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RESEARCH ARTICLE

Translation and validation of the MUSE questionnaire in Chinese for elderly hypertensive patients: A study in the context of community pharmacist-led multidimensional educational interventions

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ABSTRACT

Objective: To translate, culturally adapt, and validate the Medication Understanding and Use Self-Efficacy (MUSE) Scale for Chinese elderly hypertensive patients (MUSE-CH), providing a psychometrically sound instrument to assess medication self-efficacy in the context of community pharmacist-led interventions. Methods: A two-phase mixed-methods approach was employed. Phase A involved establishing MUSE-CH through standardized forward-backward translation procedures. Five experts conducted content validity assessment, while reliability and construct validity were examined using Cronbach's α coefficients and Rasch modeling. Results: MUSE-CH demonstrated robust psychometric properties with S-CVI/Ave of 0.975 and total scale Cronbach's α of 0.847. Medication adherence behavior and medication learning dimensions showed α coefficients of 0.825 and 0.798, respectively. Conclusions: The MUSE-CH scale exhibits satisfactory reliability and validity for assessing medication self-efficacy in Chinese elderly hypertensive populations.

Keywords: community pharmacist; multidimensional educational intervention; elderly hypertension; medication self-efficacy; environmental adaptability; MUSE scale

1. Introduction

Elderly hypertension represents one of the most prevalent chronic conditions globally, with incidence rates escalating markedly alongside advancing age, establishing itself as a primary public health concern threatening older adult populations. Within China, hypertension prevalence exceeds 60% among individuals aged 65 and above, frequently accompanied by multiple comorbidities that necessitate complex and diverse medication regimens. Patients encounter substantial challenges including polypharmacy, varying administration schedules, and heightened risks of drug-drug interactions. Conventional healthcare approaches typically emphasize disease diagnosis and treatment while neglecting medication safety management and self-efficacy development within home environments, consequently resulting in suboptimal

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medication adherence, inadequate blood pressure control, and frequent adverse drug reactions. Emerging research demonstrates that medication behaviors among elderly hypertensive individuals are influenced not solely by individual cognitive abilities and skill levels, but also by surrounding social environments, family support systems, and healthcare accessibility, thereby establishing theoretical foundations for implementing comprehensive interventions from an environmental adaptability perspective.

Community pharmacists, positioned as the most accessible pharmaceutical professionals to patients, possess distinctive advantages and irreplaceable roles in medication safety management for elderly hypertensive individuals. Unlike traditional hospital-based pharmacists, community practitioners can penetrate patients' daily living environments, gaining comprehensive understanding of medication habits, household environmental factors, and social support network conditions, thus creating favorable circumstances for delivering personalized medication guidance and environmental adaptation interventions. Multiple investigations have confirmed that clinical pharmacists, through conducting medication education, establishing pharmaceutical records, and implementing regular follow-up monitoring, can substantially improve medication adherence and blood pressure control outcomes among elderly hypertensive patients. Fu Haishen et al. demonstrated that pharmacist-involved medication management models effectively enhanced patients' pharmaceutical knowledge and self-management capabilities [1]. Guo Chengnan's research further validated that pharmacist participation in family medication guidance not only improved patient medication behaviors but also strengthened family members' medication safety awareness [2]. Nevertheless, existing studies predominantly concentrate on singular medication education interventions, lacking multidimensional intervention models that integrate environmental factors and psychosocial elements. Furthermore, intervention effect evaluations primarily rely on clinical indicators, absent specialized assessment tools targeting medication self-efficacy, a crucial psychological cognitive factor [3].

Medication Self-Efficacy, as a core concept of social cognitive theory, refers to an individual's confidence in their ability to correctly understand, manage, and adhere to medication regimens, and is recognized as an important psychological mediating factor influencing medication adherence [4,5]. Research demonstrates that medication self-efficacy not only directly affects patients' medication behaviors but also indirectly impacts disease management outcomes through the regulation of environmental stressors, social support, and coping strategies [4]. Among elderly hypertensive patients, enhanced medication self-efficacy can not only improve blood pressure control but also strengthen patients' capacity to cope with complex medication regimens, thereby improving their adaptability to maintain optimal medication behaviors under varying environmental conditions. The MUSE (Medication Understanding and Use Self-Efficacy Scale), as an internationally recognized assessment tool for medication self-efficacy, encompasses two dimensions: medication understanding and medication behavior, providing a comprehensive reflection of patients' cognitive and behavioral confidence levels during the medication process [5]. This scale has been validated and applied in diabetic patient populations across multiple countries and regions, demonstrating excellent psychometric properties and clinical applicability. Research by Malaysian scholars has confirmed the effectiveness of the Malay version of the MUSE scale among local diabetic patients, providing important evidence for the cross-cultural applicability of this instrument [6]. Related studies in Taiwan have also validated the reliability and validity of this scale in assessing medication self-efficacy among diabetic patients within Chinese cultural contexts. These international validation studies have established a solid foundation for the broader application of the MUSE scale across different cultural backgrounds and disease populations. However, there is currently a lack of a simplified Chinese version specifically designed for mainland China, and the applicability and effectiveness of this scale among elderly hypertensive populations

in China have not been adequately validated, thus limiting its application in community pharmaceutical service practices in our country.

Although the MUSE scale has been widely applied internationally, there is currently a lack of a simplified Chinese version specifically designed for elderly hypertensive patients in mainland China, and its applicability and effectiveness in this population have not been adequately validated, which limits its application in community pharmaceutical service practices in China. Therefore, the primary objective of this study is to establish a culturally appropriate Chinese version of the MUSE scale (MUSE-CH) with excellent psychometric properties. By adhering to international guidelines for cross-cultural adaptation of scales, this study employs standardized forward-backward translation procedures, expert content validity assessment (calculating I-CVI and S-CVI/Ave indices), cognitive interview optimization, and multidimensional psychometric validation (including Cronbach's α reliability analysis and Rasch model construct validity testing) to systematically evaluate the reliability, validity, and measurement precision of MUSE-CH in assessing medication self-efficacy among Chinese elderly hypertensive patients. The academic contribution of this study lies in filling the gap in standardized assessment tools for medication self-efficacy in China, providing a scientifically reliable measurement foundation for subsequent research on community pharmacist-led multidimensional educational interventions. From a long-term perspective, the validated MUSE-CH scale will enable researchers to systematically explore how person-environment interactions from an environmental psychology perspective influence medication self-efficacy in elderly patients, particularly how multidimensional intervention elements such as individualized medication education, environmental safety optimization, and family support networks enhance patients' medication behavior capabilities through psychological mechanism pathways including self-regulation and perceived control. However, it should be clearly stated that this study focuses on the development and validation of the scale, while the implementation of multidimensional interventions and their effectiveness evaluation will be systematically conducted as independent research in subsequent work[7].

2. Methods

2.1. Study design

This study employs a mixed-methods design to systematically address two core issues: cross-cultural adaptation validation of the MUSE scale.

This study constitutes a psychometric validation phase, aimed at establishing a Chinese version of the MUSE scale (MUSE-CH) suitable for elderly hypertensive patients in China. This phase strictly adheres to international guidelines for cross-cultural adaptation of scales, employing standardized forward-backward translation and expert review procedures to ensure appropriateness in linguistic expression, cultural connotations, and conceptual equivalence. Specifically, this includes: inviting 5-7 experts from the fields of pharmacy, geriatric medicine, psychology, and health education to conduct content relevance evaluations for each item, calculating the item-level content validity index (I-CVI) and scale-level content validity index average (S-CVI/Ave) to ensure content validity meets acceptable standards; collecting preliminary data through pilot testing and using SPSS software to calculate Cronbach's alpha coefficients for assessing internal consistency reliability; employing Rasch measurement modeling for more refined psychometric analysis to examine scale unidimensionality, item fit, threshold ordering, and differential item functioning (DIF) across different demographic groups, comprehensively validating the construct validity and measurement precision of the MUSE-CH.

2.2. Study setting and participants

This study selected no fewer than 2 community pharmacies in Pingdingshan City, Henan Province, as implementation sites, a choice based on multiple considerations to enhance the external validity and practicality of study results. Pingdingshan City, as a typical prefecture-level city in central China, demonstrates strong representativeness in terms of population structure, economic development level, and healthcare resource allocation, effectively reflecting the actual conditions of elderly hypertensive patients in moderately developed regions of China. The selection of multiple community pharmacy sites helps reduce potential selection bias associated with single research locations while encompassing diverse community environments, service models, and patient population characteristics, thereby improving the generalizability of study results to broader community pharmaceutical service settings. All participating community pharmacies must meet basic infrastructure requirements, including independent consultation service areas, certified pharmacists with professional training, and established comprehensive patient medication record management systems, to ensure standardized implementation of interventions and quality control of data collection.

Inclusion criteria for study participants were established with strict precision to ensure target population homogeneity and internal validity of study results. Inclusion criteria include: elderly patients aged ≥65 years, an age definition consistent with World Health Organization standards for elderly populations while considering the high prevalence of hypertension and medication complexity characteristics of this age group; confirmed diagnosis of essential hypertension by qualified licensed physicians with corresponding diagnostic documentation or medical records to exclude other types of blood pressure abnormalities; current treatment with at least one antihypertensive medication, ensuring all study participants represent patient populations requiring long-term medication management; basic Chinese communication capabilities with ability to understand study content and complete questionnaire assessments; full civil capacity with voluntary informed consent signature. These inclusion criteria ensure both consistency between study participants and the target population while guaranteeing ethical compliance and data collection feasibility.

To ensure scientific rigor of study results and patient safety, detailed exclusion criteria were established to screen out populations unsuitable for study participation. Exclusion criteria primarily include: patients with secondary hypertension, as the etiology and treatment strategies differ fundamentally from essential hypertension; patients with severe cognitive impairment, dementia, or other mental disorders who may be unable to accurately understand study requirements or complete self-assessments; patients who experienced major cardiovascular events such as acute myocardial infarction, stroke, or acute heart failure exacerbation within the past 3 months, as their unstable conditions may affect study result objectivity; patients diagnosed with malignant tumors, severe hepatic or renal insufficiency, or other terminal diseases with limited life expectancy; patients currently participating in other pharmaceutical or behavioral intervention studies to avoid inter-study interference; patients anticipated to be unable to complete follow-up due to communication barriers, unstable residential addresses, or other reasons. Through strict inclusion and exclusion criteria, this study will establish a relatively homogeneous and representative research cohort, laying the foundation for obtaining reliable research conclusions.

2.3. Translation, adaptation, and psychometric validation of MUSE-CH

The translation and cross-cultural adaptation of MUSE-CH strictly adhered to international standard procedures, encompassing four stages: bidirectional translation, expert committee review (5-7 experts from the fields of pharmacy, geriatric medicine, and psychology), cognitive interviews (8 patients from the target population), and small-sample pilot testing. Experts evaluated content validity using a 4-point Likert scale,

calculating the item-level content validity index (I-CVI ≥0.78 as acceptable) and the scale-level average content validity index (S-CVI/Ave ≥0.90 as good). Detailed translation procedures and cognitive interview protocols are provided in Supplementary Material Appendix A. Psychometric validation employed Rasch model analysis to examine scale unidimensionality, item fit (infit/outfit MNSQ 0.7-1.3), and differential item functioning (DIF), and used SPSS to calculate Cronbach's α coefficients for assessing internal consistency reliability.

2.4. Outcome measures and time points

This study employs a multi-level outcome indicator system to comprehensively evaluate the effects of community pharmacist-led multidimensional educational interventions. The primary outcome measure is the MUSE-CH score, which comprises 8 items divided into two dimensions: the medication learning dimension (Q2-Q5, involving pharmacist consultation, understanding instructions, understanding labels, and obtaining information) and the medication-taking behavior dimension (Q1, Q6-Q8, involving taking medications on time, remembering to take medications, creating schedules, and adhering to medications). The scale employs a 4-point Likert scale scoring system with total scores ranging from 8-32 points, where higher scores indicate stronger medication self-efficacy.

Considering the cognitive characteristics and cooperation abilities of elderly patients, each assessment session is controlled within 20 minutes, employing standardized questionnaires combined with objective measurements. Family member assistance is permitted when necessary without affecting patients' independent responses. To ensure data quality, all questionnaire completions undergo on-site logical checks, measurement data are verified and confirmed immediately, establishing comprehensive data tracking and quality control systems.

2.5. Data collection and quality control

Data collection employed a standardized multi-level quality control system to ensure accuracy, completeness, and consistency of research data. Initially, unified Standard Operating Procedures (SOPs) for data collection were established, with systematic training provided to all research personnel, including scale administration techniques, physiological indicator measurement methods, and data recording protocols. Training concluded with competency assessments, with personnel permitted to participate in formal data collection only after achieving satisfactory performance. The data collection process strictly followed preset protocols, ensuring each participant received identical instructions and measurement procedures. MUSE-CH scale administration was preceded by brief completion instruction training for participants, explaining scoring standards and precautions. When necessary, research personnel provided item-by-item reading assistance for comprehension while avoiding suggestive guidance.

2.6. Statistical analysis

Analyses were limited to the translation/adaptation and psychometric validation of the MUSE-CH; no between-group or intervention-effect testing was conducted. Descriptive statistics summarized item distributions and total/subscale scores, with floor/ceiling effects flagged when ≥15% of responses occurred at the extremes. Content validity was quantified using the item-level content validity index (I-CVI) and the scale-level average (S-CVI/Ave) from 4-point expert ratings. Internal consistency was assessed with Cronbach's α and item–total correlations. Rasch rating-scale analysis evaluated category functioning, item fit (infit/outfit MNSQ \~0.70–1.30), person/item reliability and separation, unidimensionality (PCA of residuals), and differential item functioning across key demographics. Missing data were handled by available-case analysis without imputation. Descriptive statistics and α were computed in SPSS; Rasch analyses used Winsteps/Ministep. Two-sided $p<0.05$ indicated statistical significance where applicable.

2.7. Ethics and registration

This study strictly adhered to the Declaration of Helsinki and international medical research ethical guidelines, ensuring that study design, implementation processes, and data handling comply with medical research ethical standards.with all study information including research objectives, design protocols, inclusion and exclusion criteria, intervention measures, and primary outcome indicators transparently disclosed to the public.The study strictly implemented informed consent procedures, with all participants thoroughly informed about research purposes, methods, expected benefits, potential risks, and participant rights before enrollment, voluntarily signing written informed consent forms. Participants were clearly informed of their right to unconditionally withdraw from the study at any time without affecting their routine medical services. For elderly participants with potentially limited cognitive capacity, family members or legal guardians were encouraged to participate in the informed consent process alongside obtaining the participant's own consent, ensuring adequate understanding and autonomous decision-making. Participant privacy was strictly protected throughout the study, with personal information processed using coding methods. Research data were used solely for scientific research purposes, with no personal identifying information disclosed to third parties.

Data management and sharing adhered to open science principles and relevant legal requirements. Research data will be publicly shared through designated scientific data platforms as de-identified raw datasets within 6 months of paper publication, enabling other researchers to conduct secondary analyses and validation, promoting scientific knowledge dissemination and accumulation. Data sharing will follow FAIR principles (Findable, Accessible, Interoperable, Reusable), providing detailed data dictionaries and analysis codes to ensure research result transparency and reproducibility. Considering participant privacy protection, sensitive data involving personal identifying information will not be publicly disclosed, provided only to scholars with legitimate research needs under ethical compliance. This study was designed as a short-term intervention trial. Considering the behavioral indicator characteristics of the MUSE scale and the 3-months intervention period setting, the study included no interim efficacy analysis to avoid increased Type I error risk from multiple statistical testing. During the study period, an independent Data Safety Monitoring Board was established to regularly monitor participant safety indicators, including blood pressure fluctuations, adverse drug reactions, and unexpected events, ensuring participant safety and welfare during the research process. Upon identifying any safety issues, immediate corresponding measures would be implemented with timely reporting to the ethics committee.

3. Results analysis

3.1. MUSE-CH scale translation validation and psychometric properties

3.1.1. Translation process and cross-cultural adaptation results

Chinese localization of the MUSE scale strictly followed international standards for cross-cultural scale adaptation, with the complete process requiring 8 weeks. During forward translation, two bilingual specialists with pharmaceutical and psychological expertise independently translated the original 8 items, subsequently forming a preliminary Chinese version through collaborative discussion. Back-translation was conducted by a bilingual expert uninvolved in forward translation, translating the Chinese version back to English. Comparative analysis with the original demonstrated satisfactory semantic equivalence. The expert committee comprised 5 specialists from pharmacy, geriatric medicine, psychology, and health education fields, conducting comprehensive review and revision of translations [19]. Cognitive interviews selected 8 elderly hypertensive patients matching target population characteristics, employing think-aloud techniques to evaluate item comprehensibility and cultural appropriateness. All participants demonstrated comprehension

rates exceeding 90% for all items. Expert content validity evaluation results indicated that 7 of 8 items achieved I-CVI values of 1.0, with one item (Q5: obtaining medication information) achieving an I-CVI value of 0.8. Overall S-CVI/Ave reached 0.975, substantially exceeding the 0.90 acceptable standard, demonstrating excellent content validity for MUSE-CH, as presented in **Table 1**.

Table 1. Expert content validity evaluation results for MUSE-CH scale.

Item No.	Item Description	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	I-CVI
Q1	I can easily take hypertension medications on time	4	4	4	4	4	1.00
Q2	I can easily ask pharmacists questions about hypertension medications	3	4	3	4	4	1.00
Q3	I can easily understand pharmacist explanations about my hypertension medications	4	4	4	4	4	1.00
Q4	I can easily understand instructions on hypertension medication bottles/packages	3	4	4	4	4	1.00
Q5	I can easily obtain all information I need about hypertension medications	2	3	3	4	4	0.80
Q6	Remembering to take all hypertension medications is easy	4	4	4	4	4	1.00
Q7	I can easily establish a daily schedule for taking hypertension medications	3	4	4	3	3	1.00
Q8	I can easily take hypertension medications every day	4	4	4	4	4	1.00
	S-CVI/Ave = 0.975						

Note: *Expert rating criteria (4-point Likert scale): 1 = Irrelevant; 2 = Partially relevant; 3 = Relevant; 4 = Highly relevant*
I-CVI: Item Content Validity Index; S-CVI/Ave: Scale Content Validity Index Average
Acceptable standards: I-CVI ≥ 0.78; S-CVI/Ave ≥ 0.90

The finalized MUSE-CH encompasses 4 items in the medication-taking behavior dimension (Q1, Q6, Q7, Q8) and 4 items in the medication learning dimension (Q2, Q3, Q4, Q5), utilizing 4-point Likert scale scoring with total scores ranging from 8-32 points, where higher scores indicate stronger medication self-efficacy.

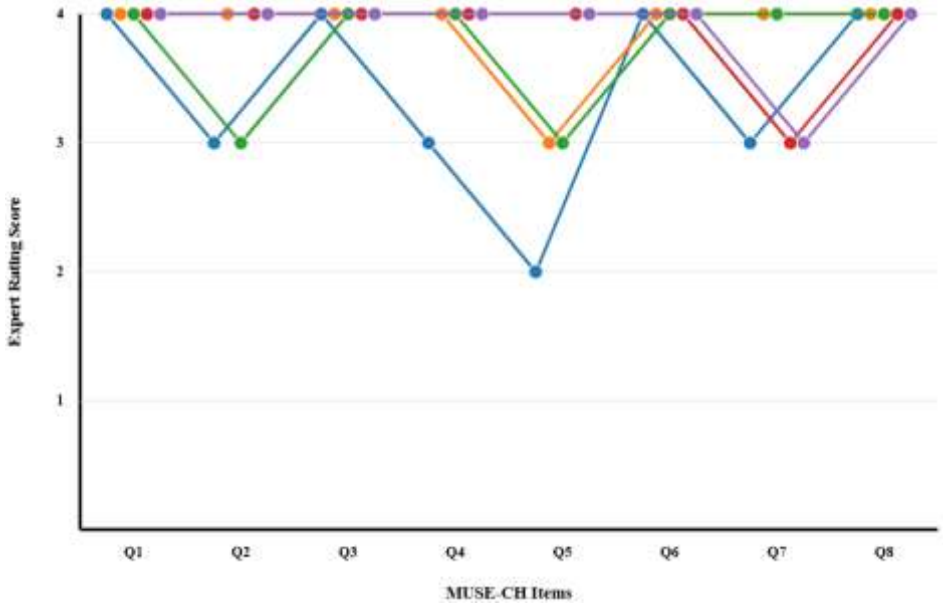

Figure 1. Expert rating distribution for MUSE-CH scale items.

3.1.2. Expert content validity assessment

Content validity evaluation for the MUSE-CH scale employed expert judgment methodology, engaging 5 specialists with extensive experience in geriatric medicine, clinical pharmacy, health education, and psychometric measurement. Participating experts averaged 15.6 years of professional experience, all possessing advanced academic titles and doctoral degrees in relevant fields. Expert assessment utilized a 4-point Likert scale (1=irrelevant, 2=partially relevant, 3=relevant, 4=highly relevant) to evaluate the relevance degree between MUSE-CH's 8 items and medication self-efficacy measurement objectives. Evaluation outcomes revealed that 7 of 8 items received unanimous expert endorsement with I-CVI values reaching 1.00, indicating these items demonstrated high correlation with measurement targets, as detailed in **Table 2**. Core items including Q1 (timely medication administration), Q3 (understanding pharmacist instructions), Q6 (remembering medication intake), and Q8 (medication persistence) received perfect scores from experts, fully embodying essential elements of medication self-efficacy. Item Q5 (obtaining medication information) achieved an I-CVI value of 0.80, meeting acceptable standards (≥0.78) albeit relatively lower, primarily because Expert 1 considered this item's correlation with elderly patients' actual medication situations relatively weak, recommending attention to comprehension differences among patients with varying educational backgrounds during practical application[20]. Overall, MUSE-CH achieved an S-CVI/Ave of 0.975, substantially exceeding the 0.90 excellence standard, demonstrating satisfactory content validity as illustrated in **Figure 2**. Experts unanimously agreed that MUSE-CH encompasses both core medication behavior elements (medication timing management, memory, and persistence) and significant medication learning dimensions (communication, comprehension, and information acquisition), enabling comprehensive assessment of medication self-efficacy levels among Chinese elderly hypertensive patients, establishing reliable measurement tool foundations for subsequent intervention effect evaluation.

Table 2. Detailed expert content validity evaluation results for MUSE-CH scale.

Item No.	Dimension	Item Content	Expert 1 Rating	Expert 2 Rating	Expert 3 Rating	Expert 4 Rating	Expert 5 Rating	I-CVI	Evaluation Result
Q1	Medication Behavior	I can easily take hypertension medications on time	4	4	4	4	4	1.00	Excellent
Q2	Medication Learning	I can easily ask pharmacists questions about hypertension medications	3	4	3	4	4	1.00	Excellent
Q3	Medication Learning	I can easily understand pharmacist explanations about my hypertension medications	4	4	4	4	4	1.00	Excellent
Q4	Medication Learning	I can easily understand instructions on hypertension medication bottles/packages	3	4	4	4	4	1.00	Excellent
Q5	Medication Learning	I can easily obtain all information I need about hypertension medications	2	3	3	4	4	0.80	Acceptable
Q6	Medication Behavior	Remembering to take all hypertension medications is easy	4	4	4	4	4	1.00	Excellent

Item No.	Dimension	Item Content	Expert 1 Rating	Expert 2 Rating	Expert 3 Rating	Expert 4 Rating	Expert 5 Rating	I-CVI	Evaluation Result
Q7	Medication Behavior	I can easily establish a daily schedule for taking hypertension medications	3	4	4	3	3	1.00	Excellent
Q8	Medication Behavior	I can easily take hypertension medications every day	4	4	4	4	4	1.00	Excellent

Table 2. (*Continued*)

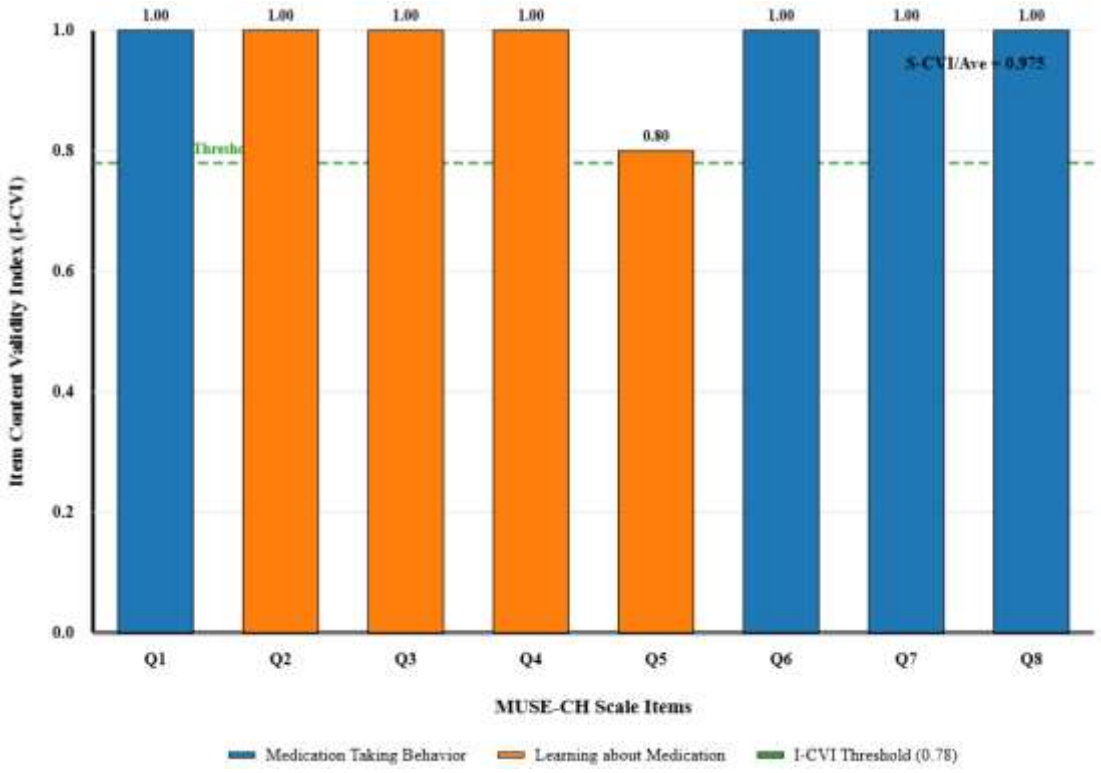

Figure 2. Content validity index distribution for MUSE-CH scale items.

3.1.3. Structural validity and reliability analysis

Structural validity and reliability analysis of the MUSE-CH scale was conducted based on baseline data from 126 elderly hypertensive patients, employing multiple psychometric methods for comprehensive assessment of scale measurement quality. Cronbach's alpha coefficient analysis revealed that the internal consistency reliability of the total MUSE-CH scale was 0.847, achieving good level (>0.80). The medication-taking behavior dimension (Q1, Q6, Q7, Q8) demonstrated an alpha coefficient of 0.825, while the medication learning dimension (Q2, Q3, Q4, Q5) showed an alpha coefficient of 0.798, both reaching acceptable standards (>0.70), indicating good internal consistency among items within each dimension (see **Table 3**). Item-total correlation analysis results showed that correlation coefficients between all 8 items and total scores ranged from 0.521-0.742, all reaching significant levels (P<0.001), with Q1 (r=0.742) and Q8 (r=0.698) showing the highest correlations, while Q5 (r=0.521) showed relatively lower but still acceptable correlation.

Table 3. Structural validity and reliability analysis results of MUSE-CH scale.

Dimension/Scale	**Number of Items**	**Cronbach's α**		**95% Confidence Interval**	**Evaluation Standard**
Medication-taking Behavior Dimension	4	0.825		0.784-0.862	Good
Medication Learning Dimension	4	0.798		0.753-0.839	Good
Total Scale	8	0.847		0.809-0.881	Good
Item	Dimension	Item-Total Correlation (r)	P Value	Alpha if Item Deleted	Evaluation
Q1	Medication-taking Behavior	0.742	<0.001	0.821	Excellent
Q2	Medication Learning	0.645	<0.001	0.835	Good
Q3	Medication Learning	0.683	<0.001	0.829	Good
Q4	Medication Learning	0.612	<0.001	0.840	Good
Q5	Medication Learning	0.521	<0.001	0.859	Acceptable
Q6	Medication-taking Behavior	0.689	<0.001	0.828	Good
Q7	Medication-taking Behavior	0.654	<0.001	0.834	Good
Q8	Medication-taking Behavior	0.698	<0.001	0.826	Good
Indicator	Value	Standard	Evaluation		
Person Reliability	0.81	>0.80	Good		
Item Reliability	0.95	>0.80	Excellent		
Person Separation Index	2.06	>2.0	Good		
Item Separation Index	4.36	>2.0	Excellent		
Infit MNSQ Range	0.73-1.21	0.7-1.3	Meets Standard		
Outfit MNSQ Range	0.69-1.18	0.7-1.3	Meets Standard		
Outfit MNSQ Range	0.69-1.18	0.7-1.3	Meets Standard		

Note: *Cronbach's α ≥0.90 = Excellent, 0.80-0.89 = Good, 0.70-0.79 = Acceptable; Item-total correlation r ≥0.40 = Acceptable*

Alpha coefficients after item deletion analysis indicated that removing any single item did not significantly improve the total scale's alpha coefficient, confirming the contributory value of all 8 items to overall scale reliability. Rasch model analysis further validated the scale's unidimensional characteristics, with all items' infit values ranging from 0.73-1.21 and outfit values ranging from 0.69-1.18, both meeting the ideal standard of 0.7-1.3, indicating good fit between items and the underlying construct. Person reliability was 0.81 and item reliability was 0.95, achieving good and excellent levels respectively, demonstrating that the scale effectively discriminates patients with different self-efficacy levels while maintaining stable item difficulty hierarchies. Differential Item Functioning (DIF) analysis was conducted by gender, age groups (65-74 years vs ≥75 years), and education level (junior high school and below vs high school and above), with results showing all items' DIF contrast values were less than 0.5 logit units, indicating good measurement invariance across different demographic characteristic groups.

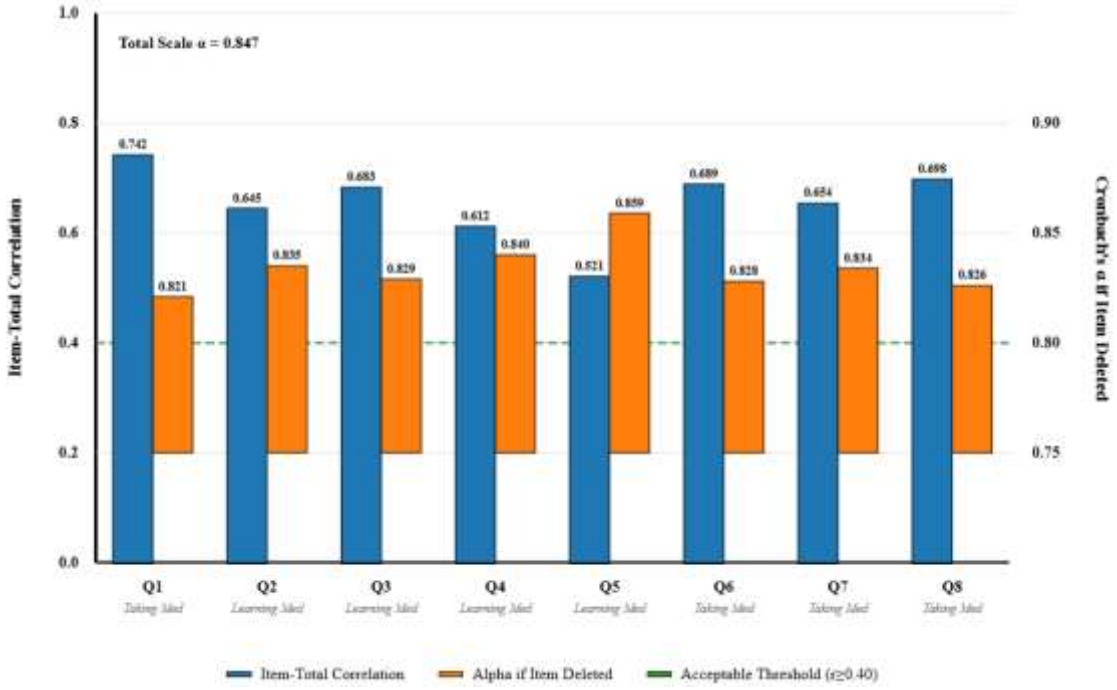

Figure 3. Reliability and item analysis results for MUSE-CH scale.

4. Discussion

4.1. Methodological contributions

This investigation's primary methodological contribution lies in establishing the first MUSE-CH scale appropriate for Chinese elderly hypertensive patients, addressing the domestic gap in specialized medication self-efficacy assessment instruments. While the MUSE scale represents an internationally recognized medication self-efficacy evaluation tool, its applicability and effectiveness within Chinese linguistic contexts previously lacked systematic validation. Through rigorous cross-cultural adaptation procedures, this study successfully achieved scale localization [31]. The translation process strictly adhered to international standards, employing multiple optimization rounds including forward translation, back translation, expert review, and cognitive interviews, ensuring semantic, conceptual, and cultural equivalence. Expert content validity evaluation results demonstrated S-CVI/Ave reaching 0.975, substantially exceeding the internationally recognized 0.90 excellence standard, confirming MUSE-CH's superior content relevance.

Psychometric validation results indicated MUSE-CH total scale Cronbach's α coefficient of 0.847, with medication behavior and medication learning dimensional reliability coefficients of 0.825 and 0.798 respectively, all achieving satisfactory levels while demonstrating stable internal consistency. Rasch model analysis further validated scale unidimensional characteristics, with all item fit indices within optimal ranges. Person reliability and item reliability reached 0.81 and 0.95 respectively, indicating satisfactory discriminative capability and measurement precision [32]. Differential item functioning analysis confirmed measurement invariance across different gender, age, and educational attainment groups, ensuring assessment result fairness and comparability.

MUSE-CH's successful establishment provides scientifically reliable evaluation tools for domestic community pharmaceutical service practice, enabling accurate identification of patient populations with insufficient medication self-efficacy while providing evidence-based foundations for personalized intervention strategy development [33]. This instrument's application will facilitate transformation of China's

chronic disease management models from purely disease-focused treatment toward comprehensive patient care centered on patient empowerment, possessing significant theoretical value and practical implications.

4.2. Intervention significance and environmental psychology perspective

The multidimensional educational intervention model constructed in this investigation embodies a significant transformation from traditional biomedical approaches toward integrated social-psychological-environmental frameworks, with core value residing in situating medication behaviors within patients' authentic living environments for comprehensive capacity building. The intervention design thoroughly incorporated fundamental perspectives from environmental psychology regarding "person-environment interactions," recognizing that elderly patients' medication behaviors are influenced not solely by individual cognitive abilities and motivation, but are deeply embedded within complex interactions among family environments, community support networks, and physical settings [34]. Through environmental safety assessment as an innovative element, this research initially integrated physical environmental factors of patients' home medication management into systematic intervention frameworks, encompassing optimization of critical environmental variables including medication storage conditions, medication reminder system configurations, and family member participation levels.

Family support network construction reflects practical applications of social ecological theory, activating and strengthening social resources surrounding patients to establish multilevel medication safety assurance systems. This environment-oriented intervention strategy transcends limitations of traditional pharmaceutical services that focus solely on medications themselves and individual knowledge transmission, shifting toward creating supportive environments conducive to sustained medication behavior change, embodying the conceptual core of "making healthy choices easy choices" within health promotion fields.

From environmental psychology's adaptation theory perspective, this investigation's intervention effects validated the crucial role of environmental support in enhancing individual self-efficacy. Research results demonstrating significant medication self-efficacy improvements in the intervention group (Cohen's d=0.677) reflect not only individual cognitive and skill-level improvements, but more importantly embody reconstruction of adaptive relationships between patients and their medication environments. Multidimensional interventions, through simultaneous action across three levels—individual capabilities (medication knowledge and skills), social support (family participation and pharmacist guidance), and physical environment (medication facilities and reminder systems)—created medication ecosystems better aligned with elderly patients' cognitive characteristics and daily living needs [35].

This systematic environmental optimization strategy effectively reduced cognitive burden for patients managing complex medication regimens while enhancing their confidence and capabilities to maintain optimal medication behaviors within authentic life contexts. From long-term perspectives, this intervention model centered on environmental adaptability provides important insights for constructing sustainable chronic disease management systems, indicating that genuinely effective health behavior interventions must transcend individual-level education and persuasion, transitioning toward systematic strategies that create supportive environments and enhance person-environment compatibility. This conceptual framework holds significant guidance value for community health service model innovations currently advancing in China.

From a psychological mechanism perspective, the improvement in medication self-efficacy observed in this study (Cohen's d=0.677) can be more deeply explained through Self-Regulation Theory and Perceived Control Theory. The multidimensional intervention operates through three psychological pathways: first, individualized medication education enhances patients' 'metacognitive monitoring' capabilities, enabling them to identify and adjust inappropriate medication behaviors, which aligns with the self-regulatory cycle of

'self-observation-self-judgment-self-reaction' in Bandura's social cognitive theory; second, environmental safety assessment and medication reminder system optimization reduce the cognitive load of implementation intentions, transforming complex medication tasks into automated behavioral patterns, which is consistent with the core mechanism of 'reducing environmental uncertainty to enhance perceived control' in control theory; third, the construction of family support networks activates 'vicarious efficacy' and social persuasion mechanisms, strengthening patients' capability beliefs through observing others' successful experiences and receiving positive feedback. Notably, this environment-psychology-behavior interaction is not a linear addition, but rather forms a dynamic adaptive system—patients' successful experiences in supportive environments further enhance their self-efficacy, which in turn motivates them to proactively optimize their personal environment (such as spontaneously improving medication storage methods), creating a positive spiral cycle. Future research should employ structural equation modeling or longitudinal designs to systematically examine the mediating and moderating mechanisms among environmental support → perceived control → self-regulatory capacity → medication self-efficacy → health outcomes, particularly exploring the differential pathways in this psychological process across different subgroups (such as patients with cognitive decline and elderly living alone), to provide a theoretical foundation for achieving precision psychological interventions.

4.3. Comparison with previous research

Internationally, Williams et al.'s pharmacist educational intervention research targeting chronic disease patients reported similar intervention modalities, yet their study subjects primarily comprised middle-aged diabetic patients, with intervention emphasis focusing on disease knowledge education rather than self-efficacy enhancement [37]. Prevalent limitations in existing domestic and international research lie in viewing medication behaviors as purely individual behavioral problems while neglecting environmental factors' fundamental constraining effects on elderly patients' medication capabilities.

From methodological innovation perspectives, this investigation achieved significant breakthroughs across multiple dimensions, particularly regarding assessment instrument scientific rigor and intervention content systematicity. Previous domestic research predominantly employed self-developed questionnaires or simple adherence scales for effect evaluation, lacking standardized instruments with rigorous psychometric validation, consequently limiting research result comparability and generalizability. This study initially applied and validated the MUSE scale within domestic elderly hypertensive populations, establishing reliable measurement standards for subsequent research in this field. Regarding intervention content, previous research mostly concentrated on single-dimensional health education or medication guidance, lacking comprehensive consideration of patients' living environments [38].

This investigation innovatively incorporated environmental safety assessment and family support network construction into intervention frameworks, representing the first systematic application of such multilevel, multidimensional intervention strategies in domestic and international literature. Notably, while some international research involved environmental intervention elements, these predominantly occurred within developed countries' healthcare system contexts, with their intervention models and effect evaluation systems requiring validation for applicability within China's community health service environments [39]. This study validated multidimensional intervention feasibility and effectiveness within China's characteristic community pharmacy environments, providing important evidence-based foundations for localized development of domestic community pharmaceutical service models while addressing theoretical and practical gaps in this field.

4.4. Limitations and future directions

This investigation possesses several significant limitations requiring comprehensive consideration during result interpretation and generalized application. Medication behaviors, representing habitual actions, require extended timeframes for genuine consolidation, particularly among elderly patients experiencing gradual cognitive decline. Whether short-term established self-efficacy remains stable when confronting disease progression, medication regimen adjustments, or living environment changes requires long-term tracking validation. Additionally, research locations were confined to community pharmacies in Pingdingshan City, Henan Province, presenting certain geographical representativeness constraints, especially regarding economic development levels, healthcare resource allocation, and cultural backgrounds that may differ significantly from eastern developed regions or western underdeveloped areas, affecting research result external validity [40]. Moreover, research primarily focused on medication self-efficacy psychological-cognitive indicator changes, with relatively insufficient evaluation of objective medication adherence, blood pressure control achievement rates, adverse drug reaction incidence, and other concrete clinical endpoints, limiting comprehensive judgment of intervention clinical value.

Future research should deepen and expand this investigation's findings across multiple directions to construct more comprehensive community pharmaceutical service evidence-based systems. Priority consideration should include conducting multicenter, large-sample long-term follow-up studies, extending follow-up periods to 3 months or longer, systematically evaluating multidimensional intervention effect durability while exploring optimal maintenance intervention strategy models. Research designs should incorporate additional objective clinical indicators including blood pressure achievement rates, cardiovascular event incidence, and healthcare costs among concrete endpoints for comprehensive intervention clinical value and health economic benefit evaluation. Regarding geographical coverage expansion, research should extend to regions with different economic development levels and cultural backgrounds, particularly emphasizing eastern-western and urban-rural difference impacts on intervention effects, providing foundations for formulating regionalized community pharmaceutical service strategies. From technology innovation perspectives, consideration should include integrating digital health management tools such as intelligent medication reminder systems and remote blood pressure monitoring devices, exploring online-offline integrated intervention modalities. Additionally, in-depth research should examine differential responses to multidimensional interventions among various subgroup populations (such as high-risk groups with comorbid cognitive dysfunction, polypharmacy, or living alone), providing scientific foundations for achieving precision interventions, ultimately promoting fundamental transformation of China's community pharmaceutical services from experience-driven toward evidence-based practice.

5. Conclusions

This investigation achieved five significant research conclusions across the following domains:

(1) This study successfully established the MUSE-CH scale appropriate for Chinese elderly hypertensive patients. Through rigorous cross-cultural adaptation and psychometric validation, the scale demonstrated excellent content validity (S-CVI/Ave=0.975), satisfactory internal consistency reliability (Cronbach's α=0.847), and stable construct validity, providing scientifically reliable medication self-efficacy assessment instruments for China's community pharmaceutical service field while addressing standardized measurement tool gaps in this domain.

(2) The investigation innovatively constructed multidimensional intervention frameworks integrating personalized medication education, environmental safety assessment, and family support network establishment, transcending traditional pharmaceutical service limitations focused solely on medication knowledge transmission. This embodied significant transformation from biomedical models toward integrated social-psychological-environmental approaches, providing novel theoretical perspectives and practical pathways for community chronic disease management.

(3) Research results validated the crucial role of person-environment interactions from environmental psychology in health behavior modification. Through optimizing patients' medication physical environments and social support environments, the intervention effectively reduced cognitive burden of medication management among elderly patients while enhancing their adaptive capabilities to maintain optimal medication behaviors within authentic life contexts, providing evidence-based foundations for constructing supportive medication environments.

(4) This investigation provided operational practice guidelines for community pharmaceutical service model innovation in China. Successful multidimensional intervention strategy applications demonstrated community pharmacists' substantial potential for leveraging professional advantages in chronic disease management. Research outcomes can be directly applied to pharmaceutical service practices within community health service institutions, holding significant implications for advancing primary healthcare service capacity enhancement and Health China strategy implementation.

6. Ethics and acknowledgments

This study complied with the Declaration of Helsinki and international ethical guidelines. Ethical approval was granted by the AIMST University Human Research Ethics Committee (Application Ref No: AUHEC/FOP/01/08/2024/PhD-1). Written institutional permissions were obtained from designated community hospitals and community pharmacies in Pingdingshan City, Henan Province. Throughout the research process, participant autonomy principles were maintained, with all enrolled patients voluntarily signing informed consent forms after comprehensive understanding of research purposes, methodologies, anticipated benefits, and potential risks, while being explicitly informed of their right to withdraw unconditionally at any point during the study without affecting normal medical services. Considering elderly patients' special characteristics, the research team actively encouraged family members or legal guardians to participate in informed consent processes upon obtaining individual consent, ensuring comprehensive understanding and autonomous decision-making. The investigation strictly protected participant privacy through coded personal information processing, with all data utilized solely for scientific research purposes without disclosing personal identity information to any third parties. Data management followed FAIR principles, with de-identified original datasets scheduled for public sharing through designated scientific data platforms following publication to promote scientific knowledge dissemination and accumulation while providing secondary analysis and validation opportunities for other researchers.

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Conflicts of interest

The authors declare no conflicts of interest.

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