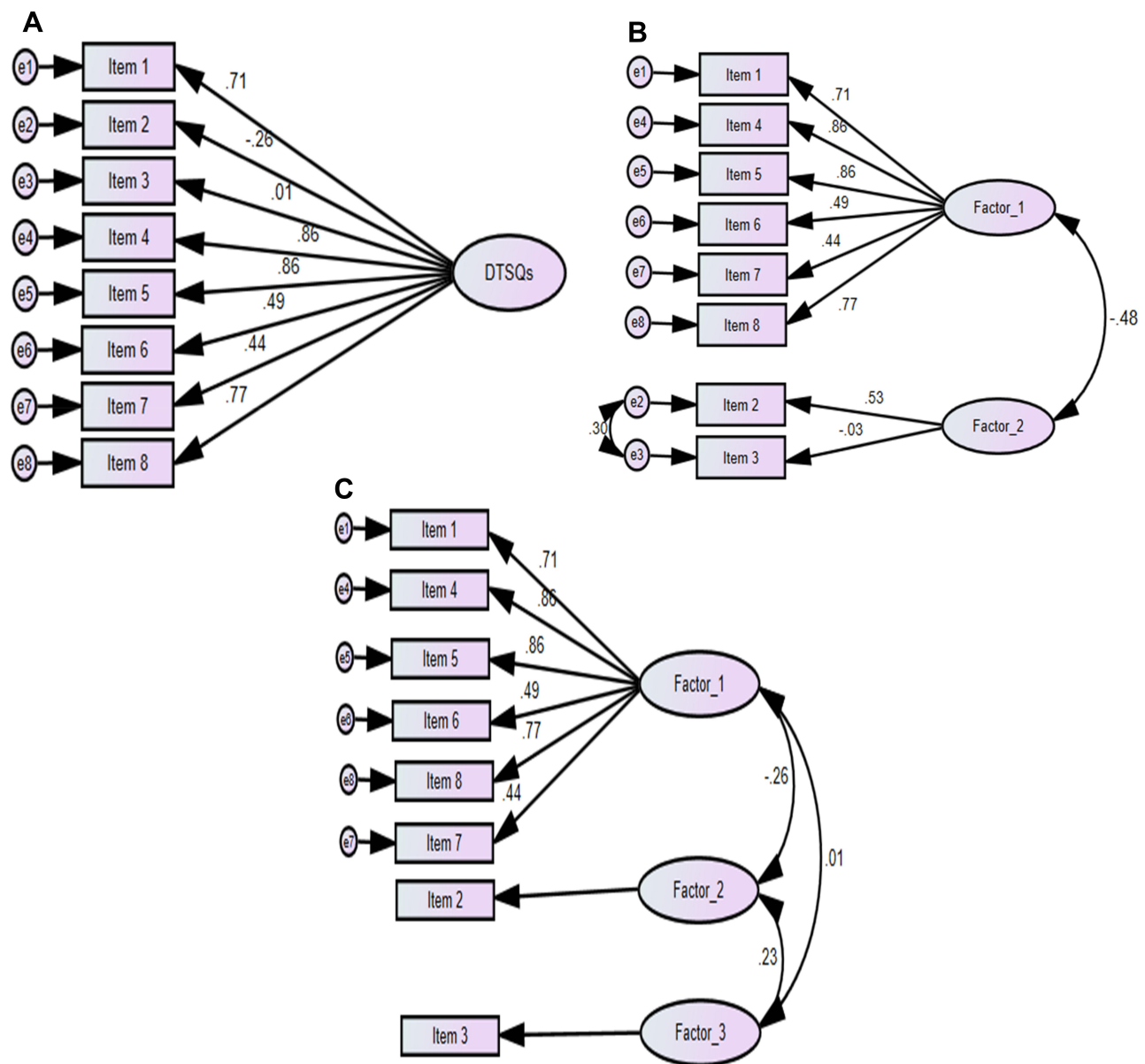
**Table 3** Goodness-of-Fit Indices for the Theoretical Models Proposed of DTSQ

	RMSEA	90% CI	TLI	CFI	AIC	df	$\chi^2$	$\chi^2/df$	P-value
Model 1	0.092	0.081–0.105	0.913	0.938	223.10	20	191.10	9.555	
Model 2	0.076	0.064–0.089	0.941	0.960	162.79	19	128.79	6.778	<0.001
Model 3	0.076	0.064–0.089	0.941	0.960	162.79	19	128.79	6.778	<0.001

**Notes:** CFI, TLI>0.9, indicates a good fit; RMSEA<0.08, indicates a good fit.

**Abbreviations:** CFI, Comparative Fit Index; TLI, Tucker-Lewis coefficient; RMSEA, Root Mean Square Error of Approximation; AIC, Akaike Information Criterion.





**Figure 1** (A) One-factor model; (B) Two-factors model; (C) Three-factors model of the DTSQ.

positive response scores of the perceived hypo- and hyperglycemia on the factorial validity of the DTSQ.

As shown in Figure 1, the standardized solution for factor loadings (range= 0.008–0.86) for model 1 indicated that the items related with perceived hypo- and hyperglycemia were inadequate indicators of the latent factors. For each factorial structure tested, it was noted that item 3 related with perceived frequency of hypoglycemia presented the poorest factor loading in model 1 and model 2 (<0.3). The standardized coefficients for the two-factor model and three-factor models were related to both dimensions of perceived hypo-hyperglycemia and treatment satisfaction.

## Invariance of DTSQ Across Gender and Type of Treatment

To perform invariance tests across gender and across patients treated with insulin or oral hypoglycemics medications, a large independent sample of 551 patients treated with insulin and 451 patients treated with oral hypoglycemics medication was used. The CFA conducted on the sample according to age and type of treatment are shown in Table 4 and show a good model fit in both groups. As displayed in Table 5, model fit was still adequate when invariance constraints were placed stepwise on factor loadings, covariances, and error variances. The CFI for all

**Table 4** Measurement Weights Constrained – Testing for Invariance Between Groups for the Factor Loadings

	RMSEA	90% CI	CFI	TLI	df	$\chi^2$	$\chi^2/df$	P-value
Analysis – Gender								
Unconstrained	0.055	0.047–0.065	0.958	0.937	38	154.85		
Measurement weights	0.052	0.043–0.061	0.958	0.945	29	159.22	4.370	0.498
Analysis – Insulin								
Unconstrained	0.057	0.048–0.066	0.955	0.933	34	160.86		
Measurement weights	0.054	0.046–0.063	0.953	0.939	29	170.50	9.641	0.086

Notes: Gender, Male (n=540) and Female (n=462); Insulin, No insulin (n=551) and Insulin (n=451).

**Table 5** Average Variance and Composite Reliability Indices of the DTSQ

Number of Factors	Number of Items	Average Variance	Composite Reliability
Two-factors	Factor 1	6	0.573
	Factor 2	2	0.582
Three-factors	Factor 1	6	0.570
	Factor 2	1	0.872
	Factor 3	1	0.775

groups showed no difference (CFI diff=0.01) between the baseline model and the subsequently more constrained models and the chi-square difference was nonsignificant, so we can assume that the factorial structure of the DTSQ was operating equivalently across genders and across patients treated with insulin and those treated with oral diabetes medication.

## Average Variance and Composite Reliability Indices of the DTSQ

The reliability of the whole scale and subscales was computed based on the estimated parameters resulting from the confirmatory factorial analysis. Reliability estimations based on unequal weighting have been suggested as more appropriate reliability measure following a CFA;<sup>28</sup> thus, composite reliability was measured in terms of weighted omega coefficients for the two-factors and three-factors model. Results showed acceptable weighted omega scores for all DTSQ subscales ( $\Omega_w \geq 0.70$ ) for both models (Table 4).

## Discussion

This study examined the factor structure and reliability of the DTSQ in Arabic speaking patients diagnosed with type 2 diabetes. Three models of DTSQ were tested using the confirmatory factor analysis method and the two-factor

model emerged as the model of choice that best fit in the current study. The two-factors model applied equally well to patients on insulin and those on oral hypoglycemic agents. Likewise, construct reliability based on the formula by Fornell and Larcker<sup>29</sup> was evaluated. The construct reliability estimates describe the variance captured by measurement errors as opposed to the variance attributable to the latent factors. A coefficient less than 0.50 indicates that the error variance is larger than the variance of the constructs. Our results revealed construct coefficients larger than 0.50 for both models. Whilst the  $\chi^2$  value for the goodness-of-fit index revealed a significant chi-square for the two- and three-factors model, this is more likely indicative of the larger sample size where sample size is an important determinant in assessing model fit.<sup>30</sup>

To our knowledge, this is the first study to confirm the construct validity of the DTSQ using confirmatory factor analysis of DTSQ in an Arabic speaking population. In line with Plowright et al's<sup>19</sup> study, our findings support the conclusion that a two-factor model of DTSQ provides the best fit for the data. The main strength of this model is that it appears to be replicable across patients treated with insulin and patients treated with oral hypoglycemic medications, supporting the notion that the DTSQ is a robust measure to evaluate patient satisfaction with treatment among Arabic speaking patients with type 2 diabetes.

The reliability of the DTSQ was supported in terms of weighted omega reliability and construct reliability coefficient of the two-factors model. While the use of alpha Cronbach reliability coefficient is more popular than the coefficient of  $\Omega_w$ , the use of  $\Omega_w$  is more appropriate in the case of multidimensional instruments analyzed through structural equation modeling.<sup>31</sup> This is because Cronbach alpha does not reflect the scale's factorial structure underlying correlations between items. Our results on reliability

of the DTSQ are satisfactory as these subscales show adequate psychometric properties in this population. Previous studies reported an alpha value of 0.782 to 0.0894 in all other languages reported in Plowright et al.<sup>19</sup>

The CFA supported the factorial validity of the DTSQ as the a priori hypothesized two-factor model revealed an acceptable model fit. The results, concurring with those reported in Bradley et al,<sup>21</sup> suggest that the two-factor solution for DTSQ based on the perceived hypo-hyperglycemia and treatment satisfaction dimensions represents the best indices of fit. Although the two- and three-factor structure of the DTSQ was empirically supported, the two-factor solution for DTSQ based on the 2-items of perceived hyper-hypoglycemia and six-items satisfaction factor presented a better theoretical fit compared to the three-factor solution. Considering the low number of items per factor in the three-factors model, Davies et al<sup>32</sup> suggested a factor solution with two items per factor can be more acceptable. In addition, that a three-model factor of the DTSQ has only one indicator for factor 3 suggests that this model is not testable.

Regarding measurement invariance, the results indicate that the dimensional structure underlying the DTSQ is invariant across gender and across patients treated with insulin or oral hypoglycemic medication. CFA showed that loading of latent variable in each item were above the recommended value of 0.30, except for the perceived hypoglycemia item. The negative correlation between factor 1 and factor 2 support the applied value of the two-factor model of the DTSQ to monitor patient's satisfaction of treatment and frequency of hypo-hyper glycaemic complaints. Monitoring patient's experience of frequent hypo-hyper glycaemic episodes provide increased opportunity to tailor interventions to support adequate glycaemic control based on their individual profile.

## Implications for Practice

The DTSQ may be valuable in diabetes care and research, although evaluating sensitivity to change in treatment will require further analysis. The rising burden of diabetes has become a global challenge, in particular for the Middle East and North Africa (MENA) regions.<sup>1</sup> In this instance, measurement of treatment satisfaction instruments are important indicators of treatment compliance and glycemic control. Therefore, the Arabic version of the DTSQ can serve as an outcome measure to help nurses, as well as other healthcare professionals in identifying patients with

low treatment satisfaction and those who are at higher risk for poor compliance with treatment.

Our findings confirm that the DTSQ is a valued instrument to explore the association between treatment satisfaction and the role of participant's gender, type of treatment, diet, and glycemic control. Within known limitations and gaps in the literature, nurses, and other healthcare professionals working with Arabic speaking patients may find this tool useful for identification of high-risk patients and those in need for interventions to promote glycemic control. We argue that treatment satisfaction is a construct that would be measured in place of compliance (potentially as a predictor) rather than in conjunction with compliance as a standard part of diabetes care.

Finally, whilst the construct validity and internal reliability of the DTSQ have been confirmed in this study, further studies are needed to establish the sensitivity of the DTSQ to changes in treatment, and further studies are needed to confirm our findings in patients with type 1 diabetes. Even though results supported the a priori hypothesized two-factor structure of the DTSQ construct validity, conclusions regarding the scale's construct validity should be based on more empirical findings that support the DTSQ theoretical presumptions. The sample was a convenience sample from one clinical setting in Amman. While this study included a large sample with a diverse population, it was limited to patients with type 2 diabetes. Lack of clarity on the rigor of the translation process of the tool into Arabic is a limitation and there is a need to replicate this study among people with a diagnosis of type I diabetes across other Arabic speaking countries. Irrespective of these limitations, our findings add to the body of knowledge on measures of diabetes outcomes worldwide.

## Conclusion

In conclusion, we were able to replicate the three different models of the 8-item DTSQs (one factor, two factors, three factors) reported in previous studies. Confirmatory factor analysis was used to compare three different models of the DTSQ, and to investigate the invariance of the factor structure across patients treated with insulin and patients treated with oral hypoglycemic medications. A two-factor model with six items loading highly on Factor 1 and the two hypo/hyperglycemic loading in factor 2 provided the best fit to the data in the two samples (patients treated with insulin and patients treated with oral hypoglycaemic medications). Our results suggest a cross-cultural invariance of



the factor structure of the DTSQ, as we were able to replicate the same factor structure using the Arabic translated version of the tool and using non-English speaking participants.

## Abbreviations

DTSQ, Diabetes Treatment satisfaction Questionnaire; MENA, Middle East and North Africa Region; CFA, confirmatory factor analysis;  $\Omega_w$ , omega reliability coefficient; AIC, Akaike's Information Criterion; CFI, The Comparative Fit Index; RMSEA, The Root Mean Square Error of Approximation; TLI, Tucker-Lewis coefficient.

## Data Sharing Statement

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## Ethics Approval and Consent to Participate

Ethical approval for this study was received from the institutional review board of the National Institute for Diabetes Endocrinology and Genetics (Ethical approval number MS/9/57 dated 9th of January 2014). Written informed consent was obtained from all participants of the study.

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## Author Contributions

All authors made substantial contributions to the conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

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## Disclosure

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