Received: 7 August 2020 | Revised: 30 March 2021 | Accepted: 8 June 2021

DOI: 10.1002/nop2.985

RESEARCH ARTICLE

NursingOpen Open Access WILEY

Core competency scale for operating room nurses in China: Scale development, reliability and validity evaluation

Na Mei[1] | Ling Chang[2] | Zhonghai Zhu[3] | Min Dong[4] | Min Zhang[5] | Lingxia Zeng[3]

[1]The First Affiliated Hospital of Xi 'an Jiaotong University, Xi'an City, China

[2]Xi'an Center for Diseases Control and Prevention, Xi'an City, China

[3]Department of Epidemiology and Health Statistics, School of Public Health, Xi 'an Jiaotong University Health Science Center, Xi'an City, China

[4]Data Management and Biometric Department, EDETEK, Inc., Beijing City, China

[5]Periodicals Publishing House of Xi'an Jiaotong University, Xi'an City, China

Correspondence
Lingxia Zeng, Department of Epidemiology and Health Statistics, School of Public Health, Xi'an Jiaotong University Health Science Center, Xi'an City, Shaanxi Province 710061, China.
Email: tjzlx@mail.xjtu.edu.cn

Funding information
The field work was supported by a grant from the New Century Excellent Talents in University (No. NCET-11-0417), and this work was supported by China Scholarship Council (CSC).

Abstract

Aims: To develop a competency scale for operating room nurses and test its reliability and validity.

Background: The existing Chinese Registered Nurse Competency Scale and the core competency scale for operating room nurses developed abroad cannot fully meet the capacity needs of Chinese operating room nurses.

Methods: The scale was developed based on the results of qualitative interview and the Delphi method. Ten experts were selected for expert consultation, and 300 operating room nurses were recruited by convenience sampling for a cross-sectional survey to test the reliability and validity of instrument.The reliability and validity of the scale was assessed based on internal consistency reliability, test–retest reliability and confirmatory factor analysis. Data collection was conducted between March to July, 2015.

Results: An initial scale with 42 items was confirmed, and 36 items remained. The internal consistency Cronbach's α was 0.97 for the overall scale and 0.88–0.94 for the subscales. The retest reliability ranged from 0.55–0.96. Five factors were extracted by exploratory factor analysis, and they explained 66% of the total variance. The fitting indices of the confirmatory factor analysis were as follows: $\chi 2/df = 3.47$, CFI = 0.83, TLI = 0.81, SRMR = 0.06 and RMSEA = 0.09.

Conclusions: The core competency scale for operating room nurses with 5 components and 36 items had acceptable reliability and validity. The scale could continue to be optimized in the future.

KEYWORDS

competency, operating room nurses, reliability, validity

1 | INTRODUCTION

The competency of nurses directly affects the quality of nursing practice and also has a great impact on clinical outcomes. With changes in medical patterns and disease spectra, the nursing model has undergone constant changes and development. The "patient oriented" view demands high-quality nursing practices. Nurses are required to adapt themselves to the various clinical contexts and provide quality care services in a changing environment. The exploration of core competencies for nurses has become a topic of great interest to

Mei and Chang should be considered joint first author.

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.
© 2021 The Authors. *Nursing Open* published by John Wiley & Sons Ltd.

administrators and nursing educators in practice disciplines, especially healthcare disciplines (Scott-Tilley, 2008). The International Council of Nurses (ICN) developed an ICN Framework of Competencies for Generalist Nurses in 2003. The competency scales of Registered Nurses that were adapted to cultural and regional discrepancies were developed under the guidance of the ICN Framework of Competencies (Andrew et al., 2008; Brammer, 2006; Chen & Lou, 2014; Cowin et al., 2008; Flinkman et al., 2016; Liu et al., 2007, 2009; Rudman et al., 2012; Simpson, 2010). With advances in medicine and technology and the diversification of patient needs, more complex and diverse nursing practices are also required. Furthermore, nursing competence has a direct and critical influence on patient care outcomes.

Specialized nurses including operating room nurses need some special competence requirements that are different from ordinary Registered Nurses. China has established a diversified nursing education system that provides a diploma and undergraduate, master's level and even doctoral nursing education to meet the needs of a growing variety of clinical practices. However, the postgraduate training of nursing, especially of specialized nurses, mainly relies on the institutional workforce training programme as well as the continuing education programmes launched by the Nursing Associations. In China, specialized nurses, including operating room nurses (ORNs), intensive care unit (ICU) nurses, nurse anaesthetists, and hemodialysis room nurses, mainly serve in tertiary comprehensive hospitals. Operating room nurses, as an important group of specialized nurses, are expected to have higher professional skills and integrated capacities than general ward nurses because of the different working environments and the context of the services. The main responsibility of ORNs is to cooperate with other surgical team members to guarantee the safety and quality of surgical processes and care. The competencies of ORNs include not only issues of technical skill (gowning and gloving, setting up instrumentation, draping, maintaining a sterile field and so on) but also communication, team work and other non-technical capacities (understand the requirements of ethics and related laws and regulations etc.). Furthermore, the abilities associated with high-stress work conditions and emergency handling, including leadership, situational awareness, decision-making in a crisis, self-control ability and interpersonal insight, are also very important for ORNs (Man et al., 2013). Based on these factors, competency inventories for Registered Nurses or other specialized nurses (Cheng et al., 2013; Dunn, 1997; Dury et al., 2014; Mitrea et al., 2014; Paige et al., 2014) that have been developed cannot cover the assessment of ORNs. The Perceived Perioperative Competence Scale-Revised (PPCS-R) was the first specific tool for the perioperative context to be developed and psychometrically validated (Gillespie et al., 2009, 2012). However, the PPCS-R cannot be fully applicable to China because of the discrepancy of work patterns, cultural background, training and cultivation models. PPCS-R emphasizes more universal ability requirements in surgical scenarios. However, ORNs in China need more techniques and skills to deal with emergencies and crises correctly and efficiently.

The aim of this study is to develop the competency scale for operating room nurses in China and provide evidence of the reliability and validity of that scale.

2 | METHODS

This study adopted a process with three stages to develop a core competency scale for operating room nurses. In stage 1, ability requirements (domains of the scale) of ORNs were identified by focus group interview. In stage 2, the item pool and initial core competency of scales were developed by a two-round expert consultant. In stage 3, the reliability and validity of the scale were confirmed by a cross-sectional questionnaire survey that involved 6 tertiary comprehensive hospitals in western China. All participants gave written informed consent before participating in the study. The research proposal was approved by the Ethics Committees of the Xi'an Jiaotong University Health Science Center and 6 tertiary comprehensive hospitals.

2.1 | Stage 1: Identification of abilities required by ORN

2.1.1 | Participants and setting

The target population for the focus group interviews was currently on-duty ORNs. Six tertiary comprehensive hospitals were randomly selected as research setting. Ten ORNs in each hospital were recruited in the focus group interview using convenience sampling.

2.1.2 | Focus group interviews and contents

The focus group interview was conducted in each hospital separately. Nurses with different years (ranging from 1–35 years) of OR experience were invited to participate in the focus group interview to ensure that as much comprehensive information was collected as possible. A research team of 3 members performed the focus group interviews with assistance of hospital head nurses. The opinions about the abilities required by ORNs (for example: in your opinion, what abilities are most needed as an operating room nurse?) were collected by using semi-structured, open-ended questions, and verbatim transcriptions and content analysis were performed after all six focus group interviews were finished. The core competencies of ORNs were extracted from these transcripts and classified into 5 domains, and an initial pool of items was identified.

2.2 | Stage 2: Development of the item pool and initial core competencies of the scale

2.2.1 | Participants

The item pool and initial scale were developed through two-round expert consultation. The target population was experts with more than 10 years of experience in the OR nursing practice, nursing education and training, and nursing administration. Potential qualified

experts who were screened from the senior membership list of the Nursing Association were invited to be members of the panellist, and 10 experts who provided informed consent were involved as panellists for expert consultation. (Hasson et al., 2000).

2.2.2 | Procedures

Before the expert consultation, the domain classifications extracted in stage 1 and items related to each domain were fully discussed by the research team and 5 external experts from the Nursing Association to reach a consensus. The initial version of core competency for ORNs was developed on the basis of a combination of the results of focus group interviews and full discussions and then distributed to the panellists for their comments. After the results of the initial round of expert consultation were collected and sorted, the second version was distributed for further improvement and refinement. The core competencies for ORNs were confirmed in a two-round expert consultation. The Core Competency Scale for ORNs is a 5-point Likert scale ranging from 0 (not competent at all) to 4 (very competent).

2.2.3 | Data collection and data analysis

The expert positive coefficient, the degree of authority of the experts and the coordination coefficient for experts were used to evaluate the results of the expert consultation (Ou et al., 2014).

Expert positive coefficient

This is the degree of concern and cooperation of experts when participating in the research. It was assessed by the response rate in every round (Jiang et al.,2016).

The degree of authority of the experts

This is assessed by the authority coefficient (Cr). The Cr is determined by the expert familiarity (Cs) and the judgement criterion (Ca), and the formula is $Cr = (Ca + Cs)/2$. A high Cr indicates a high degree of authority (Table S1) (Geng et al., 2018).

Coordination coefficient for experts

This depended on the coefficient of variation. A low coefficient of variation indicates a high coordination coefficient. It is assessed by Kendall-W. A high Kendall-W indicates a high coordination coefficient, and the value of W ranges from 0–1 (Kilner, 2004).

2.3 | Stage 3: Evaluation of the reliability and validity of the scale

2.3.1 | Study design and contents

A cross-sectional survey was conducted to evaluate the reliability and validity of the scale. In addition to the core competencies for ORNs developed in stage 2, questions on sex, age, years of ORN experience and professional education were included in the survey.

2.3.2 | Participants and setting

Sample size for reliability and validity evaluation of scale was set to 5–10 times of items under the assumption of 40 items (Lewis, 2009). In total, 300 ORNs, regardless of years of ORN experience, were recruited from six tertiary comprehensive hospitals (same as Stage 1), and informed consent was obtained. Among them, 20 nurses from 2 hospitals through convenience sampling were retested one month later to evaluate the test–retest reliability of the scale. Administrative approval was also obtained from the participants' hospitals.

2.3.3 | Data collection

A cross-sectional self-assessment questionnaire survey was undertaken at 6 comprehensive hospitals, which were also the settings for the focus group interviews.

2.3.4 | Data analysis

Descriptive statistics of items on the core competency scale of ORNs were performed with the mean ± standard deviation (*SD*). Internal consistency reliability was estimated by Cronbach's α coefficient for the items in the total score and for each domain (Meretoja et al., 2004). Scores above 0.5 were expected, which are considered acceptable.

Split-half reliability

This is a measure of consistency in which a test is split into two, and the scores for each half of the test are compared with one another. This measure was used to check the internal stability of the questionnaire.

Test–retest reliability

Test–retest measurement of the stability of an instrument is the most frequently used analysis of reliability. Measurements are gathered from a single rater who uses the same methods or instruments and the same testing conditions. It is frequently evaluated using Pearson's correlation coefficient. The correlation coefficient between test–retest scores should be at least 0.7 (Fayers & Machin, 2007).

Construct validity

Construct validity is evaluated using exploratory factor analysis (EFA). In EFA, initial factors were extracted using the principal components method, and rotations were then performed using the varimax method. Finally, this approach allows hypothetical models to be set up before the data are analysed and subsequently tested for their fit by a number of criteria.

A known-group technique was also used to assess construct validity. The participants were divided into three groups: those with 5 years or less of ORN experience, those with 6–10 years and those with 11 or more of experience. One-way ANOVA was performed to compare the differences in the mean scores of the total scale and each subscale among the three groups.

The database was established using Epidata3.1, double data entry was conducted to control for typographical errors, and the data were analysed using SPSS13.0. $p < .05$ was set as the significance level.

3 | RESULTS

3.1 | Stage 1: Qualitative interview

Fifty-three nurses in six hospitals were interviewed, including 23 nurses with 5 years or less of ORN experience, 16 nurses with between 5–10 years and 14 nurses with more than 10 years of experience. The core competencies for ORNs were summarized as follows:

- Professional skills: preventing adverse events during operations; posturing patients in appropriate operating position; setting up surgical instrumentation correctly; effective preoperative visit psychological counselling; awareness and maintenance of the sterile field.
- Collaboration and interpersonal communication skills: handling relationships correctly among doctors, nurses and patients; ability to contact clinical departments to coordinate patient-related issues; dealing with contradictions in a positive way; willingness to work as part of a team.
- Teaching ability: guiding interns, advanced students and new nurses; ability to use office software; undertaking teaching work.
- Management ability: managing inpatients effectively; actively engaging in quality control and environmental management of the department.
- Legal knowledge and self-discipline: respecting patients; protecting patient privacy; writing nursing documents earnestly and effectively; patient safety protection and self-discipline without supervision.

3.2 | Stage 2: Expert consultation

According to the inclusion criteria, 12 experts were invited to attend two rounds of Delphi consultation, and 10 experts were willing to participate. They were all female and aged 34–55 years old. Seven experts were very familiar with operating theatre nursing work. According to the ten criteria in the Delphi study (Terwee et al.,2018), it was appropriate in relevance, comprehensiveness and comprehensibility.

The positive coefficients of the experts were 70% and 100% in two rounds of expert consultation. The degrees of authority from two rounds of expert consultation were 0.79 and 0.60, which indicated a high degree of expert authority. The coordination coefficient of the first round was 0.41 ($p < .001$), and the second round was 0.59 ($p < .001$). The coordination coefficient of the second round was statistically significantly higher than the first one ($p < .001$), which indicated a higher degree of consistency of item rating among experts.

After stage 1 and stage 2, the initial version of the Chinese core competency scale for ORNs (CCS_ORN_Initial) was determined. It covered emergency and problem-solving skills (EP), specialist knowledge and skills (SK), collaboration and interpersonal communication skills (CI), teaching and research capacity (TR), laws and regulations and relevant expertise (LR) and management capabilities and basic skills (MC), for a total of 6 dimensions and 42 items.

3.3 | Stage 3 Evaluation of the reliability and validity of the scale

3.3.1 | Participant demographics

Responses were obtained from 301 ORNs who consented to participate in the questionnaire study. Three hundred responses were used in the analysis after excluding one response with missing demographic information. A total of 276 (92.0%) participants were female, and 24 (8.0%) were male. Their ages ranged from 21–55 years old, with an average of 32.8 ± 8.8 years. Additionally, 55.3% of participants had a bachelor's degree in nursing education. The length of work experience ranged from 1–35 years, with an average of 12.0 ± 9.5 years (Table 1).

3.3.2 | Item analysis

The range of means (*SDs*) for the 42 items was 2.1 (0.8)–3.6 (0.7). No floor effect (a high proportion of patients have minimum scores on the item) was seen for any item, but a ceiling effect (a high proportion of patients have maximum scores on the item) was found for two items. The results of the item analysis indicated that the ORNs tended to self-assess with higher competency. The item-total correlation coefficient ranged from 0.525–0.791, and the inter-item correlation coefficient was 0.128–0.838 (Table 2). The higher inter-item correlations (>0.7) indicated much redundancy between items and a possible loss of content validity (Streiner & Norman, 2008). Therefore, 6 items, including the two items with a ceiling effect, were deleted, and 36 items remained.

3.3.3 | Reliability analysis

Internal consistency reliability was estimated by Cronbach's α. Cronbach's α was 0.97 for the overall scale and 0.88–0.94 for subscales (Table 2). The range of Cronbach's α was 0.972–0.973 if the

TABLE 1 Baseline characteristics of the participants ($N = 300$)

Characteristics	*N* (%)
Sex	
Male	24 (8.0)
Female	276 (92.0)
Age (years) ($M \pm SD$)	32.8 ± 8.8
21–29	144 (48.0)
30–39	80 (26.7)
40–49	63 (21.0)
50–55	13 (4.3)
ORN experience (years) ($M \pm SD$)	12.0 ± 9.5
≤5	108 (36.0)
6–15	84 (28.0)
>15	108 (36.0)
Position	
Nurse	122 (40.7)
Nurse Practitioner	73 (24.3)
Nurse-in-charge and above	105 (35.0)
Education	
Bachelor	166 (55.3)
Diploma	134 (44.7)

Abbreviations: *M*, mean; *SD*, standard deviation.

item was deleted. All items were divided into two groups according to their odd and even ranks. The Guttman split-half coefficientt was 0.97 for the two groups.

Twenty participants were chosen randomly to test the retest reliability one month later. The correlation coefficients of scores from two tests in each dimension were 0.836 ($p < .001$), 0.959 ($p < .001$), 0.599 ($p = .005$), 0.584 ($p = .007$), 0.548 ($p = .012$) and 0.633 ($p = .003$), respectively.

3.3.4 | Construct validity

- Exploratory factor analysis: The instrument with 36 items was suitable for factor analysis according to the results from the Kaiser–Meyer–Olkin (KMO = 0.96) test and Bartlett test (sphericity test value was 10,955.61, $p < .05$). Five common factors were extracted by principal component analysis, which explained 66.86% of the total variance (Table 3). The five extracted components were named based on their content: factor 1, "Collaboration and interpersonal communication skills and legal knowledge" (CIL, 12 items); factor 2, "Specialist knowledge and skills" (SK, 7 items); factor 3, "Emergency and problem-solving skills" (EP, 8 items); factor 4, "Teaching and Research" (TR, 5 items); factor 5, "Management capacity and basic skills" (MC, 4 items).

The correlation coefficient between the five dimensions was 0.63–0.90 ($p < .01$) (Table 4), and the dimensions to total ratios ranged from 0.61–0.90(Table S2).

- Contrast group validity: The final version of the Core Competency Scale of Operating Room Nurses in China (CCS_ORN) with 5 components and 36 items was confirmed. The construct validity was also tested by the known-group technique. The results indicated that the total scale and subscale mean scores increased significantly with the lengthening of ORN experience ($p < .001$) (Table 5).

4 | DISCUSSION

The core competency scale for ORNs (CCS_ORN) with 5 components and 36 items was confirmed by using a literature review combined with expert consultation and qualitative research. This scale not only fills gaps in the research of the core competency scale for ORNs in China but also provids a useful tool for managers to improve and evaluate the competency of operating room nurses. The CCS_ORN would be useful for educators to formulate appropriate training programmes and continuing education, as well as researchers to assess the interventional effect and conduct the relevant research.

In the present study, moderate correlation between inter-items and the item-total indicated reasonable internal consistency of the scale after deleting 6 potentially redundant items. The factor model produced by EFA indicated that the overall distribution of dimensions is appropriate, while some items should be adjusted, and a five-factor structure seems to capture the features of the competency of operating room nurses properly. Five components embodying the core competencies of operating room nurses were extracted: "Collaboration and interpersonal communication skills and legal knowledge"; "Specialist knowledge and skills"; "Emergency and problem-solving skills"; "Research and teaching"; and "Management capacity and basic skills." Among the five components, "collaboration and interpersonal communication skills and legal knowledge" and "teaching and research capacity" are also the competencies that are most important in the roles of Registered Nurses in China. The core competency scale for ORNs increased the specialty characteristics, which included "specialist knowledge and skills," "management ability and basic skills" and "emergency and problem-solving skills."

The "specialist knowledge and skills" component in this scale has 7 items because the operating room is a strong operational department, and ORNs need good operating skills and the ability to take action effectively to prevent adverse events from occurring and to ensure the operation goes smoothly. This research combined management ability and basic skills, mainly covering nursing quality control and environmental management, evaluating the effectiveness of nursing, identifying potential risks and responding promptly. Based upon the Competency Inventory for Registered Nurses (Liu et al., 2006), "emergency and problem-solving skills," which are necessary skills for ORNs, were added. Khomeiran has summarized nurse competency, including ideological moral education, professional knowledge and legal knowledge (Khomeiran et al., 2006). Compared with other studies about core competencies for nurses

TABLE 2 Items analysis of initial Core Competency Scale for ORNs with 42 items

Item	Dimension and item statements	Scores ($M \pm SD$)	Items-Total correlation	Inter-Item correlation
Dimension 1- Emergency and problem-solving skills (5 items, Cronbach's $\alpha = 0.88$)				
a1	Has rapid and accurate emergency response capacity and ability to resolve emergencies correctly and efficiently	2.7 ± 0.8	0.679	0.258–0.681
a2	Deals with a large number of injured patients and in operation work with critically ill patients	2.6 ± 0.8	0.636	0.228–0.681
a3	Operates surgical instrument skillfully, judges and repairs common instrument malfunctions	2.8 ± 0.8	0.615	0.195–0.605
a4	Emergency operation is accurate, quick and efficient	2.8 ± 0.8	0.672	0.283–0.665
a5	Arranges emergency personnel reasonably and carries out the treatment effectively	2.5 ± 0.9	0.680	0.225–0.662
Dimension 2- Specialist knowledge and skills (12 items, Cronbach's $\alpha = 0.94$)				
a6	Improves professional technological skills actively	3.2 ± 0.8	0.676	0.245–0.615
a7	Maintains the patient in proper position to ensure the smooth operation and patient safety	3.2 ± 0.8	0.686	0.190–0.748
a8[a]	Takes effective measures to prevent adverse events in the operation, such as low temperature and pressure sores	3.3 ± 0.8	0.680	0.153–0.749
a9	Observes changes in vital signs closely. Identifies potential safety hazards	3.1 ± 0.8	0.699	0.196–0.697
a10	Ensures the integrity of surgical instruments and provides required items in surgery a timely manner	3.3 ± 0.7	0.671	0.218–0.679
a11	Carries out standard procedure correctly to control nosocomial infection. Has management ability in disinfection and isolation	3.1 ± 0.8	0.699	0.174–0.645
a12	Standardize the contents of nursing records. Written expression is clear and precis.	3.4 ± 0.6	0.720	0.202–0.679
a13	Cooperates with difficult, complex or new operations. Reserves knowledge effectively	2.7 ± 0.9	0.709	0.270–0.670
a14	Shows willingness to understand new progress in specialized surgery and grasps opportunities to enhance personal ability	3.1 ± 0.8	0.705	0.381–0.612
a15	Conducts effective preoperative visits. Evaluates patient condition comprehensively and provides multicultural nursing service	3.1 ± 0.8	0.646	0.185–0.741
a16[a]	Provides the correct psychological counseling to patients waiting for surgery	3.1 ± 0.8	0.638	0.226–0.741
a17	Uses advanced facilities actively and reasonably to improve nursing practices during operations	2.9 ± 0.8	0.779	0.401–0.662
Dimension 3- Collaboration and interpersonal communication skills (5 items, Cronbach's $\alpha = 0.89$)				
a18	Cooperates with others to ensure operation safety. Handles relationship among doctors, nurses and patients correctly	3.2 ± 0.8	0.718	0.217–0.636
a19	Expresses ideas and different views verbally in a clear and organized way	2.9 ± 0.8	0.769	0.341–0.636
a20	Shows a willingness to share workload when others are needed	3.2 ± 0.8	0.717	0.207–0.708
a21	Promotes cooperation and trust between colleagues and is willing to show personal thought. Recognizes contributions and achievements of others	3.3 ± 0.7	0.712	0.208–0.708
a22	Builds a teamwork atmosphere and resolves conflict in a positive way	3.1 ± 0.8	0.730	0.360–0.657

(Continues)

TABLE 2 (Continued)

Item	Dimension and item statements	Scores ($M \pm SD$)	Items-Total correlation	Inter-Item correlation
Dimension 4- Teaching and research capacity (8 items, Cronbach's α = 0.92)				
a23	Has teaching consciousness and abilities. Supports and assists the internship nurses to complete learning tasks	3.0 ± 1.0	0.751	0.260–0.726
a24	Supports new nurses in adapting to the new environment. Coaches junior nurses to meet their personal and professional development needs	2.9 ± 1.0	0.791	0.386–0.792
a25[a]	Owns specialized ability in theory teaching and operation demonstration	2.7 ± 1.0	0.714	0.254–0.759
a26[a]	Implements different teaching strategies for different students and guides and evaluates nursing performance of students	2.7 ± 1.0	0.758	0.340–0.792
a27	Has the ability to perform literature retrieval, research topic selection, to perform data collection and analysis, to implement research and to write papers	2.0 ± 1.0	0.642	0.238–0.838
a28[a]	Takes advantage of existing resources and equipment to perform scientific research.	1.8 ± 1.0	0.558	0.138–0.838
a29	Searches research findings comprehensively to address problems in clinical practices and applies relevant research findings to nursing practice	2.0 ± 1.0	0.521	0.128–0.836
a30	Knows own learning needs	3.0 ± 0.8	0.580	0.195–0.569
Dimension 5- Laws and regulations and relevant expertise (5 items, Cronbach's α = 0.90)				
a31	Carries out nursing practices according to legal requirements and organizational policy	3.3 ± 0.7	0.601	0.160–0.686
a32	Respects the patient's right to privacy and autonomy and protects the patient's benefits	3.4 ± 0.6	0.662	0.186–0.686
a33	Identifies illegal and immoral behaviors, supervises and reports all perceived medical malpractice to the responsible persons	3.1 ± 0.9	0.685	0.185–0.743
a34	Ensures the confidentiality and security of written and verbal information acquired in medical and nursing practices	3.3 ± 0.7	0.666	0.128–0.743
a35	Has relevant professional knowledge, such as legal knowledge and nursing psychology	2.9 ± 0.9	0.661	0.246–0.685
Dimension 6- Management capabilities and basic skills (7 items, Cronbach's α = 0.88)				
a36	Accepts and utilizes constructive criticism and opinions	3.2 ± 0.8	0.525	0.174–0.541
a37	Participates in nursing quality control in their department	2.7 ± 1.0	0.621	0.284–0.605
a38	Finds the potential risk in their work and takes effective and timely measures	3.0 ± 0.8	0.736	0.372–0.630
a39	Evaluates the effectiveness of nursing accurately	2.8 ± 0.8	0.757	0.389–0.689
a40	Involved in the environmental management of department actively	3.0 ± 0.8	0.745	0.378–0.689
a41	Has a sense of responsibility, emotional stability, spirit of self-supervision and service consciousness; has good professional ethics and capacity for coping with stress	3.3 ± 0.7	0.712	0.220–0.727
a42[a]	Takes responsibility for own performance	3.6 ± 0.7	0.612	0.138–0.727

Note: Cronbach's α for the total score was 0.97.

This instrument was developed in Chinese and these English items were translated for the purpose of the paper, and they were not tested.

Abbreviations: *M*, mean; *SD*, standard deviation.

[a]Deleted items because of redundancy with items.

TABLE 3 Exploratory factor analysis of Core Competencies of ORNs in China with 36 items

Item	Dimension and item statements	Factor Loading				
		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Factor 1 Collaboration and interpersonal communication skills and legal knowledge (CIL, 12 items)						
a34	Ensures confidentiality and security of written and verbal information acquired in medical and nursing practices	0.736				
a31	Carries out nursing practices according to legal requirements and organizational policy	0.721				
a32	Respects the patient's right to privacy and autonomy; protects the patient benefits	0.717				
a36	Accepts and utilizes constructive criticism and opinions	0.690				
a30	Knows own learning needs	0.643				
a33	Identifies illegal and immoral behaviors; supervises and reports all perceived medical malpractice to the responsible persons	0.636				
a21	Promotes cooperation and trust between colleagues and is willing to show personal thought. Recognizes contributions and achievements of others	0.625				
a35	Has relevant professional knowledge, such as legal knowledge and nursing psychology	0.571				
a41	Has a sense of responsibility, emotional stability, spirit of self-supervisiont and service consciousness; has good professional ethics and stress-coping capacity	0.554				
a20	Shows willingness to share workload when others are needed	0.554				
a18	Cooperates with others to ensure operation safety. Handles relationships among doctors, nurses and patients correctly	0.481				
a19	Expresses ideas and different views verbally and in a clear and organized way	0.451				
Factor 2 Specialist knowledge and skills (SK, 7 items)						
a10	Ensures the integrity of surgical instruments and provides required items in surgery in a timely manner		0.764			
a12	Standardizes the contents of nursing records. Written expression is clear and precise		0.708			
a11	Carries out standard procedures correctly to control nosocomial infection. Has management ability in disinfection and isolation		0.606			
a6	Improves own professional technological skill actively		0.604			
a7	Maintains the patient in proper position to ensure the smooth operation and patient safety		0.602			
a14	Shows a willingness to understand new progress in specialized surgery and grasps the opportunities to enhance personal ability		0.527			

(Continues)

TABLE 3 (Continued)

Item	Dimension and item statements	Factor Loading				
		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
a15	Conducts effective preoperative visits. Evaluates patient conditions comprehensively and provides multicultural nursing service		0.524			
Factor 3 Emergency and problem-solving skills (EP, 8 items)						
a4	Emergency operations are accurate, quick and efficient			0.771		
a1	Has rapid and accurate emergency response capacity and the ability to handle emergencies correctly and efficiently			0.769		
a3	Operates surgical instruments skillfully and judges and repairs common instrument malfunctions			0.702		
a2	Deals with a large number of injured patients and in operation work with critically ill patients			0.684		
a5	Arranges emergency personnel reasonably and carries out the treatment work effectively			0.598		
a9	Observes changes in vital signs closely. Identifies potential safety hazards			0.583		
a23	Has teaching consciousness and abilities. Supports and assists the internship nurses in the completion of learning tasks			0.449		
a17	Uses advanced facilities actively and reasonably to improve nursing practices during operations			0.400		
Factor 4 Research and teaching (TR, 5 items)						
a29	Searches researching findings comprehensively to address problems in clinical practice and applies relevant research findings to nursing practice				0.784	
a27	Has the ability to perform literature retrieval, research topic selection, to perform data collection and analysis, to implement research and to write papers				0.679	
a24	Supports new nurses in adapting to the new environment. Coaches junior nurses to meet their personal and professional development needs				0.495	
a13	Cooperates with difficult, complex or new operations. Reserves knowledge effectively				0.480	
a22	Builds a teamwork atmosphere and resolves conflict in a positive way				0.446	
Factor 5 Management capacity and basic skills (MC, 4 items)						
a37	Participates in nursing quality control in the department					0.707
a39	Evaluates the effectiveness of nursing accurately					0.516
a38	Finds potential risks in the work and takes measures in an effective and timely manner					0.508

TABLE 3 (Continued)

Item	Dimension and item statements	Factor Loading				
		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
a40	Involved in the environmental management of department actively					0.487
Rotation sums of square l loadings						
Eigenvalues	6.484	5.150	5.132	3.812	3.492	
Proportion of variance(%)	18.010	14.305	14.255	10.590	9.700	
Cumulative proportion of variance(%)	18.010	32.315	46.469	57.159	66.859	

Note: Cronbach's α for the total score was 0.93.

This instrument was developed in Chinese, and these English items were translated for the purpose of the paper, and they were not tested.

TABLE 4 Correlation analysis of 5 dimensions in the core competency scale for operating room nurses with 36 items

	CIL	SK	EP	TR	MC
CIL	1				
SK	0.784	1			
EP	0.704	0.752	1		
TR	0.633	0.629	0.722	1	
MC	0.733	0.688	0.726	0.724	1
Overall	0.898	0.875	0.894	0.824	0.854
$\overline{X} \pm S$	38.31 ± 7.18	22.67 ± 4.38	22.52 ± 5.24	12.56 ± 3.71	11.57 ± 2.79

Abbreviations: CIL, collaboration and interpersonal communication skills and legal knowledge; EP, emergency and problem-solving skills; MC, management capabilities and basic skills; SK, specialist knowledge and skills; TR, teaching and research capacity.

(Lin et al., 2010; Paige et al., 2014), this scale is more elaborate in its structure.

Testing in this study provided evidence of the reliability and validity of this instrument. The internal consistency Cronbach's α ranged from 0.88–0.94 for the subscales and was 0.97 for the overall scale, indicating a high degree of stability over a period of time and a satisfactory degree of homogeneity. Inter-dimensional analysis indicated that the correlation coefficient among all remaining dimensions ranged from 0.61–0.89, which was considered a reasonably acceptable level. The results of test–retest reliability indicated that the scales had good stability.

In this study, we addressed the issue by providing support for the conceptualization of the scale. The factors identified appear to be consistent with the theoretical framework. We put forward the core competency framework for the ORN specialty and established a scale that conformed to ORNs. Thus, to some extent, the study provides a basic structure and foundation for ORNs in professional employment, training and assessment. Compared with PPCS-R, in addition to the general ability requirements, CCS-ORN emphasizes the detailed requirements of techniques and skills, while the CCS-ORN highlights the concept of full-term nursing; that is, the core competencies of ORNs cover the requirements preoperatively (e.g. a15 Conducts effective preoperative visits. Evaluates patient conditions comprehensively and provides multicultural nursing service), intraoperative (e.g. a7 Maintains the patients in proper position to ensure the smooth operation and patient safety) and postoperative (e.g. a12 Standardizes the contents of nursing records. Written expression is clear and exact) and is a more comprehensive capacity requirement.

There are a few limitations to this study. First, to obtain a full explanation for core competencies, the objects for scale evaluation were chosen from tertiary comprehensive hospitals. However, for some ORNs in low-level hospitals, it is difficult to achieve this standard. To date, this scale has only adapted to ORNs in tertiary comprehensive hospitals. Second, in the interview, the focus group interviewed different levels of nurses. However, stratified sampling for various nurses was ignored. Third, China is a multiethnicc country. There is a considerable difference among nationalities. We need to improve the core competency scale for ORNs of different nationalities. In addition, the confirmatory factor analysis with large different samples to further test the construct validity needs to be considered in the future. Although the scale with 5 components and 36 items presented better construct validity, further adaptation is necessary. Another limitation is that we did not perform convergent and

TABLE 5 Core Competency Scale (CCS_ORN) scores and subscale scores, by years of operating room (OR) experience

Subscale	Years of OR Experience	*N*	Scores $\overline{X} \pm S$	*F*	Sig.
CIL	0–5 years	108	32.9 ± 7.0	112.671	<.001
	6–10 years	60	37.2 ± 5.5		
	≥11 years	132	43.3 ± 3.6		
SK	0–5 years	108	19.4 ± 4.4	107.184	<.001
	6–10 years	60	22.0 ± 3.4		
	≥11 years	132	25.7 ± 2.1		
EP	0–5 years	108	18.4 ± 4.5	124.726	<.001
	6–10 years	60	21.9 ± 3.7		
	≥11 years	132	26.3 ± 3.3		
TP	0–5 years	108	9.8 ± 2.9	119.880	<.001
	6–10 years	60	11.9 ± 2.7		
	≥11 years	132	15.2 ± 2.7		
MC	0–5 years	108	9.5 ± 2.5	101.434	<.001
	6–10 years	60	11.2 ± 2.2		
	≥11 years	132	13.5 ± 1.8		
Overall	0–5 years	108	89.9 ± 17.2	183.314	<.001
	6–10 years	60	104.2 ± 14.4		
	≥11 years	132	124.0 ± 9.9		

Abbreviations: CIL, collaboration and interpersonal communication skills and legal knowledge; EP, emergency and problem-solving skills; MC, management capabilities and basic skills; SK, specialist knowledge and skills; TR, teaching and research capacity.

discriminant analysis to test external validity. In addition, the statement of the items based on Chinese grammar habits, so some items composed of the common statement of the required capabilities and further statement about a specific explanation of this ability in the operating room environment, which could bring about bias and potentially limits the scale's applicability to other cultural backgrounds.

5 | CONCLUSIONS

The core competency scale for operating room nurses with 5 components and 36 items that was developed in this study had acceptable reliability and validity, and this scale provides an effective tool for the competency assessment and setting targeted training courses for nurses working in operating rooms in China, especially in large comprehensive hospitals. However, studies with larger samples are needed to test the applicability of this scale and make the necessary adjustment of items.

ACKNOWLEDGEMENTS

We gratefully acknowledge all the advisory consultant's support and help. Thanks to every nurse who was involved in. Sincere thanks are also due to the members of the core competency for operating room nurses research team and all the study participants.

CONFLICT OF INTEREST

No conflict of interest has been declared by the authors.

AUTHOR CONTRIBUTIONS

All the authors have participated in the design, implementation and analyses of the data, which form the basis of this manuscript and contributed to drafts of the paper. Na Mei & Lingxia Zeng: Study conception and design. Na Mei, Ling Chang, Zhonghai Zhu, Min Dong & Min Zhang: Data collection, double data entry and data clean. Na Mei & Ling Chang: Data analysis and drafting. Lingxia Zeng: Supervision and data analysis and interpretation, and editing.

ETHICAL APPROVAL

The study proposal was approved by the Academic Committee in the first Affiliated Hospital of Xi'an Jiaotong University (No.2013YK51). All participants gave written informed consent before participating in the study.

DATA AVAILABILITY STATEMENT

Some data that has been used is confidential, otherwise, the remaining data generated or analysed during this study are included in this published article (and its supplementary information files).

ORCID

Lingxia Zeng https://orcid.org/0000-0002-4649-9818

REFERENCES

Andrew, S., Gregory, L., Cowin, L. S., Eagar, S. C., Hengstberger-Sims, C., & Rolley, J. (2008). Psychometric properties of the Australian nurse

competency 2000 standards. *International Journal of Nursing Studies*, *45*, 1512–1515. https://doi.org/10.1016/j.ijnurstu.2007.10.008

Brammer, J. (2006). A phenomenographic study of registered nurses' understanding of their role in student learning–An Australian perspective. *International Journal of Nursing Studies*, *43*, 963–973. https://doi.org/10.1016/j.ijnurstu.2005.11.004

Chen, C., & Lou, M. (2014). The effectiveness and application of mentorship programmes for recently registered nurses: A systematic review. *Journal of Nursing Management*, *22*, 433–442. https://doi.org/10.1111/jonm.12102

Cheng, S., Gao, M., & Bai, L. (2013). Cultivation and usage of the ICU nurse specialists. *Chinese Nursing Management*, *13*, 15–17. PMID: CSCD:4916111(in Chinese).

Cowin, L. S., Johnson, M., Craven, R. G., & Marsh, H. W. (2008). Causal modeling of self-concept, job satisfaction, and retention of nurses. *International Journal of Nursing Studies*, *45*, 1449–1459. https://doi.org/10.1016/j.ijnurstu.2007.10.009

Dunn, L. (1997). A literature review of advanced clinical nursing practice in the United States of America. *Journal of Advanced Nursing*, *25*, 814–819. https://doi.org/10.1046/j.1365-2648.1997.1997025814.x

Dury, C., Hall, C., Danan, J. L., Mondoux, J., Aguiar Barbieri-Figueiredo, M. C., Costa, M. A. M., & Debout, C. (2014). Specialist nurse in Europe: Education, regulation and role. *International Nursing Review*, *61*, 454–462. https://doi.org/10.1111/inr.12123

Fayers, P. M., & Machin, D. (2007). *Quality of life: Assessment, analysis and interpretation*. Wiley Press.

Flinkman, M., Leino-Kilpi, H., Numminen, O., Jeon, Y., Kuokkanen, L., & Meretoja, R. (2016). Nurse competence scale: A systematic and psychometric review. *Journal of Advanced Nursing*, *73*, 1035–1050. https://doi.org/10.1111/jan.13183

Geng, Y., Zhao, L., Wang, Y., Jiang, Y., Meng, K., & Zheng, D. (2018). Competency model for dentists in China: Results of a Delphi study. *PLoS One*,*13*(3), e0194411. https://doi.org/10.1371/journal.pone.0194411

Gillespie, B. M., Chaboyer, W., Wallis, M., Chang, H. Y., & Werder, H. (2009). Operating theatre nurses' perceptions of competence: A focus group study. *Journal of Advanced Nursing*, *65*, 1019–1028. https://doi.org/10.1111/j.1365-2648.2008.04955.x

Gillespie, B. M., Polit, D. F., Hamlin, L., & Chaboyer, W. (2012). Developing a model of competence in the operating theatre: Psychometric validation of the perceived perioperative competence scale-revised. *International Journal of Nursing Studies*, *49*, 90–101. https://doi.org/10.1016/j.ijnurstu.2011.08.001

Hasson, F., Keeney, S., & McKenna, H. (2000). Research guidelines for the Delphi survey technique. *Journal of Advanced Nursing*, *32*, 1008–1015. https://doi.org/10.1046/j.1365-2648.2000.t01-1-01567.x

Jiang, X., Yan, L., Zheng, X., Liu, X., & Wei, X. (2016). Development and evaluation of a new curriculum based on the Delphi method for master of nursing programs in China. *Chinese Nursing Research*, *3*, 162–167. https://doi.org/10.1016/j.cnre.2016.11.005

Khomeiran, R. T., Yekta, Z. P., Kiger, A. M., & Ahmadi, F. (2006). Professional competence: Factors described by nurses as influencing their development. *International Nursing Review*, *53*, 66–72. https://doi.org/10.1111/j.1466-7657.2006.00432.x

Kilner, T. (2004). Desirable attributes of the ambulance technician, paramedic, and clinical supervisor: Findings from a Delphi study. *Emergency Medicine Journal*, *21*, 374–378. https://doi.org/10.1136/emj.2003.008243

Lewis, S. C. (2009). Sample size calculations in clinical research. *Journal of Applied Statistics*, *36*, 469. https://doi.org/10.1080/02664760802366775

Lin, C. J., Hsu, C. H., Li, T. C., Mathers, N., & Huang, Y. C. (2010). Measuring professional competency of public health nurses: Development of a scale and psychometric evaluation. *Journal of Clinical Nursing*, *19*, 3161–3170. https://doi.org/10.1111/j.1365-2702.2009.03149.x

Liu, M., Kunaiktikul, W., Senaratana, W., Tonmukayakul, O., & Eriksen, L. (2007). Development of competency inventory for registered nurses in the People's Republic of China: Scale development. *International Journal of Nursing Studies*, *44*, 805–813. https://doi.org/10.1016/j.ijnurstu.2006.01.010

Liu, M., Wipada, K., & Wilawan, S. (2006). Framework of the Chinese registered nurse's competency: A qualitative research. *Chinese Journal of Nursing*, *41*, 691–694. PMID: CSCD:2434422 (in Chinese).

Liu, M., Yin, L., Ma, E., Lo, S., & Zeng, L. (2009). Competency Inventory for Registered Nurses in Macao: Instrument validation. *Journal of Advanced Nursing*, *65*, 893–900. https://doi.org/10.1111/j.1365-2648.2008.04936.x

Man, G., Gu, X., & Zhao, J. (2013). Development of a competency model for operating-room nurse specialist. *Journal of Nursing Science*, *28*, 42–44. PMID: CSCD:4898191(in Chinese).

Meretoja, R., Isoaho, H., & Leino-Kilpi, H. (2004). Nurse competence scale: Development and psychometric testing. *Journal of Advanced Nursing*, *47*, 124–133. https://doi.org/10.1111/j.1365-2648.2004.03071.x

Mitrea, N., Rogozea, L., & Mosoiu, D. (2014). 58 Professional competencies of nurses working in specialised palliative care services in Romania. *European Journal of Oncology Nursing*, *18*, S16. https://doi.org/10.1016/S1462-3889(14)70077-8

Ou, G., Zhang, S., & Ji, G. (2014). Application of Delphi method in establishment of health information Hteracy evaluation index system for diabetes patients. *Chinese Journal of Health Education*., *30*, 107–110. (in Chinese).

Paige, J. T., Garbee, D. D., Kozmenko, V., Yu, Q., Kozmenko, L., Yang, T., Bonanno, L., & Swartz, W. (2014). Getting a head start: High-fidelity, simulation-based operating room team training of interprofessional students. *Journal of the American College of Surgeons*, *218*, 140–149. https://doi.org/10.1016/j.jamcollsurg.2013.09.006

Rudman, A., Gustavsson, P., Ehrenberg, A., Bostrom, A. M., & Wallin, L. (2012). Registered nurses' evidence-based practice: A longitudinal study of the first five years after graduation. *International Journal of Nursing Studies*, *49*, 1494–1504. https://doi.org/10.1016/j.ijnurstu.2012.07.007

Scott-Tilley, D. (2008). Competency in nursing: A concept analysis. *Journal of Continuing Education in Nursing*, *39*, 58–64. https://doi.org/10.3928/00220124-20080201-12

Simpson, M. R. (2010). Development and psychometric evaluation of the Core Nurse Resource Scale. *Journal of Nursing Management*, *18*, 1048–1059. https://doi.org/10.1111/j.1365-2834.2010.01137.x

Streiner, D. L., & Norman, R. G. (2008). *Health measurement scales. A practical guide to their development and use (4thedn)*. Oxford University Press.

Terwee, C. B., Prinsen, C. A., Chiarotto, A., de Vet, H. C., Bouter, L. M., Alonso, J., Westerman, M. J., Patrick, D. L., & Mokkink, L. B. (2018). *COSMIN methodology for assessing the content validity of PROMs-User manual*. Retrieved from, https://www.cosmin.nl/wp-content/uploads/COSMIN-methodology-for-content-validity-user-manual-v1.pdf

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Mei, N., Chang, L., Zhu, Z., Dong, M., Zhang, M., & Zeng, L. (2022). Core competency scale for operating room nurses in China: Scale development, reliability and validity evaluation. *Nursing Open*, *9*, 2814–2825. https://doi.org/10.1002/nop2.985