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Research Paper

Psychometric testing of the cross-culturally adapted Thai version of the Self-Care Self-Efficacy Scale version 3.0 in individuals with chronic illnesses

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ABSTRACT

Objective: To assess the psychometric properties of the Thai version of the Self-Care Self-Efficacy Scale version 3.0 (SCSES-v3.0) in individuals with chronic illnesses. Although originally developed and tested in a Western context, its applicability in Asian populations, including Thailand, remains inadequately explored.

Methods: Psychometric tests were guided by COSMIN principles. This included the translation of the English version into Thai based on the ISPOR framework. Nine nursing experts evaluated the content validity. Data were obtained from a multicenter cross-sectional study conducted between July and November 2022. This study included individuals with chronic conditions from 16 primary care centers in Thailand. We tested the structural validity using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), and concurrent validity in relation to the Self-Care of Chronic Illness Inventory version 4.c (SC-CII-v4.c). We tested the scale's reliability with McDonald's ω, Cronbach's α, and the intraclass correlation coefficient (ICC).

Results: The Thai SCSES-v3.0 demonstrated excellent content validity ($k = 1.00$). The final analysis included a total of 385 participants. The EFA with the first split-half subsample ($n = 193$) extracted a two-factor structure. One reflected SCSES for maintenance and monitoring behaviors and another captured SCSES for management behaviors (item 6–10). CFA with the second split-half subsample ($n = 192$) and the overall sample ($n = 385$) supported the scale's two-factor model with high factor loadings. Each dimension and the overall SCSES-v3.0 positively correlated with each scale and the overall SC-CII-v4.c. McDonald's ω and Cronbach's α (both ranged 0.91–0.94) and ICC (ranged 0.95–0.96), indicated excellent internal reliability and test-retest reliability, respectively.

Conclusions: The identification of a valid and reliable two-factor model for the Thai SCSES-v3.0 renders it a valuable tool for clinicians and investigators, facilitating the assessment of self-efficacy in self-care across diverse contexts.

What is known?

- The Self-Care Self-Efficacy Scale (SCSES) is a theoretically derived scale designed to measure self-efficacy in self-care among individuals with chronic illnesses.
- Original testing has validated the scale, suggesting a one-factor model.
- Recently, a simultaneous scale measuring self-efficacy in caregivers has indicated a two-factor model.

What is new?

- Refinement of the SCSES version 3.0 revealed a two-factor model structure.

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- The scale unfolds into the dimensions of SCSES for Maintenance and Monitoring, and SCSES for Management.
- The scale demonstrated robust validity and reliability in the Thai context.

1. Introduction

Chronic illnesses have become a prominent global health concern, with a steady increase in incidence and ranking among the leading causes of morbidity and disability worldwide [1]. In Thailand, the prevalence and burden of chronic noncommunicable diseases, particularly cardiovascular diseases, diabetes, chronic respiratory diseases, chronic kidney disease, and cancer, have surged over the past four decades [2]. This escalating trend poses formidable challenges to the national healthcare system and economics, reflecting the burden on a global scale.

Promoting long-term self-care is a critical challenge in addressing chronic illnesses to maintain stability and manage specific conditions. Comprehensive self-care entails embracing behaviors that encompass maintenance, monitoring, and management [3]. Self-care maintenance promotes well-being and prevents illness deterioration, while self-care monitoring involves observing changes in health conditions, as well as signs and symptoms [3,4]. Self-care management involves proactive steps to address changes in symptoms and worsening conditions [3]. Despite medical advancement, poor self-care persists among Thai with chronic illnesses [5–8], similar to international contexts [9–12]. For instance, less than half of Thais with hypertension adhered to antihypertensive treatment [7], and a similar proportion engaged in regular exercise [6,13]. Even in clinical trials, self-care interventions have a negligible effect on outcomes in various chronic illnesses [14]. Addressing these challenges require a sustained commitment to self-care efforts and consideration of determinant factors like motivation.

Self-efficacy, rooted in Bandura's social cognitive theory [15] and inherent to self-care for chronic illness theory [3], stands as a crucial motivator for actively engaging, adapting, and adhering to comprehensive self-care and treatment plans [16–19]. Understanding this motivational factor is imperative for devising effective interventions and support systems. Individuals with high self-efficacy persist in self-care efforts despite setbacks [3,17], engage in problem-solving [16,20], adhere to medication schedules, adopt healthy lifestyle changes, and foster a positive mindset [19]. Belief in one's ability to manage a chronic illness fosters a sense of control [17], reduces anxiety [21], enhances resilience [16], and improves overall health and well-being [20–23]. Interventions targeting self-efficacy improvement showed positive effects in reducing exacerbation along with delaying disease progression [18].

A credible scale for measuring self-efficacy in chronic illnesses self-care is essential for accurate assessment, decision-making, progress monitoring, empowerment, interventions, and research validity. Several validated scales serve this purpose, with no single standard measure. Two forms of measures are utilized: disease-specific and generic scales. Disease-specific scales focus on challenges and behaviors related to particular conditions like heart failure [24], asthma [25], cancer [26], chronic kidney disease [27], diabetes [28], chronic obstructive pulmonary disease [29], and arthritis [30]. On the other hand, generic scales offer a broader assessment, allowing comparisons across conditions. Examples include Self-Care Self-Efficacy Scale (SCSES) [31], Chronic Disease Self-Efficacy Scales (CDSES) [32], Self-Efficacy for Managing Chronic Conditions Scale (SEMCC) [33], General Self-Efficacy Scale (GSE) [34], Patient-Reported Outcomes Measurement Information System Measures of Self-Efficacy for Managing Chronic Conditions (PROMIS-SE) [35], and Patient-Reported Outcomes Measurement Information System Measures of General Self-Efficacy (PROMIS-GSE) [32]. Both forms of scales undergo rigorous psychometric evaluations, ensuring their validity and reliability.

Among the existing scales, the SCSES [31] was developed under the Middle-Range Theory of Self-Care of Chronic Illness [3]. This generic scale was designed for individuals with any chronic conditions. Assessing self-efficacy in maintenance, monitoring, and management [31]. The recently updated version 3.0 is in conjunction with the Self-Care of Chronic Illness Inventory (SC-CII) scale [36]. It underwent multinational validation in the United States, China, Italy, and Brazil, confirming shared theoretical orientation among populations with chronic illnesses [31]. Excellence in internal consistency reliability was observed across contexts. Concurrent validity with self-care practices in various chronic conditions has been demonstrated in several studies [36–39].

The SCSES has been demonstrated validity, reliability, and applicability across diverse chronic conditions and cultures [31]. However, its psychometric evaluation in the Thai population, including test-retest reliability, has yet to be previously conducted. Evaluating cross-culturally adapted SCSES in Thailand extended knowledge of its generalizability and applicability and ensured clinical utility and research validity. This allows for developing tailored interventions addressing self-efficacy that suit Thai culture. Investigators can confidently compare self-efficacy levels across conditions and countries enhances understanding of self-care comprehensively.

The structural validity of the SCSES was conceptualized as a one-factor model [31], while the disease-specific scale [40] and relevant Caregiver Self-Efficacy in Contributing to Patient Self-Care Scale (CSE-CSC) [41] adopted a two-factor model. Given the fact that SCSES and CSE-CSC were developed concurrently, drawing inspiration from three contemporaneous theories: Heart Failure Self-Care [42,43], Caregiver Contribution to Heart Failure Self-Care [44], and Self-Care of Chronic Illness [3]. The theoretical structures of these self-efficacy scales share similarities. To date, no recent studies have updated and confirmed the two-factor model of the SCSES-v3.0. Hence, we consider the scale's two-factor model. This hypothesis is based on the robust theoretical foundation it presents, potentially representing self-care self-efficacy (SCSE) in maintenance and monitoring, and SCSE in management behaviors [41].

This study aimed to assess the psychometric properties of the Thai SCSES-v3.0 among individuals with chronic illnesses. Specifically, we aimed to validate structural validity to reflect the theoretical construct of the scale. To achieve this, we first explored the factorial structure through exploratory factor analysis (EFA) followed by confirmatory factor analysis (CFA). Additionally, we examined the concurrent validity, internal consistency reliability, test-retest reliability, and measurement error of the scale.

2. Methods

2.1. Study design

The data for this analysis were sourced from a parent study assessing the validity and reliability of scales for self-care and caregiver contribution to self-care for individuals with chronic illnesses. This multicenter, cross-sectional study explored factors influencing self-care, including self-care self-efficacy. The psychometric study followed the COSMIN guidelines [45]. The dataset, gathered from a study evaluating the psychometric of the Thai SC-CII-v4.c [46], conducted from July to November 2022, provides pertinent information for SCSES-v3.0 psychometric testing.

2.2. Study settings, participants, and procedures

The study's details are available elsewhere [46]. Briefly, it employed convenience sampling, involving 430 eligible patients from 16 primary care centers across six provinces in southern Thailand. Eight declined, resulting in 422 (98.1%) participants. This sample size surpasses the maximum requirement of one item scale per 20 samples for CFA [47]. Inclusion criteria were individuals aged 18 years or older, with a confirmed chronic disease diagnosis for at least three months, receiving care at selected primary care settings, and willing to participate. This study focused on the following prevalent chronic diseases: hypertension, diabetes, heart disease (heart failure, myocardial infarction, valvular heart disease, cardiac arrhythmia), stroke (ischemic stroke, hemorrhagic stroke, transient ischemic attack), chronic respiratory disease (asthma, chronic obstructive pulmonary disease), chronic kidney disease (stages 3–5, dialysis), and cancer.

Exclusion criteria included individuals discharged from the hospital within the previous three months and hospitalized patients, aligning with previous recommendations [4,48]. A recent hospital discharge might indicate a period of recovery or adjustment, potentially impacting health stability. This variability could introduce confounding factors to self-efficacy measurement, affecting responses and reflecting short-term adjustments rather than long-term self-care behaviors. Excluding recently discharged individuals maintains homogeneity in the study sample, ensuring that the scale reflects the ongoing nature of self-care.

Sixteen nurses, primarily from chronic care clinics, collected data after comprehensive training. Sessions covered the research protocol, including self-care concepts, ethical considerations, project orientation, design overview, instruments, participant engagement, informed consent, data collection procedures, and data protection. Practical training involved self-completing the survey package, role-playing, field practice, supervised activities, and question-and-answer sessions. Face-to-face interviews with a paper-based survey package were scheduled based on participants' preferences at healthcare centers or their homes. Most participants finished within 30 mins, while older adults and illiterate participants required up to 50 mins. Clinical data were also gathered from electronic health records.

To assess test-retest reliability, this study included 60 participants from four settings who completed the SCSES-v3.0 twice, with 10–14 days intervals between administrations. All participants were included in the final sample for psychometric analysis.

2.3. Measures

2.3.1. Translation processes and translational validity

Simultaneously with the Thai Sc-CII-v4.c [46], the translation and cross-sectional adaptation of the Thai SCSES-v3.0 were conducted. Both the first author (CP) and corresponding author (JS) actively engaged in the translation processes. Following the ISPOR Task Force for Translation and Cultural Adaptation framework [49], we followed a multi-step process to translate and cross-culturally adapt the SCSES-v3.0 from English into Thai.

A panel of seven committees, five with doctoral degree in nursing and specializing in chronic illness self-care, engaged in thorough processes including preparation, forward translation, reconciliation, back-translation, back-translation review, harmonization, cognitive debriefing, review of the cognitive debriefing results and finalization, and proofreading [49]. They have experienced translating relevant self-care measures for hypertension [5]. Among these, four have studied abroad in the United States, and one currently holds a faculty position at a nursing school in the United States. Two members are native English speakers with ties to Thai families. One possesses a master's degree in education, has residency experience in Thailand, and has been a faculty member at Thai universities for a decade. The other holds a doctoral degree in education and is a faculty member at a university in the United States. Steps were taken to ensure linguistic precision and cultural fit. The overall scale was easily translatable and comprehensible. Cognitive debriefing under the ISPOR framework, akin to a pilot study, involved ten individuals with various chronic conditions providing feedback on clarify and meaning. Their comments led to minimal revisions in four items (1, 4, 6, and 7). In item 1, the phrase "physically as well as emotionally stable" was added to clarify the conditions. In item 4, the phrase "physical and emotional" was also added. Item 6 saw the inclusion of "worsen" for specification, and item 7 replaced "important" with "urgent" for significance. Consequently, prefinal Thai and English SCSES-v3.0 versions were generated. The final Thai version and back-translation versions of both instruments were reviewed and approved by the developer (B. Riegel). See Appendix A for translation details.

Prior to psychometric testing, another panel of nine expert nurses assessed the content validity of the scale for translational appropriateness [50]. The panel, with expertise in chronic care, included three primary care nurse practitioners (two with master's degree, and one with post-baccalaureate training), and four clinical nurse specialists from tertiary care settings (three with master's degree and advanced practice nursing, and one with post-baccalaureate training). Two doctoral nurses, experts in scale development and chronic illness self-care, were also involved. They rated a 1–4 ordinal scale for relevant (1, not relevant; 4, very relevant), clarity (1, not clear; 4, very clear), simplicity (1, not simple; 4, very simple), and ambiguity (1, doubtful; 4, meaning is clear) [51]. All items scored 4, except for item 7 (scoring 3 for clarity) and item 10 (scoring 3 for ambiguity). No additional recommendations were made. The average scale-level content validity index (S-CVI), estimated based on the kappa table [52], was perfect at 1.00 (Appendix B). Notably, the SCSES-v3.0 is integral to the SC-CII-v4.c, both translated into Thai by our team. Content validity of the Thai SC-CII-v4.c, reported elsewhere [46], demonstrated an S-CVI of 0.99 for the maintenance, monitoring, and management scales, as well as the overall instrument.

2.3.2. Self-Care Self-Efficacy Scale

The cross-culturally adapted Thai SCSES-v3.0, a 10-item scale, aligns with the original English version [31]. Items 1–5 represent SCSE in maintenance and monitoring, focusing on daily self-care for health promotion, illness management, and monitoring changes. Items 6–10 reflect SCSE in management, evaluating responses to worsened health conditions and assessing their strategies to manage the symptoms. Participants rate items on a 5-point Likert scale, ranging from 1 (not confident) to 5 (very confident). Higher SCSES scores indicate a higher level of self-efficacy in performing self-care.

2.3.3. Self-Care of Chronic Illness Inventory version 4.c

The Thai SC-CII-v4.c, employed to test concurrent validity with Thai SCSES-v3.0, displayed robust validity and reliability with cross-cultural applicability [46]. This 19-item instrument, comparable to the original English version [36], comprises three scales: seven-item Self-Care Maintenance (items 1–7), five-item Self-Care Monitoring (items 8–12), and seven-item Self-Care Management (items 13–19). The Self-Care Maintenance scale evaluates patients' engagement in routines to maintain health and manage their illness, including actions related to sleep, sickness avoidance, diet, physical activity, stress management, medication usage, and clinical check-ups [36]. The Self-Care Monitoring scale assesses

patients' adherence to monitoring health changes, including signs and symptoms of illnesses, medication side effects, and treatment complications. The Self-Care Management scale emphasizes patients' awareness and handling of symptoms and worsening health conditions, evaluating strategies such as recognizing changes, adjusting lifestyle, medication use, and communicating symptoms with healthcare providers [36].

Participants rated responses using a 5-point Likert format, ranging from 1 "never/not likely" to 5 "always/very likely." Two items from the Self-Care Management scale used a scale of 0–5. For item 13, participants indicated how quickly they recognized symptoms related to their health condition, from 0 (I had a symptom but did not recognize it as a symptom of my health condition) to 5 (very quickly). Item 19 assessed participants' reflections on the treatment used during their last symptom episode, with options from 0 "I did not do anything", to 5 "Very sure". Higher scores on each scale and the overall SC-CII-v4c indicated better self-care behaviors [36].

2.3.4. Participants characteristics

Sociodemographic data (e.g., age, gender, education, household income) and clinical data (e.g., types of chronic diseases, medications) are provided. This also covered other chronic conditions (e.g., dyslipidemia, visual problems). All chronic diseases and other chronic conditions were counted as the total number of comorbidities. Medications and treatment modalities were recorded, including type, form, and administration route. These include oral pills, injections, inhalation or external medication, rehabilitation, cardiac procedures, dialysis, chemotherapy, and radiotherapy.

2.4. Ethical considerations

The original study was approved by the Institutional Review Board of Walailak University (Approval No. WUEC-22-168-01). The same institute approved the analysis based on the exemption protocol (Approval No. WUEC-23-217-01). This study adhered to the standards outlined in the declaration of Helsinki. All participants in the original study provided oral and written informed consent and were aware of their rights and responsibilities. Their right to withdraw and the confidentiality of their personal data was also ensured. The analyzed data were anonymized and treated as strictly confidential.

2.5. Data analysis

Data analysis utilized SPSS version 28.0 for descriptive statistics and EFA, along with AMOS version 24.0 for CFA. Descriptive statistics summarized sociodemographic characteristics, clinical profiles, and item responses, employing mean and standard deviation ($Mean \pm SD$) or median and interquartile range (IRQ) measures. Raw scores of SCSES-v3.0 and SC-CII-v4.c were standardized to a $0-100$ scale to enhance interpretability, comparability, and facilitate statistical analysis [36]. A significance level of $P < 0.05$ was set. Assumptions were checked with a total of 422 samples, excluding 37 cases with Mahalanobis distance outliers. Skewness, kurtosis, and Kolmogorov-Smirnov tests confirmed a normal data distribution. The final sample ($n = 385$) was randomly split into two subsamples (EFA subsample $= 193$ and CFA subsample $= 192$) for EFA and CFA, respectively.

Structural validity was evaluated through EFA followed by CFA, employing the maximum likelihood estimator for data with a normal distribution [53]. EFA with varimax rotation was used to examine the factorial structure. A Kaiser-Meyer-Olkin (KMO) ≥ 0.60 and Bartlett's test of sphericity ($P < 0.05$) indicated that the correlation matrix was suitable for factor analysis [54]. CFA utilized the Comparative Fit Index (CFI), Tucker and Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR) as model fit indices [36,41,55–57]. Acceptable CFI and TLI values ranged between 0.90 and 0.95, while values > 0.95 indicate a good fit [58]. RMSEA values < 0.05 indicated a well-fit model, 0.05–0.08 a moderate fit, and $\geq$0.10 a poor fit [59]. Additionally, the null hypothesis was rejected if the associated $P < 0.05$, and a close fit was indicated if $P > 0.05$, considering the 90% confidence interval (90%CI) [59]. An SRMR value of ≤ 0.08 was considered indicative of a good fit. The chi-square test, as reported in alignment with relevant self-care measures [36], was not employed for model fit interpretation. This decision was influenced by the chi-square likelihood ratio's sensitivity to large sample sizes, limiting its robustness in reflecting model fit. Factor loadings of $\geq$ |0.30| are generally deemed minimally acceptable, with a commonly suggested guideline indicating that loadings $\geq$ |0.40| are considered adequate, while loadings $\geq$ |0.70| are considered very good [60].

In this study, the correlation between SCSES-v3.0 and SC-CII-v4.c scores was examined to establish concurrent validity. Concurrent validity, a criterion validity, assesses correlations between measures administered at the same time [61]. Pearson's correlation coefficient r (two-tailed) was calculated for SCSES-v3.0 (dimensions and overall) and SC-CII-v4.c (dimensions and overall). Positive and significant correlations ($P < 0.05$) between the two measures indicated concurrent validity. Pearson's coefficients of $0.10 - 0.29$ were considered weak, $0.30 - 0.49$ moderate, and $\geq$ 0.50 strong [62].

To assess internal consistency reliability, the methods approach was guided by the scale's dimensionality. Cronbach's α coefficient, suitable for unidimensional scales [63], and a global reliability index such as McDonal's ω coefficient for multidimensional scales [64,65] were utilized. Corrected item-to-total correlation gauged each item's association with the total score [36], with coefficients of $\geq$ 0.30 considered acceptable for item discrimination [66]. Test-retest reliability was determined using intraclass correlation coefficients [67]. All reliability estimate values of $\geq$ 0.70 indicate satisfactory scale reliability [68].

Finally, the measurement error of the Thai SCSES-v3.0 was estimated by calculating the standard error of measurement (SEM), providing insight into the scale's overall measurement precision [41]. Additionally, the smallest detectable change (SDC) was computed to identify the minimum clinically significant score difference. These methods are recommended for relevant self-efficacy measures [41]. SEM was calculated using the formula [69]: $SD \times \sqrt{(1 - \text{reliability coefficient})}$, where SD is the SCSES-v3.0 score's standard deviation, and the reliability coefficient is Cronbach's α. A precise instrument was determined when the SEM was less than SD/2 [70]. To calculate the SDC, we used the formula [70]: $1.96 \times \sqrt{2} \times SEM$.

3. Results

3.1. Participants characteristics

In the final sample of 385 participants (Table 1), the majority were women and older adults ($Mean = 67.68$, $SD = 13.22$). Most had completed primary school, lived in large families, earned income, and had sufficient household income. On average, they reported two chronic diseases, with three treatment modalities, and had an eight-year illness duration. The most prevalent conditions were hypertension, diabetes, and stroke. All sociodemographic and clinical characteristics of the EFA subsample were comparable to the CFA subsample.

Table 1
Characteristics of the overall participants, and EFA and CFA subsamples

Characteristics	Overall sample (n =385)	EFA subsample (n = 193)	CFA subsample (n = 192)
Sociodemographics			
Gender			
Women	223 (57.9)	114 (59.1)	109 (56.8)
Men	162 (42.1)	79 (40.9)	83 (43.2)
Age (years)	67.68 ± 13.22	67.31 ± 13.36	67.35 ± 13.03
Age group			
Adults, age <60 years	107 (27.8)	54 (28.0)	53 (27.6)
Older adults, age ≥60 years	278 (72.2)	139 (72.0)	139 (72.4)
Education			
Less than primary school graduate	42 (10.9)	25 (13.0)	17 (8.9)
Primary school graduate	234 (60.8)	107 (55.4)	127 (66.1)
Secondary, or high school graduate	66 (17.1)	35 (18.1)	31 (16.1)
Some college, or higher educated	43 (11.2)	26 (13.5)	17 (8.9)
Literacy			
Unable to read	352 (91.4)	173 (89.6)	179 (93.2)
Able to read	33 (8.6)	20 (10.4)	13 (6.8)
Marital status			
Married or partnered	284 (73.7)	142 (73.6)	142 (74.0)
Single, never married	16 (4.2)	8 (4.1)	8 (4.1)
Divorced, separated, or widowed	85 (22.1)	43 (22.3)	42 (21.9)
Living status			
Alone	17 (4.4)	6 (3.1)	11 (5.7)
With a couple	79 (20.5)	35 (18.1)	44 (22.9)
With a large family	289 (75.1)	152 (78.8)	137 (71.4)
Work status			
Working, with irregular income	173 (44.9)	95 (49.2)	78 (40.6)
Working, with regular income	92 (23.9)	39 (20.2)	53 (27.6)
Not working, no income	87 (22.6)	40 (20.7)	47 (24.5)
Retired, with pension income	33 (8.6)	19 (9.9)	14 (7.3)
Household income			
Insufficient; do not have enough to make ends meet	94 (24.4)	46 (23.9)	48 (25.0)
Sufficient; have enough to make ends meet	187 (48.6)	90 (46.6)	97 (50.5)
Comfortable; have more than enough to make ends meet	104 (27.0)	57 (29.5)	47 (24.5)
Clinical characteristics			
Type of chronic diseases[a]			
Hypertension	308 (80.0)	159 (82.4)	149 (77.6)
Diabetes	173 (44.9)	87 (45.1)	86 (44.8)
Heart diseases	55 (14.3)	26 (13.5)	29 (15.1)
Stroke	96 (24.9)	47 (24.4)	49 (25.5)
Chronic kidney diseases	61 (15.8)	30 (15.5)	31 (16.1)
Chronic lung diseases	37 (9.6)	19 (9.8)	18 (9.4)
Chronic joint problems	57 (14.8)	29 (15.0)	28 (14.6)
Cancer	19 (4.9)	12 (6.2)	7 (3.6)
Others	15 (3.9)	9 (4.7)	6 (3.1)
Total number of chronic diseases	2 (1, 3)	2 (1, 3)	2 (1, 3)
Type of other chronic conditions[a]			
Dyslipidemia	211 (54.8)	106 (54.9)	105 (54.7)
Visual problem	132 (34.3)	71 (36.8)	61 (31.8)
Hearing problem	77 (20.0)	46 (23.8)	31 (16.1)
Walk difficulty	145 (37.7)	70 (36.3)	75 (39.1)
Wheelchairs	30 (7.8)	13 (6.7)	17 (8.9)
Bedridden	7 (1.8)	2 (1.0)	5 (1.3)
Total number of other chronic conditions	1 (1, 2)	1 (1, 2)	1 (1, 2)
Total number of all chronic comorbidities	3 (2, 5)	3 (2, 5)	3 (2, 5)
Type of treatment modality[a]			
Blood pressure lowering pill	318 (82.6)	162 (83.9)	156 (81.3)
Blood glucose lowering pill	173 (44.9)	88 (45.6)	85 (44.3)
Blood glucose lowering injection	35 (9.1)	15 (7.8)	20 (10.4)
Lipid-lowering pill	265 (68.8)	129 (66.8)	136 (70.8)
Antiplatelet, or anticoagulation pill	130 (33.8)	65 (33.7)	65 (33.9)
Bronchodilator pill	30 (7.8)	15 (7.8)	15 (7.8)
Bronchodilator inhaler	36 (9.4)	17 (8.8)	19 (9.9)
External medicines (e.g., balm, eyes drop)	100 (26.0)	56 (29.0)	44 (22.9)
Hematologic-related injection	10 (2.6)	3 (1.6)	7 (3.6)
Renal replacement therapies	26 (6.8)	10 (5.2)	16 (8.3)
Chemotherapy, or radiotherapy	19 (4.9)	13 (6.7)	6 (3.1)
Physical rehabilitation program	47 (12.2)	25 (13.0)	22 (11.5)
Cardiac procedures	12 (3.1)	4 (2.1)	8 (4.2)
Total number of treatment modality	3 (2, 4)	3 (2, 4)	3 (2, 4)
Duration of illness treatment (years)	8 (4, 14)	8 (4, 15)	8 (4, 12)

Note: Data are *n* (%) or *Mean* ± *SD* or *Median* (P_{25}, P_{75}). All sociodemographic and illness characteristics of the EFA and CFA subsamples did not show significant differences ($P > 0.05$). CFA = confirmatory factor analysis, EFA = exploratory factor analysis, [a] Participants were allowed to select one or more options.

3.2. Descriptive analysis of scale items

For the overall sample (Table 2), the item with the highest score was #2: "Follow the treatment advice you have been given." The item with the lowest score was #9: "Persist in finding a remedy for your symptoms even when difficult." The mean standardized score for the total scale was 65.48 ± 16.95 out of 100, with a raw score of 36.19 ± 6.76 out of 50. Appendix C details the descriptive analysis of scale items in the EFA subsample, CFA subsample, and overall sample.

3.3. Structural validity of the Thai SCSES-v3.0 as one-factor model

3.3.1. Exploratory factor analysis of the scale as one-factor model

EFA, employing the default extraction method based on the Eigenvalues criterion [53] of greater than 1.00, extracted a one-factorial structure for the scale (*KMO* = 0.93 and Bartlett's sphericity $P < 0.001$). The model explained 58.52% of the variance (Eigenvalues = 5.85) with moderate-to-high factor loadings (0.66 – 0.83). This extraction method was applied to the second subsample and the overall sample before CFA, yielding similar results. Further details are in Appendix D.

3.3.2. Confirmatory factor analysis of the scale as one-factor model

Table 3 (Models A1-A5 and Models B1-B5) presents the CFA results. This analysis was conducted on the second subsample, resulting in a poorly fit model (Model A1). Inspection modification indices (MIs) revealed inadequate fit due to residual covariances among several item pairs. We rerun the models involving three trimmed specified models to enhance model fit before finalization. The first specified model (Model A2) allowing four covariances (items 1 and 2, 2 and 3, 6 and 7, and 8 and 9) with the largest MIs (20.18 – 49.29), produced adequate fit for all indices except RMSEA. The second model included additional residual covariances from the first model and suggested pairs from estimated parameter changes ≥ 0.07 (items 1 and 4, and 9 and 10), and the third model included item pairs with estimated parameter change ≥ 0.05 (items 4 and 5, 7 and 9, and 8, and 10). Although all fit indices improved significantly across these trimmed models, reaching good fit, RMSEA remained inadequate (Models A3 and A4). In the final step, inspection of MIs in the last trimmed model suggested four additional item pairs. Adding two covariances with estimated parameter changes ≥ 0.05 (items 3 and 5, and 7 and 8), totaling 11 item pairs covariances, produced the final specified model with a good fit (Model A5). All factor loadings were high (0.70 – 0.84), consistent with previous unspecified and trimmed models (Appendix E).

We reran the models with the overall sample (n = 385) for robustness, mirroring the CFA subsample procedures. As expected, results across all models were consistent (Models B1-B5). The final specified model produced an excellent fit (Model B5). All factor loadings were high (0.70 – 0.85). Appendix F (Fig. F1-Fig.F5) provides detailed factor loadings, error variances, and correlation covariances for the one-factor model of the Thai SCSES-v3.0 in the overall sample.

3.4. Structural validity of the Thai SCSES-v3.0 as a two-factor model

Drawing on substantial evidence from various CFA models examining the one-factor structure, we identified inadequate RMSEA confirmation and misfit models linked to specific residual covariances. As a preliminary step, we tested the two-factor model using EFA and CFA on subsample groups, mirroring the approach used in testing the one-factor model.

3.4.1. Exploratory factor analysis of the scale as two-factor model

In the EFA subsample, we applied the fixed number of factors method EFA with two factors [53], revealing initial Eigenvalues of 6.26 and 0.85 for the first and the second factors, respectively (*KMO* = 0.93 and Bartlett's of sphericity $P < 0.001$). Varimax rotation revealed comparable sums of squared loadings for the first factor (Eigenvalues = 3.31, explaining 33.11% of variance) and the second factor (Eigenvalues = 3.08, explaining 30.86% of variance), with 63.97% of total variance. Table 2 presents EFA results from the EFA subsample (n = 193). As expected, the first factor reflected SCSE in maintenance and monitoring behaviors (items 1 – 5) with moderate-to-high factor loadings (0.59 – 0.78). The second factor reflected SCSE in management behaviors (items 6–10) with moderate-to-high factor loadings (0.51 – 0.78). This method was applied to the CFA subsample and overall sample, and similar results were obtained (Appendix G).

3.4.2. Confirmatory factor analysis of the scale as a two-factor model

The CFA results are presented in Table 3 (Models D1-D3 and E1-E3), Figs. 1–3, and Appendix H (Fig. H1-H3). In parallel with the analyses conducted for the one-factor model, a CFA was initially performed with the CFA subsample (n = 192). The first-order factor of the scale explored two dimensions: SCSE for Maintenance and Monitoring and SCSE for Management. While most fit indices were

Table 2
Factor loadings from EFA and CFA, item-total corrected correlation, means and standardized deviation of individual items in the Thai SCSES-v3.0.

Thai SCSES-v3.0		EFA			CFA	ITC	Score (*Mean* ± *SD*)
		Factor 1	Factor 2	n^2			
SCSE for Maintenance and Monitoring dimension							
1.	Keep your physical as well as emotional stable and free of symptoms?	**0.59**	0.45	0.59	0.73	0.70	3.57 ± 0.83
2.	Follow the treatment advice you have been given?	**0.78**	0.31	0.78	0.83	0.76	3.79 ± 0.77
3.	Persist in following the treatment plan even when difficult?	**0.72**	0.34	0.72	0.84	0.74	3.74 ± 0.86
4.	Monitor your physical and emotional condition routinely?	**0.60**	0.44	0.60	0.87	0.75	3.76 ± 0.83
5.	Persist in routinely monitoring your condition even when difficult?	**0.70**	0.49	0.70	0.85	0.80	3.62 ± 0.85
SCSE for Management dimension							
6.	Recognize the worsen changes in your health if they occur?	0.40	**0.51**	0.43	0.74	0.69	3.67 ± 0.86
7.	Evaluate the urgent of your symptoms?	0.37	**0.62**	0.53	0.81	0.73	3.57 ± 0.83
8.	Do something to relieve your symptoms?	0.37	**0.78**	0.76	0.81	0.76	3.46 ± 0.87
9.	Persist in finding a remedy for your symptoms even when difficult?	0.40	**0.78**	0.77	0.82	0.78	3.44 ± 0.89
10.	Evaluate how well a remedy works?	0.37	**0.74**	0.67	0.84	0.76	3.58 ± 0.81

Note: The factor loadings for the EFA were identified from the first split-half subsample (EFA subsample, n = 193). The factor loadings for the CFA were identified from the final specified two-factor model for the overall sample (n = 385). CFA = confirmatory factor analysis. EFA = exploratory factor analysis. ITC = item-total corrected correlation. n^2 = communalities. SCSES-v3.0 = Self-Care Self-Efficacy Scale version 3.0.

Table 3
Fit index values for the Thai SCSES-v3.0 in the CFA subsample ($n = 192$), and the overall sample ($n = 385$).

Sample group	Model	$\chi2$ test goodness of fit				CFI	TLI	RMSEA	90%*CI*	*P*	SRMR
		$\chi2$	*df*	*P*	CMIN/df						
One-factor model											
CFA subsample ($n = 192$)	A1: Unspecified	236.54	35	<0.001	6.75	0.87	0.83	0.17	0.15 – 0.19	<0.001	0.04
	A2: First trimmed specified	117.81	31	<0.001	3.80	0.94	0.91	0.12	0.09 – 0.14	<0.001	0.03
	A3: Second trimmed specified	100.43	29	<0.001	3.46	0.95	0.92	0.11	0.09 – 0.13	<0.001	0.03
	A4: Third trimmed specified	78.03	26	<0.001	3.00	0.96	0.94	0.10	0.07 – 0.12	<0.001	0.02
	A5: Final specified	50.59	24	0.001	2.10	0.98	0.96	0.07	0.04 – 0.10	0.070	0.02
Overall sample ($n = 385$)	B1: Unspecified	322.72	35	<0.001	9.22	0.89	0.86	0.14	0.13 – 0.16	<0.001	0.03
	B2: First trimmed specified	139.91	31	<0.001	4.51	0.96	0.94	0.09	0.08 – 0.11	<0.001	0.02
	B3: Second trimmed specified	117.15	29	<0.001	4.04	0.96	0.95	0.08	0.07 – 0.10	<0.001	0.02
	B4: Third trimmed specified	81.11	26	<0.001	3.12	0.98	0.96	0.07	0.05 – 0.09	0.014	0.02
	B5: Final specified	33.80	23	<0.001	1.47	0.99	0.99	0.03	0 – 0.05	0.836	0.01
Two-factor model											
CFA subsample ($n = 192$)	C1: Unspecified, first-order	132.51	34	<0.001	3.89	0.93	0.91	0.12	0.10 – 0.14	<0.001	0.03
	C2: Final specified, first-order	73.58	30	<0.001	2.45	0.97	0.95	0.08	0.06 – 0.11	0.009	0.02
	C2: Final specified, second-order	73.58	30	<0.001	2.45	0.97	0.95	0.08	0.06 – 0.11	0.009	0.02
Overall sample ($n = 385$)	D1: Unspecified, first-order	145.37	34	<0.001	4.27	0.96	0.94	0.09	0.07 – 0.10	<0.001	0.02
	D2: Final specified, first-order	58.43	30	0.001	1.94	0.99	0.98	0.05	0.03 – 0.06	0.484	0.01
	D2: Final specified, second-order	58.43	30	0.001	1.94	0.99	0.98	0.05	0.03 – 0.06	0.484	0.01

Note: CFI = comparative fit index. *CI* = confidence interval. CMIN/df = minimum discrepancy per degree of freedom. RMSEA = root mean square error of approximation. TLI = Tucker–Lewis index.SRMR = standardized root means square residual. CFA = confirmatory factor analysis, EFA = exploratory factor analysis.

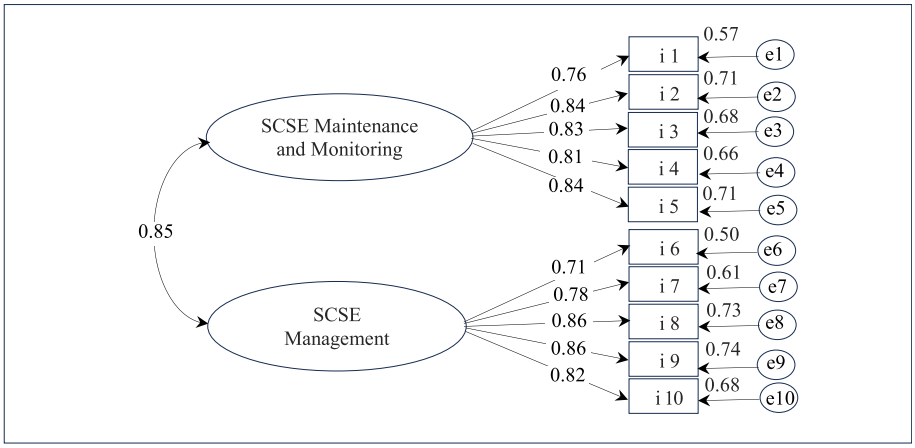

Fig. 1. First-order factor analysis of unspecified two-factor model of the Thai SCSES-v3.0 in the overall sample. SCSE=self-care self-efficacy.

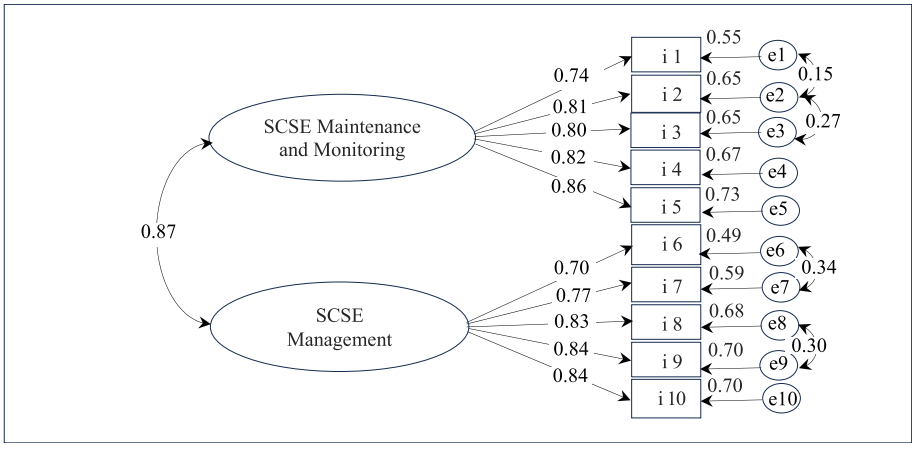

Fig. 2. First-order factor analysis of final specified two-factor model of the Thai SCSES-v3.0 in the overall sample. SCSE=self-care self-efficacy.

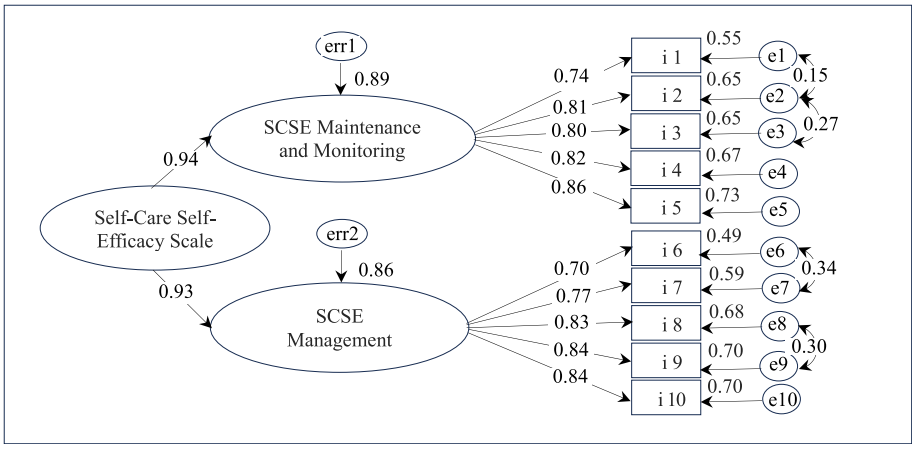

Fig. 3. Second-order factor analysis of final specified two-factor model of the Thai SCSES-v3.0 in the overall sample. SCSE=self-care self-efficacy.

adequate, RMSEA presents poor (Model D1 and Fig. H1 in Appendix H). Even after implementing a trimmed model, which addressed extreme residual covariance in one item pair (items 6 and 7), RMSEA remained inadequate. Added another five item pairs covariances with estimated parameter changes ≥ 0.05 (items 1 and 2, 1 and 4, 4 and 6, 6 and 7, and 8 and 9) in the final specified model, achieving a good fit (Model D2, and Fig. H2 in Appendix H). All factor loadings were high (0.70 − 0.88), consistent with previous unspecified and trimmed models. Given the significant correlation of 0.87 between the two dimensions, a second-order model was analyzed and demonstrated a good fit (Model D3 and Fig H3 in Appendix H). All factor loadings and goodness-of-fit indices remained unchanged. Therefore, a multidimensional model of the Thai SCSES-v3.0 at the second-order factor level was supported.

For robustness, we reanalyzed the overall sample (n = 385), employing methodologies akin to those used in the CFA subsample. As expected, the overall results across all models aligned with the findings in the CFA subsample (Models E1-E3). Factor loadings for the models were consistent before (Fig. 1) and after adjusting for covariances (Fig. 2). The final specified first-order model produced a good fit (Model E2). Similarly, the final specified second-order model demonstrated a good fit (Model E3 and Fig. 3). Table 2 displayed high factor loadings for all items (0.73 − 0.87). Further, all factor loadings and goodness-of-fit indices for both the final specified first-order and second-order models demonstrated comparability.

3.5. Concurrent validity

As expected, the overall SCSES-v3.0 correlated with the Self-Care Maintenance scale (r = 0.51), Self-Care Monitoring scale (r = 0.53), Self-Care Management scale (r = 0.62), and overall SC-CII-v4.c (r = 0.61). Each dimension, SCSE for Maintenance and Monitoring, correlated with self-care scales (r = 0.44 − 0.57) and overall SC-CII-v4.c (r = 0.60). Similarly, SCSE for Management correlated with self-care scales (r = 0.42 − 0.58) and overall SC-CII-v4.c (r = 0.57). All correlations were statistically significant at $P < 0.001$.

3.6. Reliability

3.6.1. Scale internal consistency reliability and item analysis

For the overall sample, both Cronbach's α and McDonald's ω coefficients were consistently excellent at 0.94. All α coefficients were 0.93 if the items were deleted (Appendix I), with no item expected to significantly increase the coefficient if deleted. All items demonstrated adequate discrimination, with the item-to-total corrected correlation ranging between 0.69 and 0.80 (Table 2). For each dimension, the SCSE for Maintenance and Monitoring achieved both Cronbach's α and McDonald ω coefficients of 0.90. Similarly, the SCSE for Management attained both Cronbach's α and McDonald ω coefficients of 0.90. These results were also observed in both the subsample groups (Appendix I).

3.6.2. Test-retest reliability

The intraclass correlation coefficient of each item ranged between 0.94 and 0.98, and 0.96 (95% CI = 0.95 − 0.97) for the overall scale (Appendix B). Insignificant correlations between two consecutive administrations of the scale were found for each item, as well as the overall scale. These findings indicate that the scale has robust test-retest reliability.

3.6.3. Measurements error

SEM and (SD/2) values were as follows: 0.96 (1.99) for SCSE for the Maintenance and Monitoring dimension, 0.96 (1.99) for SCSE for the Management dimension, and 1.83 (3.77) for the overall scale. These measures are considered adequate. The SDC values were 2.72 for the SCSE for the Maintenance and Monitoring dimension, 2.72 for the SCSE for the Management dimension, and 3.75 for the overall scale. These SDC coefficients provide valuable insights into the magnitude of change that can be deemed meaningful across various dimensions and the overall Thai SCSES-v3.0.

4. Discussion

In this study, we evaluated the psychometric properties of the cross-culturally adapted Thai SCSES-v3.0 in individuals with one or multiple chronic conditions, with the primary aim of verifying the dimensionality of the scale. CFA supported structural validity for both the one-factor and two-factor models. However, we advocate the adoption of a two-factor model based on its measurement model and theoretical foundation. The SCSES-v3.0 has the potential to serve as a valid and reliable scale for measuring the motivation factors of self-care across different illness conditions.

To our knowledge, this is the second study to test the psychometric characteristics of the SCSES in Asia countries. We highlight

the meticulous processes undertaken in translation and cross-cultural adaptation, emphasizing the importance of ensuring linguistic accuracy, cultural appropriateness, and clarity of the scale. Its outstanding content validity score is a noteworthy finding, which reflects the success of these efforts, affirming that the scale effectively captures the nuances of self-care self-efficacy in the Thai population with chronic conditions and cultural context. This robust translational validity adds credibility to the scale's applicability across diverse chronic conditions and comprehensive coverage of self-care behaviors and is comparable to the original English version.

The one-factor model's structural validity was comparable to the originally proposed model [31]. While most fit indices improved with the first specified model, a notable concern arose with RMSEA. Adjustments to almost all item pair covariances were needed for satisfactory RMSEA. As RMSEA is sensitive to model misspecifications, precautionary measures were taken before finalization through trimmed models in both a spit-half subsample and an overall sample. These steps aimed to scrutinize the measurement model of the one-factor Thai SCSES-v3.0 compared to its alternative [31]. Across three datasets, these CFA steps lead to the conclusion that the one-factor model may be less suitable.

We demonstrated that the two-factor model of Thai SCSES-v3.0 provides a more concise theoretical measurement model. Like the one-factor model, the final two-factor model demonstrated satisfactory performance after refined covariance adjustment, addressing the RMSEA with fewer item pair covariances. The two-factor model reflects its simplicity and supports its structural validity. Grounded in the relevant self-care measure, specifically the CSE-CSC [41], the dimensions of SCSES-v3.0 aligns with their foundational theory of chronic illness self-care [42]. The scale demonstrated an almost perfect fit with a two-factor model, capturing underlying dimensions of self-care self-efficacy akin to the caregiver version.

Therefore, we propose an updated SCSES-v3.0 model with two dimensions: SCSE for Maintenance and Monitoring, and SCSE for Management. This nuanced approach provides a detailed understanding of self-care and self-efficacy in chronic conditions. Our investigation not only scrutinized the factor structure of the Thai SCSES-v3.0, but also delved into hierarchical relationships within the scale. Noteworthy, similar factor loadings, fit indices, and estimated parameters in first-order and second-order models indicate a robust and stable underlying structure [71]. The second-order model effectively explains correlations among first-order factors, emphasizing scale internal structure. Further, uniformity in factor loadings suggests an equal contribution to latent factors, reinforcing stability [71]. Consistent fit indices and estimated parameters support the validity of the hierarchical model. The two-factor model's higher-order construct underscores scale multidimensionality, aligning with theory-based relationships among dimensions [71]. This insight supports using the scale to assess self-efficacy in self-care maintenance, monitoring, and management in individuals with chronic illnesses. Our findings align with previous studies on self-care scales in specific diseases like heart failure [72], chronic obstructive disease [73], spinal cord injuries [74], and diabetes [75,76], which also identified a two-factor structure for the self-efficacy component.

The Thai SCSES-v3.0 demonstrated robust validity with overall self-care and individual components. Our findings are consistent with specific conditions like heart failure [77,78], chronic obstructive pulmonary disease [40,73], hypertension [79], coronary heart disease [80], and spinal cord injuries [74]. The established concurrent validity supports the scale's accuracy in capturing individuals' beliefs about their capacity for self-care in maintenance, monitoring, and management. The correlations with the SC-CII-v4.c scale further endorse the two-factor structure of the Thai SCSES-v3.0. It can serve as a determinant of self-care, health-related outcomes, and clinical-related outcomes in both observational studies and clinical trials.

The Thai SCSES-v3.0 exhibited excellent internal reliability, aligning with the original study [31]. Both unidimensional and multidimensional indices, regardless of the method employed [63,64], confirmed strong reliability [67], consistent with various disease-specific scales seen in heart failure [72], hypertension [81], coronary heart disease [82], diabetes [75,76], chronic obstructive pulmonary disease [73] and spinal cord injuries [74]. Test-retest reliability, reflected in a high intraclass correlation coefficient, corresponds to disease-specific scales in hypertension [5,81], affirming stability over time. Good precision, with SEM less than SD/2 for both dimensions and overall scale, akin to CSE-CSC [41], ensures accurate assessment, facilitating understanding of individual progress. A small detectable change of 3.75 in the overall scale score indicates clinically meaningful change. Our reliability approaches established SCSES-v3.0 as a reliable scale for assessing self-efficacy, contributing to enhanced self-care in this population. Clinicians and investigators can confidently attribute changes in the scale scores to actual shifts in self-efficacy rather than random fluctuations.

Our analysis confirms Thai SCSES-v3.0 as a reliable, valid instrument. It adapts well across cultures, benefiting Thai individuals with chronic illnesses. This study strengthens the literature by supporting its robust, two-factor model.

4.1. Strengths and limitations

Our study had several strengths. First, we highlight the Thai SCSES-v3.0 scale's robust psychometric properties, including cross-cultural adaptability, validity, and reliability. Structural validity, supported by good fit indices, aligns with the theoretical underpinning. The scale demonstrated stability over time, aiding in precise measurement error estimates and establishing thresholds for clinically significant changes in self-efficacy scores. Second, our multicenter approach, including primary care settings, enhances findings' generalizability, capturing a diverse range of participants and illnesses, thus better representing the target population. Third, the study examined the scale's psychometric properties across various chronic conditions, expanding its utility. Finally, the scale's feasibility, even among those with low education and older adults, encourages its use in assessing self-care motivation across diverse backgrounds.

This study had limitations to consider. First, convenience sampling introduces potential participant selection bias. Second, the study's regional focus in Thailand may limit generalizability due to unique cultural factors. Unequal representation can affect the generalizability of the findings, particularly if certain chronic diseases are overrepresented (i.e., hypertension and diabetes) or underrepresented (i.e., cancer and chronic kidney disease) in the sample. Finally, the overall scale's user-friendliness for laypersons is acknowledged, yet the lack of an inter-rater reliability test among nurses collecting data poses concern about data consistency. These limitations underscore the need for cautious interpretation and consideration of the study's scope and applicability beyond its specific context.

4.2. Implication for practice

The SCSES, developed within the framework of self-care of chronic illness [3,43], assesses motivation for self-care

maintenance, monitoring, and management. Clinicians can use it to gauge self-efficacy levels in patients with single or multiple chronic conditions. Despite its Western origin, the scale has shown cross-cultural applicability in Asian populations. The scale provides insights into patients' confidence in self-care activities. This includes maintaining stability, monitoring changes, and managing symptoms. The scale enables clinicians to pinpoint areas where patients lack confidence, allowing for target support. This individualized approach enhances patient engagement and empowerment, fostering improved self-care and better health outcomes [3]. Psycho-educational interventions, including technology like telehealth and mobile applications, have proven effective in enhancing self-efficacy for various chronic conditions [83].

4.3. Implication for research

This is the second study evaluating the psychometric properties of the SCSES-v3.0 in Asian populations. Further investigations should include participants from diverse regions in Thailand to ensure cultural stability and enhance generalizability. It is crucial to test the scale's measurement invariance in various Asian populations, languages, and contexts to validate its applicability across backgrounds. Conducting psychometric testing within disease-specific populations is essential for broad usability. To accurately interpret scale results and assess intervention impact on self-efficacy, considering SEM and SDC is vital. These metrics provide insights into reliability and sensitivity, facilitating accurate interpretation of scores and meaningful changes over time. To mitigate selection bias, future studies should use random sampling methods like simple random sampling, stratified sampling, or cluster sampling. These methods create a representative sample that minimizes biases from a convenience sample. Furthermore, implementing a stratified sampling can offer a balanced representation of diagnosed chronic illnesses within the sample.

5. Conclusions

This study validates SCSES-v3.0 as a credible scale for assessing self-care self-efficacy among Asians, specifically Thai individuals with chronic conditions. The scale can be utilized to track patients' self-efficacy and tailor interventions for effective self-care practices. However, further psychometric testing is necessary to ensure the generalizability and cultural suitability of the scale in different populations and backgrounds. Additionally, evaluating the measurement invariance of the scale across diverse cultural contexts is needed.

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CRediT authorship contribution statement

Chennet Phonphet: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing - original draft, Writing - review & editing. **Jom Suwanno:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - original draft, Writing - review & editing, Funding acquisition, Supervision, Project administration. **Chonchanok Bunsuk:** Conceptualization, Methodology, Validation, Investigation, Data curation, Writing - review & editing, Funding acquisition. **Wanna Kumanjan:** Conceptualization, Methodology, Validation, Investigation, Writing - review & editing. **Ladda Thiamwong:** Conceptualization, Methodology, Validation, Formal analysis, Funding acquisition, Writing - original draft, Writing - review & editing, English editor, Supervision.

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) used the ChatGPT to improve language and readability with caution. After using this tool, the author(s) reviewed and edited the content as required and took (s) full responsibility for the content of the publication.

Declaration of competing interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Appendices. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijnss.2024.08.010.

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