Translation and Psychometric Validation of a Patient-Reported Outcome-Based Medication-Related Quality of Life Scale in Elderly Patients with Polypharmacy: A Postprint

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Date: 2023-07-18T00:00:00+00:00

Abstract

Background The elderly polypharmacy population is substantial, and the medication landscape is challenging. To maximize both lifespan and quality of life for patients on medication, there is an urgent need to employ specific assessment tools for a more comprehensive and objective evaluation of post-medication benefits and risks.

Objective To translate and culturally adapt the Patient-Reported Outcome-Based Medication-Related Quality of Life Scale (PROMPT-QoL) and evaluate its reliability and validity among elderly polypharmacy patients.

Methods With authorization from the original author, the Chinese version of the PROMPT-QoL test draft was developed using Brislin's dual direct translation-back-translation method, cultural adaptation, and cognitive interviews. From June to August 2022, elderly polypharmacy patients who visited outpatient clinics, underwent health examinations, or collected medications at community health service centers in Gongyuan Street, Beishan Street, and Henan Street of Yanji City, as well as at Yanji City Hospital and the Affiliated Hospital of Yanbian University, were conveniently selected as survey participants. Item-dimension correlation analysis and the critical ratio method were employed for item analysis. The item-level content validity index (I-CVI), scale-level content validity index based on universal agreement (S-CVI/UA), and average S-CVI (S-CVI/Ave) were utilized to evaluate content validity. Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were applied to examine construct validity. Internal consistency (Cronbach's α coefficient) and split-half reliability were used to assess the scale's reliability.

Results A total of 590 patients were surveyed, with 564 valid questionnaires collected, yielding a valid response rate of 95.8%. Among these, 234 questionnaires were used for first-stage item analysis and EFA, and 330 questionnaires for second-stage CFA. Correlation coefficients between individual item scores and their respective dimension scores ranged from 0.504 to 0.915 (P<0.01), with critical ratio (CR) values for all items >3.0 (P<0.05). The I-CVI ranged from 0.89 to 1.00, S-CVI/UA was 0.91 (>0.80), and S-CVI/Ave was 0.99 (>0.90). EFA extracted eight common factors, largely consistent with the original questionnaire structure; however, item G34 exhibited a factor loading <0.40 on its designated factor and was consequently removed. CFA conducted on the remaining 41 items yielded: 2/df=2.160, goodness-of-fit index (GFI)=0.791, normed fit index (NFI)=0.848, incremental fit index (IFI)=0.912, comparative fit index (CFI)=0.911, Tucker-Lewis index (TLI)=0.902, root mean square error of approximation (RMSEA)=0.059. The Cronbach's α coefficient for the total scale was 0.839, with dimension-specific Cronbach's α coefficients ranging from 0.823 to 0.955 (P<0.01). Split-half reliability for each dimension ranged from 0.815 to 0.957 (P<0.01).

Conclusion The Chinese version of PROMPT-QoL, following translation and cultural adaptation, demonstrates satisfactory reliability and validity and can be applied to assess medication-related quality of life in elderly polypharmacy patients in China.

Full Text

Translation of the Patient-Reported Outcomes Measure of Pharmaceutical Therapy for Quality of Life and Its Validation in Elderly Patients with Polypharmacy

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Abstract

Background: The prevalence of polypharmacy among elderly patients is substantial and presents a serious clinical challenge. To maximize both longevity and quality of life for these patients, there is an urgent need for specific assessment tools that can comprehensively and objectively evaluate the benefits and risks of medication use from the patient's perspective.

Objective: To translate the Patient-Reported Outcomes Measure of Pharmaceutical Therapy for Quality of Life (PROMPT-QoL) scale into Chinese and

evaluate its reliability and validity among elderly patients with polypharmacy in China.

Methods: With authorization from the original author, we employed Brislin's forward-backward translation model, cultural adaptation, and cognitive interviews to develop a Chinese version of the PROMPT-QoL. Elderly patients with polypharmacy were conveniently sampled from June to August 2022 at community health centers in Gongyuan, Beishan, and Henan streets of Yanji City, as well as outpatient clinics, health examination centers, and pharmacies at Yanji City Hospital and Yanbian University Affiliated Hospital. Item analysis was conducted using item-dimension correlation analysis and critical ratio methods. Content validity was evaluated using the item-level content validity index (I-CVI), universal agreement scale-level content validity index (S-CVI/UA), and average scale-level content validity index (S-CVI/Ave). Structural validity was assessed through exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). Reliability was examined using internal consistency (Cronbach's α coefficient) and split-half reliability.

Results: A total of 590 patients were surveyed, yielding 564 valid responses (95.8% valid response rate). Two hundred thirty-four responses were used for initial item analysis and EFA, while 330 responses were used for the second-stage CFA. Correlation coefficients between individual item scores and their respective dimension scores ranged from 0.504 to 0.915 ($P<0.01$), and all item critical ratio (CR) values exceeded 3.0 ($P<0.05$). The I-CVI ranged from 0.89 to 1.00, S-CVI/UA was 0.91 (>0.80), and S-CVI/Ave was 0.99 (>0.90). EFA extracted eight common factors that generally aligned with the original questionnaire structure, though item G34 showed a factor loading <0.40 on its intended factor and was therefore removed. CFA of the remaining 41 items yielded the following fit indices: ^{2}/df=2.160, goodness-of-fit index (GFI)=0.791, normed fit index (NFI)=0.848, incremental fit index (IFI)=0.912, comparative fit index (CFI)=0.911, Tucker-Lewis index (TLI)=0.902, and root mean square error of approximation (RMSEA)=0.059. The overall scale Cronbach's α coefficient was 0.839, with dimension-specific coefficients ranging from 0.823 to 0.955 ($P<0.01$). Split-half reliability coefficients for each dimension ranged from 0.815 to 0.957 ($P<0.01$).

Conclusion: The Chinese version of the PROMPT-QoL scale demonstrates good reliability and validity and can be applied to assess pharmaceutical therapy-related quality of life among elderly patients with polypharmacy in China.

Keywords: Polypharmacy; Patient-reported outcome measures; Pharmaceutical therapy-related quality of life; Patient-reported Outcomes Measure of Pharmaceutical Therapy for Quality of Life Scale; Aged; Validation; Reliability

1. Introduction

The rising threat of chronic non-communicable diseases has become a major public health concern in China, with the current public health landscape characterized by the coexistence of multiple disease threats and intertwined health risk factors. According to the Global Burden of Disease Study, the proportion of disease burden attributable to non-communicable diseases and injuries increased from 21% to 34% between 1990 and 2019, with medication use identified as a significant risk factor contributing to this burden. Within the constraints of existing specialty care models, polypharmacy is widespread among older adults, with reported prevalence rates reaching as high as 65.2%. Many health challenges faced by elderly patients with polypharmacy stem from clinicians' and caregivers' neglect of patients' self-reported health status and medication experiences. Despite this reality, most domestic clinical research continues to focus on disease-oriented health outcomes, with few studies considering patients' subjective experiences. This has created a research gap in medication-related quality of life in China. Furthermore, the lack of mature, specific assessment tools for medication-related quality of life has resulted in substantial variation in research findings, potentially interfering with healthcare providers' ability to accurately evaluate patient medication outcomes.

As modern concepts of health and medical models evolve, patient-reported outcomes (PROs)—which comprehensively evaluate patients' subjective experiences, functional status, and quality of life—have become increasingly important in efficacy assessment. PROs enable patients to report on their health status, symptoms, health-related quality of life, and satisfaction with clinical care, providing intuitive and comprehensive reflections of their treatment experiences. The Patient-Reported Outcomes Measure of Pharmaceutical Therapy for Quality of Life (PROMPT-QoL) is a screening tool designed to identify medication-related problems from the patient's perspective. Developed to assess pharmaceutical therapy-related quality of life across physiological, psychological, and social dimensions, this instrument enables a comprehensive understanding of medication benefits and risks, thereby providing a rational basis for targeted interventions. This study aimed to introduce and translate the PROMPT-QoL scale, subsequently testing its reliability and validity among elderly patients with polypharmacy in China to provide a robust assessment tool for this population.

2. Methods

2.1 The PROMPT-QoL Scale

The PROMPT-QoL scale was developed by Sakthong et al. in 2014 through a rigorous process involving theoretical modeling, literature review, qualitative interviews with 120 patients, expert consultation, and Rasch analysis. Designed as a self-report instrument for patients with chronic diseases requiring continuous medication for three months or longer, the original scale demonstrated strong psychometric properties with scale-level content validity indices (S-CVI)

of 0.91–1.00 and item-level content validity indices (I-CVI) of 0.87–1.00. In a subsequent cross-sectional study of 1,156 patients, Sakthong et al. reported Cronbach's α coefficients ranging from 0.77 to 0.89 across all dimensions except medication accessibility (α=0.58), with test-retest reliability coefficients of 0.67–0.83, indicating stable psychometric characteristics.

2.2 Translation and Revision of the Scale

Following authorization from Professor Sakthong, the original author, we translated and revised the English version of the scale following Brislin's translation model. The process involved: (1) Forward translation by two independent translators—a nursing doctoral student with four years of overseas education and an English professor without medical background—producing forward translation versions 1 and 2; (2) Synthesis of forward translations by the research team and both translators to create a reconciled forward version; (3) Back-translation by a pharmacy expert and a medical English teacher, both unfamiliar with the original scale, producing back-translation versions 1 and 2; (4) Synthesis of back-translations by the researcher and a nursing professor, with a third English professor (blinded to the original scale) reviewing and providing feedback on disputed items; and (5) Documentation of differences between back-translated and original versions, with detailed records maintained at each step to prepare for expert panel review during cultural adaptation.

2.3 Cross-Cultural Adaptation

Nine experts in relevant fields were invited to review the scale, including specialists in pharmacy, nursing, and psychometrics. Expert inclusion criteria required: (1) master's degree or higher education, (2) associate professor or deputy chief physician rank or above, and (3) extensive clinical knowledge of geriatric medication management. Following informed consent, a Chinese version of the PROMPT-QoL scale was developed.

2.4 Cognitive Interviews

In May 2022, eight elderly patients with polypharmacy from Gongyuan Street Community Health Center were conveniently sampled (using the same inclusion/exclusion criteria as described in section 2.5.1). After completing the initial Chinese version of the PROMPT-QoL scale independently or with researcher assistance, participants were asked standardized questions about their overall comprehension of the scale, understanding of individual items, and interpretation of key terms. Items identified as difficult to understand or ambiguous were revised through group discussion to ensure clarity and comprehension, resulting in the final Chinese version of the PROMPT-QoL scale for field testing.

2.5 Reliability and Validity Testing

2.5.1 Study Participants Elderly patients with polypharmacy were conveniently sampled from June to August 2022 at community health centers in Gongyuan, Beishan, and Henan streets, as well as outpatient clinics, health examination centers, and pharmacies at Yanji City Hospital and Yanbian University Affiliated Hospital. The study employed two-stage sampling: the first stage for item analysis and exploratory factor analysis (EFA), and the second stage for confirmatory factor analysis (CFA). Based on the principle that sample size should be 5–10 times the number of items, with a 10% increase to account for invalid responses, the first stage targeted 240 participants. For CFA, a minimum sample size of 300 was required, so the second stage targeted 350 participants.

Inclusion criteria were: (1) age $ $60 years; (2) use of $ $5 prescription medications (including traditional Chinese and Western medicine) for $ $3 months; (3) residence in the community for $ $6 months; (4) clear consciousness and ability to cooperate with the survey; and (5) voluntary participation. **Exclusion criteria** were: (1) severe brain, heart, liver, or kidney disease, advanced malignancy, or serious physical illness; and (2) participation in similar research within the previous three months. The study was approved by the Medical Ethics Committee of Yanbian University Medical School and conducted in accordance with the Declaration of Helsinki.

2.5.2 Assessment Instruments General Demographic Questionnaire: This self-designed questionnaire included: (1) sociodemographic data (gender, age, ethnicity, education level, marital status); (2) disease-related information assessed using the Charlson Comorbidity Index (CCI), duration of longest diagnosed disease, and self-perceived disease control status; and (3) medication-related information (monthly medication costs, daily number of medication types, duration of medication use, history of adverse drug reactions).

The CCI, developed by Charlson et al. in 1987 based on relative risk of one-year mortality across different diseases, is a widely used comorbidity assessment tool. CCI scores are calculated as the sum of age index (starting at 0 for age 50, increasing by 1 point for each additional decade) and comorbidity index (weighted scores of 1, 2, 3, or 6 for 19 specific conditions). CCI severity is categorized as mild (1–2 points), moderate (3–4 points), or severe ($ $5 points).

Chinese Version of the PROMPT-QoL Scale: The translated scale contained 43 items across nine dimensions: general attitude toward medication, medication information, satisfaction with therapeutic efficacy, side effects, psychological impact of medication, convenience of medication use, medication accessibility, patient-provider relationship, and overall medication-related quality of life. The general attitude dimension used descriptive statistics, while all other dimensions employed a 5-point Likert scale (1="not at all" to 5="to a great extent"), with higher scores indicating better medication-related quality

of life.

2.5.3 Data Collection Prior to formal data collection, permission was obtained from hospital management and community health centers. Trained investigators conducted the survey with assistance from these institutions. The research purpose was explained to patients and their families, and surveys were administered only after obtaining consent. All questionnaires were distributed and collected on-site by research team members using standardized instructions, with completion time controlled at 15–20 minutes. Completed questionnaires were promptly reviewed, and invalid responses were excluded.

2.5.4 Quality Control Strict adherence to the translation process ensured conceptual, semantic, and technical equivalence between the Chinese and original versions. Investigators received uniform training to ensure consistent administration. A pilot survey was conducted before formal data collection to anticipate potential issues and develop solutions. During data collection, questionnaires were checked promptly to ensure completeness. Data entry followed a double-entry protocol to guarantee accuracy, with quality control maintained throughout the study.

2.5.5 Statistical Analysis Data were analyzed using IBM SPSS Statistics 26.0 and IBM SPSS AMOS 21.0.

Item Analysis: (1) Item-dimension correlation analysis using Pearson correlation coefficients: items with correlation coefficients <0.4 or non-significant correlations were considered for deletion. (2) Critical ratio (CR) method to examine each item's ability to discriminate between participants with different psychological characteristics, with higher CR values indicating stronger discriminative ability.

Validity Testing: (1) Content validity was assessed by nine domain experts using a 4-point rating scale (1=not relevant, 2=weakly relevant, 3=moderately relevant, 4=highly relevant). Experts could suggest modifications for ambiguous items. I-CVI, S-CVI/UA, and S-CVI/Ave were calculated, with I-CVI>0.78, S-CVI/UA>0.80, and S-CVI/Ave>0.90 considered indicative of good content validity. (2) Structural validity was evaluated through EFA and CFA. In EFA, items with factor loadings <0.4, similar loadings across multiple factors (difference <0.2), or factors containing fewer than three items were deleted. CFA model fit was assessed using ^{2}/df, GFI, NFI, IFI, CFI, TLI, and RMSEA.

Reliability Testing: (1) Internal consistency reliability was examined using Cronbach's α coefficient. (2) Split-half reliability was assessed using the odd-even split method, calculating the correlation between total scores of odd and even items.

3. Results

3.1 Translation and Cultural Adaptation of the PROMPT-QoL Scale

Based on expert feedback and cognitive interviews, several modifications were made. Experts suggested changing "food supplements" to "medicinal diets" in item A1, which the research team accepted after confirming that "food supplements" did not fit the cultural context. The term "community pharmacies" was uniformly translated as "pharmacies" to align with Chinese cultural characteristics and participant understanding. The phrase "doctors, pharmacists, or nurses" was simplified to "healthcare professionals" to reduce redundancy. For item B2, experts recommended changing "generic name" to "pharmaceutical name" due to difficulty distinguishing between generic and brand names, but the research team retained the original terminology to respect the author's intent and considering increasing public health literacy. Item C12, originally phrased as "disease relief," was modified to "disease treatment effectiveness" to avoid leading language. Item E23, "using medication regularly and strictly every day," was revised to "using medication regularly and strictly according to medical advice every day" to improve clarity for elderly respondents.

During cognitive interviews, participants generally understood the scale well but identified some items with low comprehension or unclear semantics. For item A1, respondents found the options too broad, so option A was clarified as "drug therapy (medications obtained from hospitals, clinics, or pharmacies)" and option B as "complementary and alternative therapies (e.g., traditional medicine such as Chinese herbs, acupuncture, massage; natural products such as vitamins, herbal supplements; mind-body medicine such as hypnotherapy, yoga)." Item F31's reference to "dosage form" was modified to "appropriate medication form (e.g., whether the shape and taste of the medication are easy to use)" to aid comprehension. Item G37 regarding "traffic congestion and parking difficulties" was adjusted to "problems with hospital visits for medication (e.g., transportation difficulties, unfamiliarity with self-service systems)" to better reflect the experiences of elderly patients.

3.2 Participant Characteristics

A total of 590 patients were surveyed across both sampling stages, yielding 564 valid responses (95.8% valid response rate). Two hundred thirty-four responses were used for the first-stage item analysis and EFA, while 330 responses were used for the second-stage CFA. General demographic characteristics are presented in .

3.3 Item Analysis Results

3.3.1 Item-Dimension Correlation Analysis Correlation coefficients between individual item scores and their respective dimension scores ranged from 0.504 to 0.915, all exceeding 0.4 and achieving statistical significance ($P<0.01$). No items were deleted based on this criterion. Detailed results are shown in .

3.3.2 Critical Ratio Analysis Total scores from the 234 Chinese version PROMPT-QoL responses were sorted in descending order, with the top 27% classified as the high-score group (>69.6 points) and the bottom 27% as the low-score group (<57.7 points). Independent samples t-tests comparing these groups revealed that all items had CR values >3.0, with statistically significant differences between high and low scorers (P<0.05). No items were deleted. Detailed results are presented in .

3.4 Content Validity

Nine experts were invited to evaluate the scale. Results showed I-CVI values ranging from 0.89 to 1.00, S-CVI/UA of 0.91 (>0.80), and S-CVI/Ave of 0.99 (>0.90), all within acceptable ranges.

3.5 Structural Validity

3.5.1 Exploratory Factor Analysis EFA results indicated a Kaiser-Meyer-Olkin (KMO) value of 0.811, suggesting weak partial correlations among variables and suitability for factor analysis. Bartlett's test of sphericity was significant (^{2}=5,314.242, P<0.001), confirming that factor extraction could explain most of the statistical information represented by scale items.

Using principal component analysis with varimax rotation, eight common factors with eigenvalues >1 were extracted ([Figure 1: see original paper]). The rotated factor matrix revealed that all items except G34 had factor loadings >0.40 on their intended factors. Item G34 was therefore deleted, and a second analysis was conducted on the remaining 41 items. This analysis yielded a cumulative variance contribution rate of 63.659%, with good correspondence between items and dimensions that aligned with theoretical expectations. Detailed factor loadings are shown in , and the adjusted scale structure after deleting item G34 is presented in .

3.5.2 Confirmatory Factor Analysis Using AMOS 21.0, CFA was performed on 330 responses to test whether the scale structure matched the theoretical structure of the original instrument. Dimensions B through I were specified as latent variables, with items B2 through I42 as observed variables. Maximum likelihood estimation was used as the data approximated a normal distribution. Initial model fit was suboptimal, requiring model modification. Based on modification indices, five error covariances were added (e1 with e6, e13 with e20, e14 with e15, e17 with e18, and e22 with e27) ([Figure 2: see original paper]). The modified model achieved satisfactory fit across all indices except GFI, as detailed in .

3.6 Reliability Testing

The overall scale Cronbach's α coefficient was 0.839, with dimension-specific coefficients ranging from 0.823 to 0.955. Split-half reliability coefficients ranged

from 0.815 to 0.957, indicating good internal consistency. Detailed results are presented in .

4. Discussion

4.1 Rigorous Translation and Cultural Adaptation Process

This study strictly adhered to Brislin's forward-backward translation model, with the research team engaging in multiple rounds of consultation and discussion with translators until consensus was reached, ensuring accuracy of each item while preserving the original meaning. The nine experts involved in cross-cultural adaptation demonstrated high authority and representativeness. Two rounds of expert consultation were conducted, with feedback analyzed and discussed collectively to determine which modifications to adopt. Subsequently, cognitive interviews with eight elderly patients with polypharmacy were performed to gather suggestions for improvement, ultimately yielding the Chinese version of the PROMPT-QoL scale for field testing.

4.2 Strong Item Discrimination of the Chinese PROMPT-QoL Scale

Item analysis is a critical step in scale revision that helps evaluate item quality. This study employed both Pearson correlation analysis and critical ratio methods to examine item discrimination. Item-dimension correlation coefficients ranged from 0.504 to 0.915, indicating that all items adequately reflected medication-related quality of life in elderly patients with polypharmacy. Critical ratio analysis revealed that all items had CR values >0.3, with statistically significant differences between high and low scorers (P<0.001), demonstrating strong discriminative ability.

4.3 Good Validity of the Chinese PROMPT-QoL Scale

During cultural adaptation, nine experts in medication-related quality of life were invited to participate in two rounds of consultation, evaluating the relevance of each item to the measured construct. The Chinese PROMPT-QoL scale demonstrated I-CVI values of 0.89–1.00, S-CVI/UA of 0.91, and S-CVI/Ave of 0.99, all meeting reference standards and indicating excellent content validity for assessing medication-related quality of life in elderly patients with polypharmacy.

In EFA, item G34 showed a factor loading <0.40 and was deleted, possibly due to differences in participant understanding compared to the original questionnaire. After removing G34, the second analysis yielded a cumulative variance contribution rate of 63.659%, with all remaining items meeting factor loading criteria and extracting eight common factors consistent with the original scale structure: medication information, side effect impact, psychological impact of medication, medication accessibility, overall medication-related quality of life,

therapeutic efficacy satisfaction, medication convenience, and patient-provider relationship.

CFA was used to validate the structure of the Chinese PROMPT-QoL scale. To achieve optimal model fit, error covariances were added between some items based on modification indices. Error covariances typically result from measurement artifacts, including artificial measurement errors (similar item wording, increased number of items, or items inadvertently measuring unknown constructs). For example, an error covariance was added between items D14 (mobility) and D21 (daily activities or social activities). Although these items had similar content, cognitive interview participants generally understood them without difficulty. Therefore, future research should further refine item wording and validate the model with larger samples. Fit indices showed that all criteria were met except for GFI, with ^{2}/df, NFI, IFI, CFI, TLI, and RMSEA all achieving acceptable standards, indicating satisfactory CFA results.

4.4 Good Reliability of the Chinese PROMPT-QoL Scale

The Chinese PROMPT-QoL scale demonstrated an overall Cronbach's α coefficient of 0.839, with dimension-specific coefficients ranging from 0.823 to 0.955, indicating good internal consistency. Split-half reliability coefficients of 0.815–0.957 further confirmed that the scale met criteria for internal consistency.

4.5 Application Prospects of the Chinese PROMPT-QoL Scale

The primary goal of medication use is to achieve optimal therapeutic effects with minimal safety risks, thereby improving quality of life. In the context of healthcare reform, traditional biological indicators are no longer sufficient to comprehensively reflect individual health status. Medication-related quality of life, as a comprehensive indicator, addresses the multidimensional health outcomes—physiological, psychological, and social—experienced by elderly patients with polypharmacy during their treatment. This provides healthcare professionals with a new perspective for understanding patients' medication experiences. However, existing generic assessment tools have limitations that prevent precise evaluation of medication-related quality of life. The Chinese PROMPT-QoL scale helps address this gap in China's measurement system and provides a reliable tool for future research on specific assessments and targeted interventions for medication-using populations.

This study introduced and translated the English version of the PROMPT-QoL scale, demonstrating through rigorous psychometric evaluation that all indices meet measurement requirements. The final Chinese version contains 42 items across nine dimensions. The "general attitude toward medication" dimension (item A1) uses descriptive statistics to understand patients' medication preferences, while all other dimensions employ a 5-point Likert scale (1="not at all" to 5="to a great extent"), with items D14–E30 and G34–G36 reverse-scored. Dimension and total scores range from 0–100, calculated as: Score = 100 ×

(actual score − minimum possible score) / (maximum possible score − minimum possible score), with higher scores indicating better medication-related quality of life. Scores are categorized into four levels: 0–25=poor, 25–50=fair to moderate, 50–75=moderate to good, and 75–100=good to excellent.

The Chinese PROMPT-QoL scale integrates a health-related quality of life theoretical framework to comprehensively assess medication-related quality of life among elderly patients with polypharmacy across multiple domains: general attitude toward medication, medication information, therapeutic efficacy satisfaction, side effects, psychological impact, convenience, accessibility, patient-provider relationship, and overall quality of life. This instrument can be applied in clinical comprehensive assessment and evaluation of pharmacotherapy effectiveness, facilitating precision interventions by healthcare professionals.

Author Contributions: XU Huijing contributed to study conception and design, statistical analysis, interpretation of results, and manuscript writing. XU Huijing, WU Yuanhong, WANG Xiaohui, GAO Ge, WANG Zhe, and WANG Yuyu participated in data collection and statistical processing. JIANG Jiawei was responsible for quality control and manuscript review. WU Shanyu supervised the study, revised the manuscript, and assumes overall responsibility for the work.

Conflicts of Interest: None declared.

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Received: April 5, 2023; Revised: July 2, 2023
Edited by: JIA Mengmeng

Note: Figure translations are in progress. See original paper for figures.