

Nationally validating the core competency evaluation instrument for gerontological nurse specialists: based on exploratory and confirmatory factor analysis

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Research Article

Keywords: Gerontological nurse specialist, competency, instrument, confirmatory factor analysis, exploratory factor analysis, cross-validation, reliability, validity

Posted Date: May 3rd, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1533071/v1>

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Abstract

Objectives: This study aims to further test the psychometric properties of the core competency evaluation instrument for gerontological nurse specialists nationwide and to optimize it.

Design: Cross-sectional study

Settings and Participants: This study was conducted on gerontological nurse specialists trained at 13 province-level or above training organizations in China.

Methods: Online questionnaires were adopted to collect data from March 2019 to January 2020. The exploratory and confirmatory factor analyses were applied to revise and cross-validate the instrument.

Results: Twenty items were excluded from the original scale, and nine factors were extracted from the revised scale by exploratory factor analysis. Of nine extracted factors, two (professional self-identification and learning enthusiasm), five (clinical nursing skill, communication and management skill, professional development skill, legal/ethical practice skill, and research/analysis decision-making skill), and two factors (professional knowledge and basic knowledge) were extracted from Attitude, Skill, and Knowledge subscale, respectively. 87.02%, 81.70%, and 81.70% of the total variances were explained respectively by factors extracted from these three subscales, which were much higher than those of the original version scale (i.e., 68.58%, 69.60%, and 75.87% respectively). The revised scale was cross-validated by confirmatory factor analysis, which showed good model fitness in all three subscales, that is, $\chi^2/df < 3$, SRMR ≤ 0.05 , RMSEA ≤ 0.05 , GFI, AGFI, IFI, TLI, and CFI > 0.9 . The Cronbach's α coefficients of nine factors ranged from 0.91 to 0.98. The retest reliability was 0.87.

Conclusion: The factor structure of the core competency evaluation instrument for gerontological nurse specialists was more stable and concise after modification. The revised scale could be preliminarily used nationwide as it has excellent reliability and validity. However, it is also necessary to make further adjustments.

Background

Population aging is sweeping the world, posing a significant challenge to healthcare systems in low-, middle- and high-income regions to address the issues arising from older adults¹. By the end of 2020, there were currently 176 million populations aged 65 or older in China, and this figure will be projected to be 380 million in 2050². Many chronic diseases present age-dependent, such as dementia, stroke, diabetes, and chronic obstructive pulmonary disease, which are closely related to disability, declining in self-care ability, and mortality^{3–8}. Aging, accompanied by problems such as multimorbidity, polypharmacy, and geriatric syndromes, results in the increasing complexity of nursing for older adults. It indicates that geriatric nurses need to improve and strengthen their competencies to meet the health needs of elderly patients^{9,10}.

Gerontological nurse specialists aim to solve complicated health problems and provide high-quality nursing services for older adults, playing an essential role in achieving healthy aging. Gerontological nurse specialists have been developed for decades in many countries such as the United States and Australia^{9,11,12}. However, there is still a shortage of gerontological nurse specialists and other geriatric nurses currently^{13,14}. Because nursing students and nurses are unwilling to choose geriatric nursing as their career due to age discrimination, lack of positive experiences with the elderly, negative attitudes of nursing teachers, and other reasons that are difficult to change and intervene in a short period^{15–18}. Facts have proven that it is challenging to attract sufficient nurses to work in geriatric nursing, so it may be a more effective way to solve the current dilemma by improving and enhancing the competency level of existing gerontological nurse specialists¹⁴. It is because gerontological nurse specialists scatter in various medical institutions all over the country after receiving the gerontological nurse specialist certificate; Thereby, they can pass on their professional geriatric nursing knowledge and skills to other nurses, benefiting more older adults.

The level of competency can be assessed by tools, and competency assessment is one of the critical methods to improve nurses' competency because the results of competency assessment can provide feedback to nurses, nursing educators, and clinical nursing administrators and which can also point out the direction that the competency of nurses needs to be further improved¹⁹. Nursing researchers in different countries are currently developing appropriate competency assessment tools for different nurse roles^{20–24}, including the competency standard statements (it can be used as a blueprint for competency assessment tools) and core competency assessment tools for gerontological nurse specialists^{11,12,25–27}. However, most of these tools used to assess the core competency of gerontological nurse specialists have not been validated, or they have only been validated in local areas.

We had previously constructed a core competency evaluation instrument for gerontological nurse specialists through multi-methodologies¹². This instrument has been validated preliminarily by exploratory factor analysis, including three subscales (i.e., Attitude, Skills, and Knowledge), nine dimensions, and 69 items. The validation results showed that this instrument had excellent psychometric properties. The internal consistency and the test-retest reliability were 0.98 and 0.83, respectively. The exploratory factor analysis showed that factors extracted from three subscales (Attitude, Skill, and Knowledge) explained 68.58%, 69.60%, and 75.87% of the total variance, respectively¹². However, the promotion and application of this instrument nationwide were limited because it had only been validated in one province of China.

Therefore, the purpose of this study was to further validate the Core Competency Evaluation Instrument for Gerontological Nurse Specialists nationally by the methods of confirmatory factor analysis and to optimize it appropriately.

Methods

Design and setting

A cross-sectional survey was conducted from March 2019 to January 2020 in thirteen province-level and above gerontological nurse specialists training organizations in China.

Participants and data collection

One of our previous surveys showed a total of 13 province-level or above training organizations specializing in training gerontological nurse specialists up to April 2019 in China. Gerontological nurse specialists would return to their original workplace after receiving two to three months of intensive training at the training organization, making it difficult to collect data face-to-face. Therefore, an online survey platform (www.wjx.cn), widely applied by researchers in China, was chosen to collect data. The research group invited one to two administrators from each training organization to distribute the link of the online questionnaire to their corresponding training organization's WeChat or QQ groups which gathered gerontological nurse specialists.

The inclusion criteria for gerontological nurse specialists were as follows: (1) registered nurses who received the gerontological nurse specialists training at the provincial level or above training organizations and obtained the certificate of gerontological nurse specialists between January 2014 and April 2019. (2) Those who participated in this survey voluntarily. The exclusion criteria were as follows: (1) Those who cannot complete the online questionnaire for various reasons (e.g., critically ill, did not receive the online questionnaire link). (2) Those who no longer work in medical institutions during the study period (e.g., resignation, change of job).

The online questionnaire included two parts, i.e., socio-demographics and the Core Competency Evaluation Instrument for Gerontological Nurse Specialists. The instrument composes of three subscales (i.e., Attitude, Skill, and Knowledge subscale), nine second-level dimensions (i.e., professional self-identity, learning enthusiasm; clinical nursing skill, communication management and research skill, legal/ethical practice skill, professional development skill, analysis/judgment decision-making skill; professional knowledge, basic knowledge), and 69 items. Participants were required to rate each item using a five-point Likert scale where a score of 1 indicated highly inconsistent, and a score of 5 indicated highly consistent.

Sample size calculation

The sample size was at least ten times as much as the required estimated parameters when performing confirmatory factor analysis²⁸. We intended to perform the confirmatory factor analysis on three subscales separately. As the Skill subscale had the most parameters (i.e., 92) to be estimated, the sample size calculation was based on the number of parameters that needed to be estimated in the Skill subscale. The required minimum sample size was 920. We sent the online questionnaire link to about 2 400 gerontological nurse specialists. A total of 1 939 questionnaires were received, of which 208 questionnaires were excluded from analysis because all items in the core competency evaluation instrument were rated identically. Finally, 1 731 questionnaires were involved in the analysis.

Quality control

Several measures were used to control the quality of this study. Firstly, we set each item as required fields, so there would not be missing data in the collected questionnaires. Secondly, as the pilot study showed that it took about 15 to 20 minutes to complete the questionnaire, we adopted the advanced functions provided by the online survey platform to improve the response rate, that is, the items that had been answered can be saved when the respondents did not have enough time to complete all the items at once, and then, the respondents can continue to complete the questionnaire when they had time. Thirdly, we set up "the questionnaire could be only filled in once by one IP address" to avoid the respondents filling out questionnaires repeatedly because this survey lasted for a long period.

Statistical analysis

Data were analyzed by SPSS 19.0 and AMOS 19.0. Descriptive statistics, such as mean, median, quartile, and percentage, were used to describe the characteristics of participants. Since the latent structure of the core competency evaluation instrument for gerontological nurse specialists had been explored in the previous study by exploratory factor analysis¹², the construct validity was evaluated by confirmatory factor analysis in this study. The criteria used to evaluate the construct validity included²⁹: (1) preliminary model fitness criteria: no negative value of estimated parameters and *t* value should over 1.96; the absolute value of the estimated parameter statistics related to each other cannot be too close to 1; the standardized factor loading is preferably between 0.50 and 0.95; (2) overall model fitness: $\chi^2/df < 5$, standardized root mean square residual (SRMR) and root mean square error of approximation (RMSEA) < 0.08 , and comparative fit index (CFI), goodness of fit index (GFI), adjusted goodness of fit index (AGFI), Tucker–Lewis index (TLI) and incremental fit index (IFI) > 0.9 ; (3) fitness of internal structural model: the square multiple correlations (SMC) reflecting item reliability should be over 0.5, the composite reliability (CR) reflecting construct reliability should be over 0.7, and average variance extracted (AVE) reflecting the degree to which the latent variable can explain the variance of the indicator variable should be greater than 0.5. The discrimination validity would be considered acceptable if the correlation coefficient within the dimension was greater than the correlation coefficient between dimensions. The internal consistency reliability was obtained by calculating Cronbach's *a* coefficient. The Spearman correlation coefficient was used to evaluate the test-retest reliability.

It showed that the original core competency evaluation instrument needed to be revised due to initial confirmatory factor analysis performed on each subscale of the original scale leading to an unsatisfactory solution (Table 1 and Supplementary Table 1). In this case, the statistical experts recommended randomly dividing the sample into two subsamples as the sample size of this study was over 600. The scale can be revised by using exploratory factor analysis in one subsample. Then the revised scale can be internally validated by using confirmatory factor analysis in another subsample to verify the stability of the revised scale structure. Therefore, this study randomly divided the 1731 samples into two subsamples ($n_1 = 866$, $n_2 = 865$). The exploratory factor analysis was performed on subsample 1 ($n_1 = 866$) with principal component analysis and oblique rotation. Multifaceted methods were applied to determine the extracted factor numbers, including eigenvalue over 1, interpretability of the factor structure³⁰, and the theoretical sense of the factors³¹. Subsequently, the revised

scale's factor structure, reliability, and validity were evaluated by confirmatory factor analysis with the maximum likelihood estimator method. A second-order confirmatory factor analysis was also conducted to further evaluate the revised scale's structure. Because the sample did not follow the multivariate normal distribution, which would lead to overestimating the χ^2 value and underestimating the model fitness, the Bollen-Stine bootstrap method was applied to adjust the χ^2 value and model fitness to reduce the deviation of the results²⁸. Finally, the cross-validation was performed by multi-sample analysis with subsample 1 and subsample 2 to test the structural stability of the revised scale. The scale's cross validity could be considered good if two subsamples were congruent in aspects of the factor loading, intercept, covariance, and variance, or the $\Delta CFI \leq |0.01|$ and $\Delta TLI \leq |0.05|$.

Table 1
Model fitness indices of the original scale drawn by confirmatory factor analysis.

Domain	χ^2/df	SRMR	RMSEA	GFI	AGFI	IFI	TLI	CFI
Attitude	8.68	0.15	0.07	0.86	0.78	0.70	0.61	0.69
Skill	5.13	0.21	0.05	0.67	0.63	0.58	0.55	0.58
Knowledge	7.62	0.15	0.06	0.75	0.68	0.65	0.59	0.65

Results

1. Validation of the Core Competency Evaluation Instrument for Gerontological Nurse Specialists

1.1 Preliminary validation by confirmatory factor analysis

The validation results performed by confirmatory factor analysis showed that most of the model fitness indexes of the three subscales did not meet the standards, and the standardized factor loadings of most items exceeded 0.95 (Table 1, Supplementary Fig. 1, and Supplementary Table 1). Therefore, the sample was randomly split into two subsamples ($n_1 = 866$ and $n_2 = 865$). Exploratory factor analysis was performed on subsample 1 to revise the scale, and confirmatory factor analysis was subsequently conducted on subsample 2 to validate the revised scale.

1.2 Scale revision by exploratory factor analysis

The results of the Kaiser-Meyer-Olkin test for the Attitude, Skill, and Knowledge subscale were 0.94, 0.98, and 0.97, respectively, and Bartlett's Test of Sphericity for all three subscales was significant ($p < 0.001$), indicating that performing exploratory factor analysis was appropriate in these three subscales.

In the Attitude subscale, items from A-5 to A-8 were excluded because of cross-loading. After deleting these four items, two factors were extracted from the Attitude subscale, explaining 87.02% of the total variance.

Firstly, only four factors whose eigenvalues > 1 were extracted in the Skill subscale. The eigenvalue of the factor of analysis/judgment decision-making skill was less than 1, which was greater than one in the original version subscale. Thus, we tracked back to the initial process of developing this scale to decide whether to retain or remove this factor. The factor of analysis/judgment decision-making skill was crucial for gerontological nurse specialists to be qualified for their work according to theoretical analysis and the Delphi methods results. In addition, we also reviewed numerous studies on the construction of core competency evaluation instruments in other nursing specialties, which scales included this dimension. Therefore, we intended to retain the dimension of analysis/judgment decision-making skill and preset to extract five factors in exploratory factor analysis. The items of S-10, S-13, S-14, S-15, S-24, S-25, S-29, S-30, and S-32 in the Skill subscale were deleted because they had the conditions of cross-loading or the factor loading < 0.4 . Item S-37 was deleted because of mis-loading to another dimension. According to the current analysis results, items S-26 to S-28 were adjusted to the factor of analysis/judgment decision-making skill. After adjustment, the factor of communication management and research skill was renamed communication and management skill. The factor of analysis/judgment decision-making skill was renamed research/analysis decision-making skill.

In the Knowledge subscale, items K-5, K-16, and K-17 were deleted for cross-loading, and item K-4 was adjusted to the factor of basic knowledge. The exploratory factor analysis results are shown in Table 2.

Table 2
Results of exploratory factor analysis in subsample 1 after revising scale ($n_1 = 866$)

Factors and items	Factor loading	Eigenvalue	Cumulative variance	Cronbach's α
				Explained, %
Attitude				
Factor 1: professional self-identity		4.87	69.58	0.93
A-3	0.98			
A-2	0.97			
A-1	0.92			
A-4	0.84			
Factor 2: learning enthusiasm		1.22	87.02	0.95
A-10	0.99			
A-9	0.88			
A-11	0.87			
Skill				
Factor 3: clinical nursing skill		20.31	65.52	0.97
S-1	0.92			
S-2	1.05			
S-3	1.02			
S-4	0.96			
S-5	0.88			
S-6	0.82			
S-7	0.73			
S-8	0.69			
S-9	0.63			
S-11	0.53			
S-12	0.59			
Factor 4: communication and management skill		1.96	71.85	0.96
S-16	0.49			
S-17	0.89			
S-18	1.05			
S-19	0.99			
S-20	0.90			
S-21	0.47			
S-22	0.55			
S-23	0.48			
Factor 5: professional development skill		1.475	76.61	0.93
S-38	0.81			
S-39	0.90			
S-40	0.79			
S-41	0.77			
Factor 6: legal/ethical practice skill		1.000	79.84	0.94
S-34	1.01			
S-35	0.88			

Factors and items	Factor loading	Eigenvalue	Cumulative variance Explained, %	Cronbach's α
S-36	1.04			
Factor 7: research/analysis decision-making skill		0.577	81.70	0.93
S-26	0.73			
S-27	0.73			
S-28	0.80			
S-31	0.65			
S-33	0.62			
Knowledge				
Factor 8: professional knowledge		10.550	75.36	0.97
K-6	0.68			
K-7	0.85			
K-8	0.86			
K-9	0.88			
K-10	0.82			
K-11	0.83			
K-12	0.89			
K-13	0.68			
K-14	0.94			
K-15	0.91			
Factor 9: basic knowledge		0.888	81.70	0.94
K-1	0.99			
K-2	0.80			
K-3	0.96			
K-4	0.71			

In addition, items S-2, S-18, and S-19 were eliminated because other entries covered these entries' content, more or less. The revised version of the scale is shown in Supplementary table 2 and Table 3.

Table 3
Results of confirmatory factor analysis performed on the revised scale with subsample 2 ($n_2 = 865$)

Subscales	Dimensions	Items	Unstd.	S.E.	<i>t</i>	<i>p</i>	Convergent validation			
							Std.	SMC	CR	AVE
Attitude	Professional self-identity	A-1	1.00				0.90	0.81	0.92	0.74
		A-2	1.01	0.02	51.89	***	0.97	0.94		
		A-3	1.01	0.02	48.76	***	0.95	0.90		
		A-4	0.93	0.02	39.31	***	0.88	0.77		
	Learning enthusiasm	A-9	1.00				0.91	0.83	0.86	0.68
		A-10	1.02	0.03	37.71	***	0.86	0.75		
		A-11	1.01	0.02	44.30	***	0.94	0.88		
Skill	Clinical nursing skill	S-1	1.00				0.76	0.58	0.97	0.76
		S-3	1.11	0.04	26.87	***	0.83	0.69		
		S-4	1.15	0.04	26.78	***	0.83	0.69		
		S-5	1.16	0.04	28.34	***	0.87	0.76		
		S-6	1.19	0.04	28.18	***	0.87	0.75		
		S-7	1.21	0.04	29.76	***	0.91	0.83		
		S-8	1.22	0.04	29.75	***	0.91	0.83		
		S-9	1.21	0.04	29.81	***	0.91	0.83		
		S-11	1.18	0.04	29.81	***	0.91	0.83		
		S-12	1.22	0.04	29.97	***	0.91	0.83		
	Communication and management skill	S-16	1.00				0.86	0.74	0.96	0.79
		S-17	1.07	0.03	34.19	***	0.85	0.73		
		S-20	1.11	0.03	36.51	***	0.89	0.78		
		S-21	1.08	0.03	37.56	***	0.90	0.81		
		S-22	1.11	0.03	40.70	***	0.93	0.87		
		S-23	1.10	0.03	39.99	***	0.93	0.86		
	Research/analysis decision-making skill	S-26	1.00				0.93	0.86	0.94	0.75
		S-27	1.02	0.02	49.22	***	0.93	0.86		
		S-28	1.02	0.03	40.39	***	0.87	0.75		
		S-31	0.94	0.02	38.14	***	0.85	0.72		
		S-33	0.89	0.03	27.21	***	0.72	0.52		
	Legal/ethical practice skill	S-34	1.00				0.96	0.92	0.95	0.87
		S-35	0.99	0.02	49.28	***	0.90	0.82		
		S-36	0.96	0.02	55.22	***	0.93	0.86		
	Professional development skill	S-38	1.00				0.88	0.78	0.94	0.79
		S-39	1.07	0.03	40.10	***	0.91	0.82		
		S-40	0.97	0.03	37.68	***	0.90	0.90		

*** $p < 0.001$. Unstd.: unstandardized path coefficient; S.E.: standard error; Std.: standardized path coefficient;

		S-41	0.97	0.03	36.72	***	0.88	0.79	
Knowledge	Basic knowledge	K-1	1.00				0.88	0.77	0.94
		K-2	0.97	0.02	39.95	***	0.91	0.83	
		K-3	0.95	0.03	33.70	***	0.84	0.7	
		K-4	0.96	0.03	38.29		0.91	0.82	
Professional knowledge	Professional knowledge	K-6	1.00			***	0.90	0.81	0.97
		K-7	1.02	0.02	47.53	***	0.94	0.88	
		K-8	1.02	0.02	47.47	***	0.94	0.88	
		K-9	0.99	0.02	47.88	***	0.94	0.89	
		K-10	0.97	0.02	43.03	***	0.91	0.83	
		K-11	1.01	0.02	44.02	***	0.92	0.84	
		K-12	1.00	0.02	47.23	***	0.94	0.88	
		K-13	0.96	0.03	36.15	***	0.84	0.71	
		K-14	0.92	0.03	34.02	***	0.82	0.67	
		K-15	0.91	0.03	30.07	***	0.77	0.59	

*** $p < 0.001$. Unstd.: unstandardized path coefficient; S.E.: standard error; Std.: standardized path coefficient;

1.3 Validation of the revised scale by confirmatory factor analysis

The revised scale was subsequently tested by confirmatory factor analysis in subsample 2. Results showed that the model fitness indices of all three revised subscales met most of the requirements mentioned in the Methods part. The detailed results are shown in Table 3 and Table 4.

Table 4
Model fitness indices of the revised scale drawn by confirmatory factor analysis

Domain	Bootstrap adjustment	χ^2/df	SRMR	RMSEA	GFI	AGFI	IFI	TLI	CFI
Criteria		< 5	< 0.08	< 0.08	> 0.90	> 0.90	> 0.90	> 0.90	> 0.90
Attitude	before	11.18	0.04	0.11	0.95	0.90	0.98	0.97	0.98
	after	1.73	-	0.03	1.00	1.00	1.00	1.00	1.00
Skill	before	7.13	0.04	0.08	0.82	0.78	0.93	0.92	0.93
	after	1.61	-	0.03	0.98	0.98	0.99	0.99	0.99
Knowledge	before	13.27	0.05	0.12	0.84	0.78	0.94	0.93	0.94
	after	2.15	-	0.04	0.99	0.98	0.99	0.99	0.99
Second-order CFA	before	5.06	0.06	0.07	0.75	0.72	0.92	0.92	0.92
	after	1.46	-	0.02	0.97	0.97	0.99	0.99	0.99

2. Results Of Second-order Confirmatory Factor Analysis

The first-order confirmatory factor analysis performed on the revised scale showed a medium to high correlation among dimensions, indicating that the first-order latent variables might be affected by a higher-order latent variable. Therefore, we performed the second-order confirmatory factor analysis on the revised scale. The results showed that: (1) all of the model fitness indexes reached the requirements (Table 4); (2) The factor loading of all first-order latent variables was greater than 0.7, and the SMC values were greater than 0.5; (3) the CR values of the three second-order latent variables (attitude, skills, and knowledge) were 0.98, 0.94 and 0.97 respectively, and the AVE values were 0.95, 0.77 and 0.87 respectively. The standardized second-order model of the revised scale is shown in Fig. 1.

3. Results Of Cross-validity

The cross validity of the revised scale was tested by multi-sample analysis. Under the assumption that the revised scale structure was correct, we performed a multi-sample analysis using the data of subsample 1 and subsample 2 in three subscales (i.e., Attitude, Skill, and Knowledge subscale). The results showed

that the factor loading, intercept, covariance, and variance were congruent between the two samples ($p > 0.05$) in all three revised subscales (Table 5). Moreover, the ΔCFI was within $|0.01|$ and the ΔTLI was within $|0.05|$ between the two subsamples in all three subscales, which can be considered that the two subsamples were congruent and the cross validity of the revised scale showed an excellent performance.

Table 5
Results of cross validity of three revised subscales performed by multiple-sample analysis

Domain	Model	χ^2	df	Δdf	$\Delta\chi^2$	p	ΔCFI	ΔTLI
Attitude	Unconstrained	243.23	26	-	-	0.00	-	-
	Measurement weights	251.07	31	5	7.85	0.16	0.00	0.01
	Measurement intercept	265.00	38	7	13.93	0.05	0.00	0.00
	Structure covariance	268.57	39	1	3.57	0.06	0.00	0.00
	Structure variance	267.20	40	2	2.21	0.33	0.00	0.00
	Measurement residuals	319.90	48	9	51.33	0.00	0.00	0.00
Skill	Unconstrained	4598.63	680	-	-	0.00	-	-
	Measurement weights	4616.44	703	23	17.81	0.77	0.01	0.00
	Measurement intercept	4650.78	731	28	34.34	0.19	-0.01	0.00
	Structure covariance	4661.04	741	10	10.26	0.42	0.00	0.00
	Structure variance	4653.14	736	5	2.36	0.80	0.00	0.00
	Measurement residuals	4745.67	774	33	84.63	0.00	0.01	0.00
Knowledge	Unconstrained	1772.52	152	-	-	0.00	-	-
	Measurement weights	1781.38	164	12	8.86	0.71	0.00	0.00
	Measurement intercept	1792.18	178	14	10.80	0.70	0.00	0.01
	Structure covariance	1792.72	179	1	0.55	0.46	0.00	0.00
	Structure variance	1792.61	180	2	0.43	0.81	0.00	0.00
	Measurement residuals	1841.31	195	16	48.58	0.00	0.00	0.00

4. Results Of Discriminant Validity

It adopted the AVE method to evaluate the discriminant validity among dimensions. The AVE value reflects the degree of correlation of items within a dimension. The higher value of AVE indicates a stronger correlation of the items within the dimension. The correlation coefficient between different dimensions should be lower than the correlation coefficient within the dimension. In Table 6, the values of the diagonal line were the values of AVE, and the values of the lower triangle area were the values of the correlation coefficient between dimensions. It can be seen from Table 6 that the correlation coefficient between the dimension of research/analysis decision-making skill and the dimension of communication and management skills was 0.93, which was greater than the correlation coefficient of 0.86 in the dimensions of research/analysis decision-making skill. The correlation coefficient between the dimension of communication and management skill and the dimension of clinical nursing skill was 0.92, greater than the correlation coefficient of 0.89 in the dimensions of communication and management skill. The internal coefficients of the remaining dimensions were greater than the external correlation coefficients (Table 6).

Table 6
The discriminant validity of each dimension in revised scale.

Dimensions	AVE	Research/analysis decision-making skill	Legal/ethical practice skill	Professional development skill	Communication and management skill	Clinical nursing skill	Professional knowledge	Basic knowledge	Learning enthusiasm
Research/analysis decision-making skill	0.75	0.86							
Legal/ethical practice skill	0.87	0.63	0.93						
Professional development skill	0.79	0.82	0.59	0.89					
Communication and management skill	0.79	0.93	0.65	0.76	0.89				
Clinical nursing skill	0.76	0.86	0.69	0.73	0.92	0.87			
Professional knowledge	0.79	0.69	0.71	0.67	0.70	0.74	0.89		
Basic knowledge	0.78	0.74	0.64	0.78	0.72	0.73	0.88	0.88	
Learning enthusiasm	0.68	0.60	0.56	0.55	0.65	0.68	0.53	0.52	0.82
Professional self-identity	0.74	0.37	0.55	0.33	0.41	0.48	0.42	0.37	0.72

5. Reliability

The Cronbach's α coefficient of the revised scale was 0.98, and the Cronbach's α coefficients of nine dimensions were ranged from 0.91 to 0.98. The test-retest reliability was 0.87.

Discussion

This study aimed to further validate the reliability and validity of the core competency evaluation instrument for gerontological nurse specialists to improve its promotion and application nationwide. At first, the original scale was poorly fitted to the national sample data, which reminded us that we should be careful when applying a new evaluation instrument in different scenarios and samples. After revision, the scale can be applied nationwide because the revised scale has excellent reliability and validity and a clear, stable structure. In addition, the second-order confirmatory factor analysis showed a good model fit to sample data, which validated the competency model—Attitude-Skill-Knowledge model proposed by Baartman³². This model decomposed the competency into three components (i.e., attitude, skills, and knowledge), which made the competency manageable and assessable. It can also be used to guide the setting of training course systems for gerontological nurse specialists.

There are several possible reasons for the poor model fitness of the original version of the scale in the initial confirmatory factor analysis. Firstly, although we adopted multiple methods to develop the scale to ensure it can be applied nationwide, we only tested its reliability and validity in one province of China. This might lead to the factor structure obtained through exploratory factor analysis only applicable to the samples in Sichuan Province. Secondly, there might be some problems with the content or structure of the original scale itself. When firstly performing the confirmatory factor analysis, the factor loading of most items was excessively high (> 0.95), and high modification indices (> 100) exist among some items and the residuals of some items. This indicated that these items were not independent and with a high degree of collinearity. In addition, the correlation coefficient value between the secondary dimensions was also too large (> 0.95), which indicated that the collinearity between these dimensions was also significant. Considering that even if the sample was divided into two subsamples evenly, the sample size was still sufficient to perform confirmatory factor analysis again. Therefore, we re-explored the structure of this scale and then tested the revised scale's reliability and validity.

The proposed factor structure still held for the majority of the items in all three subscales when performing exploratory factor analysis in subsample 1. In the Attitude subscale, the factor structure was similar to the original ones, except those items A-5 to A-8 were cross-loaded on factors of professional self-identity and learning enthusiasm. Thus, items from A-5 to A-8 were deleted because the remaining entries were sufficient to reflect these two dimensions' connotations. Two factors extracted from the revised Attitude subscale explained 87.02% of the total variance. This was much higher than the variance explained by the original factors (68.58%), indicating that the structure of the revised Attitude subscale was much clearer and can better reflect and capture gerontological nurse specialists' attitudes towards geriatric nursing.

In the Skill subscale, several differences in the factors structure existed between the original subscale and the current subscale when performing exploratory factor analysis. Firstly, the analysis/judgment decision-making skill's eigenvalue was lower than one, and items originally belonged to this factor were miss-loaded on other factors. The reason for this result might be that the majority of the current gerontological nurse specialists were bachelor or college degrees. Nevertheless, this skill was often trained in master's degree and above education. Furthermore, doctors still dominate the right to decide on clinical practice,

which might limit the cultivation and development of this skill for gerontological nurse specialists. Therefore, the gerontological nurse specialists might have a certain deviation understanding of the content of the items in this dimension. What had been mentioned above probably caused items of this dimension to be loaded to other factors. Finally, we decided to retain this factor by considering the following reasons. First of all, the weight coefficient of this dimension ranked fourth in Skill subscale¹², which showed that it was one of the essential core competencies for gerontological nurse specialists. Secondly, this skill was also one of the core competencies of other clinical nurse specialists in China, which reflected the importance of this skill to clinical nurse specialists. In addition, doctors and nurses always need to weigh the pros and cons of various therapeutic and nursing measures due to the health problems of elderly patients being relatively complex and unique, especially for those elderly patients who do not have abilities to make decisions. Therefore, gerontological nurse specialists should master this kind of skill to make accurate clinical judgments and decisions and then safeguard the rights of elderly patients. Finally, with the development of the medical-nursing collaboration model, especially for elderly patients who need more nursing than treatment, the conditions of nurses in making decisions will become more and more. Therefore, it was necessary to retain this dimension and train gerontological nurse specialists to be with this kind of skill for advancement.

In addition to this difference, items S-26 to S-28, originally loaded on communication management and research skill, were loaded on the dimension of analysis/judgment decision-making skill in the current exploratory factor analysis. It was considered that the content of these items reflected the connotation of research skill which was considered to share common intrinsic properties with the analysis/judgment decision-making skill. Furthermore, both skills were usually cultivated in postgraduate nursing education more comprehensively and systematically. Therefore, we adjusted these items to the dimension of analysis/judgment decision-making skill and renamed it research/analysis decision-making skill. After modifying the Skill subscale, five factors were extracted, explaining 81.70% of the total variance, which was much higher than the result of the original subscale (69.90%). This indicated that the revised Skill subscale had a more transparent structure, and it can reflect the skills of the gerontological nurse specialists better.

In the Knowledge subscale, if the authors only extracted factors whose eigenvalues > 1, only one factor could be extracted, which was inconsistent with the experts' opinion at the phrase of developing this scale. Scholar Polany (1964) divided knowledge into tacit knowledge and explicit knowledge. Tacit knowledge is an important raw material for any professional knowledge, referring to internal and automatic declarative knowledge that people are no longer aware of. The tacit knowledge corresponds to the dimension of basic knowledge in our original scale. Explicit knowledge refers to a kind of academic and professional knowledge that can easily be transferred from one owner to another owner³³. It corresponds to the dimension of professional knowledge in our original scale. Therefore, the authors also preset to extract two factors in exploratory factor analysis. The extracted two factors explained 81.70% of the total variance in the revised Knowledge subscale, higher than that of the original subscale (75.87%). This indicated that the structure of the revised knowledge subscale was much clearer, and it could capture the characteristics of the knowledge of gerontological nurse specialists.

The revised scale was cross-validated by confirmatory factor analysis. The first-order and second-order confirmatory factor analysis provided reasonable and sufficient evidence to support the construct validity of the revised three subscales (Attitude, Skill, and Knowledge). The factor loadings of all items on their corresponding factors were great than 0.7. Among them, only two items' factor loading (A-2 and S-34) were too large (> 0.95). However, they did not affect the model fitness. The CR values of nine dimensions were greater than 0.7, ranging from 0.86 to 0.98. And their AVE values were greater than 0.5, ranging from 0.68 to 0.87, indicating that items in each dimension were highly homogeneous and can reflect the characteristics of their corresponding dimensions. In addition, various indices were utilized to evaluate the overall model fit, of which χ^2/df , RMSEA, SRMR, GFI, AGFI, NFI, TLI, and CFI were the most frequently reported indices³⁴. Thus, we used these eight indices to evaluate the model fit of our study. Fortunately, the revised scale showed an excellent model fit as the values of $\chi^2/df < 5$, RMSEA and SRMR < 0.08, and GFI, AGFI, NFI, TLI, and CFI > 0.9, indicating that the revised scale fit the sample from all over the country and had a good external validity. The results of the multi-sample analysis showed that subsample 1 and subsample 2 were congruent in the four aspects of the factor loading, intercept, covariance and variance when testing the cross validity of the revised scale. This indicated that the revised scale could be applied to different samples from the same population, and it also indicated that the factor structure of the revised scale was steady.

The discriminant validity among the three dimensions of "clinical nursing skill", "communication and management skill", and "research/analysis decision-making skill" was relatively poor, suggesting that these three dimensions needed further revision in the following research. The internal consistency reliability of the revised scale was 0.98, and the test-retest reliability was 0.87. Both were higher than 0.7, demonstrating that the revised scale can evaluate the core competency of gerontological nurse specialists stably.

Limitations

This study still had several limitations. It did not mean that the revised scale was entirely correct, though it performed an excellent model fitness. It just indicated that the revised scale fitted well with the nationwide samples. Therefore, it still needed to be cautious to interpret this study's results. Secondly, the discriminant validity among the three dimensions of "clinical nursing skill", "communication and management skill", and "research/analysis decision-making skill" was relatively poor, so it was necessary to further revise these three dimensions. Finally, this scale was a self-rating scale, signifying that the subjective factors would affect the assessment results when gerontological nurse specialists evaluate their competencies. Therefore, a tool that can more objectively evaluate gerontological nurse specialists' competency should be developed in the following research.

Conclusion

The structure of the core competency evaluation instrument for gerontological nurse specialists was much clearer and steadier after revising and cross-validating by combining exploratory and confirmatory factor analyses. The revised scale showed excellent validity and reliability, indicating that it can be promoted and applied nationwide preliminarily; however, further revisions were needed.

Abbreviations

SRMR Standardized root mean square residual

RMSEA Root mean square error of approximation

CFI Comparative fit index

GFI Goodness of fit index

AGFI Adjusted goodness of fit index

TLI Tucker–Lewis index

IFI Incremental fit index

SMC Square multiple correlations

CR Composite reliability

AVE Average variance extracted

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Review Boards of Sichuan University West China Hospital [No.2019-216], and the study was carried out in accordance with relevant guidelines and regulations. The purpose and significance of this study as well as the informed consent were shown on the first page of the web-survey. If respondents agreed to filled out the online questionnaires, they would sign an electronic informed consent.

Consent for publication

Not applicable.

Availability of data and materials

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that there is no conflict of interest.

Funding

This work was supported by a research grant from the Department of Science and Technology Research Projects of the Sichuan Province, P.R. China. [2021YJ0016]

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Final approval of the manuscript: All authors

Acknowledgments

The authors would like to thank the managers from thirteen gerontological nurse specialist training organizations in China who assisted us in distributing the online questionnaire and thank all of the gerontological nurse specialists who participated in this study.

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Figures

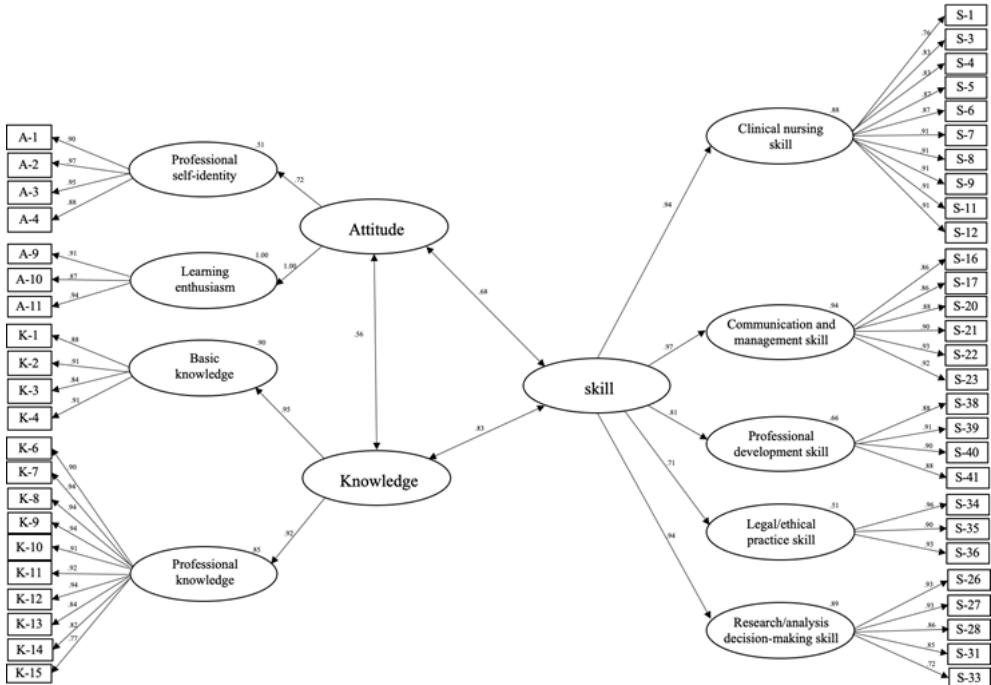


Figure 1

The results of second-order confirmatory factor analysis performed on the revised model.

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