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ORIGINAL RESEARCH

Confirmatory Factor Analysis of the Malay Version of the Malaysia Medication Adherence Assessment Tool (MyMAAT) Among Patients with Chronic Medications

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Purpose: The bilingual Malaysia Medication Adherence Assessment Tool (MyMAAT) was developed using the Exploratory Factor Analysis (EFA) and the current study intended to confirm the measurement model, dimensionality and ensure the factor structure by the Confirmatory Factor Analysis (CFA). The objective of this study was to validate the Malay version of the MyMAAT in measuring medication adherence among participants with chronic medications.

Patients and Methods: A cross-sectional study was conducted using a self-report questionnaire at five health clinics and a hospital in Kuala Lumpur and Putrajaya region between May to November 2023. The participants were selected using quota sampling and written informed consent was obtained from each participant prior to data collection. There are two constructs in the MyMAAT, namely the Specific Medication-Taking Behaviour (Factor 1) and the Social-Cognitive Theory of Self-Efficacy and Social Support (Factor 2).

Results: Two hundred and thirty-five patients participated in the CFA study. The final model for the Malay version of the MyMAAT retained the two constructs and 12 items with good fit: CFI = 0.978, TLI = 0.973, RMSEA = 0.036 (90% CI 0.001,0.067) and with good composite reliability CR 0.790 for Factor 1 and 0.787 for Factor 2. The factor loadings ranged from 0.413 to 0.832 with p-value < 0.001. The AVE for Factor 1 was 0.664 and for Factor 2 was 0.491. There was a strong correlation ($\rho = 0.507$, $p < 0.001$) between the Malay version of the MyMAAT and the Malay version of the MMAS-8 by adherence category from the data of 191 participants. Twenty-six participants completed the test–retest after five to ten days from the first administration. The Malay version of the MyMAAT showed moderate to excellent with ICC 0.932 (95% CI: 0.661,0.986) for Factor 1 and poor to excellent for with ICC 0.956 (95% CI:0.325,0.997) for Factor 2 by using the Two-Way Mixed Model and Consistency type.

Conclusion: It is concluded that the Malay version of the MyMAAT is valid and reliable in measuring medication adherence among patients with chronic medications.

Keywords: validation, questionnaire, medication-taking behaviour, social-cognitive theory, self-efficacy, social support

Introduction

In the literature, the definition of chronic medication varies in terms of duration. One way of defining chronic medication is prescription medication or over-the-counter medication for chronic disease taken daily for at least three months.[1–3] Others specify at a duration of at least 30 days[4,5] and another one interprets the frequency and duration as taken when necessary but with an expected duration of at least 30 days cumulatively within six months.[4] According to the CDC, chronic diseases are health conditions that persist for at least one year with the need for continuous medical service or restricted daily activity or both.[6] Examples of chronic diseases are hypertension, coronary heart disease, diabetes, dyslipidaemia, and arthritis.[6]

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WHO defined medication adherence as the extent to which the use of medication by the patient agrees with the prescribed regimen.[7] A thorough report about adherence to long-term therapies was published in the year 2003 to draw special attention to the magnitude and impact of poor medication adherence.[7] Non-adherence can be categorised into intentional and unintentional non-adherence. Intentional non-adherence is a deliberate choice to not use the medication as instructed by a healthcare provider while unintentional non-adherence is the failure to remember to use the medication as prescribed.[7]

Non-adherence to medication diminishes the effectiveness of therapy affecting the quality of life and population health economics.[7] For example, poor adherence to asthma medication was reported to cause a high risk of hospitalization among the moderate-to-severe asthmatic geriatric participants by 20%.[8] Healthcare providers strive to lower morbidity and mortality associated with chronic diseases but are frequently hampered by medication non-adherence.[9] Medication non-adherence heightens the likelihood of relapse, drug resistance and treatment failure, therefore reducing the survival rate.[7] The importance of reliable evaluation of adherence behaviour is to ensure that changes in health outcomes correspond with the prescribed regimen for better planning and effective treatment.[10] Population health outcomes based on treatment efficacy data may be lower than expected when adherence rate is not taken into consideration.[7]

A meta-analysis of research papers on patient adherence towards anti-hypertensive drugs over 22 Asian countries from the year 2000 to 2019 reported non-adherence rate at 48%.[11] Among all the countries in Asia, Indonesia has the highest non-adherence rate of antihypertensive medication at 71% followed by Thailand at 69%.[11] A meta-analysis of Malaysian studies up to the year 2021 on medication adherence among Type 2 diabetes mellitus participants reported a low medication adherence rate of 34%.[12] The prevalence of non-adherence to antihypertensive drugs was 39% in Sarawak for the year 2019 compared to 47% in Selangor for the year 2012.[13,14]

It is particularly important to be able to detect if drug non-adherence is present among the participants in disease prevention and clinical trials of new agents or new regimens because it attenuates the relationship between therapy and the dependent variable.[15–17] Without credible adherence data, it is impossible for clinical research to get accurate findings because a null result may not be due to poor drug efficacy but substandard adherence.[16] In other words, it is more difficult to prove that there is a significant difference in outcome if non-adherent participants are included in the study, thus increasing the size of "intend to treat" trials.[15,16] The ability to identify participants who have the likelihood of being non-adherent to medication facilitates the process of deciding which patient to target for adherence promotion.[18]

Drug adherence can be directly measured using ingestible sensor, serum drug level, urine drug level and directly observed therapy (DOT).[19] On the other hand, questionnaires, self-reports, pill counts, prescription refills, electronic drug bottle caps, assessment of clinical response and measurement of physiologic markers are examples of indirect method to measure adherence.[19] Hatah et al developed the Malaysia Medication Adherence Assessment Tool (MyMAAT) for patients on anti-diabetic drugs through Exploratory Factor Analysis (EFA) in the year 2020 and this self-report questionnaire is a promising and inexpensive tool.[10] The MyMAAT items were first prepared in Malay language and then translated to English using the forward-backward method.[10] The items were then combined into a bilingual questionnaire, and EFA was done on the bilingual MyMAAT.[10] Hatah et al reported two constructs in the MyMAAT, namely the Specific Medication-Taking Behaviour (Factor 1) and the Social-Cognitive Theory of Self-Efficacy and Social Support (Factor 2) using EFA. There are eight items under Factor 1 and four items under Factor 2.[10]

The objective of this study was to validate the Malay version of the MyMAAT in measuring medication adherence among patients with chronic medications by examining the construct validity and composite reliability using the CFA and to determine the correlation between the Malay version of the MyMAAT and the Malay version of the MMAS-8. MyMAAT was developed by EFA, but the dimensionality and factor structure had yet to be confirmed by CFA.[20] Besides that, MMAS-8 is a paid questionnaire which is costly to be used nationwide, thus a new questionnaire that is inexpensive like MyMAAT may help to address the lack of cost-effective and standardized tool for medication adherence measurement.

Methods

Study Design

A cross-sectional study using a self-report questionnaire was employed.

Study Duration and Location

The study was carried out at six Ministry of Health facilities in the Kuala Lumpur and Putrajaya region, namely, Hospital Putrajaya, Klinik Kesihatan Presint 11 Putrajaya, Klinik Kesihatan Tanglin, Klinik Kesihatan Kuala Lumpur, Klinik Kesihatan Jinjang and Klinik Petaling Bahagia between May 2023 and November 2023.

Study Population and Sample

Patients who were registered at the medical ward in Putrajaya Hospital and the patients who were registered at the outpatient clinic counter attending doctor's appointments at Klinik Kesihatan Presint 11 Putrajaya, Klinik Kesihatan Tanglin, Klinik Kesihatan Kuala Lumpur, Klinik Kesihatan Jinjang and Klinik Kesihatan Petaling Bahagia.

Patients were selected based on quota sampling[21] with the following inclusion criteria:

i) age ≥ 18 years old
ii) was prescribed with at least one chronic drug of the same generic drug name for at least six months regardless of any changes in the dose or frequency
iii) able to comprehend, understand, write, and read Malay language.

The exclusion criteria were patients that were:

i) caregiver-dependent
ii) cognitively impaired such as Alzheimer's disease and/or dementia
iii) with conditions that did not permit interaction such as but not limited to endotracheal intubated, on oxygen support or with airborne precautions tag usually in cases of COVID-19 and pulmonary tuberculosis.

Sample size calculation for the CFA analysis was done using Root Mean Squared Error of Approximation (RMSEA) by a software[22] with an expected RMSEA of 0.05, number of items 12, number of factors two, significance level set at 0.05 two-tailed, power of 80% had yielded a minimum sample size of 235 respondents. For convergent validity with other instrument, a correlation analysis requiring a minimum sample size of 43 respondents was calculated by software[22] using an expected correlation[10] of 0.44, significance level of 0.05, power 80% and an expected dropout rate of 10%. Test–retest using intraclass correlation coefficient (ICC) required a minimum sample size of 26 respondents. It was calculated by software[22] using a minimum acceptable reliability at 0.7, expected reliability of 0.9, significance level of 0.05, power 80%, two repetitions per questionnaire and an expected dropout rate of 10%. Written informed consent was obtained from each participant prior to data collection.

Variable Definition

Latent variables are also known as the factors, subscales, or domains. There are two latent variables in the MyMAAT, which are the Specific Medication-Taking Behaviour and the Social-Cognitive Theory of Self-Efficacy and Social Support.[10]

Measurement Tools

The research measurement tools consisted of socio-demographic tools and two questionnaires. Permission had been obtained from the authors of MyMAAT and the Malay version of MMAS-8. The MMAS license was also purchased online for the purpose of this study. The total number of questions was 27 items.

The MyMAAT consisted of 12 items, which measured adherence to medication with two subscales. All of the subscales were rated using a five-point Likert scale. The MyMAAT score was the sum of all the marks for the 12 individual items and then further classified to "good adherence" when the total score was ≥54, and "non-adherence" when the total score was between 12 to 53.[10]

The Malay version of MMAS-8 consisted of eight items under a single subscale. The response categories were yes/no dichotomous response for seven items and a five-points Likert response for the last item. Patients with total scores of eight were categorized as high adherence scores of less than eight but equal to or more than six were categorized as medium adherence and scores of less than six were categorized as low adherence.[23–25]

Data Collection Method

For the hospital setting, the patients who were admitted in Medical Wards 4A and 4B in Hospital Putrajaya for the past 24 hours from 9 am on the day of data collection were compiled from the ward registration list. Attempts to approach patients who fulfilled the inclusion and exclusion criteria using quota sampling were done at a timing that was deemed by the researcher as appropriate by considering patients' waking hours and without interfering in any ward activities such as clinical rounds, blood taking, medication administration and counselling. Patients who were admitted for more than five days were invited to participate in test–retest at a time gap of five to ten days from the first session.

For the health clinic setting, the patients who were registered and were waiting at the general Medical Outpatient Counter area were approached for eligibility screening using quota sampling. The outpatient waiting time is not affected as the queue number of each patient was based on the nursing and doctor appointment system, which was not interfered with in any way by this research. Quota sampling was applied in the selection of study participants in the current study to keep the total number of participants from the health clinics as compared to the hospital approximately equal to each other. The intention of obtaining a balanced coverage of both health clinic and hospitalized participants was to ensure enough representation from both the adherence and non-adherence group by assuming that the chances of encountering participants with poor adherence were higher among hospitalized participants and those with good adherence at the health clinics.

Statistical Analyses

Descriptive statistics were used to summarize the socio-demographic characteristics of participants. In the event of missing data, the incomplete cases would be deleted using listwise deletion and pairwise deletion. The assumption of multivariate normality was checked by Mardia's test to determine the normality of the data distribution prior to CFA using R Studio Version 4.1.2. A summary of the fit indices and their respective cut-off values[26] used in this study is shown in Table 1.

Construct Reliability (CR) is the variance due to each construct (squared sum of factor loadings) divided by the total variance of the composite.[26] A value of 0.7 or more implies good reliability.[26] When a measurement model is tested, relatively high standardized loadings are expected to confirm the construct validity with the rule of thumb that the loading should be |0.5| or more and ideally more than |0.7|.[26] All factor loadings must have significant *p*-values.[26] The magnitude of the factor loadings suggests how well the indicators converge on the latent construct.[26]

The indicators of the same construct should converge and share a high proportion of variance in common.[26] All factor loadings must have significant *p*-values.[26] The magnitude of the factor loadings suggests how well the indicators converge on the latent construct.[26] Communality is also known as item reliability, or the variance extracted or squared multiple correlations.[26] The square of a standardized factor loading explains the variation in an indicator that is explained by the latent construct.[26] For example, 0.5 is the square of a factor loading of 0.71 which means that half the variation in the indicator is explained by the latent construct and the other half is error variance.[26]

Table 1 Summary of the Fit Indices and Cut-off value[26] Used in This Study

Fit Indices	χ^2	CFI	TLI	RMSEA
Value for good fit	*p*-value >0.05	≥0.97	≥0.97	<0.08

Abbreviations: χ^2, Chi-square test; CFI, Comparative Fit Index; TLI, Tucker–Lewis Index; RMSEA, Root Mean Square Error of Approximation.

The ideal AVE is at least 0.5.[26] Discriminant validity was inspected by fixing the correlation between Factor 1 and Factor 2 as equal to one.[26] Another way was to change the model to a one-construct model with 12 items and compare its fit to the two-construct model.[26] Convergent validity with other similar and validated instrument was checked by analyzing the correlation between the MyMAAT and the Malay version of the MMAS-8 by adherence category was analyzed using Spearman correlation test in SPSS version 27. The level of significance was set at $\alpha = 0.05$. Based on Cohen's definition, $|\rho| < 0.3$ is deemed as small effect size, $0.3 \leq |\rho| < 0.5$ as medium, and $|\rho| \geq 0.5$ as large.[27]

The ICC of the Malay versions of the MyMAAT were analyzed by their two factors separately. The model was specified as a Two-Way Mixed Model and the type was specified as Consistency. The confidence level was set at 95% and the average output was obtained. The result from the ICC ranged between 0 and 1, the value of ICC <0.5 was interpreted as poor, 0.5 to 0.75 as moderate, 0.75 to 0.9 as good and >0.9 as excellent.[28,29]

Ethical Approval

This study followed the guidelines of the International Declaration of Helsinki and approval was obtained from the university, Human Research Ethics Committee of USM (HREC), the Medical Research and Ethics Committee (MREC) of the Ministry of Health, Jabatan Kesihatan Kuala Lumpur & Putrajaya, and the heads of facilities of each study sites prior to the commencement of data collection. The approval code for this study is NMRR ID-22-02376-XM2 (IIR) and USM/JEPeM/22100646. The Patient Information Sheets and Consent Forms were handed to the patients, and they were given sufficient time to decide on their participation. Written informed consent was obtained from each participant and all the data collected was kept confidential and solely for research purposes. The current research only accepted participants who were willing to participate voluntarily, and this matter was emphasized during patient screening. The participants were not paid for their participation and no expenses were incurred to the participants.

Results

Confirmatory Factor Analysis

Participants' Demographic Characteristics

The response rate was 95.9% with 117 from the health clinic and 118 from the hospital who answered the Malay version of the MyMAAT out of the 245 patients that the researcher approached. There was no missing data in this study because the data collector checked and reminded the participants to answer all the items in the questionnaire.

The demographic characteristics of the respondents are presented in Table 2. The participants were mostly from the Malay ethnicity (78.7%), followed by Chinese (10.6%) and then Indian (9.8%). Nearly 80% of the participants were aged

Table 2 Socio-Demographic Characteristics of the Construct Validation Participants

Variables		**Malay Version of the MyMAAT (n = 235)**
		n (%)
Ethnicity	Malay	185 (78.7)
	Chinese	25 (10.6)
	Indian	23 (9.8)
	Others	2 (0.9)
Age	18 −40	46 (19.6)
	41–60	102 (43.4)
	61–80	84 (35.7)
	>80	3 (1.3)
Gender	Male	117(49.8)
	Female	118 (50.2)

(*Continued*)

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Table 2 (Continued).

Variables		Malay Version of the MyMAAT (n = 235)
		n (%)
Level of Education	No formal education	5 (2.1)
	Primary	40 (17.0)
	Secondary	124 (52.8)
	Tertiary	66 (28.1)
Employment Status	Unemployed	90 (38.3)
	Government sector	36 (15.3)
	Private sector	64 (27.2)
	Retired	45 (19.1)
Monthly Income	<RM2000	146 (62.1)
	RM2000-RM4000	62 (26.4)
	>RM4000	27 (11.5)
Number of drugs	1–5	192 (81.7)
	6–10	39 (16.6)
	>10	4 (1.7)

between 41 and 80. There were approximately an equal number of male and female participants. About half of the participants had secondary school (52.8%) as their highest-level of education and then followed by tertiary education (28.1%). On the other hand, a larger number of participants were unemployed (38.3%) or in the private sector (27.2%). Roughly 60% of the participants earned a monthly income below RM2000. Besides that, a vast majority of the participants (81.7%) had five or less drugs.

Multivariate Normality

The results from Mardia's test showed skewness 61.42 (p-value < 0.01) and kurtosis 284.84 (p-value < 0.01). The data did not follow a normal distribution, thus the MLR estimator was used in CFA.

Internal Structure

The initial hypothesized model (Model-M1) consisted of eight items for Factor 1 and four items for Factor 2 as shown in Figure 1. Model-M1 had more than the minimum recommended CFI and TLI of 0.97, less than the maximum recommended RMSEA of 0.08, and fulfilled the criteria of the insignificant p-value for the chi-square test. The factor loadings ranged from 0.413 to 0.832 with p-value <0.001, in which items Q4, Q5 and Q7 had less than the minimum value of 0.5. The initial model showed good model fit based on all indices as shown in Table 3.

From Table 4, there was no out-of-range factor loading and all were between 0 and 1 therefore no offending estimates or Heywood cases present in Model-M1. The factor correlation between Factor 1 and Factor 2 was 0.607 which was less than 0.85 which indicated that the factors were distinct from each other and posed no multicollinearity problem. The value of factor correlation was in the range of 0 to 1. There were 13 suggested specifications with MI >4.00 but there were no SR >|2.58| found in this model and since the measurement had good fit, no change to the model was necessary. The composite reliability for Factor 1 was 0.790 and Factor 2 was 0.767 which was more than the minimum value 0.7.

Overall, the final Model-M1 had a good model fit based on all indices and good reliability. This justified the retainment of all items and factors in the Malay version of the MyMAAT. The illustration of the path diagram for the final Model-M1 is as shown by Figure 1.

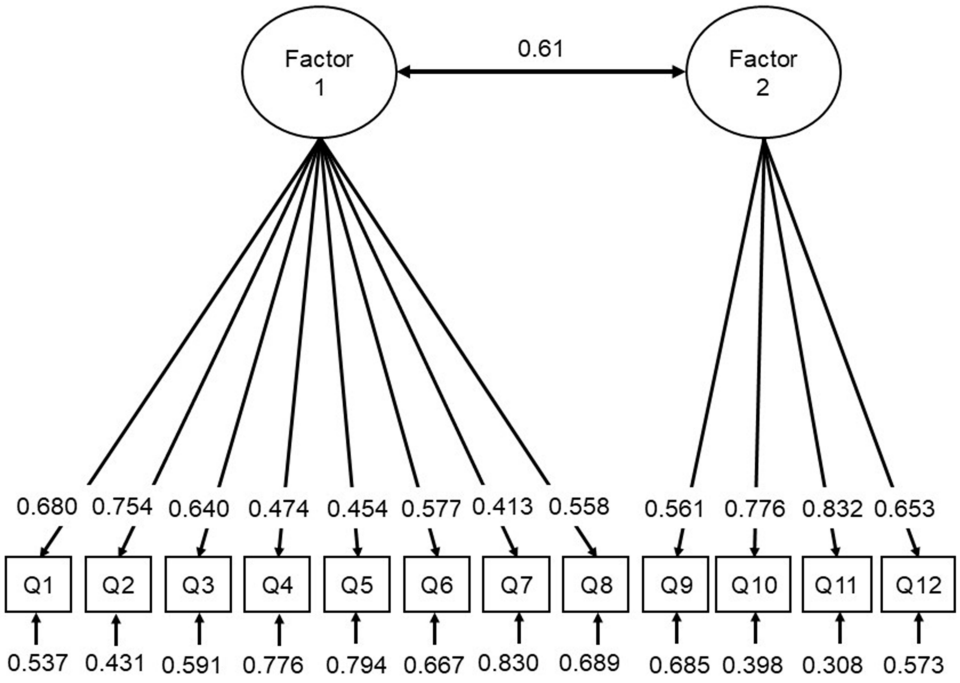

Figure 1 CFA path diagram for Model-M1 which illustrated two factors namely Factor 1 and Factor 2 which had eight items and four items respectively.

Convergent Validity and Construct Reliability

The values of the factor loadings indicated the strength of the relationship between the indicators that converged on the same latent construct. Referring to Table 4, Model-M1 had three items (Q4,Q5,Q7) from Factor 1 which had relatively low standardized factor loadings <0.5 whereas all the items from Factor 2 had more than the minimum cut-off value of

Table 3 Model Fit Indices for the Malay Version of the MyMAAT

Model	χ^2 (*p*-Value)	*Df*	CFI	TLI	RMSEA (90% CI)	AIC	BIC
Model-M1	62.921 (0.165)	53	0.978	0.973	0.036 (0.001,0.067)	7964.181	8050.670

Abbreviations: χ^2, Chi-square test; *Df*, Degree of freedom; CFI, Comparative Fit Index; TLI, Tucker–Lewis Index; RMSEA, Root Mean Square Error of Approximation; CI, Confidence Interval; AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion.

Table 4 Standardized Factor Loadings and Composite Reliability for Model-M1

Factor	Item	Factor Loading	Composite Reliability
1	Q1	0.680	0.790
	Q2	0.754	
	Q3	0.640	
	Q4	0.474	
	Q5	0.454	
	Q6	0.577	
	Q7	0.413	
	Q8	0.558	
2	Q9	0.561	0.787
	Q10	0.776	
	Q11	0.832	
	Q12	0.653	

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0.5. High factor loadings especially >0.7 of the items Q2, Q10 and Q11 confirmed the relationship between the items and factor as strong. All factor loadings had statistically significant p-value<0.001.[26]

The AVE for Factor 1 was 0.664 which meant that there was sufficient convergence and that 66% of the variation in the items Q1 to Q8 were explained by Factor 1 and 34% being error variance. The AVE for Factor 2 was 0.491 which meant that almost half the variation in the items Q9 to Q12 were explained by Factor 2 and the other half being error variance.[26]

Both Factor 1 and Factor 2 had more than the minimum 0.7 cut-off value for good construct reliability implying that the internal consistency was good, and that the indicators consistently represent the same latent factor.[26]

Discriminant Validity

The inspection was done after fixing the correlation between Factor 1 and Factor 2 as equal to one.[26] The fit of the altered model was compared to the two-construct Model-M1.[26] The fit of the Model-M1 was better than the altered model.

Next, the model fitness of the Model-M1 was compared to a one-construct model with 12 items.[26] The fit of the Model-M1 was better than the one-construct model. The Model-M1 had sufficient discriminant validity because it had better fit than the two alternative models. The summary of the alternative models was shown in Table 5.

Convergent Validity with Other Instrument

The correlation between the Malay version of the MyMAAT and the Malay version of the MMAS-8 was analysed and reported in this section. Out of the 196 participants approached, one hundred and ninety-one participants agreed and finished both the questionnaires, making it a 97.4% response rate. There was no missing data in this study because the data collector checked and reminded the participants to answer all items in the questionnaire. The crosstabulation of the adherence category of both MyMAAT and MMAS-8 was shown in Table 6.

Correlation Testing

Using Spearman correlation test, the correlation between the Malay version of the MyMAAT and the Malay version of the MMAS-8 by adherence category was $\rho = 0.507$ ($p < 0.001$). Based on Cohen's definition, the effect size was large and based on the p-value the result was significant.

Table 5 Summary of the Discriminant Validity Testing for the Model-M1

Model	Goodness-of-fit Indices					AIC	BIC	χ^2 Difference Test			
	χ^2 (*p*-value)	*Df*	CFI	TLI	RMSEA (90% CI)			χ^2	χ^2 Difference*	*Df* Difference*	(p-value)*
Model-M1	62.921 (0.165)	53	0.978	0.973	0.036 (0.001,0.067)	7964.181	8050.670	103.03			
Model-M[a]	92.655 (0.001)	54	0.915	0.897	0.071 (0.045,0.095)	8011.584	8094.614	152.43	24.059	1	<0.001
Model-M[b]	135.030 (<0.001)	54	0.814	0.773	0.105 (0.083,0.127)	8091.940	8174.970	232.79	20.567	1	<0.001

Notes: p-value. [a] Model with Factor 1 and Factor 2 correlation fixed to one. [b] One-construct model with 12 items. *In comparison with Model-M1.
Abbreviations: χ^2, Chi-square test; *Df*, Degree of freedom; CFI, Comparative Fit Index; TLI, Tucker–Lewis Index; RMSEA, Root Mean Square Error of Approximation; CI, Confidence Interval; AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion.

Table 6 Crosstabulation of the Adherence Category Based on MyMAAT and MMAS-8

Variables		Malay version of the MMAS-8			
		Low n (%)	Medium n (%)	High n (%)	Total n (%)
Malay version of the MyMAAT	Non-adherence	80 (41.9)	28 (14.7)	4 (2.1)	112 (58.6)
	Adherence	18 (9.4)	39 (20.4)	22 (11.5)	79 (41.4)
	Total	98 (51.3)	67 (35.1)	26 (13.6)	191 (100)

Crosstabulation of the Malay Version of the MyMAAT and the Malay Version of the MMAS-8

Based on the Malay version of the MyMAAT, there were 112 (58.6%) participants who were in the non-adherence category compared to 79 (41.4%) participants who were in the adherence category. Based on the Malay version of the MMAS-8, there were 98 (51.3%) participants who were in the low adherence category, 67 (35.1%) in the medium adherence category, and 26 (13.6%) in the high adherence category.

Twenty-two (27.8%) of the participants from the adherence group based on the Malay version of the MyMAAT were categorised in the high adherence category based on the Malay version of the MMAS-8. Another 39 participants (49.4%) from the adherence group by MyMAAT were in the medium adherence category by MMAS-8. About one-fifth of the participants (n = 18) of the adherence group by MyMAAT were in the low adherence category by MMAS-8.

From the non-adherence group based on the Malay version of the MyMAAT, four participants (3.6%) were categorised in the high adherence category based on the Malay version of the MMAS-8. A quarter of the participants (n = 28) from the non-adherence group by MyMAAT were in the medium adherence category by MMAS-8. The majority of the participants (n = 80, 71.4%) from the non-adherence group by MyMAAT were in the low adherence category by MMAS-8.

Clinical Agreement

The stability of the MyMAAT was analyzed using test–retest reliability and reported as ICC. All the 26 participants approached for a retest at a gap between five and ten days from the first administration of the questionnaire agreed and completed the questionnaires.

Test–Retest Reliability

The results based on the form of ICC set previously for the Malay version of the MyMAAT resulted in Factor 1 (item Q1 to Q8) having the reliability of 0.911 (95% CI: 0.554, 0.982). The reliability was considered to be moderate to excellent.[28,29] The ICC for Factor 2 (item Q9 to Q12) was 0.941 (95% CI: 0.092, 0.996). The reliability was poor to excellent.[28,29]

Discussion

The Malay version of the MyMAAT was hypothesized as a two-construct model with a total of 12 items and the results from the CFA performed in the current study supported this theoretical structure. It can be deduced that the Malay version of the MyMAAT theoretical measurement model fitted the sampled data very well based on the predetermined goodness-of-fit indices.[26] The better the model fitness, the more similarity between the estimated covariance matrix (theory) to the observed covariance matrix (real clinical data).[26] Introducing modifications to a well-fitted initial model to improve the fit further is unwise.[19] The reason is because these modifications may simply be fitting small idiosyncratic properties of the sample.[19] Thus, no further modification was necessary to the initial measurement model (Model-M1), and it was finalized as the final measurement model.

With the establishment of the Malay version of the MyMAAT measurement model, further investigation on the construct validity and reliability based on convergent validity and discriminant validity was done. Acceptable CR value alone may allow the researcher to conclude sufficient convergent validity of the construct although half of the variance is due to error.[30] This validation study was done with input from participants across diverse diseases and drug types to ensure that the various factors associated with medication non-adherence are represented in this study compared to the EFA study[10] which focused on diabetic participants only.

Reliability is a measurement of the consistency of a scale that stemmed from the Classic Test Theory, which assumed that a single true score underpinned a scale.[31] The best practice is to make sure all the participants enrolled in the test–retest to have the exact same time interval between the first and second administration with the expectation that the temporal factor has similar effect on the participants. The second administration of the MyMAAT was carried out among 26 hospitalized participants who stayed more than five days at an interval of five to ten days from the first administration, which is a limitation of this study.

There are several other limitations of test–retest as a reliability measurement. First, the assumption of perfect stability of the true score but in reality, the true score may change over time making this assumption unreasonable.[31] The hospital admission experience and the clinical condition of the participants recruited may have an influence on the participants'

perception of their medication-taking behaviour, self-efficacy, and social support throughout the admission, which may have explained the wide 95% confidence interval of the test–retest ICC results. Although all hospitalized participants were reminded that the questionnaire was to account for the medication adherence experience prior to hospitalization, the experience of being hospitalized may still influence their perception and response.

Factor 2 has a wider ICC confidence interval than Factor 1. This may be attributed to the small number of items representing Factor 2. The discrepancies in the evaluation of even a single item will be reflected in a lower ICC when the number of items is few. A poor ICC is also related to the lack of variability among the sampled participants, a small number of raters and too few participants.[28,32] ICC is also influenced by the study design component of subject variability, for example the distribution of participants and not the scale quality.[33]

In the previous EFA study, the ICC was reported at the scale-level only and the ICC at the subscale was not reported. Therefore, it is difficult to compare between the ICC of the EFA and CFA studies as the results were reported at different levels. It is more appropriate to report ICC at subscale-level for a CFA study because the performance of each subscale should be reported. The ICC reliability of the MyMAAT was higher at the scale-level than at the subscale-level. When the scale-level ICC is reported, the measurement error of the test–retest reliability will be averaged out since the individual scores are added up to achieve a total score.[34] ICC is lower when the samples are more alike towards each other (homogenous) with constant variability between measurements.[35]

The Malay version of the MMAS-8 was tested in 223 Malaysians at the outpatient department of Penang General Hospital, the largest public hospital in Penang, Malaysia. The study had the same culture and population characteristics as the current study, therefore this scale is a good choice for convergent validity. This medication adherence scale has moderate internal consistency with Cronbach's alpha of 0.675.[23]

In the current study, there was a strong correlation ($\rho = 0.507$, $p < 0.001$) between the two adherence scales the Malay version of the MyMAAT and the Malay version of the MMAS-8 as both measure the same concept. Approximately half of the participants who were classified in the adherence group based on the MyMAAT had high or medium adherence using the MMAS-8. Besides that, 71.4% of the participants classified as non-adherence group based on the MyMAAT were categorised in the low adherence category based on the MMAS-8. The similarity could be due to the presence of indicators measuring the underlying latent construct of "Specific Medication-Taking Behaviour" in both scales.

When the data was further examined for more in-depth knowledge about the discrepancy between these two scales, it was found that 22.8% of the participants who were classified in the adherence group based on the MyMAAT were considered as low adherence using the MMAS-8. Apart from that, 3.6% of the participants classified as a non-adherence group based on the MyMAAT were categorized in the high adherence category based on the MMAS-8.

Each scale has its unique ability to detect different types of non-adherence. The MyMAAT has an additional construct "Social-Cognitive Theory of Self-Efficacy and Social Support" and one item pertaining to forgetfulness (unintentional non-adherence) in the construct "Specific Medication-Taking Behaviour", whereas the MMAS-8 has three items related to forgetfulness. Therefore, participants who had issues with remembering their medication will affect the score of one item in MyMAAT compared to three items in MMAS-8.

The intention of obtaining a balanced coverage of both health clinic and hospitalized participants was to ensure enough representation from both the adherence and non-adherence groups by assuming that the chances of encountering participants with poor adherence was higher among hospitalized participants and those with good adherence at the health clinics. The Malay version of the MyMAAT did not have any item with responses ≥80% within a single option in the five-point Likert scale both for Factor 1 and Factor 2. This showed that the current study design and instrument used were successful in avoiding the ceiling effect.

A self-report tool that was employed in the current study comes with the possibility of under-reporting or over-reporting their medication-taking behaviour, self-efficacy, and social support.[36] The unresolved concerns about the validity of self-report questionnaires because they are more prone to social desirability and recall biases in relative to other assessment methods.[36] However, the information pertaining to participants' medication adherence were best evaluated by self-report questionnaires as there were no other quick, practical, cost-effective, and non-invasive methods to obtain that information in a busy clinical setting.[36]

Conclusion

The final measurement model of the Malay version of the MyMAAT demonstrated a good fit to the data with no modification necessary: CFI = 0.978, TLI = 0.973, RMSEA = 0.036 (90% CI 0.000,0.067). All 12 items were retained with standardized item loading ranging from 0.454 to 0.832. The CR was 0.790 for Factor 1 "Specific Medication-Taking Behaviour" and 0.787 for Factor 2 "Social-Cognitive Theory of Self-Efficacy and Social Support.". The AVE was 0.664 for Factor 1 and 0.491 for Factor 2. The stability of the scale by test–retest reliability was moderate to excellent with ICC 0.911 (95% CI: 0.554, 0.982) for Factor 1 and poor to excellent with ICC 0.941 (95% CI: 0.092, 0.996) for Factor 2 by using Two-Way Mixed Model with Type of Consistency. There was a strong correlation between the Malay version of the MyMAAT and the Malay version of the MMAS-8 by adherence category with Spearman's $\rho = 0.507$ ($p < 0.001$).

Disclosure

The authors report no conflicts of interest in this work. This research was self-funded by the researcher for the purpose of fulfilling her thesis requirement for graduation in Master of Science (Medical Statistics). Permission to use the MyMAAT was granted by the original author for free whereas the MMAS-8 license for use was purchased at the official website through self-funding.

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