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Cross-Linguistic Measurement Invariance of the MMAS-8 among Tamil- and Odia-speaking adults in India

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Abstract

Objectives

-To evaluate item-level psychometric performance and cross-linguistic measurement invariance of the 8-item Morisky Medication Adherence Scale (MMAS-8) among Tamil- and Odia-speaking adults in India.

Methods

-A cross-sectional psychometric study was conducted from February to May 2025 at two medical colleges in Odisha and Tamil Nadu. Adults with hypertension and/or diabetes receiving pharmacological treatment for at least 6 months were included. The MMAS-8 was translated into Odia and Tamil using translation, back-translation, expert review, and pilot testing. Item-response distributions, corrected item–total correlations, Cronbach's alpha, and alpha-if-item-deleted estimates were assessed. Categorical-data confirmatory factor analyses evaluated configural, metric, partial metric, and threshold invariance across language groups.

Key findings:-

Of 467 recruited participants, 200 were Odia-speaking and 267 were Tamil-speaking; 467 participants with complete MMAS-8 responses were included in the primary analysis. Internal consistency was modest in both groups (Cronbach's alpha: 0.492 and 0.591, respectively). Item 5 showed substantial response-pattern differences between groups (78.0% versus 10.98% adherence-consistent responses). Item 8 demonstrated the greatest difference in corrected item–total correlation (0.406 versus 0.059). Full metric invariance was not supported (change in comparative fit index: −0.035; change in root mean square error of approximation: +0.010). Releasing Items 5 and 7 supported partial metric invariance.

Conclusions

-The MMAS-8 showed partial cross-linguistic measurement equivalence, with differences in the functioning of Items 5 and 7. MMAS-8 scores should therefore be interpreted cautiously when comparing Tamil- and Odia-speaking populations. Further multicentre studies using differential item functioning and item response theory are warranted.

1. Introduction

Medication adherence is a critical determinant of treatment effectiveness, yet accurately capturing medication-taking behaviour remains challenging in both clinical practice and research. Self-report instruments are widely used because they are brief, practical, and relatively easy to integrate into clinical assessment. Their usefulness, however, depends on more than overall reliability. Patients from different populations may respond differently to individual questions even when an instrument demonstrates acceptable internal consistency. Because medication adherence is influenced by behavioural, clinical, and contextual factors, evidence that a measure performs adequately in one population does not necessarily establish that it measures the same construct in another population. [1, 2]

The 8-item Morisky Medication Adherence Scale (MMAS-8) is among the most extensively studied self-report measures of medication adherence. Its concise format and standardized scoring have supported its application across diverse clinical and linguistic settings. [3] Nevertheless, reported reliability, factor structure, and validity have varied across populations and translated versions. [2, 5, 6] The MMAS-8 also incorporates different response formats and behavioural domains, including dichotomous items, a reverse-coded item, and a frequency-based item with multiple response categories. Such features make item-level evaluation particularly relevant because differences in interpretation or response behaviour may alter the relationship between individual items and the underlying adherence construct. [4]

Translation can improve linguistic accessibility without demonstrating that an instrument functions equivalently across populations. Accurate wording alone does not establish that respondents interpret an item, process its response options, or relate it to the underlying construct in the same way. Measurement invariance provides a formal framework for evaluating this comparability across groups. [7, 8] Multigroup confirmatory factor analysis (MG-CFA) allows increasingly restrictive measurement parameters to be tested, including factor loadings and thresholds, particularly when indicators are categorical or ordinal. [5] When equivalence is not established, observed differences in scores may reflect genuine differences in medication-taking behaviour, item-level measurement differences, or characteristics of the populations being compared. [6]

India provides an informative context for examining this issue because linguistically distinct populations are evaluated within a shared national healthcare system while differing in regional, educational, and sociocultural environments. Tamil- and Odia-speaking adults therefore offer an opportunity to examine whether the MMAS-8 retains comparable measurement behaviour across distinct linguistic contexts. Importantly, language cannot be considered independently of study setting and participant characteristics. Consequently, evidence of cross-group variation should not be interpreted as proof that translation itself caused non-equivalence. The more appropriate question is whether the observed responses support comparable measurement of the underlying adherence construct across the two populations. [7]

The present study extends conventional translation validation by undertaking a sequential, item-focused psychometric evaluation of the MMAS-8 among Tamil- and Odia-speaking Indian adults. We examined item-response distributions, internal consistency, item-level performance, exploratory structure, group-specific confirmatory factor structure, and sequential measurement invariance. We further investigated whether any departure from full invariance could be localized to specific measurement parameters and whether a theoretically defensible partial-invariance model provided a better representation of the data. By moving from linguistic equivalence to formal measurement equivalence, this study aims to determine whether individual MMAS-8 items retain comparable relationships with the latent medication-adherence construct and whether adherence scores can therefore be interpreted meaningfully across these two linguistically distinct Indian populations.

2. Methods

2.1 Study design and participants

A cross-sectional psychometric study was conducted from February to May 2025 at two medical colleges, one each in Odisha and Tamil Nadu. Adults with documented hypertension and/or diabetes receiving pharmacological treatment for ≥ 6 months were eligible. The MMAS-8 was independently translated, back-translated, reviewed, and pilot-tested in Odia and Tamil. Item-response distributions, corrected item–total correlations, Cronbach's α, alpha-if-item-deleted estimates, and exploratory component loadings were assessed. Group-specific and multigroup confirmatory factor analyses (CFA) using categorical-data methods were performed to evaluate the prespecified one-factor structure and sequentially test configural, metric, partial metric, and threshold invariance, consistent with established approaches to measurement-invariance assessment for categorical indicators.[8,9] A total of 467 participants, comprising 200 Odia-speaking and 267 Tamil-speaking participants, were included in the primary psychometric analyses.

2.2 MMAS-8 and linguistic adaptation

Medication-taking behaviour was assessed using the 8-item Morisky Medication Adherence Scale (MMAS-8). The instrument includes dichotomous and frequency-based response formats, with item-specific coding incorporated into the established scoring framework.[10] Given these differing response structures, the present study examined MMAS-8 items individually rather than relying solely on the aggregate score. The response characteristics relevant to the analysis are summarized in Table 1.

Table 1
Structural and response characteristics of the MMAS-8 relevant to item-level and cross-linguistic psychometric evaluation

MMAS-8 component	Response structure	Analytical treatment	Relevance to present analysis
Items 1–7	Dichotomous response	Categorical/binary indicators according to prespecified scoring	Permits evaluation of item-specific response behaviour and factor loadings
Item 5	Dichotomous response with prespecified scoring direction	Coded according to the original scoring framework	Relevant because its response direction and subsequent loading behaviour may influence cross-group comparability
Item 8	Five-category frequency response	Ordinal categorical indicator	Introduces multiple response thresholds requiring evaluation of threshold comparability
MMAS-8 total	Mixed response structure	Established MMAS-8 scoring framework	Used for descriptive interpretation; cross-group comparability was assessed through item-level and latent-variable analyses

The original English MMAS-8 was independently translated into Odia and Tamil by bilingual translators who were native speakers of the respective target languages and proficient in English. The independent translations were reviewed and reconciled before being back-translated into English. Back-translated versions were compared with the original instrument for differences in meaning, wording, response interpretation, and conceptual content. Identified discrepancies were discussed by the translation team and resolved by consensus while maintaining the intended meaning and response structure of the original instrument.

The preliminary versions were then reviewed and pilot-tested among patients at the respective study centres to assess clarity, comprehensibility, and linguistic appropriateness. Minor linguistic or grammatical refinements were made based on participant feedback without changing the intended construct, scoring direction, or response structure. The finalized Odia and Tamil versions were subsequently used for study administration. The translation and adaptation process followed established principles for linguistic and cultural validation of health measurement instruments.[11, 12]

2.3 Data collection and quality control

Participants completed the MMAS-8 in the language appropriate to their study group during the clinical visit. For participants unable to read independently, the questionnaire was administered verbally using the same item wording and response options as the written version. No additional explanations, examples, or interpretations were provided, thereby minimizing differences in item presentation and response prompting. [13]

Sociodemographic information was obtained directly from participants, whereas relevant clinical information was extracted from medical records when available. Standardized questionnaire-administration and data-collection procedures were followed at both centres to minimize procedural variation that could otherwise influence cross-group response patterns. [14] Completed questionnaires were checked for completeness and response

consistency before data entry, and the analytical dataset was subsequently screened for missing or inconsistent responses before psychometric analysis.

2.4 Psychometric analysis

The psychometric evaluation followed a prespecified sequential framework, with each analytical stage providing evidence for the subsequent assessment. First, descriptive statistics were used to characterize participant profiles and examine the response distribution of each MMAS-8 item. Internal consistency was then evaluated using Cronbach's α, corrected item–total correlations, and alpha-if-item-deleted estimates. These complementary indices were examined to assess the contribution of individual items and identify item-level patterns requiring further investigation rather than relying on a single reliability coefficient. [15, 16]

An exploratory principal component analysis (PCA) was subsequently performed separately in the Odia and Tamil groups to examine the empirical structure of the eight observed items. Component loadings were considered together with item-response distributions and internal-consistency findings to identify potentially divergent item behaviour between groups. PCA was used only as an exploratory screening analysis and was not interpreted as evidence of measurement equivalence or as a substitute for confirmatory factor analysis. [17] The resulting item-level findings were subsequently considered alongside the prespecified one-factor model evaluated using group-specific and multigroup CFA.

2.5 Confirmatory factor analysis

Because the MMAS-8 contains dichotomous and ordinal indicators, confirmatory factor analysis (CFA) was conducted in R version 4.3.1 using the lavaan package with the weighted least squares mean- and variance-adjusted (WLSMV) estimator. All eight MMAS-8 items were specified as ordered categorical indicators, and the prespecified one-factor model was evaluated separately in the Odia and Tamil groups. This categorical-data approach accounted for the response structure without treating item responses as continuous variables.[18, 19]

Model fit was assessed using the χ^2 statistic, comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA) with its 90% confidence interval, and standardized root mean square residual (SRMR). Model adequacy was considered from the overall pattern of fit indices, standardized factor loadings, and substantive interpretability rather than from a single numerical cut-off.[20, 21] Standardized loadings were examined to assess the strength and direction of each item's association with the latent medication-adherence construct. No item was removed, rescored, or modified solely to improve model fit; any modification was considered only when supported by statistical evidence and a plausible substantive rationale.

Group-specific CFA was completed before multigroup CFA to establish whether the prespecified one-factor structure was reasonably supported within each language group, providing an appropriate basis for subsequent measurement-invariance testing.

2.6 Cross-linguistic measurement invariance

Following group-specific CFA, multigroup confirmatory factor analysis (MG-CFA) was performed to evaluate the comparability of the MMAS-8 latent medication-adherence construct between Odia- and Tamil-speaking participants. Measurement invariance was assessed sequentially using the WLSMV estimator for ordered-categorical indicators. The configural model tested whether the same prespecified one-factor structure was supported across groups without equality constraints, followed by a metric model constraining factor loadings to equality. Threshold invariance was subsequently examined by constraining the relevant threshold parameters across groups.

When full metric invariance was not supported, partial metric invariance was assessed by releasing only the loading constraints identified as sources of statistically supported non-equivalence and supported by substantive measurement considerations. In the final partial metric model, the loading constraints for Items 5 and 7 were released, while the remaining loadings were constrained equally across groups. Changes in CFI (ΔCFI) and RMSEA (ΔRMSEA), together with absolute fit indices, were used to evaluate successive models. Parameters were not released solely to improve model fit. This approach distinguished overall structural comparability from selective item-level non-equivalence and provided the basis for cautious interpretation of MMAS-8 scores across the two language groups. [22, 23, 24]

2.7 Interpretation of cross-linguistic differences

Psychometric evidence was interpreted across complementary levels, including item-response distributions, internal consistency, corrected item–total correlations, exploratory structure, group-specific CFA, and sequential measurement-invariance analyses. No single reliability coefficient, item statistic, or fit index was considered sufficient to establish cross-linguistic comparability. Instead, findings were considered collectively to determine whether MMAS-8 items maintained comparable relationships with the underlying medication-adherence construct across the two groups. Particular attention was given to items showing marked differences in response patterns, item–total correlations, or standardized factor loadings, as these may indicate item-level measurement variation that is not evident from the total score.[25, 26]

Interpretation of between-group differences was cautious because language was geographically linked to study centre, and the groups could also differ in demographic, educational, regional, and sociocultural characteristics. These factors could not be fully separated within the study design. Therefore, observed differences were not attributed to language or translation alone but were interpreted as potential cross-contextual measurement variation. Formal measurement-invariance analysis was used to determine whether such differences represented meaningful departures from comparable measurement across groups.[27, 28]

An unusual response distribution or weak item-level statistic was therefore considered a signal for further investigation rather than evidence of item invalidity. Similarly, partial invariance was interpreted as selective item-level variation within an otherwise shared measurement framework, rather than failure of the MMAS-8 as a whole.[29] This approach provided a balanced basis for interpreting the clinical relevance of cross-linguistic differences without prematurely attributing them to translation, language, or individual item validity.

2.8 Ethical considerations

The study was approved by the Institutional Ethics Committee of SCB Medical College, Odisha (IEC/14019) and Tirunelveli Medical College (IEC/20232862). Written informed consent was obtained from all participants before participation. Participation was voluntary, confidentiality was maintained throughout the study, and participants were informed of their right to withdraw without affecting their clinical care.

3. Results

3.1 Participant characteristics

The study included 467 participants, comprising 200 Odia-speaking and 267 Tamil-speaking adults. Tamil-speaking participants were slightly older than Odia-speaking participants (57.3 ± 10.1 vs. 54.8 ± 11.6 years). Women constituted 40.0% of the Odia-speaking group and 27.3% of the Tamil-speaking group. The most notable between-group difference was observed in educational attainment. Primary education was reported by 55.5% of Odia-speaking participants compared with 35.6% of Tamil-speaking participants, whereas high-school education or higher was more common among Tamil-speaking participants (38.6% vs. 13.5%). Illiteracy was reported among 31.0% of Odia-speaking participants and 25.8% of Tamil-speaking participants (Table 2).

Table 2
Sociodemographic characteristics of participants by language group

Characteristic	Odia (n = 200)	Tamil (n = 267)
Age, years	54.8 ± 11.6	57.3 ± 10.1
Sex, n (%)		
Male	120 (60.0)	194 (72.7)
Female	80 (40.0)	73 (27.3)
Educational attainment, n (%)		
Illiterate	62 (31.0)	69 (25.8)
Primary education	111 (55.5)	95 (35.6)
High school or higher	27 (13.5)	103 (38.6)

Note: Values are mean ± SD or n (%), as appropriate

Overall, the groups differed most substantially in educational attainment. This contextual difference should be considered when interpreting subsequent variations in self-reported MMAS-8 item responses.

3.2 Item-level response characteristics

Item-level response distributions showed selective differences between the Odia- and Tamil-speaking groups, particularly for Item 5 and the five-category frequency Item 8 (Tables 3 and 4).

Table 3
Item-level response characteristics and exploratory psychometric indicators in the Odia group

MMAS-8 item	Adherence-consistent response	n (%)	Corrected item–total correlation	α if item deleted	PCA loading
Item 1	No	92 (46.0)	0.481	0.409	0.519
Item 2	No	87 (43.5)	0.459	0.442	0.350
Item 3	No	99 (49.5)	0.372	0.463	0.328
Item 4	No	84 (42.0)	0.309	0.495	0.162
Item 5	**Yes**	**156 (78.0)**	**0.039**	**0.584**	**−0.268**
Item 6	No	82 (41.0)	0.401	0.445	0.384
Item 7	No	98 (49.0)	0.374	0.456	0.394
Item 8†	**Never**	**39 (19.5)**	**0.406**	**0.569**	**−0.317**
† Item 8 response distribution: Never, 39 (19.5%); Rarely, 73 (36.5%); Sometimes, 55 (27.5%); Usually, 21 (10.5%); All the time, 12 (6.0%).					

Table 4
Item-level response characteristics and exploratory psychometric indicators in the Tamil group

MMAS-8 item	Adherence-consistent response	n (%)	Corrected item–total correlation	α if item deleted	PCA loading
Item 1	No	104 (38.95)	0.661	0.487	0.429
Item 2	No	100 (37.45)	0.654	0.490	0.419
Item 3	No	72 (26.97)	0.434	0.541	0.448
Item 4	No	131 (49.81)	0.488	0.529	0.145
Item 5	**Yes**	**29 (10.98)**	**0.215**	**0.573**	**−0.148**
Item 6	No	83 (31.09)	0.461	0.536	0.391
Item 7	No	45 (16.85)	0.270	0.568	0.255
Item 8†	**Never**	**134 (50.19)**	**0.059**	**0.710**	**−0.423**
† Item 8 response distribution: Never, 134 (50.19%); Rarely, 86 (32.21%); Sometimes, 34 (12.73%); Usually, 9 (3.37%); All the time, 4 (1.50%).					

Note:-Values are n (%) for the adherence-consistent response and descriptive psychometric indicators for each item. Corrected item–total correlations assess the association of each item with the remaining scale items. α-if-item-deleted values indicate the estimated internal-consistency coefficient after removal of the respective item. PCA loadings represent exploratory contributions to the first principal component. Because the items include different response formats and coding directions, negative exploratory loadings should be interpreted in conjunction with item coding, response distributions, and subsequent categorical CFA rather than as evidence of item invalidity.

In the Odia group, adherence-consistent responses for Items 1–4, 6, and 7 ranged from 41.0% to 49.5%. Item 5 showed a markedly different response pattern, with 78.0% of participants selecting “Yes.” For Item 8, responses were distributed across all five categories: Never, 19.5%; Rarely, 36.5%; Sometimes, 27.5%; Usually, 10.5%; and All the time, 6.0%.

The Tamil group showed a different response profile. Adherence-consistent responses for Items 1–4, 6, and 7 ranged from 16.85% to 49.81%, whereas only 10.98% selected the adherence-consistent response for Item 5. Item 8 responses were concentrated in the lower-frequency categories, with Never reported by 50.19%, Rarely by 32.21%, Sometimes by 12.73%, Usually by 3.37%, and All the time by 1.50%.

Item-level psychometric indicators also showed variation between groups. For Item 5, the corrected item–total correlation was 0.039 in the Odia group and 0.215 in the Tamil group, with corresponding PCA loadings of − 0.268 and − 0.148. Item 8 showed a corrected item–total correlation of 0.406 in Odia participants compared with 0.059 in Tamil participants, with PCA loadings of − 0.317 and − 0.423, respectively.

These findings identified Items 5 and 8 as prominent item-level signals for further evaluation. However, the observed response distributions and exploratory statistics were not interpreted as evidence of measurement non-equivalence. Their cross-group behaviour was subsequently examined using group-specific CFA and multigroup measurement-invariance analysis.

3.3 Comparative item-level psychometric performance across language groups

Comparison of item-level psychometric characteristics showed selective heterogeneity between the Odia and Tamil groups rather than a uniform difference across the MMAS-8 (Table 5). The most pronounced difference in response distribution was observed for Item 5, with adherence-consistent responses of 78.0% in the Odia group compared with 10.98% in the Tamil group, representing a 67.02 percentage-point difference. However, its

corrected item–total correlation remained low in both groups (0.039 vs. 0.215), and α-if-item-deleted values were similar (0.584 vs. 0.573). Thus, the marked difference in Item 5 responses was not accompanied by a comparable difference in its contribution to internal consistency.

Table 5
Comparative item-level psychometric performance of the MMAS-8 across Odia and Tamil groups

MMAS-8 item	Odia adherence-consistent n (%)	Tamil adherence-consistent n (%)	Δ Response†	Item–total r Odia	Item–total r Tamil	Δr	α-if-deleted Odia	α-if-deleted Tamil	Δα	PCA loading Odia	PCA loading Tamil	Δ loading
Item 1	92 (46.0)	104 (38.95)	−7.05	0.481	0.661	+ 0.180	0.409	0.487	+ 0.078	0.519	0.429	−0.090
Item 2	87 (43.5)	100 (37.45)	−6.05	0.459	0.654	+ 0.195	0.442	0.490	+ 0.048	0.350	0.419	+ 0.069
Item 3	99 (49.5)	72 (26.97)	−22.53	0.372	0.434	+ 0.062	0.463	0.541	+ 0.078	0.328	0.448	+ 0.120
Item 4	84 (42.0)	131 (49.81)	+ 7.81	0.309	0.488	+ 0.179	0.495	0.529	+ 0.034	0.162	0.145	−0.017
Item 5	**156 (78.0)**	**29 (10.98)**	**−67.02**	**0.039**	**0.215**	**+ 0.176**	**0.584**	**0.573**	**−0.011**	**−0.268**	**−0.148**	**+ 0.120**
Item 6	82 (41.0)	83 (31.09)	−9.91	0.401	0.461	+ 0.060	0.445	0.536	+ 0.091	0.384	0.391	+ 0.007
Item 7	**98 (49.0)**	**45 (16.85)**	**−32.15**	**0.374**	**0.270**	**−0.104**	**0.456**	**0.568**	**+ 0.112**	**0.394**	**0.255**	**−0.139**
Item 8‡	**39 (19.5)**	**134 (50.19)**	**+ 30.69**	**0.406**	**0.059**	**−0.347**	**0.569**	**0.710**	**+ 0.141**	**−0.317**	**−0.423**	**−0.106**

† Δ response = Tamil percentage − Odia percentage. Δ values for item–total correlations, α-if-item-deleted values, and PCA loadings are calculated as Tamil − Odia.

‡ Item 8 uses a five-category frequency response. The adherence-consistent percentage represents the response category designated as adherence-consistent according to the established MMAS-8 scoring framework.

Note: Item-level statistics are descriptive/exploratory and should not be interpreted as formal tests of measurement invariance. Formal cross-group equivalence was evaluated using multigroup CFA.

Item 8 showed the greatest difference in corrected item–total correlation, decreasing from 0.406 in the Odia group to 0.059 in the Tamil group (Δ = −0.347). Its α-if-item-deleted value was also higher in the Tamil group (0.710 vs. 0.569). The exploratory PCA loading was negative in both groups (− 0.317 and − 0.423), consistent with the distinctive behaviour of this five-category frequency item. Given its different response format, these findings were considered descriptive indicators requiring further assessment rather than evidence of item invalidity.

Item 7 showed a smaller but notable reduction in both corrected item–total correlation (0.374 vs. 0.270) and PCA loading (0.394 vs. 0.255) between the Odia and Tamil groups. In contrast, Items 1–4 and 6 generally retained positive item–total correlations and PCA loadings in both groups, suggesting greater consistency in their exploratory behaviour.

Overall, the descriptive analyses indicated that cross-group differences were concentrated in selected items, particularly Items 5, 7, and 8. These findings provided an empirical basis for subsequent multigroup CFA. Importantly, the observed differences were treated as item-level signals for formal testing and were not interpreted as evidence of measurement non-equivalence until the invariance analyses were performed.

3.4 Internal consistency and item contribution

The MMAS-8 showed modest internal consistency in both groups, with Cronbach's α of 0.492 in the Odia group and 0.591 in the Tamil group. Item-level analysis demonstrated heterogeneous contributions to the overall scale. In the Odia group, corrected item–total correlations ranged from 0.039 for Item 5 to 0.481 for Item 1, with Item 5 showing the weakest association. In the Tamil group, correlations ranged from 0.059 for Item 8 to 0.661 for Item 1, with Item 8 showing the weakest association. Removal of Item 5 in the Odia group and Item 8 in the Tamil group increased α to 0.584 and 0.710, respectively.

These findings indicate that the item contributing least to internal consistency differed between language groups. However, item deletion was not used to modify the scale because internal consistency alone cannot establish measurement non-equivalence. The observed item-level differences therefore provided supportive evidence for proceeding to confirmatory factor analysis and formal multigroup measurement-invariance testing.

3.5 Exploratory and confirmatory factor-analytic findings

Exploratory PCA showed heterogeneous item contributions across the two language groups. In the Odia group, Item 4 had a relatively weak positive loading (0.162), while Items 5 and 8 showed negative loadings (− 0.268 and − 0.317). In the Tamil group, Items 5 and 8 similarly showed negative

loadings (− 0.148 and − 0.423), whereas Items 1, 2, 3, 4, 6, and 7 retained positive loadings. These patterns were considered exploratory signals of item-level differences and were interpreted alongside the item–total correlations and response distributions. They were not used as evidence of measurement non-equivalence or as a basis for item deletion.

Group-specific CFA was subsequently used to evaluate the prespecified one-factor MMAS-8 structure within each language group. The standardized factor loadings showed differences in the strength of relationships between individual items and the latent medication-adherence construct. The two-group CFA provided the basis for the subsequent multigroup analysis, with the configural model serving as the baseline against which increasingly restrictive equality constraints were evaluated. Overall, the exploratory findings suggested that selected items warranted closer examination, whereas the confirmatory analysis provided the appropriate framework for determining whether these differences represented formal cross-group measurement non-equivalence.

3.6 Measurement invariance across Odia and Tamil groups

Sequential multigroup CFA provided evidence of selective rather than widespread cross-group differences in the MMAS-8 (Table 6). The configural model established the baseline one-factor structure across the Odia and Tamil groups (CFI = 0.921, TLI = 0.889, RMSEA = 0.097, SRMR = 0.112). Constraining all seven factor loadings to equality resulted in a deterioration in model fit, with CFI decreasing to 0.886 and RMSEA increasing to 0.107 (ΔCFI = − 0.035; ΔRMSEA = + 0.010). Thus, full metric invariance was not supported, indicating that the relationships between some MMAS-8 items and the underlying adherence construct were not equivalent across the two groups.

Table 6
Sequential multigroup CFA and measurement invariance of the MMAS-8 across Odia and Tamil language versions

Model	Constraints	χ^2	df	CFI	TLI	RMSEA	SRMR	ΔCFI	ΔRMSEA	Interpretation
Configural	Same one-factor structure	126.001	40	0.921	0.889	0.097	0.112	—	—	Baseline
Full metric	All 7 loadings equal	170.295	47	0.886	0.864	0.107	0.144	−0.035	+ 0.010	**Not supported**
Partial metric	Q5 and Q7 free	132.222	45	0.920	0.900	0.092	0.121	+ 0.034*	−0.015*	**Partial metric**
Threshold	Partial metric + equal thresholds	135.449	47	0.918	0.903	0.091	0.121	−0.002	−0.001	**Supported**
Threshold score test	Equality constraints	22.209	16	—	—	—	—	—	—	**p = 0.137**

*Change shown relative to the preceding full-metric model, as reported in your manuscript.

Item-level score testing localized the loading differences primarily to Items 5 and 7. After freeing these two loadings, the partial metric model showed improved fit (CFI = 0.920, TLI = 0.900, RMSEA = 0.092, SRMR = 0.121). Compared with the full metric model, CFI improved by 0.034 and RMSEA decreased by 0.015. The remaining factor loadings could therefore be constrained to equality, supporting a partial metric interpretation in which most item–construct relationships were comparable between groups.

Threshold equality was then examined within the partial metric model. Adding threshold constraints produced only minimal changes in fit (CFI = 0.918, TLI = 0.903, RMSEA = 0.091, SRMR = 0.121; ΔCFI = − 0.002; ΔRMSEA = − 0.001). The overall threshold score test was non-significant (χ^2 = 22.209, df = 16, p = 0.137), and item-level threshold testing did not identify statistically significant threshold non-equivalence (Supplementary Table S1).

Overall, the findings indicate that cross-linguistic differences were concentrated in selected factor loadings rather than affecting the MMAS-8 measurement structure broadly. Items 5 and 7 represented the principal sources of loading non-equivalence, whereas the remaining loadings and threshold parameters showed sufficient comparability for a partial-invariance interpretation. These findings support cautious comparison of the MMAS-8 across the two groups while indicating that unrestricted equivalence of all item–construct relationships cannot be assumed.

4. Discussion

This study identified partial rather than full measurement equivalence of the MMAS-8 between Tamil- and Odia-speaking adults. The configural model suggested a broadly comparable underlying measurement structure across the two language groups. However, constraining all factor loadings to equality resulted in reduced model fit (ΔCFI = − 0.035; ΔRMSEA = + 0.010), indicating that full metric invariance was not supported. Releasing the equality constraints for Items 5 and 7 improved model fit and supported a partial metric invariance model. These findings suggest that most MMAS-8 items had broadly comparable relationships with the underlying medication-adherence construct, whereas Items 5 and 7 may function differently across the study groups. Consequently, direct comparisons of total MMAS-8 scores between Tamil- and Odia-speaking populations should be interpreted cautiously. [30, 31]

Item-level analyses provided important descriptive information but should not be interpreted as definitive evidence of measurement non-equivalence in isolation. Item 5 showed a marked difference in adherence-consistent responses between the Odia and Tamil groups (78.0% versus 10.98%). Item 8 showed the largest between-group difference in corrected item–total correlation (0.406 versus 0.059), while Item 7 demonstrated weaker item-level

associations in the Tamil group. These patterns may reflect differences in item interpretation, response processes, clinical circumstances, educational characteristics, or other group-specific factors. However, the present findings do not establish that the observed differences were caused by language or culture. The formal multigroup confirmatory factor analysis identified Items 5 and 7 as requiring the release of equality constraints, highlighting the importance of distinguishing descriptive response patterns from statistically supported differences in measurement parameters. Accordingly, item deletion or modification should not be undertaken solely on the basis of low item–total correlations or unusual response distributions. [32]

The threshold analysis indicated limited evidence of broad differences in response-category functioning. Equality constraints on thresholds produced minimal changes in model fit (ΔCFI = − 0.002; ΔRMSEA = − 0.001), and the overall threshold score test was non-significant ($\chi^2 = 22.209$, df = 16, p = 0.137). These findings suggest that the principal concern in this dataset was related to selected item–construct relationships rather than widespread threshold non-equivalence. Nevertheless, the threshold findings should be interpreted in the context of the model specification and the ordinal nature of the MMAS-8 response categories. Factor-loading and threshold invariance represent distinct components of measurement equivalence and should therefore be evaluated separately in categorical measurement models. [33]

From a clinical and research perspective, the absence of full metric invariance means that differences in observed MMAS-8 scores between the two language groups may not exclusively reflect differences in medication-taking behaviour. Some variation may arise from differences in the way selected items relate to the underlying adherence construct. However, the findings do not invalidate the MMAS-8 as a measure of medication adherence, nor do they justify the immediate removal of Items 5 and 7. Instead, these items should be prioritised for further investigation in larger and more diverse samples. Cognitive interviewing and qualitative assessment could help identify potential differences in comprehension or response interpretation, while differential item functioning and item response theory analyses could determine whether the observed item-level differences persist after accounting for participants' underlying adherence levels. [34, 35]

More broadly, these findings emphasise that translation and linguistic adaptation are necessary but insufficient to establish cross-linguistic measurement equivalence. The participants were recruited from different clinical institutions and may have differed in demographic, educational, clinical, regional, and sociocultural characteristics. Therefore, the observed differences cannot be attributed solely to the language versions of the MMAS-8. An item-aware approach is consequently warranted when using the instrument in multilingual Indian populations, particularly when comparing mean scores or adherence classifications across language groups. [36]

5. Strengths and limitations

A major strength of this study was its sequential, item-focused psychometric framework, which integrated item-response distributions, internal-consistency analysis, exploratory analyses, group-specific confirmatory factor analysis, and multigroup measurement-invariance testing. The use of categorical-data methods and the separate assessment of factor-loading and threshold constraints enabled a more detailed evaluation of cross-linguistic comparability. Several limitations should be considered. First, no a priori sample-size calculation was performed specifically for confirmatory factor analysis or measurement-invariance testing, which may have affected parameter precision and model stability, particularly in multigroup categorical analyses. Second, language was geographically confounded with study centre, and the groups differed in demographic and educational characteristics. Therefore, the observed differences cannot be attributed to language or translation alone. Third, the cross-sectional design precluded assessment of temporal stability and responsiveness to changes in medication adherence. Fourth, potential differences in response styles, comprehension, and clinical context may have influenced item responses but were not directly assessed. No independent external measure of medication adherence was available for criterion-related validation, limiting the assessment of criterion-related validity. Finally, differential item functioning and item response theory analyses were not performed; consequently, the mechanisms underlying the observed item-level differences remain uncertain.

Future multicentre studies should recruit adequately powered samples and incorporate cognitive interviewing, differential item functioning, and item response theory analyses to investigate the robustness and clinical relevance of these findings across additional Indian language groups. Overall, the results support a broadly shared MMAS-8 measurement framework with selective item-level non-equivalence, indicating that cross-language comparisons of MMAS-8 scores should be interpreted cautiously.

6. Conclusion

The MMAS-8 demonstrated a broadly similar measurement structure across Tamil- and Odia-speaking adults, with evidence of partial metric invariance. Full metric invariance was not supported, as Items 5 and 7 showed differences in their relationships with the underlying medication-adherence construct. However, threshold testing provided limited evidence of substantial additional threshold non-equivalence. Therefore, MMAS-8 scores should not automatically be considered fully interchangeable between the two language groups. These findings highlight the importance of evaluating measurement equivalence beyond translation and conventional psychometric validation. Further multicentre studies incorporating cognitive interviewing, differential item functioning, and item response theory are warranted to investigate the robustness and clinical relevance of the observed item-level differences.

References

1. Cross AJ, Elliott RA, Petrie K, Kuruvilla L, George J (2020) Interventions for improving medication-taking ability and adherence in older adults prescribed multiple medications. Cochrane Database Syst Rev 5(5):CD012419. 10.1002/14651858.CD012419.pub2
2. Tegegn HG, Wark S, Tursan d'Espaignet E, Spark MJ (2022) Measurement properties of patient-reported outcome measures for medication adherence in cardiovascular disease: a COSMIN systematic review. Clin Drug Investig 42(11):879–908. 10.1007/s40261-022-01199-7
3. Khoiry QA, Alfian SD, van Boven JFM, Abdulah R (2023) Self-reported medication adherence instruments and their applicability in low-middle income countries: a scoping review. Front Public Health 11:1104510. 10.3389/fpubh.2023.1104510
4. Oliveira HC, Hayashi D, Carvalho SDL, Barros RCL, Neves MLDS, Andrechuk CRS, Alexandre NMC, Ribeiro PAB, Rodrigues RCM (2023) Quality of measurement properties of medication adherence instruments in cardiovascular diseases and type 2 diabetes mellitus: a systematic review and meta-analysis. Syst Rev 12(1):222. 10.1186/s13643-023-02340-z
5. Rickles NM, Mulrooney M, Sobieraj D, Hernandez AV, Manzey LL, Gouveia-Pisano JA, Townsend KA, Luder H, Cappelleri JC, Possidente CJ (2003) A systematic review of primary care-focused, self-reported medication adherence tools. J Am Pharm Assoc 2023;63(2):477–490.e1. 10.1016/j.japh.2022.09.007
6. Intilangelo A, Majic S, Palchik V, Traverso ML (2024) Validated questionnaires on medication adherence and associated factors in chronic patients: a systematic review. Farm Hosp 48(4):T185–T192. 10.1016/j.farma.2024.04.019
7. Dunbar-Jacob J, Zhao J (2025) Medication adherence measurement in chronic diseases: a state-of-the-art review of the literature. Nurs Rep 15(10):370. 10.3390/nursrep15100370
8. Pareja-Martínez E, Esquivel-Prados E, Martínez-Martínez F, García-Corpas JP (2020) Questionnaires on adherence to antihypertensive treatment: a systematic review of published questionnaires and their psychometric properties. Int J Clin Pharm 42(2):355–365. 10.1007/s11096-020-00981-x
9. Zhang Y, Wang R, Chen Q, Dong S, Guo X, Feng Z, Rao Y (2021) Reliability and validity of a modified 8-item Morisky Medication Adherence Scale in patients with chronic pain. Ann Palliat Med 10(8):9088–9095. 10.21037/apm-21-1878
10. Martinez-Perez P, Orozco-Beltrán D, Pomares-Gomez F, Hernández-Rizo JL, Borras-Gallen A, Gil-Guillen VF, Quesada JA, Lopez-Pineda A, Carratala-Munuera C (2021) Validation and psychometric properties of the 8-item Morisky Medication Adherence Scale (MMAS-8) in type 2 diabetes patients in Spain. Aten Primaria 53(2):101942. 10.1016/j.aprim.2020.09.007
11. Lai PSM, Sellappans R, Chua SS (2020) Reliability and validity of the M-MALMAS instrument to assess medication adherence in Malay-speaking patients with type 2 diabetes. Pharm Med 34(3):201–207. 10.1007/s40290-020-00335-y
12. Kwan YH, Weng SD, Loh DHF, Phang JK, Oo LJY, Blalock DV, Chew EH, Yap KZ, Tan CYK, Yoon S, Fong W, Østbye T, Low LL, Bosworth HB, Thumboo J (2020) Measurement properties of existing patient-reported outcome measures on medication adherence: systematic review. J Med Internet Res 22(10):e19179. 10.2196/19179
13. Iranpour A, Sarmadi V, Alian Mofrad A, Mousavinezhad SA, Mousavinezhad SM, Mohammad Alizadeh F, Neshat S (2022) The Persian version of the 8-item Morisky Medication Adherence Scale (MMAS-8): can we trust it? J Diabetes Metab Disord 21(1):835–840. 10.1007/s40200-022-01047-7
14. Figueira JAV, Ramírez A, Valdevila Santiesteban R, Carvajal Parra ID, Morisky P, Cucalón MJP (2026) Psychometric properties of the unifactorial and bifactorial models of the Morisky medication adherence scale in Ecuadorians with neuropsychiatric disorders. Front Psychol 17:1764294. 10.3389/fpsyg.2026.1764294
15. Gagnier JJ, de Arruda GT, Terwee CB, Mokkink LB, Consensus group (2025) COSMIN reporting guideline for studies on measurement properties of patient-reported outcome measures: version 2.0. Qual Life Res 34(7):1901–1911. 10.1007/s11136-025-03950-x
16. De Arruda GT, Terwee CB, Elsman EBM, Avila MA, Gagnier JJ, Mokkink LB, PROM Reporting Group (2025) Explanation & elaboration document of the COSMIN Reporting Guideline 2.0 for studies on measurement properties of patient-reported outcome measures. Qual Life Res 34(7):1891–1899. 10.1007/s11136-025-03949-4
17. Mokkink LB, Elsman EBM, Terwee CB (2024) COSMIN guideline for systematic reviews of patient-reported outcome measures version 2.0. Qual Life Res 33(11):2929–2939. 10.1007/s11136-024-03761-6
18. Mokkink LB, de Vet HCW, Prinsen CAC, Patrick DL, Alonso J, Bouter LM et al (2018) COSMIN Risk of Bias checklist for systematic reviews of Patient-Reported Outcome Measures. Qual Life Res 27(5):1171–1179. 10.1007/s11136-017-1765-4
19. Mokkink LB, Herbelet S, Tuinman PR, Terwee CB (2025) Content validity: judging the relevance, comprehensiveness, and comprehensibility of an outcome measurement instrument - a COSMIN perspective. J Clin Epidemiol 185:111879. 10.1016/j.jclinepi.2025.111879
20. Dun RL, Tsai J, Hu XH, Mao JM, Zhu WJ, Qi GC et al (2021) A systematic review of cross-cultural adaptation of the National Institutes of Health Chronic Prostatitis Symptom Index. Health Qual Life Outcomes 19(1):159. 10.1186/s12955-021-01796-8
21. Weiss B, Grunow JJ, Rosenthal M, Hilfrich D, Mörgeli R, Neuner B et al (2020) Guideline-conform translation and cultural adaptation of the Addenbrooke's Cognitive Examination III into German. Ger Med Sci 18:Doc04. 10.3205/000280
22. Cerri LQ, Justo MC, Clemente V, Gomes AA, Pereira AS, Marques DR (2023) Insomnia Severity Index: a reliability generalisation meta-analysis. J Sleep Res 32(4):e13835. 10.1111/jsr.13835. PMID:36737257
23. Clark LA, Watson D (2019) Constructing validity: New developments in creating objective measuring instruments. Psychol Assess 31(12):1412–1427. 10.1037/pas0000626
24. Rosseel Y, lavaan (2012) An R package for structural equation modeling. J Stat Softw 48(2):1–36. 10.18637/jss.v048.i02

25. Kiwanuka F, Kopra J, Sak-Dankosky N, Nanyonga RC, Kvist T (2022) Polychoric correlation with ordinal data in nursing research. Nurs Res 71(6):469–476. 10.1097/NNR.0000000000000614
26. Balázs PG, Mitev A, Brodszky V (2022) Parallel exploratory and confirmatory factor analysis of the Hungarian Fear of COVID-19 Scale in a large general population sample: a psychometric and dimensionality evaluation. BMC Public Health 22(1):1438. 10.1186/s12889-022-13789-3
27. Finney SJ, DiStefano C (2013) Nonnormal and categorical data in structural equation modeling. In: Hancock GR, Mueller RO (eds) A Second Course in Structural Equation Modeling, 2nd edn. Information Age Publishing, Charlotte (NC), pp 439–492
28. Vandenberg RJ, Lance CE (2000) A review and synthesis of the measurement invariance literature: Suggestions, practices, and recommendations for organizational research. Organ Res Methods 3(1):4–70. 10.1177/109442810031002
29. Ubels J, Schlander M (2023) Measurement invariance and adapted preferences: evidence for the ICECAP-A and WeRFree instruments. Health Qual Life Outcomes 21(1):121. 10.1186/s12955-023-02208-9
30. Svetina D, Rutkowski L, Rutkowski D (2020) Multiple-group invariance with categorical outcomes using updated guidelines: an illustration using Mplus and the lavaan/semTools packages. Struct Equ Model 27(1):111–130. 10.1080/10705511.2019.1602776
31. Goldammer P, Annen H, Lienhard C, Jonas K (2024) An examination of model fit and measurement invariance of general mental ability and personality measures used in the multilingual context of the Swiss Armed Forces: a Bayesian structural equation modeling approach. Mil Psychol 36(1):96–113. 10.1080/08995605.2021.1963632
32. Cheung GW, Rensvold RB (2002) Evaluating goodness-of-fit indexes for testing measurement invariance. Struct Equ Model 9(2):233–255. 10.1207/S15328007SEM0902_5
33. Schuler M, Musekamp G, Bengel J, Nolte S, Osborne RH, Faller H (2014) Measurement invariance across chronic conditions: a systematic review and an empirical investigation of the Health Education Impact Questionnaire (heiQ™). Health Qual Life Outcomes 12:56. 10.1186/1477-7525-12-56
34. Peugh J, Feldon DF (2020) How well does your structural equation model fit your data? Is Marcoulides and Yuan's equivalence test the answer? CBE Life Sci Educ 19(3):es5. 10.1187/cbe.20-01-0016
35. Millsap RE (2011) Statistical approaches to measurement invariance, 1st edn. Routledge, New York. 10.4324/9780203821961
36. Thissen D (2025) A review of some of the history of factorial invariance and differential item functioning. Multivar Behav Res 60(2):211–235. 10.1080/00273171.2024.2396148
37. Bauer DJ (2023) Enhancing measurement validity in diverse populations: modern approaches to evaluating differential item functioning. Br J Math Stat Psychol 76(3):435–461. 10.1111/bmsp.12316
38. Kalaydzhyan EP, Lukina YV, Kutishenko NP, Zeynapur AA, Martsevich SY, Pestova NV, Eliseykina AS, Drapkina OM (2026) Adherence to previously prescribed pharmacotherapy in patients undergoing planned inpatient treatment: first results of the PRIMULA study. Ration Pharmacotherapy Cardiol 22(2):213–220. 10.20996/1819-6446-2026-3354
39. Oliveira HC, Hayashi D, Carvalho SDL, Barros RCL, Neves MLDS, Andrechuk CRS et al (2023) Quality of measurement properties of medication adherence instruments in cardiovascular diseases and type 2 diabetes mellitus: a systematic review and meta-analysis. Syst Rev 12(1):222. 10.1186/s13643-023-02340-z

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