#### RESEARCH

BMC Nursing



## Development and validation of an evaluation index system of health education competence for dental nurses in China: a mixed methods study

Xiaowen Feng<sup>1</sup>, Wei Xiao<sup>1\*</sup>, Fang Shen<sup>1</sup>, Ziwen Ye<sup>2,1</sup>, Wanying Su<sup>1</sup>, Anqi Cai<sup>1</sup>, Xiaohong Wu<sup>1</sup> and Jinsu Chen<sup>1</sup>

#### Abstract

**Background** The global prevalence of oral diseases has imposed substantial health and economic burden. In China, oral health knowledge, behaviors, and literacy among residents remain insufficient, highlighting the need for improvement. Thus, strengthening the health education competence of dental nurses is important to address this issue, enhance oral health education, and support the development of an effective evaluation system. Therefore, this study aimed to develop a set of evaluation tools to facilitate the scientific and objective assessment of dental nurses' health education competence.

**Methods** A mixed-methods approach integrating qualitative and quantitative research methods was employed. Initially, we constructed a pool of index system items through a thorough literature review and semi-structured interviews. The initial draft was then refined using the Delphi method, which involved expert consensus to enhance accuracy and relevance. We determined the weights of the items using the Analytic Hierarchy Process, and to assess the reliability and validity of the constructed system, a questionnaire survey was conducted, followed by exploratory factor analysis (EFA) and confirmatory factor analysis (CFA).

**Results** A total of 15 experts, including dental nursing and dentistry professionals, participated in the Delphi process, resulting in 3 primary, 11 secondary, and 46 tertiary indicators. The experts' enthusiasm in the two rounds was 93.75% and 100%, with authority coefficients of 0.88 and 0.92, and coordination coefficients ranging from 0.10 to 0.41 and 0.10–0.22, respectively. A total of 425 questionnaires were collected, with a Cronbach's  $\alpha$  value of 0.978. EFA identified four common factors and led to the exclusion of 15 items, leaving 31 items that explained 70.43% of the total variance. The final evaluation system included 4 primary, 9 secondary, and 31 tertiary indicators. CFA showed good model fit ( $\chi^2$ /df=1.538, GFI=0.966, AGFI=0.927, RMSEA=0.050). The combination reliability (CR) values of the four primary indicators were all above 0.70 (0.82, 0.94, 0.86, 0.88), and the average variance extracted (AVE) values were all above 0.5 (0.70, 0.84, 0.76, 0.79), indicating good reliability and validity.

\*Correspondence: Wei Xiao 2012690440@gzhmu.edu.cn

Full list of author information is available at the end of the article



© The Author(s) 2025. **Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by-nc-nd/4.0/.

**Conclusion** The evaluation tool constructed in this study demonstrates adequate psychometric properties (e.g., reliability and validity) and can serve as a valuable resource for evaluating the health education competence of dental nurses in China, ultimately informing the development of targeted strategies to enhance their skills and improve public oral health outcomes.

Keywords Dental nurses, Health education competence, Iceberg model, Evaluation index

#### Background

Oral health is an important component of overall health and well-being. Despite this, nearly half of the global population suffers from poor oral health. It has been shown that approximately 2.5 billion people have untreated dental caries, 3.5 billion people are edentulous, 1 billion individuals experience severe periodontal disease, and 380,000 people are affected by oral cancers [1]. The global burden of oral diseases is estimated at about 1 billion cases higher than the combined prevalence of the five major non-communicable diseases, namely mental illness, cardiovascular disease, diabetes, chronic respiratory disease, and cancer, making oral diseases among the most widespread and predominant health issues worldwide, thereby imposing a substantial economic and health burden [2]. Expenditures related to dental diseases account for approximately 4.8% of global direct health costs, resulting in estimated productivity losses of about \$42 per capita and total global productivity losses of approximately \$323 billion [3]. Beyond the economic burden, oral diseases are associated with the development and progression of chronic conditions, including diabetes, cardiovascular diseases, and dementia, due to shared risk factors and inflammatory pathways [4, 5]. Additionally, symptoms such as pain, chronic inflammation, and functional impairment linked to oral diseases substantially diminish patients' quality of life [6].

Oral health is influenced by various factors, with an individual's knowledge, experience, values, and attitudes being important intrinsic determinants [7, 8]. These factors are dynamic and can be modified through health education to improve oral health care [9]. For instance, an individual's knowledge level directly impacts the extent to which they value oral health, while their experiences and attitudes influence their ability to comprehend and apply health-related information [10]. Positive changes, such as increasing knowledge or adopting healthier behaviors, can significantly enhance an individual's capacity to understand, accept, and practice oral health principles, ultimately supporting the maintenance of good oral health [11]. As one of the main components of oral health education, the health education competence of dental nurses is important in influencing these factors, as it directly affects their ability to deliver effective education and support patients in developing better oral health practices [12]. Health education competence includes the psychological characteristics of knowledge,

skills, behaviors and attitudes essential for successful and effective health education delivery [13, 14]. Dental nurses with a high level of health education competence are more likely to implement comprehensive and effective oral health education, helping patients to better understand oral health concepts, promoting recovery from oral diseases, and ultimately improving overall oral health outcomes [15].

However, the competence of dental nurses in health education has been questioned [16]. A study reported that nursing staff perceive themselves as lacking the necessary knowledge to effectively carry out health education, which poses challenges in performing related tasks [17]. An investigation revealed that less than half of the nursing staff (~44%) had received comprehensive training in health education professional competencies, while 56% had only received partial training. Moreover, a substantial proportion of medical staff, ranging from 82.9 to 97.6%, expressed a strong desire to undergo training in health education to enhance their competencies in this area [18–20].

Currently, the challenge of systematically and scientifically evaluating the health education competence of nursing staff, identifying and addressing errors and deficiencies in a timely manner, and efficiently completing health education has become a pressing issue that has garnered widespread attention and discussion [21, 22]. Thus, developing an evaluation index system specifically for the health education competence of dental nurses can provide a foundation and standard for assessing their competence, which could be a starting point in enhancing the health education competence of dental nurses.

In many countries, comprehensive evaluation index systems for health education competence have been established and primarily target public health education workers. In 1998, the National Commission for Health Education Credentialing (NCHEC) certified ten health education competencies, including the ability to assess community and individual health education needs, plan health education activities effectively, and implement and evaluate their effectiveness [23], laying the groundwork for developing subsequent health education competency evaluation tools. In 2004, Price et al. [24] developed a self-assessment scale to evaluate the health education competence of public health educators. In 2012, NCHEC introduced the Health Educator Job Analysis 2010 (HEJA 2010) [25], followed by the release of updated versions, including the Health Education Specialist Practice Analysis 2015 (HESPA 2015) [26] and Health Education Specialist Practice Analysis 2020 II (HESPA 2020 II) [27] in 2016 and 2020, respectively. These evaluation models and systems were designed for health education specialists to certify their roles and competencies. Given the considerable differences in economic conditions, cultural backgrounds, and medical systems between domestic and international settings, it remains necessary to investigate and validate whether these foreign health education competence evaluation standards are applicable for assessing the health education competence of nursing staff in China.

In China, dental hygiene education has long lagged behind stomatology, leading to disparities in clinical practice. Most dental nursing positions are occupied by nurses who have received general nursing education, resulting in a disconnect between educational preparation and practical application, as well as a lack of clearly defined duties for dental nurses [28]. Furthermore, there is no unified national system for training, certification, assessment, or evaluation of dental nurses. Currently, the health education competence of nursing staff in China is not evaluated using a standardized tool specifically designed for dental nurses. Instead, evaluations are often based on clinical experience and self-designed general questionnaires, which lack scientific rigor and reliability, making it difficult to accurately assess health education competence and develop targeted improvement strategies in dental health education [17, 29]. Although some scholars in China have investigated the evaluation of health education competence among nursing staff, these efforts have primarily focused on general nursing rather than dental nursing. For example, Qi [30] developed a health education competence evaluation index system for obstetric nurses, Niu [31] designed a health education competence assessment scale for community nursing staff, and Mi [32] created a self-assessment scale for nursing staff's health education competence. However, these studies have several limitations. First, the existing tools often fail to capture the evolving requirements of health education competence in contemporary healthcare settings. Additionally, some tools lack expert input from the field of oral medicine, limiting their applicability to dental nursing. Moreover, the sampling and consultation processes in these studies did not sufficiently represent the dental nursing community, and the evaluation content was either too general or lacked appropriate weighting. As a result, they may not adequately reflect the specific competencies required for oral health education or the unique role of dental nurses as primary educators. Due to these gaps in literature, this study aims to develop a scientifically rigorous and systematic evaluation tool specifically for assessing the health education competence of dental nurses to provide a more accurate, comprehensive, and targeted assessment for the development of evidence-based strategies to enhance dental health education.

The health education competence of dental nurses encompasses both theoretical knowledge and practical skills, and to effectively evaluate this, it is important to consider both the observable and underlying factors that influence educational effectiveness. Spencer's "Iceberg Model" offers a theoretical framework for this purpose by categorizing competence into visible and hidden components [33]. The visible components, such as knowledge and skills, are easily observed and measured, similar to the part of an iceberg that is above the water's surface. In contrast, the hidden components, including social roles, self-cognition, traits, and motives, are less apparent and can be compared to the submerged part of the iceberg. Applying the Iceberg Model to the health education competence of dental nurses provides a comprehensive approach to evaluation by incorporating both visible skills and underlying psychological characteristics. This integrated perspective is essential for understanding the full scope of competence required for effective oral health education. Based on this framework, the present study aims to develop a systematic and scientifically validated tool to assess the health education competence of dental nurses. By considering both the visible and hidden aspects of competence, the tool will enable a more accurate and comprehensive assessment, ultimately facilitating the identification of strengths and areas requiring improvement in oral health education practices.

#### Methods

#### **Design and procedures**

This study used a mixed-method approach, combining qualitative and quantitative methods, including a literature review, qualitative research, Delphi method, and questionnaire. The study was conducted from July 2023 to June 2024 and was divided into three phases: constructing the first draft of the evaluation index system of dental nurses' health education competence, determining and validating the evaluation index system, and finalizing the system. The overall process is shown in Fig. 1.

#### Research team

The research team consisted of eight members from the Stomatology Hospital Affiliated with Guangzhou Medical University (Guangzhou, China), including one chief nurse, one deputy chief nurse, three charge nurses (two of whom held postgraduate qualifications), and three nursing postgraduates actively pursuing their studies. The team members underwent systematic training to master the implementation and application of the Delphi method. The primary tasks of the research team included



Fig. 1 Technology roadmaps

developing the draft version of the evaluation index system for dental nurses' health education competence through literature review and semi-structured interviews. They also developed the expert correspondence questionnaire, selected the expert panel, discussed and analyzed the results from expert correspondence, and made decisions on whether to incorporate the experts' feedback. Additionally, the team conducted the questionnaire survey, ensured quality control and data analysis, and ultimately established the final evaluation index system for dental nurses' health education competence.

#### Phase I: Preliminary construction of an evaluation index system for the health education competence of dental nurses (Draft)

#### Literature review

Literature search strategies The literature search was conducted on PubMed, Science Direct, Web of Science, Cochrane Library, EBSCO, CNKI, Wanfang, Weipu, and SinoMed. The Chinese search terms included "dental nurses," "nurses," "health education competence," "evaluation," and "index system." The English search terms were "dental assistant," "dental hygienist," "dental nurse," "health education competence," "health education competency," and "evaluation." The search timeframe extended from the inception of each database to July 2023. The literature screening process is shown in Fig. 2.

#### Semi-structured interviews

The research team developed an interview outline to explore and refine the framework of the indicator system and the pool of indicators based on interview findings. The purposive sampling method was employed to select nursing managers, clinical nurses, and dentists from three tertiary A dental specialty hospitals in Guangdong Province (Stomatology Hospital Affiliated to Guangzhou Medical University) and Jilin Province (University Hospital of Stomatology, Jilin University) in China. The interviews were conducted between October 2023 and November 2023. The sample size was determined based on the principle of saturation of respondents' information, and the final sample included 16 nursing managers and clinical nurses and 5 dentists.

 (1) Inclusion criteria for interviewees: (A) Dental nurses:
 ① College degree or above. ② Nurse Practitioner or higher qualification. ③ Being involved in dental nursing administration, clinical nursing or nursing education-related work. ④ Work experience ≥ 5 years.



Fig. 2 Literature screening flow chart

(§) Good communication skills, informed consent, and active participation in the study. (B) Dentists: (1) Master's degree or higher. (2) Experience in dental clinical management, clinical research, clinical diagnosis and treatment, or oral health education. (3) Work experience  $\geq 10$  years. (4) Good communication skills, informed consent, and active participation in the study.

- (2) Exclusion criteria for interviewees.
  ① Individuals who refused to be recorded. ②
  Withdrew from the interview midway.
- (3) Research outline:
  - A. Nurse interview outline: ① Please tell us your opinion about oral health education? ② What aspects of oral health education do you carry out?
    ③ What do you think are the most important health education skills that dental nurses need to improve? ④ What knowledge and skills do you think a good oral health education nurse should have? ⑤ Do you have any additional comments or suggestions on the above?
  - B. Dentists interview outline: ① In order to do a good job of oral health education, what do you think nurses need to have professional competence personality traits? ② What problems do you think exist in the current health education of dental nurses? What aspects need to be improved?
    ③ What do you think are the factors affecting the health education of dental nurses? ④ What

are your suggestions for improving the health education capacity of dental nurses?

(4) Data collection and analysis.

The researchers invited potential interviewees who met the inclusion criteria, explained the purpose and significance of the study and adhered to the principle of informed consent. Written consent was obtained before participation. Before the interview, the researchers contacted the respondents via mobile phone to arrange the interview time and location, ensuring that the interview was conducted in a quiet, independent, and undisturbed environment. Upon obtaining the interviewee's consent, the interviews were audio-recorded, lasting approximately 20 to 30 min each. The audio recordings were transcribed into Word documents within 24 h of the interview. Then, the data were imported into the NVivo 12 software and analyzed using the Colaizzi 7-step method.

(5) Quality control.

① The interviewers received training to Master effective interviewing techniques prior to conducting the interviews. ② Purposive sampling was used to select the interviewees to ensure a representative sample. ③ The transcribed audio text was provided to the interviewees to verify the authenticity of the recorded information.

## Preliminary draft of the health education competence evaluation indicator system for dental nurses

The research team initially developed a preliminary draft of the health education competence evaluation indicator system for dental nurses, which included three primary indicators: knowledge and experience, skills and abilities, and comprehensive quality. These primary indicators were further refined into 11 secondary indicators and 44 tertiary indicators. The development process was based on a comprehensive literature review and the results of semi-structured interviews.

#### Phase II: Revision of the health education competence evaluation indicator system for dental nurses (Delphi method)

#### Expert panel selection and recruitment

The Delphi method, also known as the expert consultation method, is a systematic approach for achieving consensus on a specific topic or issue by gathering expert opinions and feedback through multiple rounds of questionnaires. It is widely used in nursing research, particularly for constructing evaluation index systems and determining specific indicators [34]. The success of the Delphi method largely depends on the careful selection of experts who are knowledgeable, experienced, and capable of providing insightful feedback. Typically, the number of experts involved ranges from 15 to 50, and the process usually involves two to three rounds of consultation to achieve a consensus [35]. In this study, we plan to consult experts from two fields: dental nursing and dental clinical medicine, with the goal to validate the preliminary evaluation indicators for the health education competence of dental nurses and establish a comprehensive evaluation indicator system. The criteria for expert selection are as follows: (1) Dental nursing experts: 1) Bachelor's degree or higher; 2 Deputy senior (deputy chief nurse) or higher professional title; 3 Engaged in dental nursing and oral health education in a tertiary-level hospital for more than 10 years; ④ Voluntarily participate in this study and have a certain level of enthusiasm, able to provide comprehensive advice, and able to ensure continuous participation and consultation in this study. (2) Stomatology clinical medicine experts: 1) With a master's degree or higher; 2) Deputy senior (deputy chief physician) or higher professional title; 3 Have been engaged in stomatology medicine work in tertiary Grade-A hospitals for at least 10 years; ④ Voluntarily participate in this study and have a certain level of enthusiasm, able to provide comprehensive advice, and able to ensure continuous participation and consultation in this study.

#### Data collection

 purpose, and significance of this study; 2 Basic information of the experts, including their name, age, education, position, years of work experience, professional title, etc.; 3 Expert opinion survey form, which rates the importance of each level of indicators using the Likert 5-point scale, 5 = "very important", 1 = "not important". The indicators at each level are followed by columns for modification and the need for additional indicators. ④ Self-assessment form for experts' familiarity and basis of judgement. (2) Distribution of the expert consultation questionnaire: The questionnaire will be distributed via email or WeChat, with a request for experts to complete and return it within two weeks. After receiving the completed questionnaires, the researchers will compile and statistically analyze the data, summarize the feedback, and modify the indicators as necessary. The opinions from the first round will be incorporated into the secondround questionnaire, along with explanations for any changes. Experts will then reassess the importance and content validity of the revised indicators. The process will continue until the expert opinions converge. The research group will use the following criteria for screening the indicators: mean importance score  $\geq$  4.0, coefficient of variation < 0.25 and the full score rate > 20% as indicator screening criteria [36]. Any indicators that do not meet these criteria will be removed from the study analysis.

## Determination of the weights of the health education competence evaluation indicator system for dental nurses

After completing two rounds of Delphi correspondence to establish the indicator system, the Analytic Hierarchy Process (AHP) was employed to determine the weights of the indicators. The classic Saaty 1-9 scale method was utilized to construct judgment matrices [37]. Subsequently, a third round of expert inquiries was conducted. Ten experts who participated in the entire process of revising the indicators were invited to perform pairwise comparisons of the relative importance of the evaluation indicators at each level. A total of one, three, and eleven judgment matrices were established for the primary, secondary, and tertiary indicators, respectively. The Yaahp 10.3 software was used to calculate the weights of each indicator, as well as the combination weights and the consistency coefficient (CR). A consistency coefficient of CR < 0.1 was considered acceptable [38].

#### Phase III: Examination of the health education competence evaluation indicator system for dental nurses (Factor analysis)

This phase aimed to verify the reliability and validity of the evaluation questionnaire and to finalize the indicator system for practical application.

Firstly, a pre-survey was conducted to assess the clarity, accuracy, and comprehensibility of the questionnaire content. The convenience sampling method was employed to select 20 dental nurses from the Affiliated Stomatology Hospital of Guangzhou Medical University (Guangdong, China), which is a tertiary A-level dental specialty hospital. The nurses were asked to complete the questionnaire to evaluate the expression clarity, content accuracy, response time, and potential ambiguities. Based on the feedback, the questionnaire items were revised and adjusted to form an application version evaluation questionnaire.

Next, dental nurses from both public and private dental hospitals in Guangdong Province and Hebei Province, China, served as the primary respondents. After obtaining consent from the nursing departments of the surveyed hospitals, the questionnaires were distributed to eligible nurses. The access criteria for the target population are as follows. (1) Inclusion criteria: ① Registered nurses with at least one year of experience, currently working in clinical dental nursing or educational roles; <sup>②</sup> Willingness to participate and provided informed consent for the survey. (2) Exclusion criteria: <sup>①</sup> Nurses who were unable to complete the questionnaire due to being out of town during the survey period.; 2 Nurses undergoing advanced training. (3) Removal criteria: 1 Inconsistent or patterned responses; 2 Incomplete questionnaires or questionnaires with identical responses throughout.

To meet the requirements of questionnaire design and psychometric principles, the sample size was calculated to be at least 5 to 10 times the number of questionnaire variables [39]. Considering a 20% loss rate, the health education competence evaluation index system for dental nurses comprised 46 items. Therefore, the sample size for exploratory factor analysis was set at no less than 100 cases [40], while the sample size for confirmatory factor analysis required at least 200 cases [41]. Based on these, the sample size was calculated using the equation: 46 \* (5-10) \* (1+20%), indicating the sample size should range from 276 to 552. The questionnaire consisted of three parts: (1) Guideline: Provided an overview and instructions for completing the questionnaire; (2) Basic Information: Collected demographic and professional data of the respondents; (3) Self-Assessment Questionnaire: Evaluated the health education competence of dental nurses using a 5-point Likert scale. The scores ranged from 1 to 5, representing levels of compliance: "not compliant," "not quite compliant," "generally compliant," "relatively compliant," and "very compliant." A higher score indicated a higher level of health education competence. Questionnaires were collected through both the online platform Questionnaire Star and paper versions.

#### Statistical methodology

To ensure the quality of expert participation, correspondence questionnaires with a recovery rate exceeding 70% were considered indicative of high motivation among experts [42]. The authority coefficient (Cr) of experts, calculated as Cr = (Ca + Cs)/2, where Cs denotes the coefficient of expert familiarity and Ca denotes the coefficient of expert judgment basis, was considered acceptable if greater than 0.7 [43]. The concentration of expert opinions was evaluated using the importance value, coefficient of variation (CV), and full score rate for each indicator. The established criteria were: importance value  $\geq$  4.0, CV < 0.25, and full score rate > 20% [36, 37]. Coordination among expert opinions was assessed using Kendall's W, where a higher W value indicated better coordination. The Analytic Hierarchy Process (AHP) was employed to analyze the results and determine the weights of each indicator.

The reliability of the questionnaire was assessed using Cronbach's  $\alpha$  coefficient, with values  $\geq 0.7$  considered acceptable [36]. Content validity was evaluated using the scale-level content validity index (S-CVI/Ave) and the item-level content validity index (I-CVI). An I-CVI≥0.78 and an S-CVI/Ave≥0.90 were considered ideal [44]. Factor analysis was conducted when the Kaiser-Meyer-Olkin (KMO) value exceeded 0.7, and Bartlett's sphericity test rejected the null hypothesis (p < 0.05) [45]. The survey sample was randomly divided into two groups using SPSS 25.0: one group for exploratory factor analysis (EFA) and the other for confirmatory factor analysis (CFA). Principal components analysis (PCA) was utilized to extract common factors, and variance-maximizing orthogonal rotation was performed to enhance interpretability. Retained items met the following criteria: eigenvalue > 1, factor loadings > 0.4, and total variance > 40%. Each factor contained at least three items. In cases where an item loaded>0.4 on 2 or more factors at the same time and the difference between loadings was <0.2, the research team made the decision on whether to retain the item [41]. Confirmatory factor analysis (CFA) was performed using Maximum Likelihood estimation (ML), with  $\chi^2/v < 3$  as the ideal level, RMSEA < 0.08 as a reasonable level, and GFI, AGFI, NFI, TLI, IFI and CFI>0.80 as acceptable level [46].

The data were processed using Excel 2010, EpiData 3.1, and IBM SPSS 25.0. Measurement data following a normal distribution were expressed as mean±standard deviation ( $\chi \pm s$ ), while count data were presented as frequency and constitutive ratio, with p < 0.05 considered statistically significant.

#### **Ethical considerations**

The study was conducted in accordance with the principles outlined in the Declaration of Helsinki, and ethical approval was obtained from the Medical Research Ethics Committee of The Affiliated Stomatology Hospital of Guangzhou Medical University (Guangzhou, Guangdong, China; ID: LCYJ2023052). All participants were fully informed about the study background, objectives, and requirements related to interviews, correspondence, and questionnaire completion, and their informed consent was obtained prior to participation. The study strictly adhered to the principles of anonymity and confidentiality.

#### Results

#### Literature review extraction results

A total of 1,308 articles were retrieved during the initial search. Additionally, 15 documents were obtained by tracing the references of the included studies, resulting in a total of 1,323 documents. After screening, 23 articles were included in the final analysis. The initial evaluation framework for the health education competence of dental nurses identified the following three dimensions: knowledge, skills, and comprehensive quality. The literature screening process is illustrated in Fig. 2.

#### Semi-structured interview results

Interviews were conducted with 11 dental nursing managers, 5 clinical nurses, and 5 dentists. The participants had an average working experience of 14.5 years, ranging from 6 to 35 years, and held a Bachelor's degree or higher. The demographic characteristics of the interviewees are presented in Table 1 in the appendix. The analysis of the interviews identified three primary indicators: "Knowledge and Experience," "Skills and Ability," and "Comprehensive Quality." Additionally, the secondary indicator "Dissemination and Communication Ability" was incorporated. Consequently, the draft evaluation system comprised 3 primary indicators, 11 secondary indicators, and 44 tertiary indicators prior to applying the Delphi method.

#### Delphi method results

#### Basic information about the experts

Three rounds of expert inquiry, consisting of two rounds of importance inquiry and one round of two-by-two comparative inquiry of indicator importance, were conducted. The panel included 15 experts from 13 universities or tertiary-level A hospitals located in Beijing, Hebei Province, Jilin Province, Jiangsu Province, and Guangdong Province, China. The average age of the experts was  $48.53 \pm 6.25$  years, and their average professional experience was  $27.53 \pm 7.68$  years. The detailed demographic information is presented in Table 2 in the appendix.

#### Statistical indicators of the Delphi method

(1) Enthusiasm of experts.

The recovery rates of the inquiry questionnaires in the first and second rounds were 93.75% and 100%,

respectively. As both recovery rates exceeded 70%, this indicated a high level of enthusiasm and positive engagement among the experts [42].

(2) Authority of experts.

The degree of authority of the experts in the first and second rounds was 0.88 and 0.92, respectively. Since both values were greater than 0.7, the authority level was considered high [47].

(3) Coordination of experts.

The degree of coordination of expert opinions on indicators at all levels in rounds 1 and 2 is detailed in Table 3 in the appendix.

#### Delphi method determined the evaluation index system

The "Dental Nurse Health Education Competence Evaluation Index System" was developed through the Delphi method, incorporating 3 primary indicators, 11 secondary indicators, and 46 tertiary indicators. The results of the Analytic Hierarchy Process indicated that the CR values of the consistency indices for all levels of indicators were less than 0.1, demonstrating that all judgment matrices passed the consistency test. The finalized evaluation index system is presented in Table 4 in the appendix.

#### Reliability and validity test results

From February 2024 to June 2024, a total of 559 questionnaires were distributed, and 529 were returned. Among these, 425 questionnaires were deemed valid, resulting in a valid return rate of 80.3%. Most of the respondents were undergraduate nurses from public tertiary specialized stomatology hospitals. The general demographic characteristics of the sample are summarized in Table 5 in the appendix.

#### Reliability test results

Analysis of the 425 valid questionnaires revealed that the Cronbach's  $\alpha$  coefficient for the entire questionnaire was 0.978. The Cronbach's  $\alpha$  values for the three primary indicators ranged from 0.833 to 0.972, all exceeding the acceptable threshold of 0.7, indicating good internal consistency and reliability. Additionally, the KMO value was 0.952, and Bartlett's sphericity test yielded a  $\chi^2$  value of 9331.920 with a significance level of p < 0.01, suggesting that the dataset was suitable for factor analysis.

#### Validity test results

The scale-level content validity index (S-CVI) of the evaluation index system from two rounds of expert inquiry was 0.964, and the Item-level content validity index (I-CVI) ranged from 0.8 to 1.0, indicating good content validity. EFA was conducted using a sample of 213 respondents. Six common factors (with eigenvalues > 1)



Chi-square=32.299 DF=21 Chi/DF=1.538 RMSEA=.050 GFI=.966 AGFI=.927

Fig. 3 Parameter estimates for the evaluation index system of health education competence for dental nurses obtained from CFA

were identified through principal component analysis, accounting for a cumulative variance contribution of 70.43%, indicating adequate representation of the original data. The maximum variance orthogonal rotation was applied to enhance factor interpretability, retaining items with factor loadings > 0.4. However, some items exhibited problematic loadings: (1) Items 4, 16, 20-26, 39-41 all loaded > 0.4 on 2 factors but the difference was < 0.2, so they were deleted [41]; (2) Items 6 and 7 did not satisfy the condition of  $\geq 3$  items per common factor although they load > 0.4 on factor 6, so Items 6 and 7 and the common factor 6 were deleted; (3) Item 38 did not fulfil the condition of  $\geq 3$  entries per common factor although it loaded > 0.4 on factor 3, so Item 38 and common factor 3 were deleted. After these adjustments, four common factors comprising a total of 31 items were retained. The items were reclassified based on the rotated component matrix, and the factors were appropriately named. The factor loading matrix after maximum variance orthogonal rotation is shown in Table 6 in the appendix. The final factor naming, number of items, and factor attribution are presented in Table 7 in the appendix.

CFA was performed on a separate sample of 212 respondents to validate the model. The results demonstrated that the final model of the dental nurse health education competence evaluation index system exhibited a good fit (Fig. 3; Table 8). The Average Variance Extracted (AVE) for the four primary indicators were 0.699, 0.843, 0.756, and 0.791, respectively, all of which were greater than 0.5, indicating good convergent validity. Additionally, the Composite Reliability (CR) values for the four primary indicators were 0.883, respectively, all exceeding the threshold of 0.7, indicating good combinatorial validity [48]. The final version of the health education competence evaluation

index system for dental nurses is displayed in Table 9 in the appendix.

#### Disscusion

# The necessity and significance of developing an evaluation index system of health education competence for dental nurses

A clear and well-organized evaluation index system is essential for achieving specific goals [49]. Compared to other countries, China does not have a standardized tool to assess the health education competence of dental nurses. This field of research is still in its early stages. To fill this gap, we developed a self-assessment tool specifically for dental nurses. This tool allows dental nurses to evaluate their own health education competence, with higher scores indicating a greater level of confidence in their abilities.

#### The scientific nature of the constructed evaluation index system of dental nurses' health education competence

The evaluation index system developed in this study is based on a thorough review of the literature and qualitative interviews. The indicators were chosen because they are relevant and practical in clinical settings. The Delphi method involved experts from various provinces, including dental nursing and clinical dental specialists, ensuring a broad and diverse perspective. The high response rate (>70%) and the strong authority of the experts (coefficient > 0.8) support the reliability of the findings. The significant Kendall's coordination coefficient in both rounds shows that the experts agreed on the indicators. The process made good use of expert opinions, allowing for adjustments and improvements to the indicators, making the system more reliable.

### The theoretical basis of the constructed evaluation index system of dental nurses' health education competence

When evaluating professional skills, it is important to consider both visible abilities (like knowledge and skills) and underlying qualities (like professional attitude and motivation) [50]. This idea is based on the iceberg model, which suggests that some qualities, like professional identity and motivation, are less obvious but still important. This concept guided the design of our evaluation index system. We included both visible abilities (knowledge and skills) and less visible qualities (like attitude and motivation). This approach helps to not only assess dental nurses' skills and knowledge but also identify those who show strong professional commitment and leadership potential. This can help in choosing effective nursing managers and guiding professional development.

Our evaluation index system includes three main areas: knowledge, skills, and overall quality. These areas help measure dental nurses' competence from different perspectives. The secondary indicators were based on reliable sources, such as the "Guidelines for Building Professional Capacity of Health Educators," the "Guidelines for Oral Health of Chinese Residents," and the "10 Competencies for Public Health Educators" from the National Commission for NCHEC. By considering both international and local standards, the indicators are both globally relevant and suited to the local context.

## Weight analysis of the evaluation index system of dental nurses' health education competence

Although four common factors were extracted from the initial three primary indicators, most of the items that reflected the core themes were retained in the final 31 indicators. These indicators demonstrated good reliability and validity, and the evaluation index system established in this study largely meets the requirements for healthcare evaluation [51]. According to the results of the Analytic Hierarchy Process, the most important primary indicator is "Knowledge and Experience" (47.76%), followed by "Skills and Abilities" (31.91%), and finally "Attitude and Belief" (20.33%). After factor analysis, the most critical factor was identified as "Knowledge of Oral Health Education," followed by "Oral Health Education Literacy," "Oral Health Education Skills," and "Scientific Research", showing both similarities and differences compared to other studies [52-54].

Regarding the most heavily weighted factor, "Knowledge of Oral Health Education," its ranking aligns with the findings of Tabatabaei [52] and Ye [53], but differs from Li's study [54], in which "Professional Ethics and Attitude" were identified as the core components, followed by "Communication Knowledge" and "Communication Skills." Comparatively, Li's study aimed at constructing an interpersonal communication knowledge system for nursing students, while our study focused on developing a health education competence evaluation system for dental nurses. Although both groups consist of nurses, their competency requirements differ significantly. Firstly, nursing students usually work as interns in inpatient departments of general hospitals, whereas the target group in our study consists of dental outpatient nurses. Naturally, the competency requirements vary between these two settings. Nursing students are in the process of learning nursing knowledge and practical skills, and their professional abilities are not yet fully developed. They often require guidance from teachers to acquire practical skills and professional knowledge. Therefore, for nursing students, attributes such as "Professionalism," "Respect," and "Confidence" are essential for building interpersonal relationships and communicating effectively with patients and other healthcare professionals. Collectively, these attributes, referred to as "Professional Ethics and Attitude," hold a primary

position in the communication knowledge system of nursing students. Moreover, nursing students generally interact with inpatients who remain hospitalized for several days, weeks, or even months. Thus, the communication between nursing students, patients, teaching staff, and other medical personnel is relatively frequent and prolonged. In contrast, dental nurses typically deal with outpatients in dental clinics, where patient turnover is fast, and interactions are brief, posing unique challenges for oral health education, as dental nurses must deliver clear, personalized health education within a limited time frame, often during short appointment windows. They must also work efficiently with dentists to support diagnosis and treatment, making the integration of dental knowledge, health education theory, and nursing psychology crucial for their competence. In summary, it is reasonable that "Knowledge of Oral Health Education" holds the highest weight in evaluating the health education competence of dental nurses. The nature of their work requires a strong foundation in dental health education to effectively communicate with patients and meet the demands of a fast-paced clinical environment.

Oral health education literacy ranks second in terms of weight and includes personality literacy and professional literacy. This indicator reflects dental nurses' etiquette, attitudes, professional ethics, and sense of professional achievement when interacting with patients. Health education fundamentally involves communication, inlcuding both the transmission and reception of information. As "professionalism and ethical behavior are the core of medical practice" [55], they also form the foundation of effective communication [54]. Dental nurses have a responsibility to warmly welcome every patient and treat them with equal respect during interactions, and should patiently listen to the pain and challenges patients experience due to oral diseases and show empathy. Additionally, it is essential to maintain strict confidentiality regarding the patient's medical condition and personal information unless consent is given. Building good professional relationships with doctors and colleagues, being open to learning, accepting constructive feedback, and continuously seeking improvement are also vital components. These practices contribute to delivering high-quality dental care and fostering personal growth. Furthermore, healthcare professionals possess noble qualities that align with the goal of achieving a healthier China [56].

Oral health education skills encompass assessment, planning, and implementation, which form the core process of oral health education performed by nurses. The assessment helps nurses understand a patient's oral condition and identify risk factors, allowing them to quickly recognize educational needs and gaps. Taking timely interventions based on this assessment helps reduce the occurrence of critical situations [57]. Overall, creating individualized education programs is essential to achieving learning objectives. Selecting appropriate health education theories based on the characteristics and cultural backgrounds of the target population, and designing tailored oral health education plans according to learning environments and patient needs, can significantly improve learning outcomes [58].

Among the primary indicators, scientific research carries the least weight. One possible reason for this could be that, historically, more emphasis has been placed on nurses' clinical services and practical abilities in China, with limited focus on developing research skills [56]. Additionally, nursing has only been established as a firstlevel discipline in China within the past decade, and there remains a significant need to strengthen nurses' research abilities. Moreover, dental research itself is highly specialized, and dental nursing research is still in its early stages. The focus of this study is on evaluating the competence of dental nurses in implementing health education, which aligns with the ongoing initiative to transition dental nurses into dental hygienists in China. This shift places a higher demand on practical skills and disease prevention rather than on research abilities [59]. Nonetheless, some competencies related to research, such as the ability to develop and share health education materials and use multimedia for planning oral health lectures and public service activities, remain valuable. Nurses who possess these skills and collaborate with non-dental professionals in the community are essential for improving the oral health of vulnerable groups, particularly communitydwelling older adults who may not have regular access to dental care or health education [60].

#### Implications

The evaluation index system of health education competence for dental nurses serves as a practical tool to assess the current status of nurses' health education competence. It provides a solid foundation for nursing managers to develop strategies aimed at enhancing this competence. Additionally, it supports the planning and implementation of relevant health education training programs, ultimately contributing to the improvement of dental nurses' ability to deliver effective health education. Improving the health education competence of dental nurses has significant practical benefits. On one hand, it facilitates the dissemination and application of oral health knowledge. Dental nurses with strong competence can use simple, understandable language, employ a variety of educational methods, and develop personalized education plans. This approach not only enhances the efficiency and quality of patient education but also accelerates the turnover rate in outpatient settings, increases patient satisfaction, and supports efforts to expand the volume of outpatient visits. On the other hand, patients benefit from receiving practical, personalized, and easyto-understand oral health information. This approach helps patients develop correct oral health values and adopt healthier oral health behaviors. As a result, it plays a key role in disease prevention, supports faster recovery from oral health issues, and improves the oral healthrelated quality of life. Moreover, as frontline healthcare educators, dental nurses with proficient health education skills can actively participate in oral health promotion activities. They can develop scientifically accurate and engaging oral health materials, produce educational videos, and organize community events to spread accurate oral health knowledge, positive attitudes, and healthy behaviors. In doing so, they contribute to achieving the World Health Organization's goal of "Primary Oral Health Care for All."

#### Limitations

Despite the rigorous design and quality control measures employed in this study, several limitations should be acknowledged. Firstly, due to constraints related to time, resources, and conditions, the constructed evaluation index system may not be entirely comprehensive. The scope of health education competence encompasses a wide range of education-related topics, requiring input from experts with diverse qualifications, including pedagogy and psychology, rather than relying solely on university teachers and clinical experts. Secondly, the revision of the index system was based on expert consensus, which may be influenced by individual experiences and levels of expertise. While the Delphi method is an effective tool for reaching consensus, the subjective nature of expert input can introduce variability, particularly when the topics involve multidisciplinary perspectives. Thirdly, in Phase III, we used a questionnaire-based approach to collect data for validating the reliability and validity of the index system. This method relied on selfevaluation by survey respondents. Although self-evaluation is a widely accepted method for assessing medical professionals' competence, it is prone to bias due to factors such as self-esteem, gender, and the nature of measurement scales [61]. Research suggests that individuals often overestimate their own competence and may make overly confident judgments about their abilities, especially in areas where they perceive themselves favorably, leading to biased results [62]. To enhance the accuracy and comprehensiveness of evaluations, it is important to incorporate feedback from multiple sources. Future studies could incorporate evaluations from patients, physicians, and nursing administrators to provide a more objective assessment of nurses' performance and identify areas needing improvement.

#### Conclusion

This study developed an evaluation index system of dental nurses' health education competence based on the "Iceberg model" of competency. The system was constructed using a systematic process that included a comprehensive literature review, semi-structured interviews, and the Delphi method. The weights of each indicator were determined using the Analytic Hierarchy Process. The system's reliability and validity were verified through a cross-sectional survey, followed by modifications to improve accuracy. Overall, the final evaluation system consists of four primary indicators, nine secondary indicators, and 31 tertiary indicators, providing a structured approach to assess the health education competence of dental nurses.

#### Supplementary Information

The online version contains supplementary material available at https://doi.or g/10.1186/s12912-025-03107-8.

Supplementary Material 1

#### Acknowledgements

The authors would like to thank all the clinical nurses, clinicians, correspondence specialists, and other participants who completed the questionnaires for this study.

#### Author contributions

XWF, WX, FS and ZWY designed the research. WYS, AQC, XWF search for literature. XHW, JSC, XWF conducted semi-structured interviews. WX and XWF devised Delphi questionnaires and collection of data. XWF, WX, FS, ZWY and WYS: analysis of the Delphi study's results. All authors: Collected, analyzed data. XWF and FS wrote the paper. WX and FS editd and revised the paper. All authors approved the final manuscript. All authors read and approved the final manuscript.

#### Funding

This study was supported by the Medical Scientific Research Foundation of Guangdong Province of China(A2024302) and The nursing key specialty training project of Stomatological Hospital Affiliated to Guangzhou Medical University in 2023(HL202301). These funding sources had no role in the design of this study and did not have any role during its execution, analyses, interpretation of the data or decision to submit results.

#### Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

#### Declarations

#### Ethics approval and consent to participate

The study was conducted in accordance with the principles outlined in the Declaration of Helsinki, and ethical approval was obtained from the Medical Research Ethics Committee of The Affiliated Stomatology Hospital of Guangzhou Medical University (Guangzhou, Guangdong, China; ID: LCYJ2023052). All participants were fully informed about the study background, objectives, and requirements related to interviews, correspondence, and questionnaire completion, and their informed consent was obtained prior to participation. The study strictly adhered to the principles of anonymity and confidentiality.

#### **Consent for publication**

Not applicable.

#### Competing interests

The authors declare no competing interests.

#### Author details

<sup>1</sup>School and Hospital of Stomatology, Guangdong Engineering Research Center of Oral Restoration and Reconstruction, Guangzhou Medical University, Guangdong, China

<sup>2</sup>Department of Nursing, Guangdong Pharmaceutical University, Guangzhou 510182, China

#### Received: 31 July 2024 / Accepted: 23 April 2025 Published online: 01 May 2025

#### References

- World Health Organization. Almost half of the world's population suffer from oral diseases. [2022 Dec 16]. Available from: https://www.who.int/multi-medi a/details/almost-half-of-the-worlds-population-suffer-from-oral-diseases
- Global Burden of Disease Collaborative Network. Global burden of disease study 2019 (GBD 2019) results. Seattle, United States: Institute for Health Metrics and Evaluation (IHME); 2020.
- Global oral health. Status report: towards universal health coverage for oral health by 2030. Geneva: World Health Organization; 2022. https://www.who.i nt/publications/i/item/9789240061484. Licence: CC BY-NC-SA 3.0 IGO.
- Kapila YL. Oral health's inextricable connection to systemic health: Special populations bring to bear multimodal relationships and factors connecting periodontal disease to systemic diseases and conditions. Periodontology. 2000;2021:87(1): 11–16.
- Botelho J, Mascarenhas P, Viana J, et al. An umbrella review of the evidence linking oral health and systemic noncommunicable diseases. Nat Commun. 2022;13(1):7614.
- Peres MA, Macpherson LMD, Weyant RJ, et al. Oral diseases: a global public health challenge. Lancet. 2019;394(10194):249–60.
- King S, Thaliph A, Laranjo L, et al. Oral health literacy, knowledge and perceptions in a socially and culturally diverse population: a mixed methods study. BMC Public Health. 2023;23(1):144.
- Allen F, Fan SY, Loke WM, et al. The relationship between self-efficacy and oral health status of older adults. J Dent. 2022;122:104085.
- Bashirian S, Khoshravesh S, Ayubi E, et al. The impact of health education interventions on oral health promotion among older people: a systematic review. BMC Geriatr. 2023;23(1):805.
- 10. Badran A, Keraa K, Farghaly MM. The impact of oral health literacy on dental anxiety and utilization of oral health services among dental patients: a cross sectional study. BMC Oral Health. 2023;23(1):146.
- Tao Y, Zhang Y, Chen J, et al. Effect of oral health education on improving knowledge, attitude, practice, and oral health status of patients with liver cancer: A quasi-experimental study. Eur J Oncol Nurs. 2024;71:102660.
- 12. Congying L, Heli Z, Han Q, et al. Nurses' health education competence and health literacy: A cross-sectional survey in Chinese County hospitals. Nurse Educ Pract. 2024;79:104042.
- Du WD, Zhang JM. Medical general Psychology. Beijing: Beijing Science and Technology; 2003. pp. 233–5.
- 14. Yang XY, Li FF, Wang Y. Progress of research on health education competence of nurses in China. Chin J Mod Nurs. 2012;18(22):2718–20.
- Wang TC, Li JX, Sun YF, Guo XY, Wang JH, Liu CX. Information-knowledgeattitude-practice based oral health education for elderly stroke patients. J Nurs Scienc. 2023;38(02):77–81.
- 16. Pueyo-Garrigues M, Whitehead D, Pardavila-Belio MI, et al. Health education: A Rogerian concept analysis. Int J Nurs Stud. 2019;94:131–8.
- Pueyo-Garrigues M, Pardavila-Belio MI, Whitehead D, et al. Nurses' knowledge, skills and personal attributes for competent health education practice: an instrument development and psychometric validation study. J Adv Nurs. 2021;77(2):715–28.
- Pueyo-Garrigues M, Pardavila-Belio MI, Canga-Armayor A, et al. NURSES' knowledge, skills and personal attributes for providing competent health education practice, and its influencing factors: A cross-sectional study. Nurs Educ Pract. 2022;58:103277.
- L Y,Wu JX. Investigation on current situation and influencing factors of health educationprofessional ability training for medical staff. Chin J Health Educ. 2022;38(12):1128–32.

- Xu Y, Hou XH, Yang Y,XU Y, HOU XH, Yang Y, Q CP, Zhang Y, Wei LH. Study on health education capacity of health professionals in secondary and above levels'public general hospitals in Liuzhou. Chin J Health Edu. 2022;38(02):187–91.
- Hwang HL, Kuo TY. Competency in delivering health education: A concept analysis. J Interprofessional Educ Pract. 2018;11:20–5.
- 22. Cen Q, Yu J, Ji YD. L Y. Construction of related indexes of core competency training of dental specialist nurses. Chin Nurs Res. 2022;36(02):197–203.
- National commission for health education credentialing. A competencybased framework for Graduate-level health educator[R]. AllentowPA: NCHEC; 1998.
- 24. Price JH, Akpanudo S, Dake JA, et al. Continuing-education needs of public health educators: their perspectives. J Public Health Manage Pract. 2004;10(2):156–63.
- Doyle El, Caro CM, Lysoby L, et al. The National health educator job analysis 2010: process and Outcomes. Health Educ Behav. 2012;39(6):695–708.
- Mckenzie JF, Dennis D, Lysoby L, et al. Health education specialist practice analysis 2015 (HESPA 2015): process and Outcomes. Health Educ Behav. 2016;43(3):286–95.
- 27. Knowlden AP, Cottrell RR, Henderson J, et al. Health education specialist practice analysis II 2020: processes and outcomes. Health Educ Behav. 2020;47(4):642–51.
- Liu L, Chen SH, Jiao HQ. Development and application of a training programme for dental specialist nurses in Chongqing. China Chin J Nurs Edu. 2017;14(11):876–80.
- 29. Li X, Dang Y. Current status and thinking of the development of dental nurses in China. Chin J Mod Nurs. 2020;26(19):2521–5.
- 30. Qi Xiujie L, Mo Z, Huijun, et al. Construction of evaluation index system for health education ability of obstetric nurses. Mod Prev Med. 2018;45(3):480–4.
- 31. Niu Geng S, Ye L. Development of health education competency scale of community nurses and its reliability and validity Test. Chin Gen Pract. 2019;22(17):2116–20.
- Yu M, Dan W, Miaomiao W, et al. Reliability and validity test of self-evaluation scale of health education competency for nursing staff. Nurs Res. 2021;35(1):74–9.
- Spencer LM, Spencer SM. Competence at work: models for superior performance. NewYork: Wiley; 1993. p. 112.
- Hu Y, Wang ZW. Nursing Studies. 5th ed. Beijing: People's Health Publishing House. 2017:82–83.
- Jing CY, Liu RX, Chu HL, Sun WW, Liao X. Interpretation of standards for conducting and reporting Delphi studies (CREDES) in healthcare research. Chin J Evidence-Based Med. 2023;23(02):233–9.
- Diamond IR, Grant RC, Feldman BM et al. Defining consensus: a systematicreview recommends methodologic criteria for reporting of Delphi studies. J ClinEpidemio1. 2014;67(4):401–9.
- Zhou Y. Health information and decision support.2 ed. Beijing: People's Health Publishing House. 2014: 136–137.
- Lu WY, Zhang SX, Ma C, Shi JW. Construction of the Evaluation Index System of Health Science Popularization for Social Institutions: a Delphi Study[J/OL]. Chin Gen Prac. 1–6[2023-08-08]. http://kns.cnki.net/kcms/detail/13.1222.R.20 230504.1352.008.html
- Dai ML, Feng Y, Zhang F. Reliability and validity of the Chinese version of learning Im mersion scale in clinical simulation among nursing students. Chin J Nurs Edu. 2023;20(08):946–50.
- Ferrando PJ, Lorenzo-Seva U, Hernández-Dorado A, Muñiz J. Decalogue for the factor analysis of test Items. Psicothema. 2022;34(1):7–17.
- Guo XH. Practical medical survey and analysis techniques. Beijing: People's Military Medical Publishing House. 2005: 35–37.
- Wang YX, LIU F, Zhang SQ, et al. Construction of core competency evaluation index system for breast cancer case managers. Chin J Nurs. 2021;56(3):387–93.
- 43. Wu ML. Structural equation modelling: AMOS operation and application. Chongqing: Chongqing University; 2018.
- Zhang YL, Zheng Y, Luo JW, Zhang GY. Research and prospect of new R&D institutions based on systematic literature Review. Scienc Techno Manage Resear. 2019;39(15):83–91.
- 45. MacCallum RC, Widaman KF, Zhang S, et al. Sample size in factor analysis. Psychol Methods. 1999;4(1):84.
- Zhou YJ, Liu HT, Wang SH, Gan QH, Xiao JH, Liu YX. Research on the relationship between Well-being and personality traits in the elderly based on canonical correlation Analysis. Chin Gen Prac. 2024;27(08):955–60.

- Liu J, Qiu H, Zhang X, et al. Development of billing post competency evaluation index system for nurses in China: a Delphi study. BMC Nurs. 2023;22(1):136–46.
- Harmoinen M, Niiranen V, Munnukka J, Suominen T. Reliability and validity of a further tested appreciative management scale. J Nurs Meas. 2021;29(1):66–79.
- Li XM. Nursing Pedagogy. Beijing: People's Health Publishing House; 2002. pp. 164–5.
- Dan JJ, Chen GC, Ma ZW, Yu HW. Constructing the competence structure model of managers in scientific research institutions based on the iceberg theory. Mod Mana. 2019;39(6):52–5.
- Sidhu NS, Allen KJ, Civil N, et al. Competency domains of educators in medical, nursing, and health sciences education: an integrative review. Med Teach. 2023;45(2):219–28.
- Tabatabaei SH, Owlia F, Ayatollahi F. et al. Nurses' educational needs in the oral health of inpatients at Yazd Province in Iran: a Delphi study. BMC Nurs. 2020;19(1):120.
- 53. Ye J, Tao W, Yang L, et al. Developing core competencies for clinical nurse educators: an e-Delphi-study. Nurse Educ Today. 2022;109:105217.
- Li X, Ding L, Ning P, et al. Meng Q. Construction of a nurses' interpersonal communication knowledge system: A Delphi study. Nurse Educ Today. 2023;120:105630.
- Stern DT, Wojtczak A, Schwarz, et al. The assessment of global minimum essential requirements in medical education. Med Teach. 2003;25(6):589–95.

- Fang Q, Li X, Luo Y, et al. Developing a psychological care competences framework for nurses in China: a mixed methods study. BMC Nurs. 2024;23(1):129.
- Wan F, Yang L, Zhou N, et al. Construction of learning objectives and content for newly graduated nurses in tertiary teaching hospitals: A Delphi study. Nurse Educ Today. 2023;121:105716.
- Srinivasan M, Li ST, Meyers FJ, et al. Teaching as a competency: competencies for medical educators. Acad Med. 2011;86(10):1211–20.
- Jiang X, Ding Z, Wang F, et al. Construction of a competency framework of dental hygienists: A Delphi study. Nurse Educ Pract. 2023;70:103692.
- Mitchell G, Stark P, Wilson CB, et al. Whose role is it anyway? experiences of community nurses in the delivery and support of oral health care for older people living at home: a grounded theory study. BMC Nurs. 2023;22(1):359.
- 61. Deffuant G, Roubin T, Nugier A, et al. A newly detected bias in self-evaluation. PLoS ONE. 2024;19(2):e0296383.
- 62. Asgari I, Karimi S, Charmdooz N, et al. Competencies of dental public health for undergraduate students and their self-perceived achievements: the case of Iran. Eur J Dent Educ. 2022;26(4):767–80.

#### **Publisher's note**

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.