Research Square

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Development of a nurse knowledge, attitude and practice questionnaire on protocolized weaning from invasive mechanical ventilation

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Research Article

Keywords: intensive care units, mechanical ventilation, ventilator weaning, surveys and questionnaires, reliability and validity, scale development

Posted Date: January 22nd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-8466677/v1

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Additional Declarations: No competing interests reported.

Abstract

Aim

To develop and evaluate a questionnaire to measure the factors influencing the knowledge, attitudes and practices (KAP) of ICU nurses regarding protocolized weaning from invasive mechanical ventilation (IMV).

Methods

From July to October in 2023, an online survey was conducted among ICU nurses from 30 top-level hospitals in China. The questionnaire's items were generated through relevant literature reviews, group discussion, Delphi expert consultation and small sample pre-test. The validity and reliability of the questionnaire were assessed using exploratory factor analysis (EFA), confirmatory factor analysis (CFA).

Results

The questionnaire developed in this study consists of three dimensions: knowledge, attitude, and practice. The knowledge dimension contains 13 items, the attitude dimension has 15 items, and the practice dimension has 11 items. The Cronbach's α coefficient, split-half reliability coefficient, and test-retest reliability coefficient of each of the three dimensions are all greater than 0.7, indicating good internal consistency and stability. The CFA shows that the model fitting results are acceptable.

Conclusion

The questionnaire developed in this study can be used as an effective tool to investigate the knowledge, attitude and practice of adult intensive care unit nurses regarding the protocolized weaning process.

Implications for Profession and/or Patient Care:

A better understanding of the influencing factors of nurses' knowledge, attitude and practice regarding protocolized weaning can lay the foundation for formulating targeted intervention measures and provide a reference for optimizing the medical and nursing collaboration strategies for weaning.

Impact:

The questionnaire developed in this study has good reliability and validity, which was used to measure the factors influencing ICU nurses' knowledge, attitude and practice regarding the protocolized weaning process. By using this questionnaire for investigation, relevant intervention measures can formulate. This could optimize the collaboration strategy between doctors and nurses, promote the implementation of nurse-led protocolized weaning, and reduce the duration of mechanical ventilation for patients.

Reporting Method

: We followed the STROBE checklist in reporting this study.

Patient or Public Contribution:

No patient or public contribution.

1 Introduction

About 73% of patients in the intensive care unit (ICU) need invasive mechanical ventilation (IMV)[1]. IMV has created conditions for the treatment of critical patients with primary diseases and provided critical time for treatment, ensuring adequate ventilation and oxygenation, and plays important roles in the stability of haemodynamics and the improvement of the internal environment[2]. However, long-term application of IMV will lead to many complications, such as ventilator-associated pneumonia (VAP)[3], ventilator induced diaphragm dysfunction (VIDD)[4] , ICU-acquired weakness (ICU-AW)[5], laryngeal edema[6], and delirium[7], which can increase the length of hospital stay and medical costs[8] and increase mortality[3]. Therefore, once the primary disease of patients with IMV has improved, the ventilator should be weaned as soon as possible.

Protocolized weaning is an effective and better weaning method for reducing patients' IMV time [9], and it includes three main steps: weaning screening evaluation, spontaneous breathing trials (SBTs), and tracheal extubation[10]. American weaning guidelines[11] recommend that patients with an IMV for more than 24 hours should be weaned with a protocolized weaning scheme. Diaz-Soto et al.[9] called for the implementation of protocolized weaning in low-income and middle-income countries, which can not only improve the clinical outcomes of patients with IMV in the ICU but also reduce medical costs. Protocolized weaning is a step-by-step process that needs to be evaluated and monitored at all times[12]. In view of different working systems and responsibilities, although physicians order ventilator weaning, they cannot monitor patients at all times. Nurses work bedside for 24 h to directly monitor patients[13], and this puts them in the best position to evaluate the process of weaning patients from the ventilator. They can assess the patient’s tolerance at any time and promote the weaning process as soon as possible or suspend weaning to ensure the safety of patients. In 2001, the United States released “Mechanical ventilator weaning protocols driven by nonphysician health-care professionals: evidence-based clinical practice guidelines”[14], recommending the inclusion of nonphysician health care professionals in the development and utilization of respiratory care protocols (not limited to weaning). The nonphysician health care professionals mentioned in the guidelines refer mainly to respiratory therapists (RT) and nurses. In a systematic review, Hirzallah et al.[15] showed that nurses and other health care professionals usually adhere to procedures more strictly than physicians do and are better suited to lead the implementation of protocolized weaning, and nurse-led protocolized weaning can reduce the IMV time and ICU stay time of patients. However, influenced by traditional beliefs, in nurses’ opinions, managing mechanical ventilation is

the responsibility of physicians and respiratory therapists (RTs)[16]. Therefore, nurses may do not actively participate in the management of ventilators[13], and their knowledge of IMV might also be very limited. Zainib et.al[13] reported that nursing staff in the PICU have a knowledge deficit and high barriers to protective lung strategies for mechanical ventilation. Jansson et al.[17] reported that ICU nurses perform poorly in the sedation management of patients undergoing IMV. Therefore, an accurate understanding of ICU nurses' knowledge and attitudes towards protocolized weaning is highly important for promoting the clinical implementation of protocolized weaning and reducing the duration of IMV for patients.

2 Background

In North America, it is mainly respiratory therapists who lead the implementation of protocolized weaning, while in Europe, Australia and New Zealand, ICU nurses play the role of respiratory therapists and have high decision-making autonomy[18, 19]. There is a shortage of respiratory therapists in China[20], domestic ICU nurses play an irreplaceable role in the process of IMV weaning. Weaning is a complex and dynamic process that must be carried out carefully to reduce the duration of IMV and complications in patients [21]. ICU nurses should possess the knowledge and skills necessary for caring for patients with IMV to ensure that patients can safely and quickly be weaned off IMV and improve their treatment outcomes[22]. Guilhermino et al. [23] reported that ICU nurses' mastery of protocolized weaning knowledge, attitudes and perceptions significantly affects patients' weaning outcomes. Nurses' professional knowledge, self-confidence, personality characteristics, attitudes and interest in weaning, and professional responsibility affect weaning decisions[24, 25]. To date, research on ICU nurses' knowledge of protocolized weaning has focused mainly on qualitative interviews[26, 27]. To the best of our knowledge, there is still a lack of effective tools to measure ICU nurses' knowledge, attitudes and practices of IMV-protocolized weaning. The knowledge, attitudes, and practices (KAP) theory posits that there is a progressive relationship among knowledge, attitude, and practice [28].

3 The Study

With this background, this study presents a knowledge, attitude and practice questionnaire for ICU nurses on protocolized weaning from IMV to promote the clinical implementation of nurse-led protocolized weaning.

4 Methods

4.1 Design

The questionnaire was developed and validated in three phases (Fig. 1). In phase 1, literature review and group discussion were conducted from January 2023 to March 2023 to construct the initial item pool of the questionnaire. The phase 2 was conducted from April 2023 to June 2023, including refining and finalizing the questionnaire items through two rounds of Delphi expert consultation, testing the content validity of the

questionnaire and conducting a pilot study. In phase 3, the questionnaire was analyzed by item analysis, exploratory factor analysis (EFA), confirmatory factor analysis (CFA) and reliability testing.

4.2 Phase 1. Generating the initial item pool of the questionnaire

We established a research group to ensure that the formed item pool was rigorous and comprehensive. The research team was composed of 6 members, including 1 intensive care doctor (associate chief physician), 1 ICU head nurse (associate chief nurse), 2 ICU specialist nurses (supervisor nurse), and 2 masters of nursing students (including 1 ICU on-the-job nurse). The research team used the following keywords: ICU, intensive care unit, critical care, invasive mechanical ventilation, mechanical ventilation, weaning, ventilator weaning, protocolized weaning, standard weaning, nurse-led weaning protocol, spontaneous breathing trial, guideline, expert consensus, meta-analysis, and summary of evidence. A combination of subject words and free words were used for retrieval. Relevant clinical decisions, guidelines, expert consensus, systematic reviews, meta-analysis or randomized controlled studies were retrieved from databases such as UpToDate, BMJ best practice, CNKI, WANFANG database, VIP database, Yimaitong guide website, Chinese Medical Ace Base, SinoMed, PubMed, Web of science, and Cochrane Library. The retrieval time limit was from the establishment of the database to December 2022. Finally, 19 published papers were included as references for the initial item pool of the questionnaire, including 3 clinical decisions[29–31], 5 systematic reviews[15, 32–35], 8 guidelines[11, 14, 36–41], 2 meta analyses[42, 43], and 1 expert consensus[44]. The literature screening process is shown in Fig. 2. In accordance with the concept and steps of protocolized weaning, 40 items were extracted from 19 papers. We held a group meeting; on the basis of KAP theory, brainstorming was used to supplement the items. After the group discussion, the items were summarized and refined. Finally, the items were scientifically classified, and the first draft of the questionnaire on the KAP status of ICU nurses' IMV protocolized weaning was initially formed, including 4 secondary items and 19 tertiary items in the knowledge dimension; 3 secondary items and 17 tertiary items in the attitude dimension; and 4 secondary items and 14 tertiary items in the practice dimension.

4.3 Phase 2. Preliminary evaluation of the questionnaire

4.3.1 Delphi expert inquiry

Delphi expert selection and questionnaire structure

Experts were invited to assess the importance and relevance of the items. The expert consultation tool comprised three sections: the letter to the experts; the expert inquiry form of the questionnaire on the KAP of ICU nurses’ IMV protocolized weaning; and the basic information questionnaire of the experts. The letters to the experts include the research background, related concepts and research purposes. The expert inquiry form of the questionnaire on the KAP of ICU nurses' IMV protocolized weaning adopted the Likert 5-point scale method to score the importance of each item, and items were rated from 1 (very unimportant) to 5 (very important). In addition, columns of “item modification comments”, “new items” and “other comments” were constructed. The basic information questionnaire of the experts, which includes the name,

age, professional title and other basic information, as well as the familiarity and judgement basis of the expert with the contents of this letter.

The inclusion criteria for experts as follows: engaged in critical care medicine, intensive care nursing, or respiratory therapy; familiar with the field of IMV in ICU, and have more than 10 years' working experience in this major; medical experts should have a master's degree or higher and a senior professional title; nursing experts and respiratory therapy specialists should have a bachelor's degree or higher and hold at least a mid-level professional title; voluntarily participate in the expert consultation.

Delphi process and analysis criteria

The consultation was conducted electronically using WeChat. Deletion criteria for items in the results of two rounds of correspondence[45, 46]: coefficient of variation (CV) > 0.25 points or average score of importance assignment < 4 points or full score rate < 20%. After the first round of correspondence, the research team screened and modified the items of each dimension of the questionnaire according to the opinions of the experts and the item criteria and formed the second round of the correspondence questionnaire, which was consulted again two weeks later. The authority level of an expert was represented by the authority coefficient (Cr), which was the arithmetic mean of the expert's familiarity with the issue (Cs) and the basis for the expert's judgement on the issue (Ca). The levels of familiarity with Cs and Ca were evaluated by the experts themselves. Cs was classified as very familiar, familiar, average, unfamiliar, or very unfamiliar. Ca included theoretical analysis, practical experience, reference to domestic and foreign literature, and intuitive perception. The interrater agreement of expert opinions was represented by the coefficient of variation (CV) and the Kendall W coefficient.

Results from both rounds

A total of 17 critical care experts (Table 1) were invited to participate in the inquiry. The experts were from tertiary hospitals in Shanghai, Nanjing, Chengdu, Chongqing and Luzhou. Among them, 2 were experts in critical care, 1 was an expert in respiratory therapy, and 14 were experts in critical care; 88.23% of them had deputy senior titles or above, with an average age of 48.19 ± 6.91 years.

The effective recovery rate of the two rounds of correspondence questionnaires was 100%, and the recommendation rates of the two rounds of correspondence experts were 70.59% and 23.50%, respectively. The Cs was 0.918, the Ca was 0.959 and 0.971, and the Cr was 0.938 and 0.944, respectively. Kendall’s W was 0.154 ($p < 0.05$) in Round 1 and 0.105 ($p < 0.05$) in Round 2 (Table 2), indicating moderate agreement. The average values of the importance of each item assigned by the experts in the two rounds were 3.94 ~ 5.0 and 4.43 ~ 5.0, respectively, and the CVs were 0.0 ~ 0.27 and 0.0 ~ 0.20, respectively. The full score rates were 41%~100% and 59%~100%, respectively.

Table 1
General information of experts (n = 17)

Characteristics	Mean (SD) or n(%)
Age (y)	48.19(6.91)
Level of education	
Bachelor's degree	11(64.71)
Master's degree	5(29.41)
Doctor's degree	1(5.88)
Specialty	
Critical care medicine	2(11.76)
Critical Care Nursing	14(82.35)
Respiratory therapy	1(5.88)
Professional title	
Intermediate title	2(11.76)
Associate senior professional title	10(58.82)
Senior professional title	5(29.41)
Department	
EICU	1(5.88)
NSICU	1(5.88)
SICU	6 (35.29)
ICU	9 (52.94)
Years of working experiences (y)	25.04(8.06)

Table 2
Delphi inquiry expert opinion coordination level and significance test

Inquiry rounds	Number of items	*Kendall W*	χ^2	Degree of freedom	*P*
1st round	50	0.154	128.36	49.00	< 0.001
2^{ed} round	49	0.105	81.87	46.00	< 0.001

Final outcome of expert inquiry

Based on the screening criteria for the items, expert opinions and group meetings, after the first round of expert inquiries, 5 items were deleted, 4 items were added, and 12 items were modified. Additionally, a reverse item was set for each of the attitude dimensions and practice dimensions to reduce acquiescence

biases. The knowledge dimension items were changed to a multiple-choice format. Finally, a second round of expert questionnaires consisting of 49 items was formed. In the second round of expert correspondence, the average value of importance assignment of all the items was > 4 points, the CV was < 0.25, and the full score rate was greater than 20%. There were no added or deleted items, and 4 items were modified. After two rounds of expert correspondence, the initial questionnaire was formed. There were 49 level 3 items in total, including 20 items in the knowledge dimension, 16 items in the attitude dimension and 13 items in the practice dimension.

4.3.2 Content validity evaluation

Experts (n = 9) in Delphi's inquiry were invited to evaluate the content validity of the questionnaire, and the experts were invited to judge the correlation between each item and the questionnaire. Using a 4-point Likert scale, 1 = not relevant, 2 = somewhat relevant, 3 = quite relevant, and 4 = highly relevant. The content validity index (I-CVI) of the items is the percentage of experts who gave a score of 3 or 4 for each item. The scale-level CVI (S-CVI) is an evaluation of the content validity of the entire questionnaire. The unanimous S-CVI (S-CVI/UA, universal agreement) is the proportion of all the items that are rated as either 3 or 4[47], and the S-CVI/UA is ≥ 0.8, indicating that the content validity of the questionnaire is good. The retention standard of items is an I-CVI ≥ 0.78[48]. In this study, the I-CVI of the questionnaire ranged from 0.89 ~ 1.00, no items were deleted, and the S-CVI/UA was 0.970.

4.3.3 Pilot study

Eleven nurses of different ages, genders, professional titles and working years in the comprehensive ICU of a class A tertiary hospital in Chengdu were selected for a pilot study. In accordance with the written feedback of the pilot study subjects, our research team discussed and simplified the expression of Item P9. The subjects expressed that they could understand the rest of the survey without modification. In the pilot study, participants completed the study in 13.57 ± 5.93 minutes.

After Delphi expert inquiry, content validity evaluation and pilot study, the initial questionnaire of ICU nurses' knowledge, attitudes and practices related to IMV protocolized weaning was finally formed, which included 3 first-level items, 11 second-level items and 49 third-level items.

4.4 Phase 3: Reliability and validity test of questionnaire

4.4.1 Samples /participants

There were 49 items in the initial questionnaire and 39 items in the final questionnaire. In accordance with the principles of questionnaire development, the sample size is 5 ~ 10 times the number of items in the questionnaire[49]. Considering the 20% loss to follow-up rate, the necessary sample size required for EFA is 294 ~ 588 cases, and the sample size required for CFA is 234–468 cases. The sample inclusion criteria included the following: □ registered in-service nurses in a tertiary hospital; □ currently working in the adult ICU for more than 1 year; □ have relevant working experience in IMV treatment and nursing; and □ voluntarily participate in this study. The sample exclusion criteria included the following: □ nursing students; □ nurses

who had recently returned from maternity leave or extended illnesses for more than 1 month; and nurses who had not worked clinically.

4.4.2 Investigation tools

Presurvey tools included the following: general information questionnaire, including gender, age, professional title, position, education background, and working years; and the initial questionnaire of ICU nurses' knowledge, attitudes and practices of IMV protocolized weaning (49 items). Formal survey tools included: general information questionnaire (the same as the presurvey); the final questionnaire on the knowledge, attitudes and practices of ICU nurses' IMV protocolized weaning [Supplementary file (the final questionnaire]. The knowledge dimension includes objective questions, such as single-choice and multiple-choice questions. If the single-choice question is correct, 1 point is given, and if the answer is wrong or unclear, 0 points are given. Multiple-choice questions contain multiple correct choices; if the subject choose all the right ones, they will receive 1 point, if the subject chose fewer or wrong ones, they would receive 0 points. The attitude dimension and practice dimension were the scale questions, and all the items were scored on a 5-point Likert scale ranging from “strongly disagree” to “strongly agree”, with scores ranging from 1 to 5. Each attitude dimension and practice dimension were reverse scored.

4.4.3 Data collection

WENJUANXING is a professional questionnaire survey tool that is used to distribute and collect questionnaires. The order of the questionnaire questions was fixed and unchangeable. To improve the quality of the questionnaire, the researchers designed each question as a must answer question in the background of WENJUANXING, and each mobile IP could only fill in the questionnaire once. Using the convenience sampling method, a presurvey was conducted from July 2023 to August 2023, and the respondents were from 8 class A tertiary hospitals in Sichuan Province. A formal survey was conducted from September 2023 to October 2023. The respondents were ICU nurses from 22 tertiary hospitals in Sichuan, Chongqing and Nanjing. To ensure that the source of the respondents differed from that of the presurvey, the hospitals involved in the presurvey were avoided when the questionnaire was issued in the formal survey. To test the test-retest reliability of the questionnaire, 30 respondents were selected for convenience sampling and asked to complete the questionnaire again after 2 weeks. These 30 respondents came from two ICUs of the same tertiary hospital. If a respondent did not participate in the second survey, the corresponding questionnaire was excluded when the test-retest reliability was calculated.

4.4.4 Statistical analysis

The expert inquiry data were entered into Excel 2019 by two people. The questionnaire data were directly exported from the background of WENJUANXING, and the questionnaires with obvious rules, inconsistencies or response times < 200 seconds were removed. After two people checked and confirmed that there was no error, SPSS 25.0 was used for statistical analysis. The nominal data are expressed as the frequency and constituent ratio, and the parametric data are expressed as the mean ± standard deviation. The critical ratio method, Cronbach's α coefficient method and Pearson correlation coefficient method were used for item analysis[50]. The critical ratio method was applicable to screening the items of the attitude dimension and the practice dimension. According to the total score of the attitude dimension and the

practice dimension, the respondents were divided into high groups (the top 27%) and low groups (the bottom 27%). The independent sample t test was used to compare the scores of each item in the two groups. The larger the T value is, the greater the degree of discrimination of the item. Items whose absolute value of the decision value of the item was $t < 4$ or whose difference was not statistically significant ($p > 0.05$) were deleted[51]. The Cronbach's α coefficient method and Pearson correlation coefficient method are applicable to all the items. If the Cronbach's α coefficient of the questionnaire increases after the item is deleted, the item will be deleted. If the Pearson correlation coefficient between the item and the total score of the dimension was < 0.3, the item was deleted.[52]. EFA and CFA were used to test the construct validity of the questionnaire, EFA for identifying factor structure, and CFA for confirmation. SPSS 25.0 was used for EFA, and AMOS 26.0 was used for CFA. The Kaiser–Meyer–Olkin measure of sampling adequacy (KMO) and Bartlett's test of sphericity p value were calculated. If $KMO > 0.6$ and $p < 0.05$, it indicates that EFA is suitable. In EFA, the standard for extracting common factors was an eigenvalue > 1, and the maximum variance method was used for orthogonal rotation. The item retention standards were as follows: common degree > 0.4, factor load > 0.4 and cross load > 0.2[53]. The internal consistency reliability (Cronbach's α coefficient), test-retest reliability and split half reliability (Spearman-Brown coefficient) of the questionnaire were used for reliability analysis.

4.5 Ethical considerations

This study was approved by the Medical Ethics Committee of Sichuan Provincial People's Hospital on April 14, 2023, and the approval number was Lun (Review) Research 2023 No.155. Explained the purpose and significance of this study to the research object before the survey, and obtained the informed consent of the research object, they voluntarily filled in the questionnaire.

5 Results

5.1 Sample characteristics

A total of 332 questionnaires were collected in the presurvey. The questionnaires with obvious rules, inconsistencies or response times < 200 seconds were removed, and 304 valid questionnaires remained; this number was larger than the required minimum sample size of 294 cases, and the effective questionnaire recovery rate was 91.57%. A total of 304 valid questionnaires were used for item analysis and EFA. A total of 413 questionnaires were collected in the formal survey. After the invalid questionnaires were removed, 392 valid questionnaires remained—more than the minimum sample size of 234—which met the requirements of factor analysis. Details of the participants are listed in Table 3.

Table 3
Participant characteristics

Characteristics	EFA group (n = 304)	CFA group (n = 392)
	N (%)	
Gender		
Male	32(10.53)	45(11.48)
Female	272(89.47)	347(88.52)
Age (y)		
≦25	23(7.57)	41(10.46)
26 ~ 30	85(27.96)	113(28.83)
31 ~ 40	177(58.22)	217(55.36)
41 ~ 50	17(5.59)	20(5.10)
>50	2(0.66)	1(0.26)
Department		
ICU	189(62.17)	270(68.88)
SICU	56(18.42)	11(2.81)
EICU	15(4.93)	28(7.14)
Other ICU	44(14.47)	83(21.27)
Years of ICU working experiences (y)		
≤ 5	102(33.55)	159(40.56)
6 ~ 10	99(32.57)	134(34.18)
11 ~ 15	80(26.52)	83(23.17)
16 ~ 20	20(6.58)	12(3.06)
> 20	3(0.99)	4(1.02)
Level of education		
Junior college or below	23(7.57)	52(13.27)
Bachelor’s degree	276(90.79)	333(84.95)
Master’s degree or above	5(1.64)	7(1.79)
Professional title		
Nurse	22(7.24)	39(9.95)

Characteristics	EFA group (n = 304)	CFA group (n = 392)
	N (%)	
Senior nurse	167(54.93)	136(34.69)
Chief nurse	101(33.12)	194(49.49)
Deputy chief nurse or above	14(4.61)	23(5.87)

5.2 Item analysis

The critical ratio method revealed absolute values t < 4 for items A4 and p12, which should be deleted. The Cronbach's α method revealed that the total Cronbach's α of the questionnaire was 0.916. After deleting items A4 and p12, the total Cronbach's α of the questionnaire is 0.921 and 0.928, respectively; thus, items A4 and p12 are deleted. Pearson correlation analysis revealed that the Pearson correlation coefficients between items K11 (r = 0.281), K13 (r = 0.124), K14 (r = 0.201), K20 (r = 0.220), A4 (r = 0.187), and p12 (r = -0.08) and the total score of the dimension were less than 0.3 and should be deleted.

In summary, items K11, K13, K14, K20, A4 and p12 were deleted, and the remaining 43 items were entered into the subsequent analysis.

5.3 Construct validity

5.3.1 EFA

After 6 items were deleted from the item analysis, the remaining 43 items were entered into the EFA. The KMO test showed that KMO = 0.906 > 0.7, and the Bartlett spherical test showed $\chi 2 = 10138.835$, $p < 0.001$, indicating that the questionnaire has common factors and is suitable for EFA [51]. Items K3, K4 and K17 have a commonality of less than 0.4 and were deleted. The factor loading of item P10 on the two common factors was greater than 0.5, and the difference in factor loading was < 0.2; thus, it was deleted. Principal component analysis was used to extract common factors with eigenvalues > 1, and the maximum variance method was used for orthogonal rotation. Each time, only one item was deleted for the second EFA. At the fourth EFA, 9 common factors were extracted, and the cumulative variance contribution rate was 72.936%, which met the requirement of a cumulative variance contribution rate > 50% in the principal component analysis method[51]. The scree plot and the initial dimension setting of the questionnaire indicate that extracting 9 factors is reasonable and reliable. The factor loading of each item ranged from 0.478 ~ 0.929 (Table 4, Table 4 is uploaded as an independent appendant). The load coefficient of all the items was > 0.4, which met the requirements. EFA and item deletion will not be carried out in the next step. The items of the questionnaire were renumbered to form the final version of the questionnaire on the knowledge, attitudes and practices of ICU nurses' IMV protocolized weaning, with 3 first-class items, 9 second-class items and 39 third-class items. The names of the common factors of each dimension and the items contained are shown in Table 5.

Table 4
The results of EFA(n = 304)

Items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9
A3. I think the implementation of protocolized weaning can shorten the time of MV, weaning time and ICU stay time.	0.929								
A1. I think the knowledge related to protocolized weaning is very important.	0.927								
A2. I think protocolized weaning is more standardized than empirical weaning.	0.899								
A6. I think ICU should formulate a weaning plan based on evidence to optimize the clinical implementation of protocolized weaning.	0.883								
A5. I think the implementation of protocolized weaning can reduce the complications of MV and reduce medical costs.	0.878								
A8. I think the implementation of the protocolized weaning program can promote the	0.813								

Items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9
common understanding of doctors and nurses on the weaning process, enhance professional cooperation and improve the weaning efficiency.									
A7. I think ICU nurses should master the knowledge of protocolized weaning.	0.792								
A9. I think ICU nurses play an important role in ventilator weaning.	0.648								
P2. I actively carry out screening liberation assessment for patients with mechanical ventilation in my work.		0.887							
P5. I actively discuss with the doctor or respiratory therapist whether the patient has met the weaning standard.		0.880							
P6. After the weaning screening assessment, if the patient meets the weaning criteria, I will implement SBT and extubate		0.833							

Items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9
as soon as possible.									
P4. I take the initiative to check the patient's blood gas report to assess whether the patient meets the standard of weaning.		0.800							
P7. During SBT, I will actively assess the patient's tolerance, including respiratory mode, whether the gas exchange is sufficient, hemodynamic stability and subjective comfort, etc.		0.795							
P3. At work, I actively communicate with doctors about the sedation goals of patients with mechanical ventilation and implement sedation.		0.775							
P1. I have taken the initiative to learn the knowledge about protocolized weaning.		0.773							
P8. For patients who have failed SBT, I will immediately return to the ventilator		0.583							

Items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9
settings before SBT, let the patient rest and inform the doctor.									
A13. I am interested in the knowledge of protocolized weaning.			0.754						
A16. I would like to participate in training on knowledge or skills related to protocolized weaning.			0.749						
A15. ICU should conduct training knowledge related to protocolized weaning regularly.			0.733						
A14. I am interested in the role and responsibility of protocolized weaning.			0.692						
K1. Protocolized weaning also called programmatic weaning, which refers to the development of methods and steps for weaning based on respiratory physiology and clinical parameters, and each step has a certain standard.				0.746					

Items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9
K2. Protocolized weaning mainly includes three steps: weaning screening assessment, spontaneous breathing test (SBT) and tracheal extubation.				0.668					
K16. The airway patency and protection should be assessed before extubation. The degree of airway patency is assessed primarily using cuff leak; the assess of airway protection ability including cough strength, level of consciousness, secretion volume, and swallowing function.				0.630					
K7. SBT is a method of assessing a patient's readiness for weaning by decreasing the degree of ventilator support or withholding ventilator support.				0.616					
K6. SBT should be performed on patients who have been passed the weaning				0.504					

Items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9
screening assessment.									
K15. It is important to return to the ventilation mode and parameter settings before SBT immediately if the SBT failure, give sufficient ventilation support to relieve respiratory muscle fatigue, and check the cause of failure.				0.488					
P13. After extubation, I will carefully monitor the patient's vital signs, state of consciousness, expectoration ability, teach and encourage the patient to cough up sputum independently.					0.772				
P11. I will explain the operation techniques to the patient before extubation to obtain cooperation.					0.754				
P9. Before extubation, I will assess whether the patient's consciousness, muscle strength, vital signs and other indicators meet					0.654				

Items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9
the extubation standard.									
A10. I think ICU nurses can lead the implementation of protocolized weaning after training.						0.841			
A11. I think the implementation of ICU nurse led protocolized weaning program can ensure the safety of patients.						0.778			
A12. I think ICU nurses should take the initiative to do ventilator liberation assessment of patients with mechanical ventilation.						0.501			
K5. In weaning screening assessment, what conditions can the patient meet for SBT?							0.743		
K12.What happens during SBT we should consider the patient fail of the SBT?							0.634		
K8. In addition to the sedation related SBT failure, how many times per day is it advisable to perform SBT after the cause								0.764	

Items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9
of SBT failure has been corrected?									
K10.What are the common ways of SBT?								0.595	
K9. The time of SBT is generally 30min, and not more than 2H at most.								0.478	
K18. There is no need to increase the body's oxygen reserve before extubation.									0.805
K19. The secretions in the mouth, nose, pharynx, supraglottis and airway should be cleaned before extubation.									0.561

Table 5
Items in Each Dimension of the Final Questionnaire

Dimension	Secondary items	Number of items	Items
Knowledge	Concept and precautions	6	K1、K2、K6、K7、K15、K16
	Weaning screening and SBT assessment	2	K5、K12
	Methods of SBT	3	K8、K9、K10
	Knowledge of extubation	2	K18、K19
Attitude	Professional cognition	8	A1、A2、A3、A5、A6、A7、A8、A9
	Personal belief	3	A10、A11、A12
	Willingness to learn	4	A13、A14、A15、A16
Practice	Weaning screening and SBT	8	P1、P2、P3、P4、P5、P6、P7、P10
	Do extubation	3	P9、P11、P13
Total questionnaire		39	

5.3.2 CFA

We use Amos26.0 for CFA, and 392 samples from the formal survey were used. The initial model results (Fig. 3) revealed that the chi square degree of freedom ratio (χ^2/df) was 3.280, the root mean square error (RMSEA) was 0.077, the root mean square residual error (RMR) was 0.028, the goodness-of-fit index (GFI) was 0.771, the adjusted goodness-of-fit index (AGFI) was 0.732, the normative fit index (NFI) was 0.827, the value-added fit index (IFI) was 0.873, and the comparative fit index (CFI) was 0.872. Considering the complexity of the model, the model is no longer modified, indicating that the initial model fitting result of the questionnaire on the knowledge, attitudes and practices of ICU nurses' IMV protocolized weaning is general and that the structural validity is acceptable. The reference values[54] and results of each fit index of the model are shown in Table 6.

Table 6
Model fitting results of CFA

Fitting index	*χ2 /df*	*RMSEA*	*RMR*	*GFI*	*AGFI*	*NFI*	*IFI*	*CFI*
Reference value (good)	≤ 3.000	< 0.050	< 0.050	> 0.900	> 0.900	> 0.900	> 0.900	> 0.900
Reference value (general)	≤ 5.000	0.08 ~ 0.10	0 ~ 1	0 ~ 1	0 ~ 1	0 ~ 1	—	0 ~ 1
Initial model	3.280	0.076	0.028	0.771	0.732	0.827	0.873	0.872

5.4 Reliability

The Cronbach's α coefficient, split half reliability coefficient and test-retest reliability coefficient of the total questionnaire and the knowledge, attitude and practice dimensions were greater than 0.7 (Table 7), indicating that the internal consistency of the questionnaire was good and stable.

Table 7
Reliability analysis results of ICU nurses' IMV protocolized weaning KAP final questionnaire

Dimension	*Cronbach's α*	Retest reliability coefficient	Split half reliability coefficient
Knowledge	0.717	0.847	0.707
Attitude	0.955	0.788	0.845
Practice	0.936	0.726	0.834
Total questionnaire	0.935	0.817	0.729

6 Discussion

6.1 Reliability and validity of the questionnaire

In this study, internal consistency, the split half reliability coefficient, and test–retest reliability were used to evaluate the stability and accuracy of the questionnaire. The Cronbach's α coefficient of the questionnaire was 0.935, and the split half reliability coefficient was 0.729. The Cronbach's α coefficients of the knowledge dimension, attitude dimension and practice dimension were 0.717, 0.955 and 0.936, respectively, which were greater than 0.7, indicating that the internal consistency of the questionnaire was good [50]. The test-retest reliability coefficient of the questionnaire was 0.817, indicating that the stability of the questionnaire was good.

Content validity was used to assess the relevance, clarity, and conciseness of the items. The S-CVI/UA of the questionnaire developed in this study was 0.97, and the I-CVI ranged from 0.89 ~ 1.00, both of which were > 0.78, indicating that the content actually measured by the questionnaire was highly consistent with

the content to be measured[48], and that the content validity of the questionnaire was good. EFA extracted 9 common factors with eigenvalues > 1, and the factor load of each item was more than 0.4, which explained 72.936% of the total variance, indicating that the questionnaire had good structural validity. The nine identified common factors were categorized into the dimensions of knowledge, attitude, and practice, demonstrating strong alignment with the theoretical framework and initial dimensional design of the questionnaire. CFA showed that the initial fit model index (RMR) of the questionnaire met the good standard, and the other indicators (χ^2/df, RMSEA, GFI, AGFI, NFI, IFI, CFI) met the general standard, indicating that the model fit structure was acceptable.

During the item analysis, two reverse items in the questionnaire did not meet the item retention criteria and were deleted; this might be because many respondents were aware that the directions of these two items were different from those of the other items, but some respondents were not aware of it. As a result, the correlation between the reverse items and the other items significantly weakened for the entire sample. This finding is consistent with Robert F. DeVellis' view that reverse items are more detrimental than beneficial when a scale is developed[49].

The process of questionnaire development in this study was standardized and rigorous, ensuring the scientific nature of the survey questionnaire. The next step of our study is to use the questionnaire developed in this study to investigate the current status of protocolized weaning knowledge, attitudes and practices among adult ICU nurses in China and to explore the influencing factors. This step will help us better formulate intervention measures, promote the implementation of nurse-led protocolized weaning in China, and reduce the duration of IMV and medical cost for patients.

6.2 Limitations

The subjects of this study were drawn from the general ICU and various specialized ICUs in adult departments. Therefore, the questionnaire developed in this study can be used for investigations in all adult ICU departments. Although many pediatric ICUs are also exploring the implementation of nurse-led protocolized weaning[55, 56], the questionnaire developed in this study is not applicable for surveying nurses in pediatric ICUs, as the knowledge dimension of the questionnaire involves some physiological parameters, and the reference values for children differ from those for adults. The knowledge dimension of the questionnaire adopted multiple-choice questions instead of judgement questions, which can measure the relevant knowledge level of nurses more objectively. However, for multiple-choice questions, full 0-point penalties for partially correct responses may reduce discriminative power. In future questionnaire applications, it might be advisable to distinguish between partially correct and completely incorrect answers. The sample size of this study was determined through convenience sampling; nurses who voluntarily participated in this study may have been more interested in this study than nurses who did not participate, and selection bias or nonresponse bias may have occurred. In the initial CFA model, only a small number of fit indicators meet the good standard, and most fit indicators meet only the general standard. In the future, stratified sampling or random sampling can be used to further verify the structural validity of the questionnaire.

6.3 Implications for Practice or Research

The questionnaire developed in this study can serve as an effective tool for investigating the knowledge, attitudes and practices of adult ICU nurses regarding the protocolized weaning of IMV, identifying the barriers and facilitators in the clinical practice of protocolized weaning, and improving the implementation of this practice. The questionnaire can also be used to evaluate the effectiveness of protocolized weaning training courses, guide the formulation of nurse-led protocolized weaning intervention measures, and optimize cooperation strategies between doctors and nurses during the weaning process.

7 Conclusion

The questionnaire developed in this study can be used as an effective tool to investigate the knowledge, attitudes and practices of adult ICU nurses regarding the protocolized weaning process. By investigating the relevant situations, appropriate measures can be formulated to promote the implementation of nurse-led protocolized weaning, thereby reducing the duration of IMV for patients.

Abbreviations

CFA
confirmatory factor analysis
CFI
comparative fit index
CV
coefficient of variation
EFA
exploratory factor analysis
GFI
goodness-of-fit index
ICU
intensive care unit
ICU-AW
ICU-acquired weakness
IFI
value-added fit index
IMV
invasive mechanical ventilation
KAP
knowledge, attitudes and practices
NFI
normative fit index
RTs
respiratory therapists
SBTs
spontaneous breathing trials

S-CVI
scale-level CVI
RMSEA
root mean square error
VAP
ventilator-associated pneumonia
VIDD
ventilator induced diaphragm dysfunction

Declarations

Ethics approval and consent to participate

The medical ethics committee of Sichuan Academy of Medical Sciences Sichuan Provincial People's Hospital approved the study, and the ethics batch number is Lun Shen (Yan) No. 155 in 2023. The study adhered to the Declaration of Helsinki. Explained the purpose and significance of this study to the research object before the survey, and obtained the informed consent of the research object, they voluntarily fill in the questionnaire.**Consent for publication**

Funding

Sichuan Science and Technology Program. Investigation of the Development and Implementation of a Tracheal Tube Extubation Program in the Intensive Care Unit (ICU) within a Multidisciplinary Team (MDT) Model; Project Number: 2023YFS007.

Authors' contributions

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Acknowledgements

The author thanks all the experts who participated in the Delphi expert consultation, and also thanks the nurses who took part in the questionnaire survey.

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Acknowledgement

The author thanks all the experts who participated in the Delphi expert consultation, and also thanks the nurses who took part in the questionnaire survey.

Data Availability

The data that support the study are available from the corresponding author on reasonable request.

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Figures

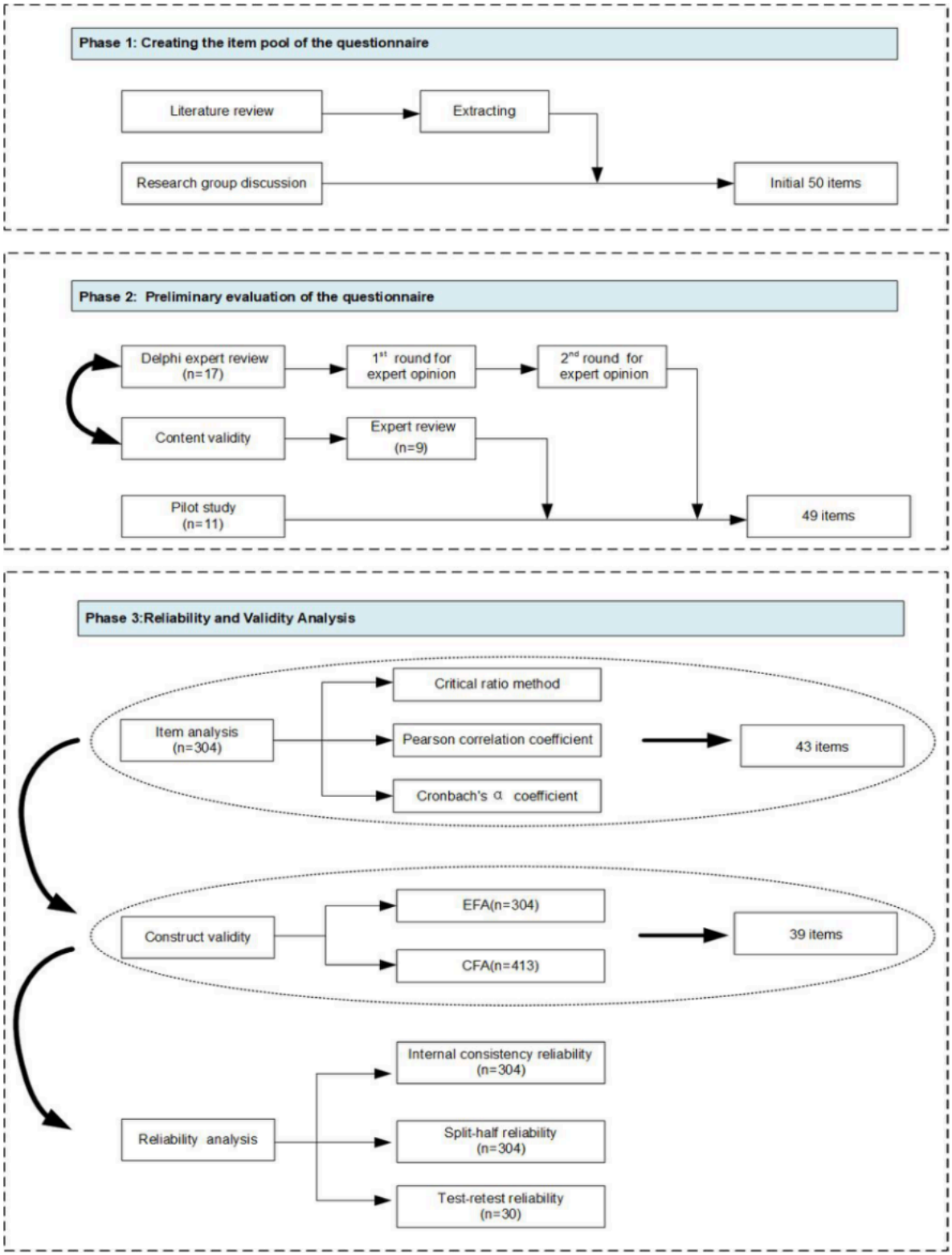


Figure 1

Phases in the study

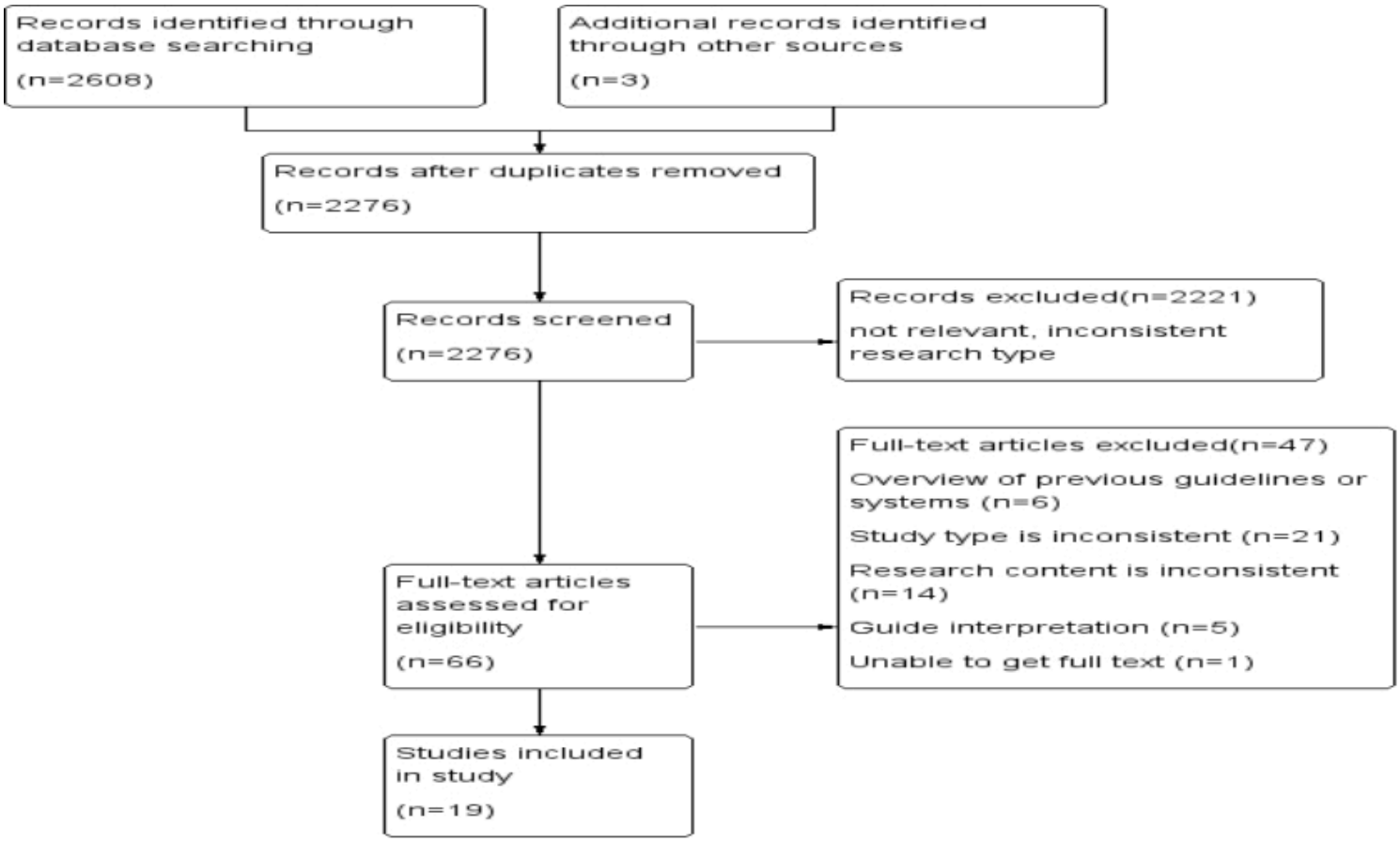


Figure 2

Flow chart of literature screening

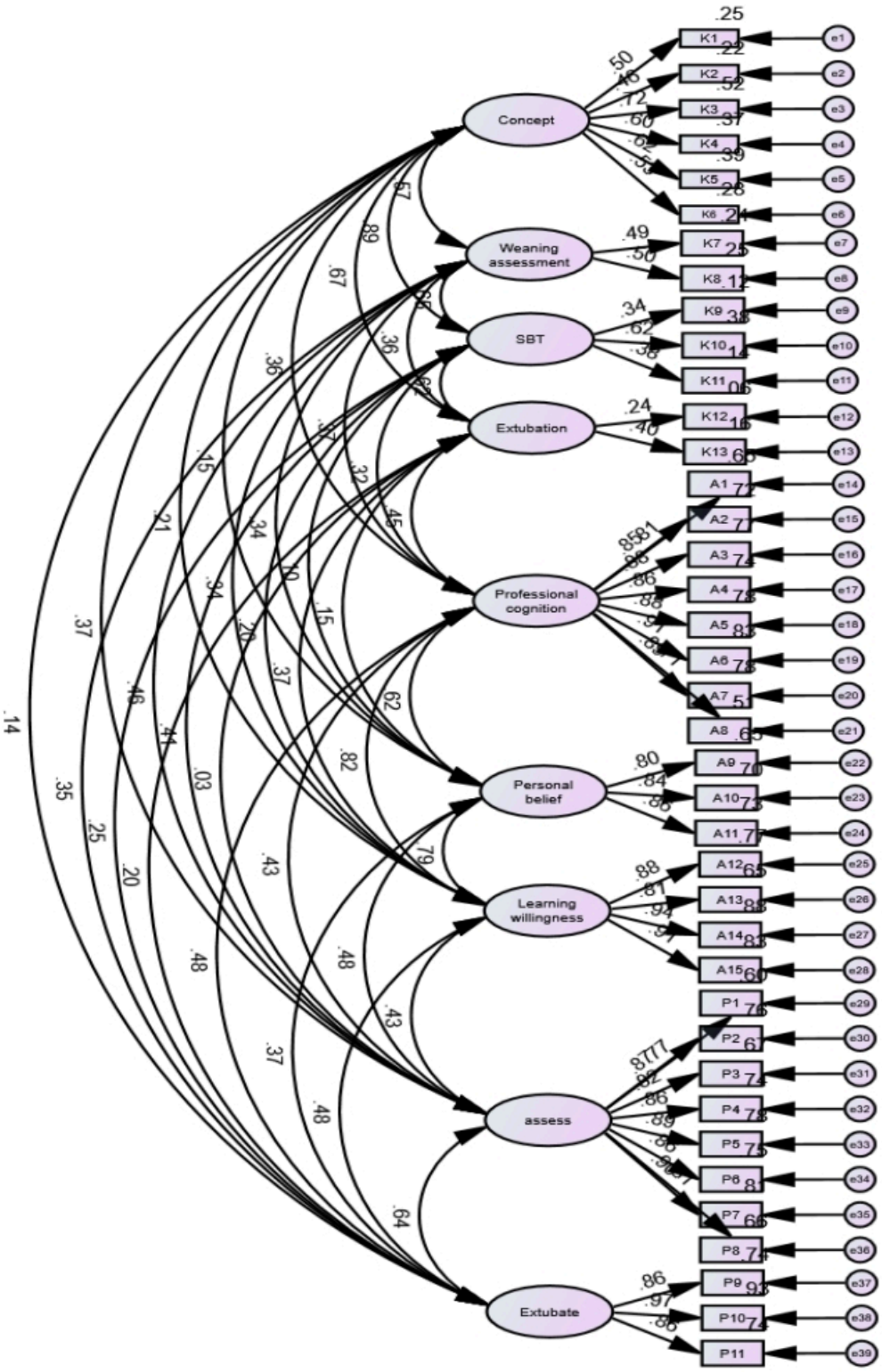


Figure 3

The standardized estimates of CFA model

Supplementary Files

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- Supplementaryfilethefinalquestionnaire.docx