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Development and Preliminary Psychometric Evaluation of the Socio-Ecological Model Questionnaire (SOCEM-Q) for Assessing Factors Associated with Tuberculosis Treatment Adherence

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Abstract: Tuberculosis (TB) treatment adherence is influenced by socio-ecological factors, but theory-based instruments for assessing these factors remain limited. This study developed the Socio-Ecological Model Questionnaire (SOCEM-Q) and conducted a preliminary evaluation of its psychometric properties. A cross-sectional study was conducted at 21 community health centers (Puskesmas) in Central Java, Indonesia, from June to July 2026. Using purposive sampling, 124 adults aged 18 years or older receiving TB treatment were recruited. Data were collected through structured interviews. The 19-item SOCEM-Q comprises five socio-ecological domains (individual, interpersonal, organizational, community, and policy) and a separate TB treatment-related behavior construct. Three experts evaluated content validity (I-CVI = 1.00), and 10 patients assessed face validity. Confirmatory factor analysis (CFA) with maximum likelihood estimation evaluated internal structure; Cronbach's alpha assessed internal consistency; and Rasch analysis using joint maximum likelihood estimation examined item characteristics. All 19 items were retained, with standardized factor loadings of 0.668–0.898 and acceptable overall model fit (CFI = 0.923; TLI = 0.904; SRMR = 0.0599; RMSEA = 0.0645; 90% CI: 0.0459–0.0818). Cronbach's alpha ranged from 0.741 to 0.758. Standardized interconstruct correlations ranged from 0.423 to 0.967 (all $p < 0.001$), indicating potential construct overlap. Composite reliability (CR) and average variance extracted (AVE) supported reliability and convergent validity, whereas the Fornell–Larcker criterion indicated limitations in discriminant validity. Rasch analysis provided preliminary information on item difficulty, fit, and separation. Findings support the SOCEM-Q's potential for assessing socio-ecological factors associated with TB treatment adherence. Further examination of dimensionality and construct distinctiveness in larger independent samples is warranted.

Introduction

Adherence to tuberculosis (TB) treatment remains a major challenge in TB control, as treatment outcomes are associated with patient characteristics, social support, and healthcare services (1–3). The Global Tuberculosis Report 2024 estimated that 10.8 million people developed TB and 1.25 million died from the disease in 2023. India accounted for 26% of global TB cases, while Indonesia contributed approximately 10% (4). Poor treatment adherence is associated with treatment failure, disease recurrence, continued transmission, and the emergence of drug resistance (3, 5, 6). Adherence is influenced not only by patients' medication-taking behavior but also by socioeconomic conditions, family support, access to healthcare services, communication with healthcare professionals, and the burden of disease and treatment (1, 7, 8). Assessing factors associated with adherence therefore requires consideration of both individual characteristics and the broader environment in which treatment takes place.

The World Health Organization (WHO) framework for adherence to long-term therapies classifies

adherence-related factors into five dimensions: socioeconomic factors, healthcare systems and healthcare professionals, disease-related factors, treatment-related factors, and patient-related factors (9). The Socio-Ecological Model (SEM) conceptualizes health behavior as the product of interactions among factors operating at the individual, interpersonal, organizational, community, and public policy levels (10, 11). These frameworks differ in their organizing principles. The WHO framework categorizes factors according to their relationship with treatment adherence, whereas SEM organizes them according to the social and environmental levels at which they operate. Previous applications of SEM to TB treatment nonadherence demonstrate its relevance for examining influences arising from patients, social relationships, healthcare services, and the broader environment (11). Accordingly, SEM provides a theoretical foundation for developing an instrument that systematically assesses factors associated with TB treatment across multiple socio-ecological levels.

Existing instruments for assessing medication adherence differ in their purposes and scope. The eight-item Morisky Medication Adherence Scale (MMAS-8) and the five-item Medication Adherence Report Scale (MARS-5) are self-report measures designed to assess medication-taking behavior and nonadherence, including forgetting or missing doses (12, 13). Both instruments focus primarily on medication-taking behavior rather than systematically mapping adherence-related factors across SEM levels. In Indonesia, Rianto *et al.* (2024) developed a questionnaire to assess risk factors for treatment nonadherence among patients with pulmonary TB, using the five domains of the WHO framework: socioeconomic factors, healthcare professionals, disease-related factors, treatment-related factors, and patient-related factors. The instrument uses a five-point agreement scale and was evaluated using confirmatory factor analysis (CFA) and partial least squares structural equation modeling (PLS-SEM). Although both instruments target patients with TB, the questionnaire developed by Rianto *et al.* (2024) organizes factors according to the WHO framework, whereas the SOCEM-Q adopts a conceptual structure explicitly based on SEM (14).

An SEM-based instrument was also developed by Abutair *et al.* (2025) for patients receiving maintenance hemodialysis in Gaza, Palestine. The Arabic-language questionnaire comprises 31 items assessing four domains of support: interpersonal, organizational, community, and policy support. Although its theoretical framework is relevant, the instrument was developed for a different population and healthcare context. Its measurement structure therefore requires separate evaluation before it can be considered suitable for patients with TB in Indonesia. The SOCEM-Q was developed to assess factors theoretically associated with TB treatment adherence through five SEM-based domains: Individual-Level Factors, Family Support, Healthcare Facility Support, Community Support, and Policy Support. A separate construct captures TB treatment-related behavior. The instrument comprises 19 items. The five factor domains use a four-point agreement scale, whereas the behavioral construct uses a four-point frequency scale. This distinction reflects the conceptual difference between factors that may influence adherence and patients' self-reported treatment-related behavior (15). The contribution of the SOCEM-Q lies in operationalizing SEM to measure factors associated with TB treatment in the Indonesian context.

This study aimed to develop the Socio-Ecological Model Questionnaire (SOCEM-Q) and evaluate its preliminary psychometric properties. The evaluation covered content validity, face validity, internal structure using CFA, internal consistency using Cronbach's alpha, and selected item characteristics through Rasch analysis. The study sought to establish initial evidence of the instrument's measurement quality and identify psychometric aspects requiring further investigation.

Methods

Study Design and Setting

This quantitative instrument-development study employed a cross-sectional design to develop the SOCEM-Q and evaluate its preliminary psychometric properties. Instrument development was guided by the SEM, which organizes factors associated with health behavior across individual, interpersonal, organizational, community, and public policy levels (10, 11). The study was conducted from June to July 2026 at 21 community health centers (Puskesmas) in Central Java, Indonesia. The study sites were selected based on TB burden and variation in social conditions and healthcare services relevant to TB treatment (4, 16).

Participants and Sampling

Participants were recruited using purposive sampling according to the eligibility criteria specified in the study protocol. The inclusion criteria were age 18 years or older, a diagnosis of TB, ongoing treatment at a participating community health center, and willingness to participate by providing written informed consent. Individuals who were unable to respond independently or did not complete the questionnaire were excluded in accordance with the study protocol. The sample size was determined with reference to the proposed confirmatory factor analysis (CFA) model, comprising six constructs and 19 observed indicators. Based on the heuristic guideline described by Hair *et al.* (2019), a minimum of five participants per indicator yielded an initial target of 95 participants (19 × 5) (17). The final sample of 124 participants exceeded this target. The CFA model included 53 free parameters and 137 degrees of freedom. However, the participant-to-indicator ratio was considered a preliminary guideline rather than definitive evidence of sample adequacy, which also depends on model complexity, the number of estimated parameters, factor loading magnitudes, and the estimation method (18–20).

Conceptual Framework and Construct Structure

SEM was used to organize factors associated with TB treatment across five socio-ecological levels (10, 11). These levels were operationalized to reflect the characteristics of patients and healthcare services in Indonesia. Individual-Level Factors was represented by the Individual-Level Factors construct. The interpersonal level was operationalized as Family Support, while the organizational level was represented by Healthcare Facility Support. Community Support and Policy Support

Table 1. Initial development of SOCEM-Q items based on the SEM and literature review.

Code Item	Item	Source (Citation)
IL01	I can remember my daily medication schedule	(14, 25)
IL02	I am determined to complete my TB treatment according to schedule	(7, 14)
FS01	My family provides emotional support throughout my TB treatment	(7, 8)
FS02	My family reminds me to take my TB medication regularly	(7, 8, 14)
FS03	My family understands the importance of preventing multidrug-resistant TB (MDR-TB)	(4, 7)
FS04	My family helps meet my needs during TB treatment	(7, 8)
HFS01	Healthcare professionals clearly explain my TB treatment	(5, 14)
HFS02	Healthcare facilities are easily accessible to me	(11, 14, 25)
HFS03	Healthcare professionals encourage me to follow the recommended TB treatment regimen	(4, 14)
HFS04	Healthcare services help me overcome difficulties during TB treatment	(4, 14, 25)
CS01	People in my community support me in completing my TB treatment	(10, 11, 15)
CS02	I do not feel excluded by people in my community	(11, 15)
CS03	Community support helps me take my medication regularly	(10, 11, 15)
CS04	Health education improves my understanding of behaviors related to TB treatment	(4, 14, 25)
PS01	Government programs support the continuity of TB treatment	(4, 14)
PS02	Policies support access to TB medication	(4, 14)
PS03	Policies protect the rights of patients with TB	(10, 11, 15)
PB01	I take my TB medication regularly	(7, 8)
PB02	I attend routine follow-up appointments at healthcare facilities during my TB treatment	(7, 8, 14)

Note: IL = Individual-Level Factors; FS = Family Support; HFS = Healthcare Facility Support; CS = Community Support; PS = Policy Support; PB = TB Treatment-Related Behavior. Items in the IL, FS, HFS, CS, and PS domains use a four-point agreement scale, whereas PB items use a four-point frequency scale

represented the community and public policy levels, respectively. The measurement model comprised six constructs. The first five assessed factors based on SEM, whereas TB Treatment-Related Behavior measured treatment-related behavior as a separate construct rather than a sixth socio-ecological level. The six-construct structure was established *a priori* based on the study's conceptual framework before CFA was conducted.

Instrument Development and Response Format

The SOCEM-Q was developed using a theory-driven approach involving four stages: concept identification, conceptual mapping, item generation, and expert review. The process followed established principles for developing and validating health and behavioral research instruments (21–23). Concepts relevant to TB treatment were identified through SEM and a review of empirical literature. These concepts were mapped onto the five socio-ecological levels and translated into operational indicators. Items were developed by adapting concepts from previous instruments and publications, with wording tailored to the experiences of patients with TB in Indonesia. Individual-level factors included the ability to remember treatment schedules and the determination to complete treatment. Family support covered emotional support and medication reminders, whereas healthcare facility support addressed clarity of information, access to services, and assistance from healthcare professionals. Community and policy support items addressed the social environment, health education, access to medication, and protection of patients' rights. The SOCEM-Q comprised 19 items distributed across five factor domains and one separate behavioral construct: Individual-Level Factors (2 items), Family Support (4 items), Healthcare Facility Support (4 items), Community Support (4 items), Policy Support (3 items), and TB Treatment-Related Behavior (2 items). The five factor domains used a four-point agreement scale: 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree. The behavioral construct used a four-point frequency scale: 1 = never, 2 = sometimes, 3 = often, and 4 = always. Four response categories were selected to distinguish levels of agreement and behavioral frequency without offering a neutral option (23, 24). Responses were coded numerically from 1 to 4 and analyzed as observed item responses to evaluate the proposed measurement structure and psychometric properties. No composite domain scores, overall questionnaire scores, or cutoff-based classifications were calculated or interpreted in this preliminary evaluation. The conceptual basis, item codes, item wording, and supporting sources are presented in **Table 1**.

Content Validity

Content validity was assessed by a panel of three experts with complementary expertise in tuberculosis (TB) management, clinical pharmacy, and instrument development. The experts were selected based on their professional backgrounds and relevant expertise to ensure clinical and methodological perspectives in evaluating the instrument. Each expert independently assessed the relevance, clarity, and representativeness of the 19 items in relation to their intended constructs using a four-point rating scale. The item-level content validity index (I-CVI) was calculated as the proportion of experts assigning relevance ratings that met the predefined criterion (26, 27). Expert feedback was also considered to refine item

wording and ensure conceptual consistency with the proposed constructs.

Face Validity

Face validity was assessed among 10 patients with TB representative of the target population who were not included in the main sample. The assessment focused on the comprehensibility of the instructions, item wording, and response options. Participants indicated that all three components were understandable. Their feedback was used to review language clarity without changing the intended meaning of the measured constructs (21, 22).

Pilot Testing

The SOCEM-Q was pilot-tested with 30 patients with TB before the main psychometric evaluation. None of the pilot participants was included in the main sample of 124 participants. The pilot test assessed questionnaire feasibility, completion time, item comprehensibility, and preliminary response patterns. The findings were used to review item clarity and determine the instrument's readiness for the main data collection phase (21, 22).

Data Collection

Data were collected from June to July 2026 at 21 community health centers in Central Java using structured interviews administered with the SOCEM-Q. Interviews were conducted by the researcher and healthcare center staff who had received orientation and training before data collection. Training covered the study objectives, interview procedures, standardized presentation of questionnaire items, objective recording of responses, participant confidentiality, and procedures for obtaining written informed consent (28). Interviewers were instructed to present questions neutrally without influencing participants' responses. All 124 participants were aged 18 years or older and provided their responses directly. Data collection followed the infection prevention and control procedures applicable at each study site. After each interview, questionnaires were checked for completeness and consistency before analysis (21).

Data Analysis

Participant characteristics were analyzed using IBM SPSS Statistics version 27 and summarized as frequencies and percentages. No missing data were identified among the 124 participants; therefore, imputation was not required (29, 30).

Confirmatory Factor Analysis

The internal structure of the SOCEM-Q was evaluated using confirmatory factor analysis (CFA) in jamovi version 2.7.31. A six-construct measurement model was specified *a priori* based on the socio-ecological model (SEM) and the proposed conceptual framework to assess whether items corresponded to their hypothesized constructs (17, 18). The model was estimated using maximum likelihood (ML), with four-category responses treated as continuous variables. Standardized factor loadings and their statistical significance were examined, using ≥0.50 and $p < 0.05$ as reference criteria. Model fit was assessed using the Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), standardized root mean square residual (SRMR), and root mean square error of approximation (RMSEA) with its 90% confidence interval. CFI and TLI values ≥0.90 and SRMR and RMSEA values ≤0.08 were considered reference criteria for acceptable overall model fit (17, 18). Item retention considered factor loadings, statistical significance, theoretical relevance, and overall model fit. No exploratory factor extraction or data-driven model modifications were performed.

Internal Consistency

Internal consistency was assessed separately for each construct using Cronbach's alpha, with values ≥0.70 considered acceptable for research purposes (22, 31). Alpha coefficients were interpreted alongside CFA findings rather than as standalone evidence of construct validity. Two-item constructs were retained based on theoretical relevance and factor evaluation, with due consideration of their limited item numbers (18). The Kaiser–Meyer–Olkin (KMO) measure and Bartlett's test of sphericity were also used as supplementary assessments of the inter-item correlation structure, not as primary evidence of CFA model adequacy.

Rasch Analysis

Rasch analysis was conducted using jMetrik with joint maximum likelihood estimation (JMLE). Item difficulty was expressed in logits, with positive and negative values indicating greater and lower difficulty, respectively. Item fit was evaluated using weighted mean-square (WMS) and unweighted mean-square (UMS) statistics, while item and person separation indices were used to describe the distinction among item difficulty levels and participant measurement levels (32, 33). Rasch analysis complemented CFA by providing preliminary item-level information. Because the SOCEM-Q comprises six conceptually distinct constructs, pooled analysis of all 19 items was not interpreted as evidence of overall unidimensionality. Further dimensionality testing and domain-specific or multidimensional Rasch analyses are needed (11, 29).

Ethical Considerations

Ethical approval was obtained from the Health Research Ethics Committee of the Faculty of Health Sciences, Universitas Muhammadiyah Magelang (UNIMMA), Indonesia (Approval No. 205/KEPK-FIKES/II.3. AU/F/2026; May 13, 2026), before data collection commenced. All participants received information about the study objectives and procedures, potential benefits and discomforts, confidentiality measures, and their right to decline or withdraw from participation without affecting the healthcare services they received. Written informed consent was obtained before data collection. Confidentiality was maintained through the use of study identification codes and restricted access to the data.

Results and Discussion

Sociodemographic Characteristics

A total of 124 adult patients with tuberculosis (TB) were included in the preliminary psychometric evaluation of the SOCEM-Q, comprising 64 women (51.6%) and 60 men (48.4%). The largest age group was 18–25 years (29.8%), followed by > 25–35 years (22.6%) and > 35–45 years (21.8%). Most participants had completed senior high

Table 2. Sociodemographic characteristics.

Variable	Category	(n)	(%)
Gender	Male	60	48.4
	Female	64	51.6
Age	18–25 years	37	29.8
	> 25–35 years	28	22.6
	> 35–45 years	27	21.8
	> 45–55 years	10	8.1
	> 55–65 years	14	11.3
	> 65 years	8	6.5
Education background	No Formal Education	19	15.3
	Elementary School	20	16.1
	Junior High School	19	15.3
	Senior High School	50	40.3
	Diploma	8	6.5
	Bachelor's Degree	7	5.6
	Master's/Doctoral Degree	1	0.8
Occupation	Unemployed	49	39.5
	Employed	75	60.5
Monthly Income	IDR 0	45	36.3
	IDR < IDR 595.000	18	14.5
	IDR 595.000 - IDR 893.000	22	17.7
	IDR 893.000 - IDR 2.080.000	32	25.8
	IDR 2.080.000 - IDR 10.120.000	7	5.6
Tuberculosis History	Yes	124	100
	No	0	0
Tuberculosis Treatment	Yes	124	100
	No	0	0
Type of Health Insurance	BPJS (national health insurance)	98	79.0
	Non-BPJS	26	21.0
Self-Reported Family Support	Poor	1	0.8
	Adequate	6	4.8
	Good	63	50.8
	Very good	54	43.5

school (40.3%), and 75 (60.5%) were employed. The largest monthly income category was IDR 0 (36.3%), while 79.0% were covered by BPJS, Indonesia's national health insurance program. All participants had been diagnosed with TB and were receiving treatment at the time of data collection. Six participants (4.8%) reported a history of temporarily interrupting treatment, whereas 118 (95.2%) reported no such history. Regarding self-reported family support, 63 participants (50.8%) selected good, 54 (43.5%) very good, 6 (4.8%) adequate, and 1 (0.8%) poor. These categories represent descriptive responses to the sociodemographic questionnaire rather than score-based classifications of the SOCEM-Q Family Support construct. Overall, the participants exhibited diverse sociodemographic characteristics, providing relevant context for the preliminary psychometric evaluation (**Table 2**).

These sociodemographic characteristics are relevant to previous research indicating that TB treatment adherence is associated with socioeconomic conditions, self-reported family support, and access to healthcare services (1–3). Dana *et al.* (2025) and Alinaitwe *et al.* (2025) also highlighted the role of family support during TB treatment (7, 8). These findings reinforce the relevance of including family and social factors as domains of the SOCEM-Q. However, the high proportion of participants reporting good or very good family support cannot be interpreted directly as evidence of high treatment adherence. This study did not directly examine the association between family support categories and adherence outcomes. The characteristics presented describe the participant profile and provide context for the preliminary interpretation of the instrument's measurement quality.

Instrument Development and Content Evaluation

The SOCEM-Q was developed using a theory-driven approach informed by SEM and literature on factors associated with TB treatment. The initial instrument comprised 19 items distributed across six constructs: Individual-Level Factors (2 items), Family Support (4 items), Healthcare Facility Support (4 items), Community Support (4 items), Policy Support (3 items), and TB Treatment-Related Behavior (2 items). Item development considered the conceptual relevance of each construct and its applicability to the experiences of patients with TB (**Table 1**).

Content validity assessment demonstrated unanimous agreement among the three experts, with all 19 items achieving an item-level content validity index (I-CVI) of

Table 3. Kaiser-Meyer-Olkin (KMO) and Bartlett's test.

Overall MSA	Bartlett's chi-square (χ^2)	Degrees of freedom (df)	p-value
0.886	1020	171	<.001

Table 4. Standardized factor loadings of individual SOCEM-Q items.

Construct	Item code	Factor loading
Individual-Level Factors	IL01	0.894
	IL02	0.895
Family Support	FS01	0.821
	FS02	0.676
	FS03	0.718
	FS04	0.825
Healthcare Facility Support	HFS01	0.862
	HFS02	0.712
	HFS03	0.790
	HFS04	0.668
Community Support	CS01	0.794
	CS02	0.672
	CS03	0.698
	CS04	0.832
Policy Support	PS01	0.842
	PS02	0.876
	PS03	0.716
TB Treatment-Related Behavior	PB01	0.896
	PB02	0.898

Note: IL = Individual-Level Factors; FS = Family Support; HFS = Healthcare Facility Support; CS = Community Support; PS = Policy Support; PB = TB Treatment-Related Behavior.

1.00. These findings indicate strong agreement regarding item relevance and provide preliminary evidence of content validity. Expert feedback informed minor wording refinements to improve clarity and conceptual consistency without altering the intended constructs (34). These findings are consistent with established principles of content validity assessment and support the conceptual relevance of the SOCEM-Q items within the socio-ecological framework (26, 27). However, content validity represents one aspect of measurement quality, and the findings should be interpreted alongside evidence from confirmatory factor analysis, internal consistency, and other psychometric evaluations.

Face validity assessment involving 10 patients with TB indicated that the instructions, item wording, and response options were understandable to the target population. A pilot test involving 30 patients was also conducted to assess questionnaire feasibility, completion time, item comprehensibility, and preliminary response patterns. These participants were excluded from the main sample of 124 participants. Collectively, these stages provided preliminary evidence regarding content relevance, comprehensibility, and the instrument's readiness for psychometric evaluation.

These findings are consistent with instrument-development principles that emphasize conceptual alignment, expert assessment, and comprehensibility among the target population as important steps before further psychometric testing (21, 26, 27). DeVellis (2017) also emphasized that instrument quality should be established through a systematic development process rather than statistical analysis alone (22). Although all items achieved an I-CVI of 1.00, satisfactory content validity does not establish that the factor structure, reliability, and ability to distinguish among constructs have been fully demonstrated. These aspects must be considered alongside the CFA, internal consistency, and item-level analyses. Thus, the content and face validity findings support the preliminary suitability of the SOCEM-Q but do not constitute comprehensive psychometric validation.

Confirmatory Factor Analysis and Internal Structure

The KMO value was 0.886, indicating adequate sampling adequacy for the inter-item correlation structure. Bartlett's test of sphericity was also significant (χ^2 = 1020, df = 171, $p < 0.001$), indicating that the correlation matrix was not an identity matrix (**Table 3**). These results provide supplementary information on the suitability of the correlation structure for multivariate analysis but do not independently confirm the proposed six-construct model.

CFA was conducted to evaluate whether the 19 items corresponded to the six constructs specified *a priori*. All items demonstrated positive and statistically significant standardized factor loadings ($p < 0.001$), ranging from 0.668 to 0.898 (**Table 4**). All loadings exceeded the prespecified threshold of 0.50; therefore, no items were removed based on this criterion. PB02 had the highest factor loading (0.898), whereas HFS04 had the lowest (0.668). Although HFS04 showed a comparatively weaker association with Healthcare Facility Support, its loading remained above the retention threshold.

The factor loadings indicate that all 19 items were associated with their hypothesized constructs. The relatively high loadings observed for most items provide

Table 5. Confirmatory factor analysis model fit indices.

Index	Result	Reference criterion
χ^2 (df), p-value	208 (137), p < 0.001	—
CFI	0.923	≥ 0.90
TLI	0.904	≥ 0.90
SRMR	0.0599	≤ 0.08
RMSEA (90% CI)	0.0645 (0.0459–0.0818)	≤ 0.08

Note: χ^2 = chi-square; df = degrees of freedom; CFI = comparative fit index; TLI = Tucker–Lewis index; SRMR = standardized root mean square residual; RMSEA = root mean square error of approximation; CI = confidence interval. Reference criteria indicate acceptable fit for CFI and TLI ≥ 0.90 and SRMR and RMSEA ≤ 0.08.

preliminary support for the proposed internal structure of the SOCEM-Q. As emphasized by Kline (2016) and Hair *et al*. (2019), factor loadings should be interpreted alongside overall model fit and theoretical foundations. Because the six constructs were specified *a priori*, the CFA evaluated the theoretically proposed measurement structure rather than explored a new factor structure based on the observed data (17, 18).

The findings should also be interpreted in light of the limited number of indicators in the Individual-Level Factors and TB Treatment-Related Behavior constructs, each comprising only two items. Although both items in each construct had high and statistically significant factor loadings, a limited number of indicators may constrain construct coverage and affect the precision and stability of parameter estimates. Wolf *et al*. (2013) and Kyriazos (2018) noted that sample adequacy and estimation stability in factor analysis depend on several factors, including model complexity, the number of estimated parameters, and factor loading magnitudes, rather than solely on the participant-to-indicator ratio (19, 20). Therefore, although the CFA findings support the proposed six-construct structure, they do not establish all aspects of construct validity, particularly the empirical distinctiveness of the constructs.

Measurement Model Fit

The CFA results indicated acceptable overall model fit of

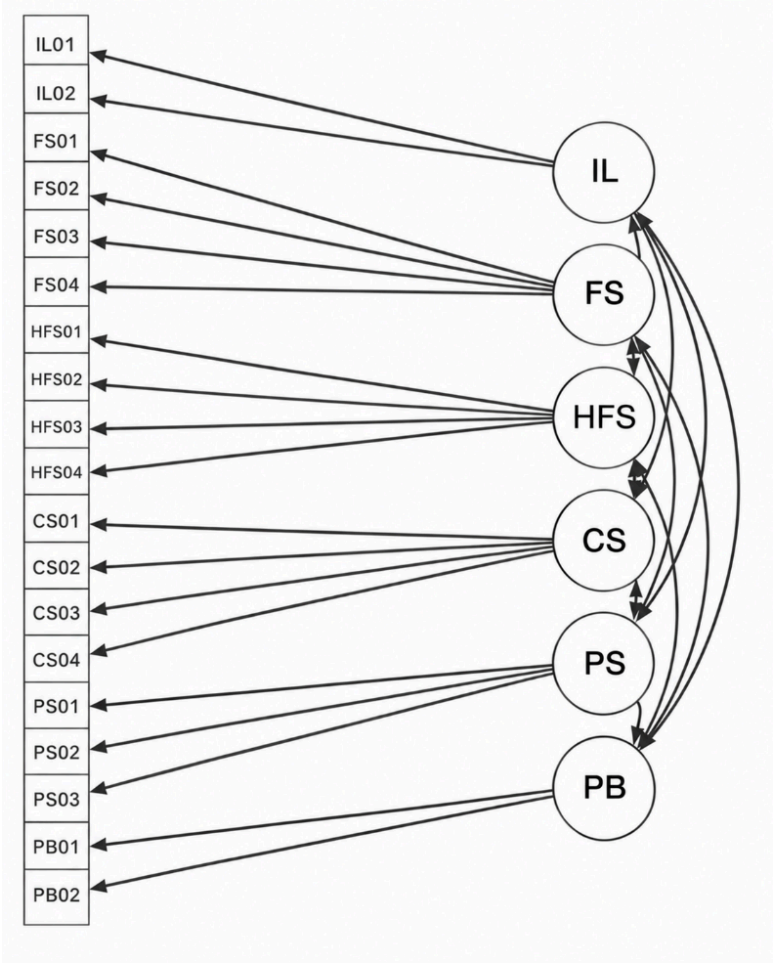

Figure 1. CFA path diagram of the six-construct SOCEM-Q model showing interconstruct correlations, with standardized estimates reported in **Table 6**.

Table 6. Standardized inter-factor correlations among the six latent constructs.

Construct	IL	FS	HFS	CS	PS	PB
IL	1.000	–	–	–	–	–
FS	0.940	1.000	–	–	–	–
HFS	0.926	0.730	1.000	–	–	–
CS	0.686	0.837	0.780	1.000	–	–
PS	0.615	0.726	0.843	0.903	1.000	–
PB	0.967	0.691	0.694	0.423	0.599	1.000

Note: Values represent standardized correlations between latent constructs. All 15 pairwise correlations were reported as statistically significant ($p < 0.001$).

Table 7. Internal consistency results.

Variable	Cronbach's α	CR	AVE
Individual-Level Factors	0.749	0.889	0.800
Family Support	0.758	0.847	0.582
Healthcare Facility Support	0.756	0.845	0.580
Community Support	0.741	0.838	0.566
Policy Support	0.758	0.854	0.663
TB Treatment-Related Behavior	0.758	0.892	0.805

Note: Cronbach's α and CR values ≥ 0.70 were considered indicative of acceptable internal consistency. AVE values ≥ 0.50 were considered indicative of adequate convergent validity. CR = composite reliability; AVE = average variance extracted.

the proposed measurement model. The CFI (0.923) and TLI (0.904) exceeded the reference threshold of 0.90, while the SRMR (0.0599) and RMSEA (0.0645) were below the threshold of 0.08. The 90% confidence interval for the RMSEA ranged from 0.0459 to 0.0818 (**Table 5**) (8, 29).

The chi-square exact-fit test was statistically significant ($\chi^2 = 208$, df = 137, $p < 0.001$), indicating that the model did not reproduce the observed covariance matrix perfectly. However, model fit should not be evaluated solely on the basis of the chi-square test. As emphasized by Kline (2016) and Hair *et al.* (2019), multiple fit indices should be considered collectively (17, 18). In this study, the CFI, TLI, SRMR, and RMSEA collectively suggested an acceptable approximation of the observed data. Nevertheless, acceptable overall model fit does not establish that the proposed structure is the only plausible model or demonstrate adequate convergent and discriminant validity.

Figure 1 illustrates the relationships between the six latent constructs and their respective indicators. All indicators showed positive and statistically significant factor loadings, providing preliminary support for the proposed measurement structure. The correlations between latent constructs represent statistical associations rather than causal relationships, as the study employed a cross-sectional design. In this study, CR and AVE provided evidence of composite reliability and convergent validity (**Table 7**), whereas the Fornell–Larcker assessment did not fully support discriminant validity. Further evaluation of construct distinctiveness in independent samples is therefore warranted (35, 36).

Interconstruct Correlations and Construct Distinctiveness

The standardized interconstruct correlations among the six latent constructs ranged from 0.423 to 0.967, with all 15 pairwise correlations statistically significant ($p < 0.001$; **Table 6**). The highest correlation was observed between Individual-Level Factors and TB Treatment-Related Behavior (r = 0.967), followed by Individual-Level Factors and Family Support (r = 0.940), Individual-Level Factors and Healthcare Facility Support (r = 0.926), and Community Support and Policy Support (r = 0.903). The lowest correlation was observed between Community Support and TB Treatment-Related Behavior (r = 0.423). These findings demonstrate varying degrees of association among the constructs, with particularly high correlations suggesting potential empirical overlap. Although composite reliability and average variance extracted supported reliability and convergent validity, respectively, the Fornell–Larcker criterion was not fully satisfied, indicating limitations in discriminant validity. Further evaluation of construct distinctiveness in independent samples is therefore warranted.

The Fornell–Larcker assessment indicated that seven of the 15 construct pairs did not satisfy the discriminant validity criterion. The strongest correlation was observed between Individual-Level Factors and TB Treatment-Related Behavior (r = 0.967), suggesting substantial empirical overlap. These findings indicate that acceptable overall CFA model fit and adequate convergent validity do not necessarily establish construct distinctiveness. Further evaluation using independent samples and additional discriminant validity assessments is warranted.

Internal Consistency

Cronbach's alpha coefficients ranged from 0.741 to 0.758 across the six constructs (**Table 7**). The highest coefficients were observed for Family Support, Policy Support, and TB Treatment-Related Behavior (α = 0.758), whereas Community Support had the lowest coefficient (α = 0.741). All coefficients exceeded the reference criterion of 0.70, indicating acceptable internal consistency for research purposes (21, 30).

Composite reliability (CR) values ranged from 0.838 to 0.892, exceeding the recommended threshold of 0.70.

Table 8. Item statistics based on JMLE estimates.

No.	Item Code	Difficulty	Std. Error	WMS	Std. WMS	UMS	Std. UMS
1	IL01	-0.26	0.20	0.87	-1.12	0.94	-0.44
2	IL02	0.67	0.19	0.86	-1.27	0.81	-1.38
3	FS01	0.27	0.19	0.98	-0.11	0.90	-0.68
4	FS02	-0.54	0.20	1.02	0.17	1.06	0.40
5	FS03	0.85	0.19	0.77	-1.93	0.74	-1.99
6	FS04	0.16	0.19	0.85	-1.35	0.77	-1.71
7	HFS01	-0.80	0.21	0.71	-2.71	0.64	-1.95
8	HFS02	0.05	0.19	0.96	-0.29	0.91	-0.57
9	HFS03	-0.75	0.21	0.80	-1.84	0.72	-1.46
10	HFS04	-0.14	0.20	0.87	-1.13	0.83	-1.14
11	CS01	0.60	0.19	0.77	-2.01	0.74	-2.03
12	CS02	0.60	0.19	0.79	-1.82	0.73	-2.15
13	CS03	0.49	0.19	0.89	-0.90	0.85	-1.07
14	CS04	0.31	0.19	0.82	-1.61	0.87	-0.91
15	PS01	-0.42	0.20	0.78	-2.07	0.68	-2.03
16	PS02	-0.26	0.20	0.72	-2.74	0.65	-2.45
17	PS03	0.38	0.19	0.64	-3.39	0.60	-3.27
18	PB01	-0.71	0.21	1.17	1.42	1.29	1.41
19	PB02	-0.54	0.20	1.27	2.23	1.14	0.77

Note: SE = standard error; WMS = weighted mean-square fit statistic; UMS = unweighted mean-square fit statistic; Std. WMS and Std. UMS = standardized weighted and unweighted fit statistics.

Table 9. Rasch measurement quality statistics.

No.	Indicator	Items	Persons
1	Root MSE	0.1969	0.5420
2	Separation Index (G)	2.4357	2.1518
3	Number of Strata	3.5809	3.2024

Average variance extracted (AVE) values ranged from 0.566 to 0.805, with all constructs exceeding the recommended threshold of 0.50. These findings indicate satisfactory composite reliability and provide evidence of adequate convergent validity across the six constructs. However, comparison of the square roots of AVE with the corresponding interconstruct correlations (Tables 6 and 7) indicated that the Fornell–Larcker criterion was not fully met; thus, discriminant validity was not fully supported (36). Nevertheless, these results should be interpreted in consideration of the number of items within each construct. In particular, Individual-Level Factors and TB Treatment-Related Behavior each comprise only two items, which may limit construct coverage. DeVellis (2017) emphasized that reliability coefficients should be interpreted in light of item count, construct characteristics, and intended instrument use (22). Mokkink *et al.* (2023) likewise highlighted that reliability represents one component of measurement quality and should be evaluated alongside other forms of validity evidence (31). Therefore, although the findings support acceptable internal consistency and convergent validity, further evaluation in independent and more diverse samples is warranted.

Rasch Analysis

Rasch analysis complemented the CFA findings by examining item characteristics, relative difficulty, model fit, and item and person separation. Estimated item difficulty ranged from −0.80 to 0.85 logits (**Table 8**). HFS01 had the lowest difficulty estimate (−0.80 logits), whereas FS03 had the highest (0.85 logits) (6, 32).

WMS values ranged from 0.64 to 1.27, whereas UMS values ranged from 0.60 to 1.29. These mean-square values generally fell within ranges commonly used to evaluate item fit (29, 33). However, interpretation of item fit should also consider the standardized statistics and the characteristics of the sample. Several standardized fit statistics showed deviations from the commonly used reference range of approximately −2 to +2. For WMS, deviations were observed for HFS01 (−2.71), PS02 (−2.74), and PS03 (−3.39), while PB02 showed a positive deviation (2.23). For UMS, deviations were observed for CS01 (−2.03), CS02 (−2.15), PS01 (−2.03), PS02 (−2.45), and PS03 (−3.27). These results suggest that, although the mean-square statistics were generally within commonly used ranges, selected items warrant further examination. Smith *et al.* (2008) emphasized the importance of considering fit statistics and sample characteristics when interpreting Rasch analysis results (33). Bond (2015) likewise explained that item parameter estimates should be interpreted in relation to model fit and the characteristics of the measured construct (32). The item separation index of 2.4357 corresponded to approximately 3.5809 strata, whereas the person separation index of 2.1518 corresponded to approximately 3.2024 strata (**Table 9**). These results suggest that the instrument could distinguish among several levels of item difficulty and participant measurement levels in this sample. However, separation indices do not imply uniform measurement precision across the entire range of the measured

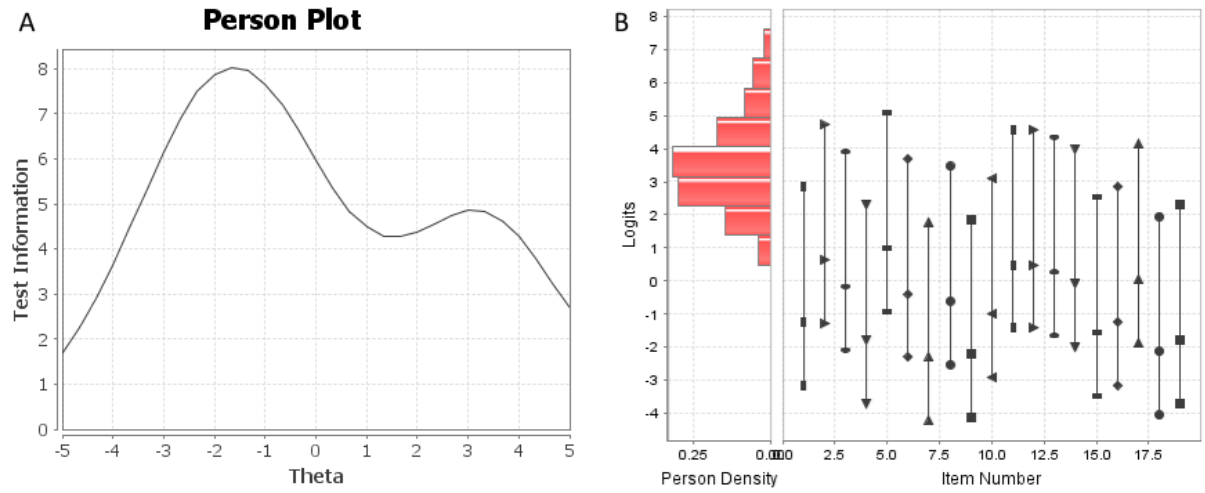

Figure 2. Measurement precision and item–person distributions based on Rasch analysis. (A) Person plot; (B) measurement information and item–person distribution plot.

characteristics.

The information curve in **Figure 2** showed the highest measurement information in the range of θ = −2 to −1. The item distribution included both negative and positive logit values, indicating variation in item difficulty. Nevertheless, the information curve suggests that measurement precision was not uniform across the full range of the latent trait. The Rasch findings should be interpreted as preliminary item-level evidence. The SOCEM-Q was designed to measure six conceptually distinct constructs; therefore, pooled analysis of all 19 items cannot establish the unidimensionality of the entire instrument. Research by Pitaloka *et al.* (2023) and Sari *et al.* (2026) demonstrates the relevance of Rasch analysis for psychometric evaluation of health instruments, but its application still requires alignment between model assumptions and the instrument's measurement structure (30, 34). Further analyses should examine dimensionality more comprehensively and consider domain-specific Rasch analyses or a multidimensional approach. Items exhibiting deviations in standardized fit statistics should also be reviewed in terms of wording, conceptual relevance, and response patterns before final decisions are made regarding their retention (37).

Integration of Psychometric Findings

The CFA and Rasch analyses provide complementary preliminary evidence regarding the measurement properties of the SOCEM-Q. CFA demonstrated acceptable overall model fit, with all 19 items showing statistically significant factor loadings. Rasch analysis further characterized item difficulty, item fit, and item and person separation. However, the high interconstruct correlation between Individual-Level Factors and TB Treatment Related Behavior (r = 0.967), together with other relatively high correlations, suggests potential empirical overlap among some constructs. Consistent with the Fornell–Larcker assessment, acceptable overall model fit and adequate convergent validity did not establish discriminant validity for all constructs (36). Further evaluation of construct distinctiveness and dimensionality in independent samples is warranted. Overall, the findings provide preliminary support for the proposed six-construct structure, which reflects conceptually related influences on TB treatment adherence within the socio-ecological perspective (10, 11).

Practical Implications

The SOCEM-Q provides a theory-informed framework for assessing factors associated with tuberculosis (TB) treatment adherence across five socio-ecological domains and a separate behavioral construct. It may support researchers and healthcare professionals in identifying areas requiring further assessment and inform context-specific adherence support (38). However, standardized scoring procedures and clinically meaningful cutoff values have not been established, and discriminant validity requires further evaluation (11, 39). Additional research is needed to confirm construct distinctiveness, establish scoring guidelines, and assess clinical utility before routine application (40).

Limitations and Future Research

Several limitations should be considered. First, the relatively small, purposively selected sample from 21 community health centers in Central Java may limit generalizability. Further validation in larger and more diverse populations is needed. Second, some interconstruct correlations were high, particularly between Individual-Level Factors and TB Treatment-Related Behavior (r = 0.967), indicating potential construct overlap. Although CR and AVE supported convergent validity, the Fornell–Larcker assessment indicated that discriminant validity was not fully supported (36). Further studies should investigate construct distinctiveness using additional approaches, such as the heterotrait–monotrait ratio (HTMT) (17, 18). Third, the cross-sectional design precluded assessment of test–retest reliability and predictive validity. Longitudinal studies should examine score stability, measurement invariance, and associations

with TB treatment outcomes. Fourth, the two-item composition of the Individual-Level Factors and TB Treatment-Related Behavior constructs may limit construct coverage and measurement precision. Finally, the pooled Rasch analysis did not establish unidimensionality, and deviations in selected item-fit statistics warrant further investigation through domain-specific or multidimensional Rasch analyses (32, 33). Overall, the SOCEM-Q demonstrates promising preliminary psychometric evidence. Further validation in larger, independent, and more diverse samples is needed before its broader application in research and healthcare settings.

Conclusion

The SOCEM-Q demonstrated promising preliminary psychometric properties for assessing factors associated with tuberculosis (TB) treatment adherence. All 19 items were retained, with standardized factor loadings ranging from 0.668 to 0.898 and acceptable overall CFA model fit. Internal consistency across the six constructs was satisfactory, with Cronbach's alpha coefficients ranging from 0.741 to 0.758. Composite reliability and AVE supported reliability and convergent validity. However, the Fornell–Larcker criterion was not fully satisfied, and high interconstruct correlations suggested potential overlap between some constructs, indicating that discriminant validity and empirical construct distinctiveness require further evaluation. Rasch analysis provided preliminary evidence regarding item difficulty, item fit, and item and person separation, but did not establish the unidimensionality of the instrument. Overall, the SOCEM-Q offers a theory-informed framework encompassing five socio-ecological domains and one treatment-related behavioral construct. Further validation in larger, independent, and more diverse samples is needed to evaluate its construct validity, dimensionality, temporal stability, measurement invariance, and predictive validity before its broader application in research or healthcare settings.

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Conflict of Interest

The authors declare no conflict of interest.

Data Availability

The data are available from the corresponding author upon reasonable request, subject to ethical and confidentiality restrictions.

Ethics Statement

This research received ethical approval from the Health Research Ethics Committee, Faculty of Health Sciences, Universitas Muhammadiyah Magelang (UNIMMA), under approval number 205/KEPK-FIKES/II.3.AU/F/2026, issued on 13 May 2026.

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