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Psychometric properties of the Chinese version of the quality of nursing care scale among hospital nurses: a bifactor exploratory structural equation modeling analysis

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Abstract

Background Nurses play an indispensable role in healthcare teams. The quality of nursing care reflects nurses' ability to integrate care and their overall performance in patient care, making it a core objective of clinical nursing. The Chinese version of the Quality of Nursing Care (QNC) scale is a multidimensional assessment tool used for self-evaluation of nursing care quality and holds significant importance in clinical practice. This study aimed to assess the reliability and validity of the Chinese version of the QNC scale among nurses.

Methods This was an observational, cross-sectional, methodological study conducted at three hospitals in southern Taiwan. The 25-item Chinese version of the QNC scale was employed in the study. Data were collected from 944 nurses (response rate: 65.42%) through an online survey conducted between July and August 2022. The factor structure of the QNC scale was evaluated using confirmatory factor analysis (unidimensional, independent cluster model, higher-order, and bifactor) and first-order, higher-order, and bifactor ESEM. Model comparisons were conducted to determine the best-fitting factor structure.

Results The bifactor ESEM provided the best fit for the QNC scale, consisting of a general QNC factor and seven specific factors: patient satisfaction, health promotion, complication prevention, well-being and self-care, functional readaptation, nursing care organization, and responsibility and rigor. Some items exhibited significant cross-loadings, highlighting the model's ability to capture the multidimensional nature of nursing care quality.

Conclusions The bifactor ESEM model demonstrated the best model fit for the Chinese version of the QNC scale, offering a reliable and interpretable representation of the multidimensional nature of nursing care. The validated scale provides a valuable tool for assessing nursing care quality in clinical practice.

Keywords Bifactor model, Chinese, Confirmatory factor analysis (CFA), Exploratory structural equation modeling (ESEM), Hospital, Nurses, Quality of nursing care

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Background

Quality of care (QOC) is a subjective, complex, and multidimensional concept describing the extent to which healthcare services achieve desired health outcomes for individuals and populations [1, 2]. Enhancing QOC is a challenging, multifaceted endeavor [3]. Current QOC research often relies on data from hospital information systems, focusing on quality indicators such as in-hospital mortality, unplanned 30-day readmissions, complications, length of stay, fall rates, pressure ulcers, restraint use, unplanned tube removal, and infection rates [4]. Among these, patient mortality is the most commonly used measure to assess the quality of nursing care (QNC) in hospitals [5]. However, because various medical factors influence patient mortality, this measure may not fully capture the quality, effectiveness, specificity, or complexity of nursing care [6]. Nurses constitute the largest proportion of healthcare teams, accounting for approximately one-third of the time spent on direct patient care and spending more time with hospitalized patients than any other healthcare staff [7]. Nurses are integral to all aspects of hospital care quality, including patient care, surgical assistance, bedside management, and medication administration. Nurses' perceptions of the QOC they provide significantly influence their work practices, job satisfaction, and retention [8]. The quality of nursing care is crucial to patient outcomes and safety; higher QOC not only enhances satisfaction among patients, families, and healthcare staff but also improves the performance of healthcare institutions [1, 9].

QNC is a multidimensional construct that reflects the comprehensive nature of nursing practice [10]. It encompasses skilled, safe, holistic, ethical, collaborative, personalized, and interpersonal care processes, each designed and delivered based on the best available evidence to achieve positive patient outcomes, optimize health, alleviate symptoms, or ensure a peaceful death [11]. Despite its recognized importance, QNC lacks a universally accepted definition [12]. The essence of QNC is complex, often explored through "structure," "process," and "outcome." Structure refers to factors like skill mix, time, and workload (human resources). Process captures nurses' perceptions of care quality complexity, including teamwork, interdisciplinary processes, and competence. Outcome reflects nurses' views on nursing care quality, defined by patient satisfaction, meeting patient needs, and providing information [13]. Measuring quality in nursing practice is essential for improving patient outcomes [14]. However, Juanamasta et al. [15] noted that achieving consensus on the QNC concept may be challenging owing to differing perspectives between nurses and patients. Furthermore, patients' limited medical knowledge may restrict their ability to assess care quality accurately [16]. Tafreshi et al. [17] defined QNC as the provision of safe, standard-based care to ensure patient satisfaction, while Burhans and Alligood [9] emphasized meeting human needs with empathy and responsibility. Juanamasta et al. [15] described QNC as the degree of excellence in nursing practices for meeting patient needs. Other descriptions include demonstrating competence, professionalism, and commitment based on professional standards [1]; providing direct patient care and assessing the needs of patients and families to achieve optimal outcomes [18]; as well as ensuring high-quality nursing care through quality assurance, improved outcomes, patient satisfaction, and harm prevention [19].

Despite the widespread use of QNC scales, consensus on core components remains lacking. Early research highlighted patient satisfaction (PS) as a key quality factor, though many PS tools are provider-focused, limiting their value for improvement [20]. Differences between patient and nurse perceptions also affect QNC assessments [21]. The SERVQUAL scale, commonly used for service quality, lacks specific healthcare and nursing quality aspects [1, 22]. While nurse self-assessment is another method [5], comprehensive QNC tools remain scarce. Stalpers et al. [23] identified a positive association between objective nursing quality indicators and subjective QNC perceptions. Although single-item questions are commonly used to assess nurses' perceptions, this measurement approach has limitations given the complexity of care [5]. Liu et al. [22] developed a 48-item QNC scale and identified six dimensions through factor analysis: staff characteristics, task-oriented activities, human-oriented activities, physical environment, patient outcomes, and preconditions. Gaalan et al. [24] utilized a 58-item, seven-point Likert Good Nursing Scale with nurse practitioners, identifying six self-assessed QNC dimensions: staff characteristics, nursing-related activities, prerequisites, physical environment, progression of the nursing process, and family cooperation. However, the high item count in these scales may reduce their clinical practicality. Based on literature related to nursing activities and the quality of nursing care, Martins et al. [25] developed the "scale of perception of nursing activities that contribute to nursing care quality" (EPAECQC scale) with a focus on the nursing process. This scale primarily assesses the quality of nursing processes through nurses' self-evaluation of care activities across seven dimensions: PS, health promotion (HP), prevention of complications (PC), well-being and self-care (SC), functional readaptation (FR), nursing care organization (NCO), and responsibility and rigor (RR). These dimensions reflect the key professional activities in the nursing process and the multidimensional nature of care quality. Alshehry et al. [26] validated this 25-item scale with Saudi nurses, confirming its cross-cultural applicability. Although originally based on Portuguese nursing activities, these activities align closely with international nursing standards, making the scale widely useful for assessing QNC.

EFA and CFA are foundational methods in factor analysis [27]. EFA is commonly used in the initial stages of creating psychological tests where theoretical underpinnings might be weak, while CFA is a widely accepted method for evaluating psychological structures and validating predefined theoretical models. EFA is prone to misspecification from incorrect factor selection, and CFA faces criticism for the inflation of factor correlations due to forced zero cross-loadings [28, 29]. Achieving good model fit with multidimensional scales in CFA remains challenging, and although modification indices can improve fit, they frequently lack theoretical support, complicating the interpretation of factor overlaps [30–32]. Advancements in statistical software have introduced Exploratory Structural Equation Modeling (ESEM) and its bifactor variant, making their application more accessible [31]. ESEM effectively addresses multidimensionality by allowing cross-loadings between indicators and non-target constructs, thus improving discriminant validity through more precise and lower estimates of factor correlations [28, 33]. Morin et al. [33] expanded this by developing a more comprehensive bifactor ESEM approach, which merges bifactor and ESEM models into a unified analytical framework. This integration examines both global factors (G-factor) that influence all items and specific factors (S-factors) pertinent to particular dimensions [33, 34]. Although these methods have been widely applied in psychometric research [35, 36], their use in nursing studies remains limited. This study aimed to evaluate the validity and reliability of the Chinese version of the QNC scale among Taiwanese nurses through comparative model analysis. It was hypothesized that the Chinese version of the QNC scale would demonstrate acceptable validity and reliability among Taiwanese nurses.

Methods

Study design

This research employed a cross-sectional design to collect data from nurses working in inpatient units at three hospitals in southern Taiwan between July and August 2022. Participation was voluntary, and responses were kept confidential.

Study setting and sampling

In this study, the sample size was determined using Kline's [37] rule of thumb, suggesting a participant-to-parameter ratio of 10:1. With 25 observed variables, a minimum of 250 participants was thus required. With data collected from 944 nurses, semPower (R, version 4.4.1; R Core Team, Vienna, Austria) was used to calculate the post hoc power for the root mean square error of approximation (RMSEA) [38]. The results indicated a model power of 0.99, confirming that the sample size was more than sufficient.

Inclusion and exclusion criteria

The inclusion criteria required nurses to be over 20 years old and to have at least six months of hospital work experience. The exclusion criteria were as follows: (1) nurses whose roles did not involve direct inpatient care (such as those working in supply rooms or operating rooms), (2) nurses on extended leave during the data collection period, and (3) nurses in positions at or above the assistant head nurse level.

Data collection

Following ethics approval, the nursing departments of three hospitals distributed QR codes for an online survey. To ensure participant confidentiality and data security, the online survey platform utilized encryption protocols, and all collected data were stored on secure servers with restricted access. Personal identifiers were removed during data processing, and only aggregated data were used for analysis. A total of 1,443 questionnaires were distributed, resulting in 951 responses, of which 944 were valid, yielding an effective response rate of 65.42%. The survey took approximately 15 min to complete. Quality control procedures included screening for missing data, identifying outliers and invalid responses, and verification of data entry and coding accuracy. The participants received a virtual gift card worth NT$100 (approximately US$3.3) as compensation.

Instrument

The QNC scale used in this study was based on the EPAECQC developed by Martins et al. [25], comprising 25 items across seven dimensions: PS (3 items, $\alpha = 0.74$), HP (3 items, $\alpha = 0.74$), prevention of complication (PC, 3 items, $\alpha = 0.78$), well-being and self-care (SC; 4 items, $\alpha = 0.86$), FR (4 items, $\alpha = 0.83$), NCO (2 items, $\alpha = 0.68$), and RR (6 items, $\alpha = 0.86$). This scale adopts a four-point Likert rating system, with higher scores indicating better QNC. The overall Cronbach's α coefficient is 0.94, demonstrating good internal consistency [25]. The original scale was translated into Chinese with permission from Professor Martins. This study adhered to Brislin's [39] translation model, employing translation and back-translation procedures to ensure accuracy and consistency. Content validity was evaluated by a panel of seven experts, including four experienced nurses, two nursing professors, and one hospital director. The scale demonstrated a content relevance content validity index (CVI) of 1.00 and a content appropriateness CVI of 0.96, both exceeding the recommended threshold of 0.90 [40], indicating strong content validity.

Statistical analysis

Data were analyzed using descriptive statistics, including mean, standard deviation (*SD*), skewness, kurtosis, and Pearson correlation coefficients. Models were estimated using maximum likelihood in Mplus 8.10 [41]. Following established decision tree methods [34, 35, 42], we compared seven models: (1) unidimensional CFA (baseline); (2) seven-factor first-order CFA (ICM-CFA); (3) higher-order CFA; (4) bifactor CFA (G factor and seven S factors); (5) seven-factor first-order ESEM; (6) higher-order ESEM; and (7) bifactor ESEM. In CFA models, items loaded only on their target factors with factor correlations are estimated. Higher-order models specified seven first-order factors converging into a higher-order QNC factor. Bifactor CFA included one G factor and seven S factors with restricted cross-loadings. ESEM models used target rotation with ideal factor loadings above 0.50 (minimum 0.30) [32, 35]. In bifactor ESEM, items were defined by one G factor and seven S factors with free cross-loadings under orthogonal rotation. Cross-loadings above 0.40 warranted discussion, and those above 0.50 required detailed examination [41]. Model selection followed Alamer and Marsh's [43] decision-tree approach: if CFA showed a good fit, all models were compared; if poor, only ESEM models were considered. The final selection integrated empirical results and theoretical foundations [31].

Models reported standardized factor loadings (λ) to indicate item-factor associations. Model fit was evaluated using χ^2, CFI, TLI, SRMR, and RMSEA with its 90% CI. Given the sensitivity of χ^2 to sample size, model fit was primarily assessed using CFI/TLI (≥ 0.95 excellent, ≥ 0.90 acceptable) and RMSEA (≤ 0.06 excellent, ≤ 0.08 acceptable) [44]. Lower AIC, BIC, and SABIC values indicated a better fit [37]. Model comparisons favored parsimony when CFI/TLI decreased by ≤ 0.01 and RMSEA increased by ≤ 0.015 [32]. In ESEM, convergent validity was indicated by higher target factor loadings and discriminant validity by non-significant non-target loadings [35]. The reliability of the QNC scale was assessed using McDonald's omega (ω) and explained common variance (ECV) [45]. Omega provides a more accurate measure of reliability than Cronbach's α for multidimensional scales with orthogonal factors [46, 47]. Hierarchical omega (OmegaH) indicates the proportion of total score variance explained by the general factor (G-factor) [48]. ECV was calculated to determine the appropriateness of using a composite total score. Omega values above 0.70 indicated good reliability [31], and ECV values above 0.70 suggested a strong general factor [45]. Reliability indices were calculated using the BifactorIndicesCalculator package in R (version 4.4.1; R Core Team).

Ethical approval and consent to participate This study complied with the ethical guidelines of the Declaration of Helsinki and received approval from the Ethics Review Committee of a medical center on June 9, 2022 (IRB number: 11104-014). This approval was also recognized by two other hospitals within the same healthcare system. Participants accessed the online survey via a QR code, and informed consent was implied upon completion of the questionnaire.

Results

Descriptive statistics

The QNC scale item mean ranged from 2.87 to 3.65 on a 1–4 scale. Skewness and kurtosis values were all below 2.00, indicating no severe violation of data normality (Table 1). Pearson correlations between indicators ranged from 0.30 to 0.70, indicating moderate to strong associations.

Assessing measurement models

Model fit indices

This study evaluated the psychometric properties of the Chinese QNC scale by testing seven measurement models: unidimensional, first-order, second-order, and bifactor CFA, as well as first-order, second-order, and bifactor ESEM. Table 2 summarizes the fit indices for the CFA and ESEM models. Four structures were tested in the CFA models: unidimensional (Model 0), seven-factor (Model 1), higher-order (Model 2), and bifactor (Model 3). The unidimensional model showed the poorest fit (χ^2 = 4466.39, CFI = 0.78, TLI = 0.76, RMSEA = 0.13 [90% CI: 0.124, 0.130]), indicating that the QNC scale is not unidimensional. The seven-factor model showed considerable improvement (χ^2 = 2124.73, CFI = 0.90, TLI = 0.88, RMSEA = 0.09 [90% CI: 0.085, 0.093]) but did not fully meet the ideal criteria. The higher-order model performed slightly worse than the seven-factor model (χ^2 = 2411.62, CFI = 0.89, TLI = 0.87, RMSEA = 0.09 [90% CI: 0.089, 0.095]). The bifactor CFA model (χ^2 = 2067.00, CFI = 0.90, TLI = 0.89, RMSEA = 0.09 [90% CI: 0.084, 0.091]) showed the best fit among CFA models, although it still did not fully meet the ideal standards.

In the ESEM models, the seven-factor ESEM (Model 4) demonstrated a good fit (χ^2 = 753.11, CFI = 0.97, TLI = 0.93, RMSEA = 0.07 [90% CI: 0.061, 0.071]). However, the higher-order ESEM (Model 5) did not meet ideal standards (χ^2 = 1141.98, CFI = 0.95, TLI = 0.91, RMSEA = 0.08 [90% CI: 0.074, 0.082]). In contrast, the bifactor ESEM (Model 6) showed the best performance (χ^2 = 507.86, CFI = 0.98, TLI = 0.95, RMSEA = 0.06 [90% CI: 0.051, 0.061]), with the lowest AIC, BIC, and SABIC

Table 1 Skewness and kurtosis for each item of the Chinese QNC scale ($n = 944$)

Factor	Item		Skewness	Kurtosis
PS				
	y1	Nurses show respect for the abilities, beliefs, values and desires of individual patient while providing nursing care.	-0.03	-1.09
	y2	Nurses are constantly seeking to show empathy in interactions with the patient (patient's family).	0.20	-0.47
	y3	Nurses involve significant cohabitants of individual patient in the nursing care process.	-0.17	-0.47
HP				
	y4	Nurses identify the health situation of the population and the resources of patient/family and community	-0.31	0.20
	y5	Nurses use the hospitalization time to promote healthy lifestyles	-0.13	-0.01
	y6	Nurses provide information that generates cognitive learning and new abilities in the patient.	-0.05	0.26
PC				
	y7	Nurses identify potential problems of the patient.	-0.02	0.46
	y8	Nurses prescribe and perform interventions to prevent complications.	-0.65	1.33
	y9	Nurses evaluate the interventions that help prevent problems or minimize undesirable effects.	0.15	0.35
SC				
	y14	Nurses identify patient's problems that will help improve the patient's well-being and daily activities.	0.08	0.62
	y15	Nurses prescribe and perform interventions that will help improve the patient's well-being and daily activities.	-0.66	1.37
	y16	Nurses evaluate the interventions that help improve the patient's well-being and daily activities.	-0.07	0.49
	y18	Nurses address problematic situations identified that will help improve the patient's well-being and daily activities.	0.32	0.09
FR				
	y20	Nurses ensure continuity of nursing service provision.	-0.03	0.57
	y21	Nurses plan discharge of hospitalized patients in health institutions, according to each patient's needs and community resources.	-0.42	0.01
	y22	Nurses optimize the abilities of the patient and his/her significant cohabitants to manage the prescribed therapy.	-0.24	0.98
	y23	Nurses teach, instruct and train patients for their individual adaptation and teach, instruct and train patients on what is required for their functional readaptation.	0.01	0.62
NCO				
	y24	Nurses know how to handle the nursing record system.	-0.73	-1.18
	y25	Nurses know the hospital's policies.	0.09	-0.43
RR				
	y10	Nurses show technical/scientific rigor in the implementation of nursing interventions aiming to prevent complications	0.09	0.51
	y11	Nurses refer problematic situations to other professionals, according to the social mandates.	-0.37	1.07
	y12	Nurses supervise the activities that support nursing interventions and the activities they delegate.	-0.00	1.02
	y13	Nurses show responsibility for the decisions they make and for the acts they perform and delegate, aiming to prevent complications.	-0.12	0.54
	y17	Nurses show technical/scientific rigor in the implementation of nursing interventions that help improve the patient's well-being and daily activities.	0.06	0.40
	y19	Nurses show responsibility for the decisions they make and for the acts they perform and delegate, aiming to ensure well-being and self-care of patients.	0.00	0.50

Note PS = patient satisfaction; HP = health promotion; PC = prevention of complications; SC = well-being and self-care; FR = functional readaptation; NCO = nursing care organization; RR = responsibility and rigor

values, confirming it as the most fitting model. As shown in Table 3, the seven-factor first-order ESEM (Model 4) significantly improved model fit over the ICM-CFA (Model 1) (ΔCFI = + 0.068, ΔTLI = + 0.052, ΔRMSEA = -0.022) and the bifactor CFA (Model 3) (ΔCFI = + 0.065, ΔTLI = + 0.049, ΔRMSEA = -0.021). Furthermore, the bifactor ESEM (Model 6) demonstrated even greater improvement, with better-fit indices compared to the bifactor CFA (ΔCFI = + 0.077, ΔTLI = + 0.067, ΔRMSEA = -0.031) and the seven-factor ESEM (ΔCFI = + 0.012, ΔTLI = + 0.018, ΔRMSEA = -0.010). These results confirm the bifactor ESEM (Model 6) as the best-fitting model.

Comparison of alternative models' factor structure

Table 4 presents the factor correlations for the ICM-CFA and first-order ESEM models of the QNC scale. The ICM-CFA model exhibited higher correlations among factors compared to the ESEM model. In the ESEM model, only the NCO factor showed significant

Table 2 Goodness-of-fit statistics for the estimated models on the QNC scale

Model	Type	χ^2	df	CFI	TLI	RMSEA[90% CI]	SRMR	AIC	BIC	SABIC	Meets criteria
Confirmatory factor analysis models											
Model 0	Unidimensional first-order CFA	4466.39	275	0.78	0.76	0.13 [0.124, 0.130]	0.06	25459.08	25822.84	25584.65	No
Model 1	Seven first-order CFA	2124.73	254	0.90	0.88	0.09 [0.085, 0.093]	0.04	23159.42	23625.03	23320.14	No
Model 2	Higher-order CFA	2411.62	268	0.89	0.87	0.09 [0.089, 0.095]	0.05	23418.31	23816.02	23555.59	No
Model 3	Bifactor CFA	2067.00	253	0.90	0.89	0.09 [0.084, 0.091]	0.05	23103.69	23574.15	23266.08	No
Exploratory structural equation models											
Model 4	Seven first-order ESEM	753.11	148	0.97	0.93	0.07 [0.061, 0.071]	0.02	21999.80	22979.53	22337.99	Yes
Model 5	Higher order ESEM	1141.98	169	0.95	0.91	0.08 [0.074, 0.082]	0.12	22346.67	23224.54	22649.70	No
Model 6	Bifactor ESEM	507.86	128	0.98	0.95	0.06 [0.051, 0.061]	0.01	21794.55	22871.28	22166.22	Yes

Note ESEM = exploratory structural equation modeling; CFA = confirmatory factor analysis; χ^2 = chi-square; df = degrees of freedom; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; CI = confidence interval; SRMR = standardized root mean square residual; AIC = Akaike information criterion; BIC = Bayesian information criterion; SABIC = sample-size-adjusted Bayesian information criterion

Table 3 Comparison of CFA and ESEM models

Model comparison	$\Delta\chi^2$	Δdf	*p*	ΔCFI	ΔTLI	ΔRMSEA	ΔSRMR	ΔAIC	ΔBIC	ΔSABIC
M4 vs. M1	-1371.61	-106	0.000	0.068	0.052	-0.022	-0.021	-1159.61	-645.50	-982.15
M4 vs. M3	-1313.88	-105	0.000	0.065	0.049	-0.021	-0.025	-1103.88	-594.62	-928.09
M6 vs. M3	1559.14	125	0.000	0.077	0.067	-0.031	-0.032	-1309.14	-702.87	-1099.86
M6 vs. M4	-245.25	20	0.000	0.012	0.018	-0.010	-0.007	-205.25	-108.25	-171.77

Note M = model; χ^2 = chi-square; df = degrees of freedom; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; AIC = Akaike information criterion; BIC = Bayesian information criterion; SABIC = sample-size-adjusted Bayesian information criterion

Table 4 Standardized factor correlations for ICM-CFA and ESEM of the QNC scale

Factor	1.	2.	3.	4.	5.	6.	7.
1. PS	–	0.79^{***}	0.66^{***}	0.65^{***}	0.68^{***}	0.57^{***}	0.63^{***}
2. HP	0.35^{***}	–	0.77^{***}	0.80^{***}	0.84^{***}	0.53^{***}	0.69^{***}
3. PC	0.37^{***}	0.40^{***}	–	0.94^{***}	0.87^{***}	0.60^{***}	0.80^{***}
4. SC	0.41^{***}	0.41^{***}	0.59^{***}	–	0.95^{***}	0.59^{***}	0.79^{***}
5. FR	0.46^{***}	0.46^{***}	0.50^{***}	0.55^{***}	–	0.62^{***}	0.80^{***}
6. NCO	0.08^{*}	0.07	0.07	0.14^{***}	-0.01	–	0.71^{***}
7. RR	0.57^{***}	0.40^{***}	0.59^{***}	0.64^{***}	0.62^{***}	0.24^{***}	–

Note ICM-CFA (above the diagonal) and ESEM (below the diagonal); ICM-CFA = independent cluster model–confirmatory factor analysis; ESEM = exploratory structural equation modeling; PS = patient satisfaction; HP = health promotion; PC = prevention of complications; SC = well-being and self-care; FR = functional readaptation; NCO = nursing care organization; RR = responsibility and rigor. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$

relationships with a few other factors, including PS (CFA: $r = .57$; ESEM: $r = .08$) and SC (CFA: $r = .59$; ESEM: $r = .14$). Table 5 shows that in the ICM-CFA model, the highest loadings were for RR-item 10 ($\lambda = 0.89$), SC-item 14 ($\lambda = 0.87$), and HP-item 5 ($\lambda = 0.85$), while NCO-item 24 had the lowest ($\lambda = 0.59$). Most items had strong loadings exceeding 0.70. In the first-order ESEM model, target loadings for factors ranged as follows: PS ($\lambda = 0.48$–0.74), HP ($\lambda = 0.43$–0.54), PC ($\lambda = 0.20$–0.92), SC ($\lambda = 0.28$–0.67), FR ($\lambda = 0.28$–0.54), NCO ($\lambda = 0.22$–0.25), and RR ($\lambda = 0.60$–0.99). Notably, five items had loadings below 0.30, and several items exhibited cross-loadings exceeding 0.30, indicating multidimensionality. Therefore, a further comparison between the first-order ESEM and bifactor-ESEM models was recommended.

As shown in Table 5, the G factor in the bifactor CFA model had loadings (λ) from 0.39 to 0.85, while S factors ranged from 0.07 to 0.82. In the bifactor ESEM model (Fig. 1; Table 5), the G factor had λ values from 0.40 to 0.84, and S factors had loadings as follows: PS (0.42–0.57), HP (0.37–0.42), PC (0.08–0.67), SC (0.20–0.37), FR (0.12–0.44), NCO (0.40–0.53), and RR (0.08–0.69). The G factor generally had stronger λ values than the S factors. Some items, such as PC-item 7, SC-item 15, and FR-items 20 and 23, had relatively low λ values. In a few cases, cross-loadings were higher than the lowest target factor loadings. Overall, cross-loadings in the bifactor ESEM model were smaller than in the bifactor CFA model, remaining below primary target loadings and under 0.30. The first-order ESEM model showed some

Table 5 Parameter estimates for four QNC measurement models

Factor	Item	ICM-CFA	First-order ESEM							Bifactor CFA		Bifactor ESEM							
		λ	PS-λ	HP-λ	PC-λ	SC-λ	FR-λ	NCO-λ	RR-λ	S-λ	G-λ	PS-λ	HP-λ	PC-λ	SC-λ	FR-λ	NCO-λ	RR-λ	G-λ
PS	y1	**0.70*****	**0.74*****	0.01	0.09**	-0.02	-0.04	0.10**	-0.02	**0.54*****	**0.49*****	**0.53*****	0.02	0.02	-0.04	-0.07**	0.17***	0.01	**0.50*****
	y2	**0.79*****	**0.74*****	0.13***	0.06*	0.06	-0.10**	0.08**	-0.01	**0.63*****	**0.56*****	**0.57*****	0.08**	-0.01	0.01	-0.08**	0.08**	0.03	**0.56*****
	y3	**0.77*****	**0.48*****	0.37***	0.04	-0.02	0.06	-0.06*	0.04	**0.40*****	**0.60*****	**0.42*****	0.21***	-0.03	-0.07	0.07**	-0.13***	-0.04	**0.61*****
	(ω)	(0.80)								(0.80)		(0.82)							
HP	y4	**0.79*****	0.24***	**0.54*****	0.07*	-0.04	0.17***	-0.08**	0.06*	**0.44*****	**0.66*****	0.18***	**0.37*****	-0.01	-0.07**	0.12***	-0.12***	-0.07***	**0.67*****
	y5	**0.85*****	0.20***	**0.53*****	-0.04	0.14*	0.13***	-0.05	0.11***	**0.49*****	**0.72*****	0.13***	**0.39*****	-0.08***	0.04**	0.06*	-0.08**	-0.03	**0.72*****
	y6	**0.81*****	0.18***	**0.43*****	0.11***	0.07	0.13**	0.01	0.11**	**0.37*****	**0.72*****	0.06*	**0.42*****	0.02	0.01	-0.00	0.05*	-0.02	**0.72*****
	(ω)	(0.86)								(0.86)			(0.86)						
PC	y7	**0.75*****	0.05	0.21***	**0.20*****	0.19***	0.16***	-0.03	0.16***	**0.07*****	**0.74*****	-0.05	0.16***	**0.08****	0.08**	0.03	0.00	-0.00	**0.72*****
	y8	**0.76*****	0.07**	-0.04	**0.92*****	-0.01	-0.03	-0.01	0.03	**0.43*****	**0.69*****	0.00	-0.06**	**0.67*****	0.03	-0.02	-0.04*	0.00	**0.69*****
	y9	**0.88*****	0.09**	0.02	**0.40*****	0.33***	0.03	-0.02	0.16***	**0.33*****	**0.81*****	-0.03	-0.01	**0.22*****	0.17***	-0.05*	0.03	0.01	**0.79*****
	(ω)	(0.83)								(0.84)				(0.87)					
SC	y14	**0.87*****	0.02	*0.08***	0.18***	**0.49*****	0.12**	-0.01	0.16***	**0.14*****	**0.85*****	-0.09***	0.04	0.07**	**0.27**$*^{**}$	-0.02	0.03	0.00	**0.82*****
	y15	**0.77*****	-0.08**	0.10***	0.50***	**0.28*****	0.16***	0.02	-0.00	**0.15*****	**0.74*****	-0.11***	0.05	0.31***	**0.20*****	0.09**	-0.07*	-0.02	**0.72*****
	y16	**0.89*****	0.04	0.09***	0.05	**0.67*****	0.19***	-0.03	0.06*	**0.50*****	**0.85*****	-0.03	-0.02	-0.03	**0.37*****	0.04*	-0.08***	-0.04*	**0.84*****
	y18	**0.86*****	0.14***	-0.01	0.05	**0.54*****	0.25***	0.07*	0.07*	**0.17*****	**0.84*****	0.04*	-0.06**	-0.01	**0.29*****	0.09***	0.05*	-0.01	**0.82*****
	(ω)	(0.91)								(0.91)					(0.92)				
FR	y20	**0.82*****	0.14***	-0.02	0.03	0.47***	**0.28*****	0.03	0.11**	**0.08*****	**0.81*****	0.08**	-0.13***	-0.04	0.23***	**0.14*****	-0.02	0.01	**0.79*****
	y21	**0.73*****	-0.13***	0.33***	0.05	0.10	**0.54*****	-0.01	0.04	**0.24*****	**0.68*****	-0.09***	0.16***	-0.02	-0.00	**0.44*****	-0.16***	-0.06**	**0.68*****
	y22	**0.83*****	0.01	0.10	0.06*	0.20**	**0.48*****	0.07*	0.13*	**0.61*****	**0.77*****	-0.05*	0.01	-0.03	0.04	**0.31*****	0.06*	0.00	**0.77*****
	y23	**0.75*****	0.07*	0.11*	0.12**	0.21***	**0.32*****	0.06	0.10*	**0.15*****	**0.73*****	-0.05	0.09**	0.02	0.07*	**0.12****	0.13***	-0.02	**0.72*****
	(ω)	(0.85)								(0.87)						(0.87)			
NCO	y24	**0.59*****	0.34***	-0.25***	0.01	0.11*	0.07	**0.22****	0.15**	**0.33*****	**0.39*****	0.12***	-0.11***	-0.02	0.01	-0.10***	**0.53*****	0.08**	**0.40*****
	y25	**0.81*****	0.17***	-0.05	0.02	-0.05	0.16*	**0.25*****	0.37***	**0.82*****	**0.54*****	0.04	0.02	-0.02	-0.07**	0.04	**0.40*****	0.23***	**0.54*****
	(ω)	(0.67)								(0.73)							(0.68)		
RR	y10	**0.89*****	-0.04	0.04	0.04	0.06	-0.21***	-0.15***	**0.99*****	**0.60*****	**0.71*****	-0.07**	-0.12***	-0.04	-0.16***	-0.22***	-0.07**	**0.35*****	**0.79*****
	y11	**0.70*****	0.09**	-0.06	0.07*	-0.20***	0.35***	-0.16**	**0.60*****	**0.26*****	**0.65*****	-0.00	-0.06	-0.03	-0.22***	0.05	0.03	0.08	**0.70*****
	y12	**0.81*****	0.07*	-0.11***	0.02	-0.06	0.26***	-0.09*	**0.72*****	**0.34*****	**0.72*****	0.01	-0.13***	-0.05*	-0.13***	0.02	0.02	**0.20*****	**0.77*****
	y13	**0.78*****	-0.07*	0.14**	0.04	-0.01	-0.00	0.49***	**0.65*****	**0.31*****	**0.68*****	0.05**	0.10***	0.07***	0.14***	0.14***	0.17***	**0.69*****	**0.62*****
	y17	**0.89*****	-0.03	0.01	0.00	0.07*	-0.15***	-0.19***	**0.98*****	**0.58*****	**0.72*****	-0.08**	-0.16***	-0.08***	-0.18***	-0.21***	-0.09**	0.**32*****	**0.81*****
	y19	**0.83*****	-0.05	0.09*	-0.01	0.06*	-0.05	0.34***	**0.75*****	**0.36*****	**0.72*****	0.02	0.02	0.01	0.08*	0.03	0.13***	**0.55*****	**0.69*****
	(ω)	(0.92)								(0.94)	(0.97)							(0.96)	(0.98)

Note Boldface indicates target ESEM factor loadings; ICM = independent cluster model; CFA = confirmatory factor analysis; ESEM = exploratory structural equation modeling; G = global factor estimated as part of a bifactor model; S = specific factor estimated as part of a bifactor model; λ = standardized factor loadings; S.E. = standard error; ω = omega coefficient for model-based composite reliability (shown in parentheses); PS = patient satisfaction; HP = health promotion; PC = prevention of complications; SC = well-being and self-care; FR = functional readaptation; NCO = nursing care organization; RR = responsibility and rigor. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$

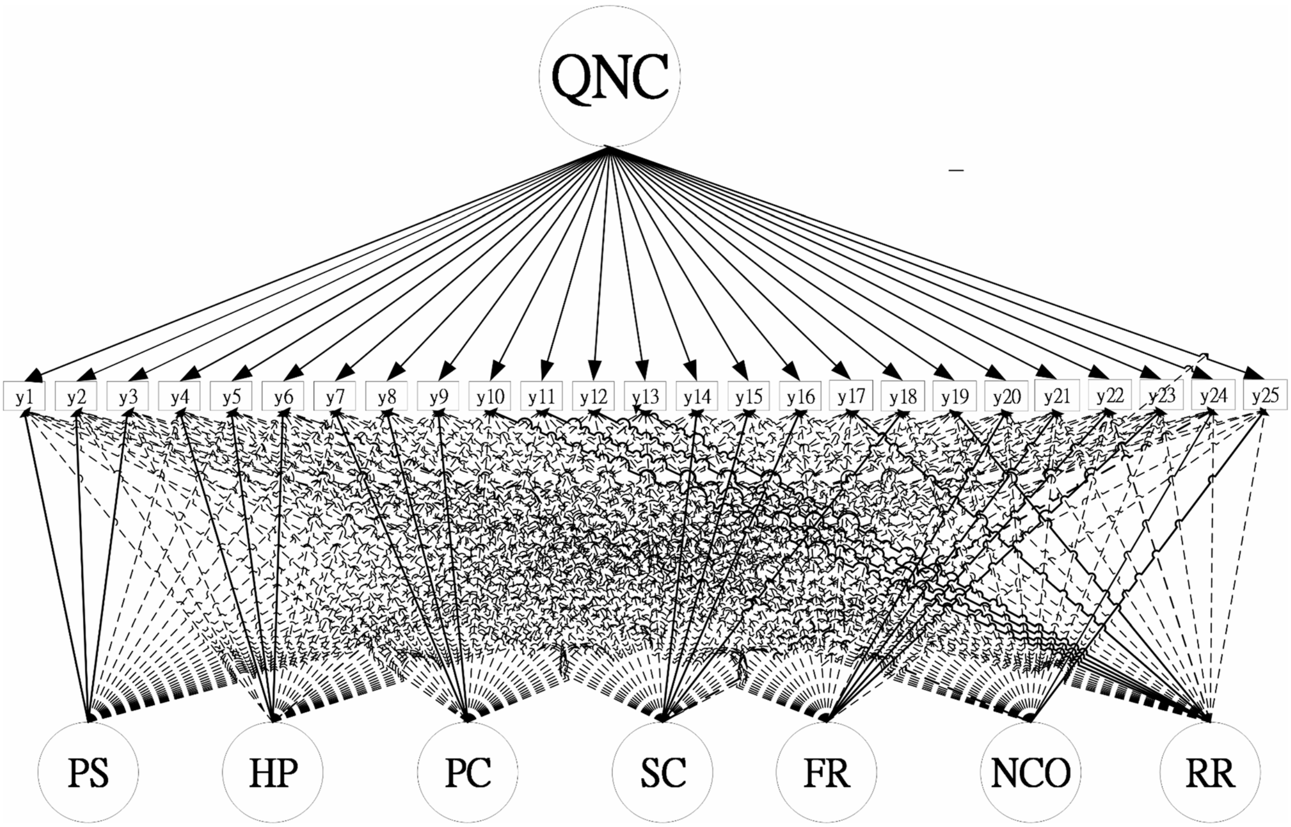

Fig. 1 Simplified factor loading diagram of the bifactor ESEM model for the QNC scale, which includes a general factor and seven specific factors for individual items. Note Circles represent latent factors, and squares represent observed variables (scale items). Error terms were specified but not shown. Bold solid lines indicate target factor loadings, while dashed lines represent cross-loadings for non-target factors. Each item is influenced by both the general QNC factor and seven specific factors: patient satisfaction (PS), health promotion (HP), prevention of complications (PC), well-being and self-care (SC), functional readaptation (FR), nursing care organization (NCO), and responsibility and rigor (RR)

Table 6 Reliability indices for different model specifications

Model	**Unidimensional CFA**	**7-factor CFA**		**Bifactor ESEM**		
Indices	**Chrobach α**	**CR (ω)**	**AVE**	**ω**	**ωH**	**ECV**
QNC	0.96	0.96	0.51	0.98	0.94	0.71
PS	0.79	0.80	0.57	0.82	0.36	0.05
HP	0.86	0.86	0.67	0.86	0.17	0.04
PC	0.83	0.84	0.64	0.87	0.14	0.04
SC	0.90	0.91	0.72	0.92	0.09	0.03
FR	0.85	0.86	0.61	0.87	0.02	0.02
NCO	0.65	0.66	0.50	0.68	0.34	0.04
RR	0.92	0.92	0.67	0.96	0.21	0.07

Note: CFA = confirmatory factor analysis; ESEM = exploratory structural equation modeling; CR = composite reliability; AVE = average variance extracted; ω = omega; ωH = hierarchical omega; ECV = explained common variance; QNC = quality of nursing care; PS = patient satisfaction; HP = health promotion; PC = prevention of complications; SC = well-being and self-care; FR = functional readaptation; NCO = nursing care organization; RR = responsibility and rigor. $^{*}p<.05$. $^{**}p<.01$. $^{***}p<.001$

cross-loadings over 0.30, indicating multidimensionality. In contrast, the bifactor ESEM model, with a dominant G factor, reduced S factor loadings and cross-loadings (Table 5), offering a better fit and clearer factor structure than the first-order ESEM, ICM-CFA, and bifactor CFA models. These results affirm the QNC scale's multidimensional nature.

Reliability

As shown in Table 6, reliability analysis of the QNC scale showed a Cronbach's α of 0.96 for unidimensional CFA. For the seven-factor CFA, omega values were: PS = 0.80, HP = 0.86, PC = 0.84, SC = 0.91, FR = 0.86, NCO = 0.66, and RR = 0.92. In the bifactor ESEM model, the G factor's omega (ω = 0.98) and all S factors except NCO (ω = 0.68) exceeded the threshold. Omega values for S factors were:

PS (ω = 0.82), HP (ω = 0.86), PC (ω = 0.87), SC (ω = 0.92), FR (ω = 0.87), and RR (ω = 0.96). The G factor's omegaH (0.94) and ECV (0.71) supported the use of composite total scores, demonstrating good psychometric properties.

Discussion

This study confirmed the reliability and validity of the Chinese QNC scale among Taiwanese nurses. To our knowledge, this is the first study in the nursing field to apply bifactor ESEM to examine the QNC scale's factor structure and to test alternative models using both bifactor CFA and ESEM approaches. Using bifactor ESEM, we validated its multidimensional structure by simultaneously examining the global QNC and seven specific factors. This aligns with Spearman's [49] two-factor theory, which suggests that individual performance is influenced by both general intelligence (G-factor) and domain-specific abilities (S factors, such as mathematical and verbal abilities). Similarly, our findings demonstrate that QNC exhibits a comparable structure: a global QNC factor affecting overall nursing care and seven specific QNC dimensions. This bifactor structure captures both overall nursing activities and specialized competencies across different nursing care dimensions, providing a foundation for nursing education and professional development.

The comparison of alternative models showed that the unidimensional model had the poorest fit, followed by ICM-CFA models, which are restrictive as they allow only single-factor item loadings. Marsh et al. [50] noted that ICM-CFA models are too restrictive for most multidimensional psychological measurements. Prokofieva et al. [51] advocated for a systematic decision process in factor analysis: use EFA without theoretical basis, CFA when theory exists, and ESEM when measurement models show poor fit and theoretical alternatives are needed. Chen et al. [52] demonstrated bifactor models fit data significantly better than second-order models. Morin et al. [53] recommended avoiding higher-order models unless there is strong theoretical support, suggesting a comparison with bifactor models. Finally, Hong et al. [54] clarified that ESEM is preferred when it demonstrates a better fit and lower factor correlations than CFA, whereas CFA is preferred for its parsimony when models show a similar fit.

While Martins et al. [25] used EFA and found that nurses perceived HP and NCO as having a smaller impact on improving care quality, EFA's limitation of restricting each item to a single factor overlooks interactions between factors. In contrast, bifactor ESEM, which allows cross-loadings, considers the effects of both G and S factors, suggesting that EFA may have underestimated the impact of HP and NCO on QNC. Chen et al. [55] noted that bifactor models help clarify concepts, and even when evaluating the presence of an overall structure, neglecting cross-loadings may result in biased estimates of G factors [33]. The factor structure of the QNC became clearer through the application of newer models like ESEM and bifactor ESEM.

Among the seven dimensions, patient satisfaction (PS) had the highest and most stable factor loadings, underscoring its key role in QNC. This aligns with Liu et al. [22], who identified patient satisfaction as a crucial indicator of QNC. Nurses frequently adjust care strategies to meet patient expectations, thereby enhancing both satisfaction and QOC. Suhonen et al. [56] demonstrated that individualized care effectively predicts patient satisfaction, as it respects patients' unique health values, needs, and expectations. Individualized care not only strengthens patient-centered nursing care but also enhances overall QNC [57], demonstrating that patient satisfaction-oriented approaches are essential for achieving excellence in nursing care.

The health promotion (HP) dimension demonstrated the second-highest factor loading on the QNC scale, underscoring its importance in nursing care quality. The World Health Organization defines health promotion as empowering individuals and communities to improve their health [58]. Kemppainen et al. [59] emphasized that nurse-led health promotion interventions improve patient health outcomes and QNC, while Zheng et al. [60] demonstrated how these programs enhance patients' self-efficacy and health behaviors, supporting the integration of health promotion strategies into routine nursing practices to optimize QNC.

The third dimension of QNC is the prevention of complications (PC). Item 8 (prescribing and implementing interventions to prevent complications) exhibited a high factor loading, whereas Item 7 (identifying potential patient issues) had a lower loading, suggesting that nurses in resource-limited settings prioritize addressing known health issues over potential risks. Soh et al. [61] demonstrated that enhancing nurses' evidence-based knowledge improves their ability to prevent complications, reinforcing their critical role in patient safety.

The fourth dimension, well-being and self-care (SC), focuses on nurse-led interventions that promote patient independence and psychological well-being. Notably, Item 15 (prescribing and implementing interventions) showed higher factor loading on prevention of complications (non-target factor) than on well-being and self-care (target factor), indicating that complication prevention and self-care interventions are inherently interconnected within holistic nursing practice. This finding aligns with Martins et al. [25], who observed that certain nursing care attributes span multiple dimensions rather than being confined to a single category. Clinical practice demonstrates that nurse-led self-care interventions effectively enhance patients' self-management capabilities, thereby promoting better health outcomes and independence [62]. Research further emphasizes that improvements in self-care ability and psychological health demonstrate a bidirectional positive relationship, meaning better self-care ability enhances psychological health and vice versa [63], highlighting the importance of this dimension in the QNC scale. The study results further confirm the cross-dimensional impact of nursing activities, underscoring the importance of adopting a multidimensional perspective in nursing care quality assessment. These cross-loadings highlight the interconnected nature of nursing care, where specific competencies span multiple dimensions, rather than indicating measurement errors [32].

The fifth dimension, nurse-provided functional readaptation care activities (FR), focuses on facilitating patient adaptation and rehabilitation. Item 21 (planning discharge based on needs and community resources) and 22 (optimizing patients' and key cohabitants' ability to manage prescribed treatments) exhibited high standardized factor loadings, underscoring their importance in functional adaptation. This aligns with findings by Nordmark et al. [64], who highlighted the importance of discharge planning in functional adaptation. In contrast, Item 20 (ensuring continuity of nursing services) and Item 23 (training patients in FR) showed lower factor loadings, indicating a relatively weaker influence within this dimension. Davis et al. [65] found that implementing a nurse-led care coordination model in a multidisciplinary setting improved continuity of care.

The sixth dimension, nursing care organization (NCO), reflected moderate nurse engagement with record systems and hospital policies. Nursing activities should meet patients' needs, and each activity should include a record that demonstrates critical thinking. If records are unclear or inaccurate, communication between healthcare professionals may become suboptimal [66]. McCarthy et al. [67] found that implementing electronic nursing records reduced documentation time and recording errors, increased clinical care time, and improved patient care quality. Additionally, a thorough understanding of patient care policies enables nurses to follow standardized procedures, ensure compliance with hospital quality standards, and foster a safe and efficient care environment [5].

The seventh dimension, responsibility and rigor (RR) showed standardized factor loadings greater than 0.30 for items 10, 13, 17, and 19. Item 11 (referring issues to professionals) had a lower loading, suggesting that nurses may perceive referrals as secondary to direct patient care responsibilities. Item 25 (understanding hospital policies) exhibited a higher cross-loading than Item 12, indicating a broader influence. Additionally, Items 10 (demonstrating technical and scientific rigor in interventions to prevent complications) and 17 (technical/scientific rigor contributing to patient health improvement) showed significant negative cross-loadings, suggesting that technical rigor may sometimes conflict with functional adaptation nursing activities. Adherence to hospital policies reflects nurses' responsibilities, impacting the rigor of execution and decision-making processes. This finding aligns with Burhans and Alligood [9], who emphasize that responsibility, intentionality, and initiative form an essential foundation for this approach.

In this study, the bifactor ESEM model showed good reliability, with McDonald's ω for the G factor exceeding 0.70 and an ECV of 0.71. McDonald's ω, a model-based reliability coefficient, provides an estimate of composite reliability [68]. This indicates that a significant proportion of the total score variance is jointly explained by both general and specific factors [48, 69], supporting the use of composite total scores. ECV analysis revealed that the G factor accounted for a greater proportion of common variance than the S factors [48], suggesting that while the seven specific dimensions are important, they are intrinsically intertwined with general QNC.

Limitations

This study has some limitations. First, the inclusion of participants from only three hospitals in southern Taiwan may limit the generalizability of findings. Second, the cross-sectional design captured nurses' assessments at a single time point, requiring longitudinal studies to evaluate temporal stability. Third, the NCO dimension showed slightly lower reliability, suggesting the need for item revision in future studies. Fourth, while the bifactor ESEM model offers valuable insights into the multidimensionality of QNC, its complex coding and computational requirements may present challenges for practical implementation [35]. To improve usability in clinical and research settings, future studies should consider developing a short-form QNC scale. Finally, future research is needed to establish a consensus on the definition of QNC through systematic reviews and expert consensus methods. Additionally, researchers should identify and validate core QNC components across different healthcare contexts and cultures.

Implications for practice

This study validates the multidimensional nature of nursing care quality, contributing to both practice and research. For clinical practice, the validated Chinese QNC scale provides nurses with a reliable tool for comprehensive quality assessment. Our methodological approach demonstrates the importance of rigorous validation processes in developing nursing measurement tools. These findings provide evaluation tools for nurses and a foundation for future research.

Conclusions

This study validated the psychometric properties of the Chinese version of the QNC scale through systematic model comparisons. The ESEM models demonstrated a better fit than traditional CFA models, with bifactor ESEM performing better than seven-factor first-order ESEM. These findings indicate that QNC comprises both general and specific factors, enhancing the understanding of its multidimensional nature. The validated Chinese QNC scale provides a reliable assessment tool for evaluating nursing care quality and establishes a foundation for future research in clinical nursing practice.

Abbreviations

AIC	Akaike information criterion
AVE	Average variance extracted
BIC	Bayesian information criterion
CFA	Confirmatory factor analysis
CFI	Comparative fit index
CI	Confidence interval
CR	Composite reliability
CVI	Content validity index
df	Degrees of freedom
ECV	Explained common variance
EFA	Exploratory factor analysis
ESEM	Exploratory structural equation modeling
FR	Functional readaptation
G factor	General factor
HP	Health promotion
ICM-CFA	Independent cluster model CFA
M	Model
NCO	Nursing care organization
PC	Prevention of complications
PS	Patient satisfaction
QNC	Quality of nursing care
QOC	Quality of care
RMSEA	Root mean square error of approximation
RR	Responsibility and rigor
S factor	Specific factor
SABIC	Sample-size adjusted BIC
SC	Well-being and self-care
SRMR	Standardized root mean square residual
TLI	Tucker-Lewis index
χ^2	Chi-square
ωH	Hierarchical omega

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Author contributions

CHF, CHL, and FHC: conceptualization, data collection, and manuscript writing. CHF and SCM: data collection. CHF, CHL, and FMH: data analysis and interpretation. SCM and MMM: manuscript revision and improvements. All authors reviewed and approved the final manuscript.

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Data availability

Data is provided within the manuscript.

Declarations

Ethical approval

This study was approved by the Ethics Review Committee of Chi-Mei Medical Center on June 9, 2022 (IRB number: 11104-014).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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