Saudi Pharmaceutical Journal (2026) 34:27
https://doi.org/10.1007/s44446-026-00083-1

RESEARCH ARTICLE

Translation, cultural adaptation, and validation of the Arabic version of the Medication Adherence Universal Questionnaire among Omani patients with type 2 diabetes mellitus

Iman Asrawi[1] · Juhaina Salim Al-Maqbali[1,2] · Ana C. Cabral[3,4] · Margarida Castel-Branco[3,4] · Isabel V. Figueiredo[3,4] · Fernando Fernandez-Llimos[5,6] · Raya Al Maskari[1] · Abdullah M. Al Alawi[7] · Asma Al Shidhani[8] · Mohammed Al Za'abi[1]

Received: 8 December 2025 / Accepted: 2 April 2026

Abstract

This study aimed to translate, culturally adapt, and validate an Arabic version of the Medication Adherence Universal Questionnaire (MAUQ-ar-OM) for Omani adults with type 2 diabetes mellitus (T2DM), and to assess its association with glycated hemoglobin (HbA1c). A cross-sectional psychometric validation was conducted at a tertiary-care hospital in Oman from October 2024 to January 2025, enrolling 300 participants. The MAUQ was translated and culturally adapted using forward–backward translation, expert panel review (n = 4), and cognitive interview testing and then administered by a trained clinical pharmacist using a standardized script. Confirmatory factor analysis (CFA) compared second order and bifactor models using CFI, TLI, RMSEA (90% CI) and SRMR. Convergent validity with HbA1c was assessed using Spearman's correlation (ρ). The bifactor model showed superior fit indices (CFI = 0.904; TLI = 0.868; RMSEA = 0.055; SRMR = 0.057) compared with the second-order model (CFI = 0.849; TLI = 0.819). Cronbach's α coefficients for total scores, positive attitude towards healthcare and medication (PAM), lack of discipline, aversion towards medication and active coping with health problems subscales were 0.69, 0.71, 0.67, 0.59 and 0.42, respectively. The PAM subscale showed small inverse correlation with HbA1c (ρ = -0.157; 95% CI: − 0.269 to − 0.041; p < 0.01), whereas other subscales and the total score showed no significant correlation. The MAUQ-ar-OM demonstrates construct validity for assessing medication adherence beliefs and behaviors among Arabic-speaking Omani adults with T2DM, with the bifactor structure supporting domain-level interpretation and the total score used descriptively. Further research is warranted to confirm reliability and generalizability across other Arabic-speaking populations, conditions and administration modes.

Keywords medication adherence · MAUQ · psychometric validation · Arabic · Oman · type 2 diabetes mellitus

✉ Mohammed Al Za'abi
zaabi@squ.edu.om

[1] Department of Pharmacology and Clinical Pharmacy, College of Medicine and Health Sciences, Sultan Qaboos University, Muscat, Oman

[2] Department of Pharmacy, Sultan Qaboos University Hospital, University Medical City, Muscat, Oman

[3] Institute for Clinical and Biomedical Research (iCBR), Coimbra, Portugal

[4] Pharmacology and Pharmaceutical Care Laboratory, Faculty of Pharmacy, University of Coimbra, Coimbra, Portugal

[5] Applied Molecular Biosciences (UCIBIO), University of Porto, Porto, Portugal

[6] Laboratory of Pharmacology, Faculty of Pharmacy, University of Porto, Porto, Portugal

[7] Department of Medicine, Sultan Qaboos University Hospital, University Medical City, Muscat, Oman

[8] Department of Family Medicine and Public Health, Sultan Qaboos University Hospital, University Medical City, Muscat, Oman

Published online: 04 May 2026

1 Introduction

Chronic diseases such as Type 2 Diabetes Mellitus (T2DM) are among the leading causes of morbidity and mortality globally, with a particularly high burden observed in the Middle East and North Africa region (Sun et al. 2022). In Oman, the increasing prevalence and complications of T2DM continue to place a considerable burden on individuals, families, and the healthcare system (Alareeki et al. 2024). Successful long-term management of chronic illnesses like T2DM relies on patients' consistent adherence to prescribed medication regimens. However, medication nonadherence remains a widespread challenge, significantly compromising treatment efficacy and health outcomes (Al-Noumani et al. 2023). Medication nonadherence is a multifactorial, dynamic process shaped by a complex interplay of personal, clinical, and social factors (Burkhart and Sabaté 2003). Contemporary adherence research distinguishes between two primary forms: intentional nonadherence, in which patients deliberately choose not to follow prescribed treatment recommendations due to beliefs or concerns about medications, and unintentional nonadherence, which arises from forgetfulness, misunderstanding, or logistical barriers (Clifford et al. 2008). This distinction is crucial for both assessment and intervention, as each form of nonadherence requires different clinical approaches (Xu et al. 2020).

A substantial body of evidence highlights the role of patients' beliefs, particularly perceptions of medication necessity and concerns, as key determinants of intentional nonadherence (Kvarnström et al. 2021). The Necessity-Concerns Framework postulates that patients who perceive high necessity and low concerns are more likely to adhere intentionally, whereas those with high concerns or low perceived necessity may purposely avoid medication (Horne and Weinman 1999). While widely used tools such as the Beliefs about Medicines Questionnaire (BMQ) assess these cognitive components, they do not provide a comprehensive measure of adherence behaviour itself (Salgado et al. 2013). Moreover, these tools cannot distinguish between unintentional nonadherence and intentional nonadherence.

On the other hand, self-report adherence tools such as the Morisky Medication Adherence Scale (MMAS-8) and the General Medication Adherence Scale (GMAS) primarily focus on whether patients take their medications as prescribed. However, these tools include items that broadly address both intentional and unintentional nonadherence; their structure and brevity limit their capacity to clearly distinguish between these two types or to identify specific underlying reasons for nonadherence (Nassar et al. 2022; Islam et al. 2023). The GMAS, for example, includes specific items to assess cost-related nonadherence, a domain that may have limited applicability in healthcare settings such as Oman, where medications are typically provided free of charge to citizens (Islam et al. 2023; Abdo-Rabbo et al. 2009). Another limitation is that adherence instruments have not been rigorously validated in Arabic-speaking populations, such as those in Oman. Furthermore, few tools have been designed to integrate both behavioural and cognitive aspects of adherence within a single framework.

To address the limitations of existing adherence assessment instruments, the Medication Adherence Universal Questionnaire (MAUQ) was developed as an open-access instrument that integrates the assessment of medication-taking behaviour and underlying beliefs that influence adherence (Cabral et al. 2023). The original MAUQ (MAUQ-pt–PT) is a 16-item self-report questionnaire designed to assess both medication-taking behaviours and underlying beliefs. It was derived from the Maastricht Utrecht Adherence in Hypertension short version (MUAH-16) and comprises four subscales that captures key belief domains related to adherence: positive attitudes towards healthcare and medication (PAM), lack of discipline (LD), aversion towards medication (ATM), and active coping with health problems (ACHP) (Cabral et al. 2023). Responses are rated on a 7-point Likert scale, with negatively worded items reverse-scored to ensure consistent scoring. The MAUQ provides an overall adherence score as well as domain-specific scores that possibly reflect the multifaceted nature of nonadherence, encompassing both intentional and unintentional dimensions. It has demonstrated robust psychometric properties and improved fit compared with disease-specific tools such as the MUAH-16, making it applicable across different chronic diseases (Cabral et al. 2023).

Despite these advances, the MAUQ has yet to be translated, culturally adapted, and validated for use among Arabic-speaking populations, including patients with T2DM in Oman. This represents a notable gap, especially given the high regional burden of diabetes and the urgent need for culturally relevant, validated tools to assess adherence behaviour. Thus, this study aims to translate, culturally adapt, and validate an Arabic version of the MAUQ (MAUQ-ar-OM) in Omani patients with T2DM.

2 Materials and methods

2.1 Study design, participants, and setting

This cross-sectional validation study was conducted between 1 October 2024 and 31 January 2025 at Sultan Qaboos University Hospital (SQUH), Muscat, Oman, a single tertiary-care academic centre serving patients from across Oman.

Inclusion criteria were Arabic-speaking adults aged ≥ 18 years with a confirmed diagnosis of T2DM for ≥ 1 year, currently prescribed ≥ 1 hypoglycaemic medication, and a documented glycated hemoglobulin (HbA1c) within the prior six months. Exclusion criteria were type 1 or gestational diabetes, and cognitive impairments that could compromise consent or questionnaire comprehension.

2.2 Instrument translation and cultural adaptation

Procedures followed the International Society for Pharmacoeconomics and Outcomes Research (ISPOR) guidelines (Wild et al. 2005), with formal permission from the original developers and a written agreement to adhere to international validation standards. The process comprised: (i) forward translation by two native Omani Arabic translators with medical backgrounds, followed by reconciliation to a single draft; (ii) back-translation by two native English speakers fluent in Arabic to assess semantic equivalence; (iii) review by a multidisciplinary expert panel (n = 4; clinical pharmacy, endocrinology/medicine, psychometrics/methodology, medical linguistics) to resolve discrepancies and ensure conceptual and cultural adequacy; and (iv) cognitive interviews with Arabic-speaking adults with T2DM (n = 30) using structured probes (comprehension, relevance, response mapping) to confirm clarity and cultural relevance (Perneger et al. 2015). The original developers approved the final Arabic version (MAUQ-ar-OM) before its application to the study participants.

2.3 Face validation/pilot testing

Cognitive interviews were conducted with Arabic-speaking Omani adults with T2DM (N = 30) to assess items clarity and cultural relevance. Both interviewer-administered and self-administered formats were explored during this phase. Given that substantial proportion of participants had limited formal education, and considering evidence that lower literacy impairs discrimination among Likert response categories in self-administered questionnaires, an interviewer-administered approach was selected for main validation sample (N = 300) (Chachamovich et al. 2009). Minor wording refinements were made to enhance clarity. The mean questionnaire completion time was approximately 6 min.

2.4 Sampling and data collection

Participants were recruited by convenience sampling in the waiting areas of outpatient clinics (Diabetes, Endocrinology, Family Medicine, and General Medicine). A single trained, non-treating clinical pharmacist conducted the questionnaire sessions using a neutral, standardized script in a private area. The interviewer provided a standardized, neutral explanation of the 7-point Likert scale at the beginning of the interview. For each item, all response options were repeated verbatim, and participants could respond either by selecting the verbal anchor or by indicating the corresponding numerical value. For participants with limited literacy, all items and response options were read aloud, and responses were recorded by the interviewer. No visual response aids were used. Participants were reminded that there were no right or wrong answers and that responses were confidential. Sociodemographic and clinical variables (age, sex, diabetes duration, medication regimen, comorbidities, and most recent HbA1c) were obtained and verified in the hospital information system in same day.

2.5 Outcomes validation

The validity of the primary outcome, the Arabic MAUQ (MAUQ-ar-OM), used assessed using confirmatory factor analysis (CFA), comparing the second order and bifactor models. Model fit was evaluated using Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA) with 90% confidence intervals (CI), and the Standardized Root Mean Square Residual (SRMR).

Convergent validity, specified as the secondary outcome, was examined by assessing the association between MAUQ-ar-OM scores (with higher scores indicating greater adherence) and glycaemic control, as measured by HbA1c, using Spearman's rank correlation coefficient (ρ), with an a priori hypothesis that higher adherence would be associated with lower HbA1c values.

HbA1c was selected as the convergent validity criterion for several reasons. First, it is the standard clinical marker of long-term glycemic control in T2DM and represents a clinically meaningful downstream outcome of adherence behavior. Second, it was routinely available in the electronic medical record for all participants, allowing standardized assessment without additional burden or cost. Third, previous adherence validation studies in diabetes have commonly used HbA1c as a convergent criterion, despite acknowledging its multifactorial determinants (Krapek et al. 2004). Alternative adherence-related measures (e.g., pharmacy refill data, electronic monitoring, or parallel self-report adherence scales) were considered but were not feasible within the constraints of the current study setting.

2.6 Sample size

Following Nunnally's rule of thumb of 10 participants per item (Nunnally 1978), A minimum of 160 participants was needed for the 16-item MAUQ. Additionally, a minimum of 150 participants was suggested for conducting factor analysis (Everitt 1975; Hair et al. 2006). To exceed

the conventional criteria for CFA, including both absolute thresholds and the subject-to-variable ratio (≥ 10:1), a target sample size of 300 participants was established to ensure robust psychometric validation, model stability, and generalizability of the findings.

2.7 Data analysis

Descriptive statistics summarized participant characteristics (categorical variables as n (%); continuous variables as median (IQR)). CFA tested a priori measurement structures derived from the MAUQ framework and prior validation work. Two prespecified models were evaluated: (i) a second-order four-factor model with PAM, LD, ATM, and ACHP loading on a higher-order General Adherence factor; and (ii) a bifactor model with one General Adherence factor plus four orthogonal domain factors. Global fit was summarized with CFI, TLI, RMSEA (90% CI), and SRMR; following widely cited guidance, CFI/TLI ≥ 0.90 were considered indicative and ≥ 0.95 good, RMSEA ≤ 0.08 (≤ 0.06 good), and SRMR ≤ 0.08, with exact indices reported and values near cut-offs interpreted as borderline (Hu and Bentler 1999; Kline 2023). Negatively worded items were reverse-coded, so higher scores reflect better adherence. Convergent validity with HbA1c was examined using two-sided Spearman's ρ for MAUQ total and subscale scores (α = 0.05). Analyses were conducted in IBM SPSS Statistics v24 and R (lavaan 0.6–19).

Internal consistency was assessed by calculating Cronbach's alpha coefficients for each four-item subscale, consistent with the scale's hypothesized multidimensional structure. Although a total-scale alpha was also calculated for completeness, it was interpreted descriptively only, as COSMIN guidelines caution against reliance on total-score reliability estimates when a measure comprises multiple related but distinct constructs and demonstrates a bifactor structure (Prinsen et al. 2018).

3 Results

Table 1 summarizes participant characteristics. A total of 300 adults with T2DM completed the study. The median age was 58 years (IQR 51–64), with 62.0% aged ≥ 55 years; 55.0% were female. Most participants resided in the central governorate region (67.3%) and were married (77.3%). Educational attainment varied: 21.6% were illiterate, 44.0% had high school or less, and 34.4% held a university degree. Employment status was as follows: 44.3% unemployed, 35.7% retired, and 20.0% employed. The median diabetes duration was 15 years (IQR 10–20), with 68.0% having diabetes for > 10 years. Median HbA1c was 7.7% (IQR 6.6–8.98). Polypharmacy (≥ 5 medications) was present in 86.0%. Common comorbidities were dyslipidemia (83.7%) and hypertension (62.0%); macrovascular complications affected 27.0%, and microvascular complications 55.3% (neuropathy 5.3%, nephropathy 16.3%, retinopathy 16.7%, mixed 17.0%). Most patients (96.3%) reported independent medication administration; 3.7% were partially or wholly dependent.

Table 2 shows the CFA results. The bifactor model showed better, though borderline-global fit (CFI 0.904; TLI 0.868; RMSEA 0.055; SRMR 0.057) compared with the second-order model (CFI 0.849; TLI 0.819; RMSEA 0.064; SRMR 0.071). Given that TLI < 0.90, a single total score warrants cautious interpretation; domain-level scores provide a more informative summary of adherence beliefs and behaviors. Figures 1–2 display the model schematics corresponding to these indices.

Table 3 summarizes associations between MAUQ scores and HbA1c. The PAM subscale showed a small inverse correlation with HbA1c (ρ = − 0.157; 95% CI − 0.269 to − 0.041; p < 0.01). Correlations between LD, ATM, ACHP, and the total MAUQ score were not statistically significant. Figure 3 shows the PAM–HbA1c relationship.

The PAM subscale demonstrated acceptable internal consistency (0.71), LD showed borderline reliability (0.68), ATM demonstrated moderate internal consistency (0.59), and ACHP showed low internal consistency (0.42), indicating heterogeneity among its items. The total 16-item score was 0.69 (Table 4).

4 Discussion

This study presents the first validated Arabic translation of MAUQ among Omani patients with T2DM. The findings demonstrate that MAUQ-ar-OM is a clinically relevant tool for evaluating medication adherence in this population. The bifactor model exhibited superior structural validity compared to the second-order model, supporting the conceptualization of adherence behavior as a multidimensional construct comprising both general and specific factors.

The bifactor model demonstrated a better fit, although the global fit indices were borderline (CFI = 0.904; TLI = 0.868; RMSEA = 0.055; SRMR = 0.057), thereby supporting a multidimensional structure and favoring domain-level interpretation over a total-score approach.

The observed pattern of internal consistency (α = 0.42–0.71), with higher alpha values for PAM and lower values for ACHP, suggests that the PAM domain is assessed by relatively homogeneous items, whereas ACHP likely reflects a broader and more heterogeneous set of adherence-related behaviors. This pattern is consistent with the multidimensional nature of medication adherence beliefs and behaviors and supports the use of domain-level scores, rather

Table 1 Participant characteristics ($N = 300$)

Variable	Category/Statistic	n (%) or Median (IQR)
Age, years	Median (IQR)	58 (51–64)
	< 55	114 (38.0%)
	≥ 55	186 (62.0%)
Gender	Male	135 (45.0%)
	Female	165 (55.0%)
Region of residence	Central	202 (67.3%)
	Other	98 (32.7%)
Marital status	Married	232 (77.3%)
	Not married	68 (22.7%)
Education	Illiterate	65 (21.6%)
	High school or less	132 (44.0%)
	University	103 (34.4%)
	Employed	60 (20.0%)
	Unemployed	133 (44.3%)
	Retired	107 (35.7%)
Duration of diabetes, years	Median (IQR)	15 (10–20)
	≤ 10	96 (32.0%)
	> 10	204 (68.0%)
Most recent HbA1c, % (last 6 months)	Median (IQR)	7.7 (6.6–9.0)
Months since last HbA1c	Median (IQR)	1 (1–3)
Comorbidities	Dyslipidemia	251 (83.7%)
	Hypertension	186 (62.0%)
	Pulmonary (asthma/COPD)	21 (7.0%)
	Hypothyroidism	62 (20.7%)
Macrovascular complications	Heart disease and/or stroke	81 (27.0%)
Microvascular complications	None	134 (44.7%)
	Neuropathy	16 (5.3%)
	Nephropathy	49 (16.3%)
	Retinopathy	50 (16.7%)
	Mixed	51 (17.0%)
Total number of medications	Median (IQR)	8 (6–10)
Polypharmacy	Yes	257 (85.7%)
	No	42 (14.0%)
Adverse effects from medication	Yes	32 (10.7%)
	No	268 (89.3%)
Medication administration	Self	290 (96.7%)
	Caregiver	9 (3.0%)
Difficulty obtaining medication every 3 months	Yes	12 (4.0%)
	No	288 (96.0%)

Continuous variables are median (IQR); categorical variables are n (%); $N = 300$. Comorbidities are not mutually exclusive; totals may exceed 100%. Macrovascular complications = heart disease and/or stroke. Polypharmacy ≥ 5 concurrent medications

than a single total score, for clinical and research interpretation (Prinsen et al. 2018; Cabral et al. 2023).

Consistent with the original MAUQ conceptualization (Cabral et al. 2023), which posits adherence as a general tendency coupled with belief-specific variance, only the PAM domain exhibited a small but statistically significant inverse association with HbA1c ($\rho = -0.157$, $p < 0.01$), indicating that more favorable medication beliefs are associated with slightly better glycemic control. This finding aligns with the Necessity, Concerns Framework, which links positive medication beliefs to improved adherence and downstream clinical outcomes (Horne and Weinman 1999). In contrast, other adherence domains and the overall adherence score exhibited no significant relationship with HbA1c levels.

Table 2 Model fit indices for second order and bifactor confirmatory factor analysis (CFA) of the translated Arabic version of Medication Adherence Universal Questionnaire (MAUQ-ar-OM)

Fit index	Second-order	Bifactor
χ^2	223.01	166.70
CFI	0.849	0.904
TLI	0.819	0.868
RMSEA (90% CI)	0.064 (0.053–0.075)	0.055 (0.042–0.068)
SRMR	0.071	0.057

Interpretation*:* The bifactor model shows better though borderline fit; TLI < 0.90 indicates the total score should be used cautiously alongside domain scores

This pattern corresponds with previous research, including studies using the Morisky Medication Adherence Scale-8 in Chinese adults (Wong et al. 2015) and reports from Pakistan that identified weak or nonsignificant associations between adherence and glycemic control (Nazir et al. 2016).

Conceptually, these weak or null correlations are expected, given that HbA1c reflects average glycaemic exposure over roughly 2–3 months and is shaped by multiple determinants beyond medication taking, including treatment regimen intensity, diet, physical activity, weight changes, comorbid conditions, and the quality and frequency of clinical follow-up. Because adherence is only one contributor within this complex causal chain, even valid self-report adherence instruments typically show weak or modest correlations with HbA1c, and a substantial proportion of HbA1c variance remains unexplained by adherence measures alone (Krapek et al. 2004; Mulvaney et al. 2011). Consequently, future validation studies should, where feasible, incorporate more direct and objective adherence indicators—such as pharmacy refill–based metrics (e.g. medication possession ratio or proportion of days covered), electronic monitoring, or linked dispensing records—to provide stronger convergent validity evidence and to disentangle true nonadherence from other clinical and behavioral influences on glycemic control (Choudhry et al. 2009). Notwithstanding these limitations, the collective evidence supports the use of MAUQ-ar-OM domain scores to identify modifiable, belief-related adherence barriers and to inform brief, targeted counseling in routine clinical practice. The total score should be interpreted primarily as a descriptive summary rather than as a prognostic surrogate for glycemic control.

These findings gain additional relevance considering the contextual challenges of healthcare delivery in Oman, where low-to-moderate medication adherence rates have been consistently documented across studies (Al-Noumani et al. 2023; Burkhart and Sabaté 2003). The MAUQ-ar-OM's brevity and its conceptual framework offer a

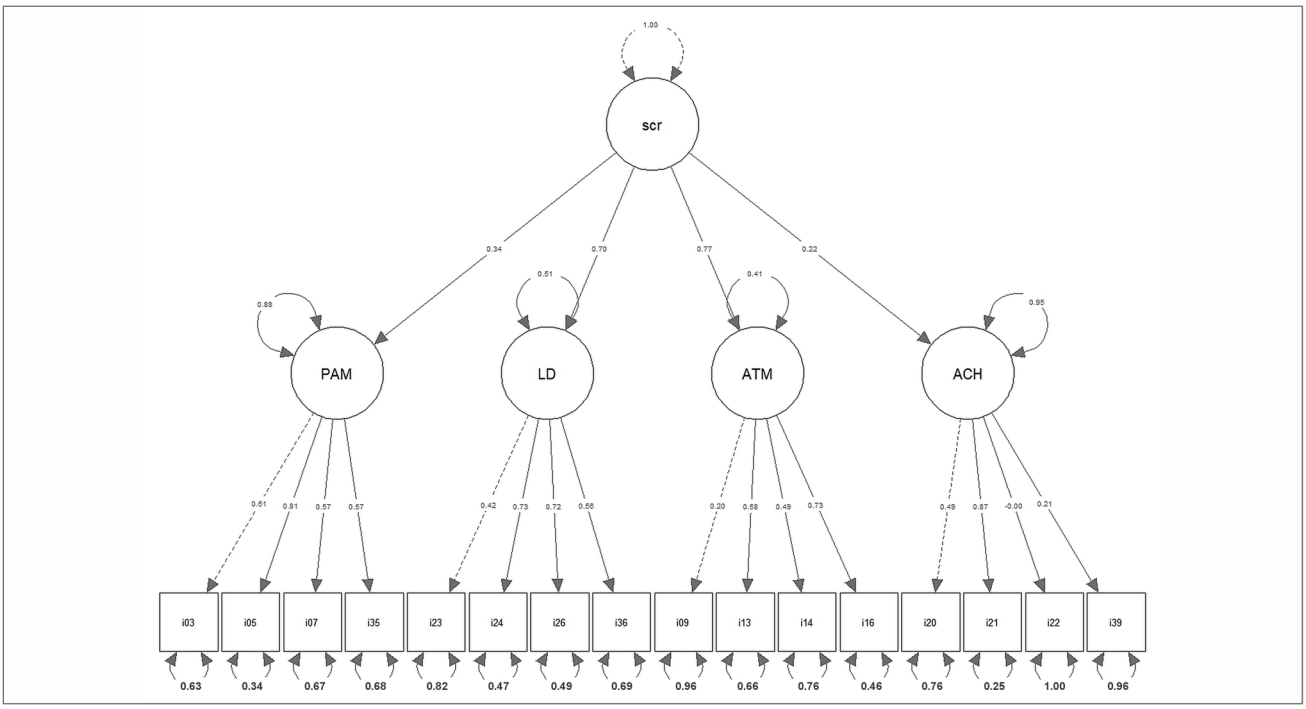

Fig. 1 Second-order CFA for MAUQ-ar-OM. Items (i03–i39) load on four domains-PAM (Positive Attitudes towards Health Care & Medication), LD (Lack of Discipline), ATM (Aversion Towards Medication), ACHP (Active Coping with Health Problems)-which load on a higher-order General Adherence factor (SCR). Global fit: CFI = 0.849; TLI = 0.819; RMSEA = 0.064 (90% CI 0.053–0.075); SRMR = 0.071. Interpretation: suboptimal global fit

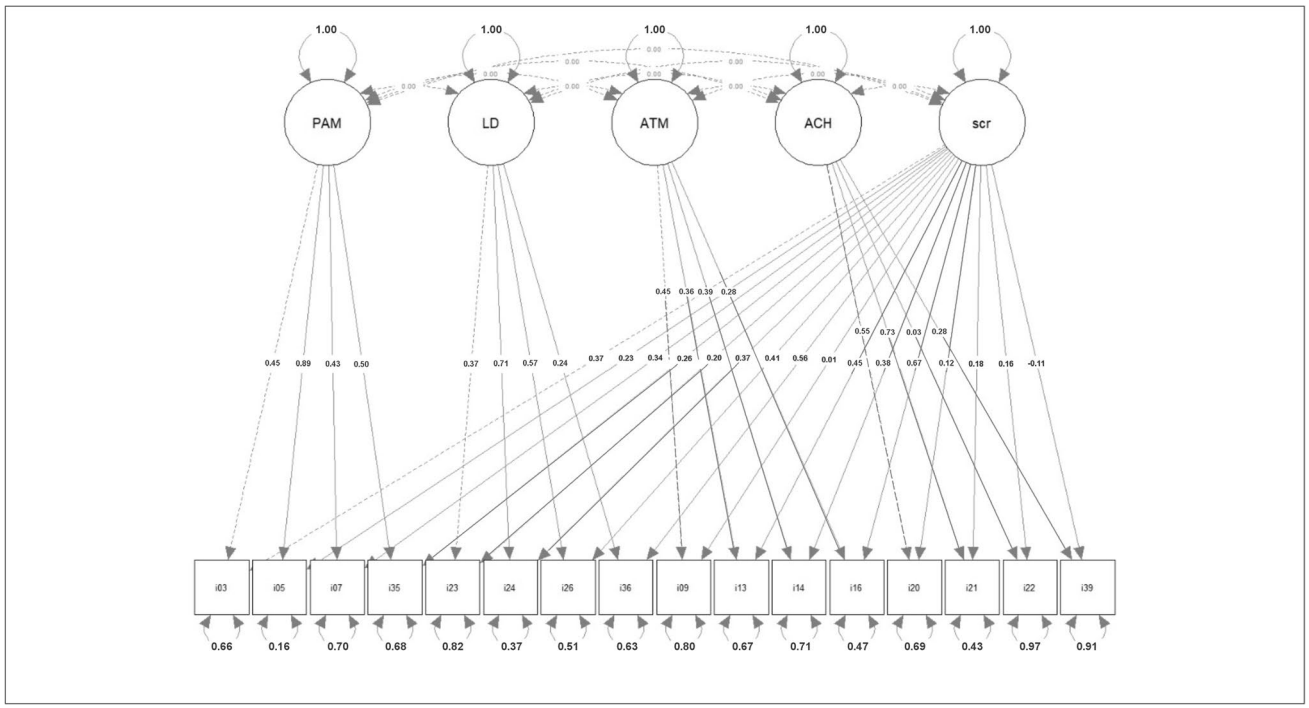

Fig. 2 Bifactor CFA for MAUQ-ar-OM. Each item loads on a General Adherence factor (SCR) and exactly one domain (PAM/LD/ATM/ACHP; domain factors orthogonal). Global fit: CFI = 0.904; TLI = 0.868; RMSEA = 0.055 (90% CI 0.042–0.068); SRMR = 0.057. Interpretation: better though fit relative to the second-order model; supports cautious use of a total score alongside domain scores

Table 3 Correlations (Spearman ρ) between total score and different subclass scores of the translated Arabic version of Medication Adherence Universal Questionnaire scores and glycated hemoglobin ($N = 300$)

MAUQ construct	Spearman ρ (95% CI)	*p*-value
Positive Attitudes towards Health Care & Medication	−0.157 (−0.269, −0.041)	< 0.01
Lack of Discipline	−0.045 (−0.161, 0.072)	0.438
Aversion Towards Medication	−0.036 (−0.152, 0.081)	0.533
Active Coping with Health Problems	0.002 (−0.114, 0.119)	0.966
MAUQ total score	−0.070 (−0.185, 0.047)	0.229

Two-sided Spearman correlations reported. Confidence intervals are formatted as (lower, upper). Negative values are shown with a leading hyphen (e.g., −0.24; CI (−0.38, −0.10))

pragmatic solution for busy outpatient clinics, efficiently facilitating the timely identification of adherence barriers and enabling tailored interventions without imposing an excessive burden on patients or healthcare providers. Moreover, its integration of belief and behavior constructs within a single, open-access tool addresses enduring gaps in disease-specific scales and restrictive licensing, thereby promoting applicability and comparability across diverse settings and populations.

Methodologically, the study's robust cross-cultural adaptation process, including developer approval, multidisciplinary expert panel review, cognitive interviews with patients, and administration in a private setting with a neutral script sensitive to varying health literacy levels, strengthens content validity and acceptability. The sample size (N = 300) exceeded common thresholds for CFA, providing stable parameter estimation and facilitating linkage with the original MAUQ validation framework (Cabral et al. 2023).

Nevertheless, several limitations warrant consideration. The reliance on single-country, single-center convenience sampling and a single disease context limits the generalizability of the findings beyond the study setting. Interviewer-administered self-report may introduce social desirability bias, though neutral delivery protocols were followed to mitigate this risk. Convergent validity evidence was constrained by the use of HbA1c as the sole available external criterion; given the multifactorial determinants of HbA1c, observed correlations should be interpreted as partial support for convergent validity rather than as definitive criterion validation. The cross-sectional nature of this study limits the ability to draw causal conclusions, and critical psychometric characteristics such as test–retest reliability, sensitivity to clinical change, and the establishment of clinically meaningful cut-off points, key elements for broader clinical applicability, remain to be evaluated. Although the bifactor model

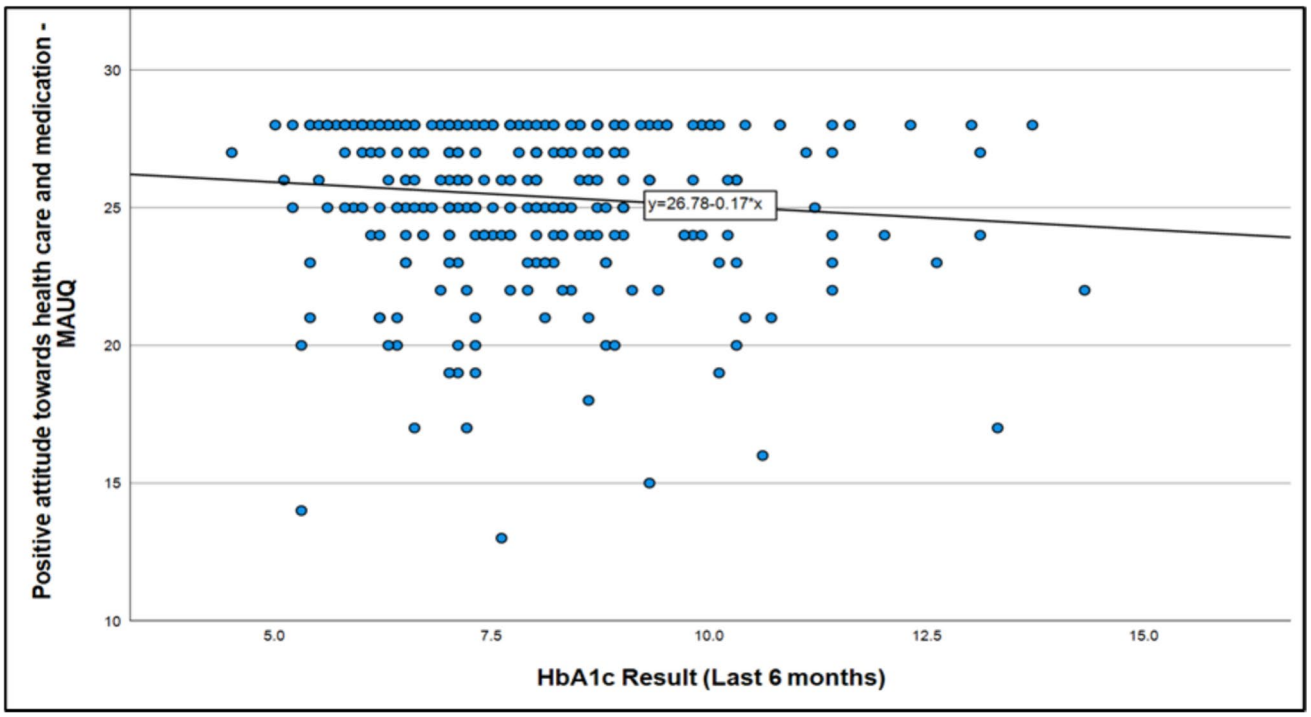

Fig. 3 Relationship between MAUQ–PAM domain and HbA1c. Scatterplot of Positive Attitudes towards Health Care & Medication (PAM) score versus HbA1c (%) for adults with T2DM ($n = 300$). Points represent individual participants; the solid line is the least-squares linear fit ($y = 26.78 - 0.17x$), shown to illustrate the negative gradient. Spearman's $\rho = -0.157$ (95% CI −0.269 to −0.041; $p < 0.01$). Higher PAM scores indicate more favorable attitudes toward medication. HbA1c values were verified in the hospital information system within the preceding six months

Table 4 Internal consistency reliability (Cronbach's alpha) for MAUQ-ar-OM subscales and total score ($N = 300$)

Construct	Cronbach's alpha
Positive Attitudes towards Health Care & Medication (4 items)	0.71
Lack of Discipline (4 items)	0.68
Aversion Towards Medication (4 items)	0.59
Active Coping with Health Problems (4 items)	0.42
MAUQ total score (16 items)	0.69

yielded a better fit compared to alternative models, some fit indices hovered near threshold levels, suggesting that further refinement is needed.

Future research should prioritize evaluating these psychometric characteristics and extend validation efforts to other Arabic-speaking populations and chronic disease groups, strengthen reliability (particularly for ATM and ACHP), and triangulate convergent validity using multiple objective adherence indicators where feasible. Additionally, longitudinal intervention studies assessing the effectiveness of MAUQ-guided counseling on medication adherence and glycemic outcomes, such as HbA1c, are essential to establish clinical utility and support integration into routine care guidelines.

In summary, the MAUQ-ar-OM represents a valid, theoretically grounded instrument that can enhance medication adherence assessment and support belief-focused counseling for adults with type 2 diabetes in Oman. Its adoption may facilitate personalized care strategies in resource-limited settings, contributing to global efforts to standardize and adapt adherence measurement tools across populations and conditions.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s44446-026-00083-1.

Acknowledgements We express our sincere gratitude to the original developers of the MAUQ for granting permission to translate, culturally adapt, and validate the instrument, and for their critical review of the final Arabic version (MAUQ-ar-OM). We thank the multidisciplinary expert panel, professional translators, outpatient clinic teams at Sultan Qaboos University Hospital, and all study participants for their valuable time and insightful contributions.

Author contributions Conceptualization: Mohammed Al Za'abi; Iman Asrawi; Juhaina Salim Al-Maqbali. Methodology: Iman Asrawi; Juhaina Salim Al-Maqbali; Fernando Fernandez-Llimos; Raya Al Maskari; Mohammed Al Za'abi. Material preparation, data collection and analysis: Iman Asrawi; Juhaina Salim Al-Maqbali; Ana C. Cabral; Margarida Castel-Branco; Isabel V. Figueiredo; Fernando

Fernandez-Llimos; Raya Al Maskari; Abdullah M. Al Alawi; Asma Al Shidhani; Mohammed Al Za'abi. Writing-original draft: Iman Asrawi; Mohammed Al Za'abi. Writing-review and editing: Juhaina Salim Al-Maqbali; Fernando Fernandez-Llimos; Raya Al Maskari; Asma Al Shidhani. All authors have read and agreed to the published version of the manuscript.

Funding This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability Data available on a reasonable request from the authors.

Declarations

Ethical approval This study received ethical clearance from the Sultan Qaboos University Medical Research Ethics Committee (SQU-EC/207/2024; MREC #3408; 17 July 2024) and was conducted in strict accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants in a private setting prior to enrollment. Participation was entirely voluntary and did not influence routine clinical care. Data confidentiality was maintained by assigning unique study identifiers and securely storing linkage keys on password-protected, restricted-access institutional servers.

Competing interests The authors declare that they have no competing interests related to this research.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process Declaration of AI Assistance. During the preparation of this manuscript, the authors used ChatGPT (OpenAI; accessed 11 October 2025) to assist with language editing and reference formatting. The authors critically reviewed and revised all AI-assisted text and accept full responsibility for the integrity and accuracy of the final manuscript. No AI tools were used for data collection, statistical analysis, or drawing scientific conclusions, and no confidential or personally identifiable data were entered into the tool.

References

Abdo-Rabbo A, Al-Ansari M, Gunn BC, Suleiman BJ (2009) The use of medicines in Oman: public knowledge, attitudes and practices. Sultan Qaboos Univ Med J 9:124–131

Alareeki A, Awad SF, Al-Mawali A, Morsi M, Critchley JA, Al-Lawati JA et al (2024) Impact of mitigating obesity, smoking, and physical inactivity on type 2 diabetes mellitus burden in Oman: insights from mathematical modeling. BMJ Open Diabetes Res Care 12:e004248. https://doi.org/10.1136/bmjdrc-2024-004248

Al-Noumani H, Alharrasi M, Lazarus ER, Panchatcharam SM (2023) Factors predicting medication adherence among Omani patients with chronic diseases through a multicenter cross-sectional study. Sci Rep 13:7067. https://doi.org/10.1038/s41598-023-34393-4

Burkhart PV, Sabaté E (2003) Adherence to long-term therapies: evidence for action. J Nurs Scholarsh 35:207

Cabral AC, Lavrador M, Castel-Branco M, Figueiredo IV, Fernandez-Llimos F (2023) Development and validation of a Medication Adherence Universal Questionnaire: the MAUQ. Int J Clin Pharm 45:999–1006. https://doi.org/10.1007/s11096-023-01612-x

Chachamovich E, Fleck MP, Power M (2009) Literacy affected ability to adequately discriminate among categories in multipoint Likert Scales. J Clin Epidemiol 62:37–46. https://doi.org/10.1016/j.jclinepi.2008.03.002

Choudhry NK, Shrank WH, Levin RL, Lee JL, Jan SA, Brookhart MA et al (2009) Measuring concurrent adherence to multiple related medications. Am J Manag Care 15:457–464

Clifford S, Barber N, Horne R (2008) Understanding different beliefs held by adherers, unintentional nonadherers, and intentional nonadherers: application of the necessity–concerns framework. J Psychosom Res 64:41–46. https://doi.org/10.1016/j.jpsychores.2007.05.004

Everitt BS (1975) Multivariate analysis: the need for data, and other problems. Br J Psychiatry 126:237–240. https://doi.org/10.1192/bjp.126.3.237

Hair JF, Black WC, Babin BJ, Anderson RE, Tatham RL (2006) Multivariate data analysis, 6th edn. Pearson Prentice Hall, Upper Saddle River, NJ

Horne R, Weinman J (1999) Patients' beliefs about prescribed medicines and their role in adherence to treatment in chronic physical illness. J Psychosom Res 47:555–567. https://doi.org/10.1016/s0022-3999(99)00057-4

Hu LT, Bentler PM (1999) Cut-off criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Struct Equ Modeling Multidiscip J 6:1–55. https://doi.org/10.1080/10705519909540118

Islam MA, El-Dahiyat F, Nouri A, Alefan Q, Naqvi AA (2023) Validation of the Arabic version of the general medication adherence scale in patients with type 2 diabetes mellitus in Jordan. Front Pharmacol 14:1194672. https://doi.org/10.3389/fphar.2023.1194672

Kline RB (2023) Principles and Practice of Structural Equation Modeling. Guilford Publications, London

Krapek K, King K, Warren SS, George KG, Caputo DA, Mihelich K et al (2004) Medication adherence and associated hemoglobin A1c in type 2 diabetes. Ann Pharmacother 38:1357–1362. https://doi.org/10.1345/aph.1D612

Kvarnström K, Westerholm A, Airaksinen M, Liira H (2021) Factors contributing to medication adherence in patients with a chronic condition: a scoping review of qualitative research. Pharmaceutics 13:1100. https://doi.org/10.3390/pharmaceutics13071100

Mulvaney SA, Hood KK, Schlundt DG, Osborn CY, Johnson KB, Rothman RL et al (2011) Development and initial validation of the barriers to diabetes adherence measure for adolescents. Diabetes Res Clin Pract 94:77–83. https://doi.org/10.1016/j.diabres.2011.06.010

Nassar RI, Basheti IA, Saini B (2022) Exploring validated self-reported instruments to assess adherence to medications used: a review comparing existing instruments. Patient Prefer Adherence 24:503–513. https://doi.org/10.2147/PPA.S352161

Nazir SUR, Hassali MA, Saleem F, Bashir S, Aljadhey H (2016) Disease-related knowledge, medication adherence, and glycaemic control among patients with type 2 diabetes mellitus in Pakistan. Prim Care Diabetes 10:136–141. https://doi.org/10.1016/j.pcd.2015.09.004

Nunnally JC (1978) Psychometric theory, 2nd edn. McGraw-Hill, New York

Perneger TV, Courvoisier DS, Hudelson PM, Gayet-Ageron A (2015) Sample size for pre-tests of questionnaires. Qual Life Res 24:147–151. https://doi.org/10.1007/s11136-014-0752-2

Prinsen CAC, Mokkink LB, Bouter LM, Alonso J, Patrick DL, de Vet HCW et al (2018) COSMIN guideline for systematic reviews of patient-reported outcome measures. Qual Life Res 27:1147–1157. https://doi.org/10.1007/s11136-018-1798-3

Salgado T, Marques A, Geraldes L, Benrimoj S, Horne R, Fernandez-Llimos F (2013) Cross-cultural adaptation of the beliefs about medicines questionnaire into Portuguese. Sao Paulo Med J 131:88–94. https://doi.org/10.1590/s1516-31802013000100018

Sun H, Saeedi P, Karuranga S, Pinkepank M, Ogurtsova K, Duncan BB et al (2022) IDF diabetes atlas: global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. Diabetes Res Clin Pract 183:109119. https://doi.org/10.1016/j.diabres.2021.109119

Wild D, Grove A, Martin M, Eremenco S, McElroy S, Verjee-Lorenz A et al (2005) Principles of good practice for the translation and cultural adaptation process for patient-reported outcomes (PRO) measures: report of the ISPOR task force for translation and cultural adaptation. Value Health 8:94–104. https://doi.org/10.1111/j.1524-4733.2005.04054.x

Wong MCS, Wu CHM, Wang HHX, Li HW, Hui EMT, Lam AT et al (2015) Association between the 8-item morisky medication adherence scale (MMAS-8) score and glycaemic control among Chinese diabetes patients. J Clin Pharmacol 55:279–287. https://doi.org/10.1002/jcph.408

Xu HY, Yu YJ, Zhang QH, Hu HY, Li M (2020) Tailored interventions to improve medication adherence for cardiovascular diseases. Front Pharmacol 11:510339. https://doi.org/10.3389/fphar.2020.510339

MAUQ-ar-OM

الاستبانة العامة للالتزام بالأدوية

العبارة			أعارض بشدّة ←						أوافق بشدّة
PAM	3	أشعر بتحسن عند تناول الدواء كل يوم	1	2	3	4	5	6	7
PAM	5	إذا تناولت أدويتي كل يوم، فأعتقد أن مرضي تحت السيطرة	1	2	3	4	5	6	7
PAM	7	ايجابيات تناول الدواء تفوق سلبيات	1	2	3	4	5	6	7
ATM	9	أرغب بتناول كمية أقل من الدواء عندما تكون حالتي المرضية تحت السيطرة من خلال فحوصاتي الطبية	1	2	3	4	5	6	7
ATM	13	لا أرغب بتناول الدواء كل يوم	1	2	3	4	5	6	7
ATM	14	أنا أخشى من الآثار الجانبية	1	2	3	4	5	6	7
ATM	16	أعتقد أنه ليس أمرًا صحيًّا لجسمك أن تتناول الدواء كل يوم	1	2	3	4	5	6	7
ACPH	20	احرص بشكل خاص على ممارسة التمارين الرياضية الكافية للعناية بصحتي	1	2	3	4	5	6	7
ACPH	21	أتناول طعاماً صحياً للعناية بصحتي	1	2	3	4	5	6	7
ACPH	22	أتجنب السلوكيات التي من الممكن أن تضر بصحتي (مثال: التبغ والكحول)	1	2	3	4	5	6	7
LD	23	يحدث أنني أكون غير متأكداً مما إذا كنت تناولت أدويتي	1	2	3	4	5	6	7
LD	24	أحيانا أنسى تناول أدويتي بسبب أن لدي حياة مليئة بالأشغال	1	2	3	4	5	6	7
LD	26	أنسى أحيانا تناول أدويتي خلال أيام الإجازات أو إجازة نهاية الأسبوع	1	2	3	4	5	6	7
PAM	35	أعتقد أنني أساهم في تحسين حالتي المرضية عندما أقوم بتناول أدويتي كل يوم	1	2	3	4	5	6	7
LD	36	أجد صعوبة في الالتزام بالنظام اليومي لتناول الدواء	1	2	3	4	5	6	7
ACPH	39	أجمع المعلومات حول إمكانيات حل المشكلات الصحية	1	2	3	4	5	6	7

PAM: المواقف الإيجابية تجاه الرعاية الصحية والأدوية; LD : قلة الانضباط; ATM :النفور من الأدوية ; ACHP : التأقلم الفعّال مع المشكلات الصحية