

Construction of a nursing quality evaluation indicator system for extubation of endotracheal tube in the Postanesthesia care unit in China: A Delphi study

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Article

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Abstract

Background

The goal of this study was to construct a nursing quality evaluation indicator system for the extubation of endotracheal tubes in the Postanesthesia Care Unit (PACU) in China. The aim was to provide a reference for improving the quality of nursing care during tracheal extubation.

Methods

This study is rooted in the principles of evidence-based nursing, synthesizing insights from clinical decision-making research, recommended practices, guidelines, evidence summaries, and expert consensus. Utilizing the "Structure - Process-Outcome" quality model as a guiding framework and incorporating findings from semi-structured interviews, an initial draft of the quality evaluation index system for tracheal extubation care was developed. To refine and enhance the draft, the study conducted two rounds of Delphi consultations with Chinese experts, including anesthesia nurses, anesthesiologists, and clinical administrators. These consultations were designed to gather expert feedback and further optimize the evaluation system.

Results

A total of 35 indicators were extracted from the literature. Two rounds of Delphi consultations were conducted to collect opinions from a panel of 22 Chinese experts. The response rates for the two rounds of expert consultations were 92.0% and 100.0%, respectively. The expert authority coefficients were 0.92 and 0.945, and the Kendall's harmony coefficients were 0.13 and 0.15 ($P < 0.05$). The final version of the nursing care quality evaluation index system for the PACU included 3 structure indicators (11 items), 5 process indicators (17 items), and 2 outcome indicators (10 items).

Conclusions

The nursing quality evaluation indicator system developed for endotracheal tube extubation is scientifically valid and can be applied to nursing care in the PACU to improve care quality.

Introduction

Tracheal extubation during the postoperative recovery period is a critical procedure, typically performed by nurses in the Postanesthesia Care Unit (PACU) under physician supervision. Nurses play a central role in monitoring patients recovering from general anesthesia, managing the extubation process, and identifying potential complications. However, extubation remains a high-risk procedure, with complications such as hypoxia, respiratory distress, laryngospasm, and pulmonary aspiration posing significant threats to patient safety. In China, these complications are prevalent and represent a significant clinical challenge. Globally, studies indicate that complications like hypoxia and airway obstruction occur at high rates, particularly among high-risk populations, including obese patients and those with preexisting respiratory conditions[1–4]. These findings highlight the urgent need for standardized protocols and enhanced nursing practices to mitigate risks, reduce complications, and improve patient outcomes. Addressing these challenges is essential for advancing postoperative care and ensuring patient safety in clinical practice.

The Delphi method is a qualitative research approach that achieves consensus through multiple rounds of expert consultation, characterized by anonymity, feedback, and statistical analysis. This method systematically addresses complex factors in the process of tracheal tube extubation, such as patient assessment, operational standards, and complication prevention, through iterative expert consultations. It ensures that the developed evaluation index system is both comprehensive and targeted. Notably, numerous studies have demonstrated the widespread application of the Delphi method in areas such as nursing quality evaluation and clinical guideline development. Its effectiveness and reliability have been validated, making it suitable for constructing a quality evaluation index system for tracheal tube extubation care.

The objective of this study is to develop a standardized nursing quality evaluation system for tracheal extubation in the PACU to enhance patient safety and reduce complications. The findings will provide a framework for optimizing postoperative care and ensuring safer transitions for patients recovering from general anesthesia.

Methods

Design

This study mainly focuses on the design from the above aspects. The literature search adopts the method of evidence-based nursing, and searches databases worldwide using the relevant keywords system of this study. Two or more researchers extract literature related to the topic, and experts were invited to participate in semi-structured interviews. Using the findings and guided by the "structure-process-outcome" framework, an initial draft of the nursing quality evaluation index system was developed[5]. Select experts in the relevant field from China to conduct a Delphi study, revise and clarify the final draft of the nursing quality evaluation indicator system based on the inquiry results of each expert on this index. Finally, based on the results of expert inquiries, calculate the expert authority coefficient, Kendall's coefficient of concordance, and weights of each indicator in the evaluation system[6].

Ethical considerations

This study was approved by the Ethics Committee of the Affiliated Hospital of Jiangsu University (Approval No. KY20210702-7), with all participants participating voluntarily. The study adhered to recognized national and international standards, with informed consent obtained from all participants prior to their involvement. Participant privacy was strictly protected. The authors declare no conflicts of interest.

Establishing a research team

The team comprises eight members: one head nurse from the anesthesiology department, a male with a master's degree; three head nurses from the inpatient wards, all female with bachelor's degrees; two specialist nurses, both female with master's degrees; and two female nursing graduate students. The head nurses from the anesthesiology and inpatient departments are responsible for overall coordination, while the specialist nurses focus on evaluating the quality of the literature and developing the indicator evaluation system. The nursing graduate students handle the literature search, questionnaire design, distribution, and data analysis. All members have undergone relevant training. The training content includes systematic evidence-based nursing methods and the Delphi method, covering literature search and screening, literature quality evaluation methods, the steps of the Delphi method, and the design of survey questionnaires.

Literature review

This study adopts an evidence-based nursing approach, utilizing a systematic search strategy across multiple international and Chinese databases. The databases searched include the British Medical Journal Best Practice, Up to Date, Joanna Briggs Institute (JBI), Evidence-Based Health Care Center Database, National Institute for Health and Clinical Excellence (NICE), National Guideline Clearing House (NGC), Cochrane Library, CINAHL Database, PubMed, American Society of Anesthesiologists (ASA), Embase, Yimaitong, China Anesthesiologists Official Network, China Biomedical Abstracts Database (CBM), China National Knowledge Infrastructure (CNKI), Wanfang, and VIP. The key words used were: ("extubation" OR "tracheal extubation") AND ("postoperative" OR "post-anesthesia") AND ("nursing" OR "nursing care" OR "care management") AND ("nursing quality" OR "patient safety" OR "quality indicators" OR "quality assessment" OR "evaluation index" OR "quality management" OR "quality improvement"). The inclusion criteria for the literature were as follows: 1) studies focusing on patients undergoing general anesthesia with tracheal intubation; 2) literature types including guidelines, systematic reviews, evidence summaries, best clinical practice information booklets, recommended practices, and expert consensus. The exclusion criteria were: 1) studies with incomplete literature; 2) studies failing to meet quality standards. The search timeframe spanned from the inception of each database to October 2023. Relevant evidence was extracted from the included literature and synthesized for analysis.

Literature quality assessment

The evaluation of literature quality is conducted utilizing the "2014 JBI Evidence Preclassification and Evidence Recommendation Level System," developed by the Joanna Briggs Institute (JBI) Centre for Evidence-Based Healthcare in Australia[7]. This system facilitates the grading of evidence and the determination of recommendation levels. Literature pertaining to clinical decision-making and best practices is regarded as the pinnacle of evidence resources, occupying the apex of the evidence hierarchy due to its high quality. Evidence that is congruent with the clinical scenario under investigation is directly utilized. The quality of clinical guidelines is appraised using the "Appraisal of Guidelines for Research & Evaluation II" (AGREE II) instrument from the United Kingdom[8]. Expert consensus documents are evaluated in accordance with the corresponding JBI Evidence-Based Healthcare Centre evaluation criteria (2016)[9].

The JBI Evidence Preclassification and Recommendation Level System (2014 edition) was employed to categorize the included studies. The evidence was stratified into five levels, ranging from Level 1 to Level 5. Additionally, the recommendation level of the evidence was classified into Grade A (strong recommendation) and Grade B (weak recommendation)[7], based on criteria such as feasibility, appropriateness, clinical significance, and effectiveness. After rigorous evaluation process, a total of 9 publications were ultimately included in the review, comprising 4 clinical decision-making studies[10-13], 1 recommended practice article[14], 1 evidence summary[15], 1 clinical guideline[4], and 2 expert consensus documents [16-17](as detailed in Figure 1). From these selected publications, 35 distinct indicators were extracted.

Semi-structured interviews

After identifying the research team members, the study's objectives were clarified, and a structured expert interview format was developed. The interviews utilized purposive and snowball sampling methods, targeting anesthesiologists, PACU nurses, and nursing manager. Selection criteria for the interview participants were established based on the study's definitions and objectives. The criteria for expert inclusion are as follows: anesthesiologists were required to i) have at least one year of PACU experience, ii) hold an intermediate or higher professional rank, and iii) voluntarily agree to participate in the study. PACU nurses needed to i) be PACU-certified and have at least one year of PACU experience, ii) hold an intermediate or higher professional rank, and iii) voluntarily agree to participate. Nursing manager were

expected to i) have at least three years of PACU experience, ii) hold an intermediate or higher professional rank, and iii) voluntarily agree to participate.

To ensure high-quality semi-structured interviews, the content was developed from a review of relevant literature and evidence linked to the study, further refined by incorporating feedback from each expert. The full semi-structured interview guide is provided in Additional file 1. The interviews were carried out in a face-to-face manner, each session spanning from 30 to 60 minutes. They were conducted in a serene and secluded environment, free from any external disturbances, thereby fostering a comfortable atmosphere for participants to freely express their insights. All interviews were audio-recorded and transcribed verbatim, with informed consent obtained from each participant prior to the interview. Interviews concluded once data quality and saturation were achieved.

Drawing on insights from the literature review and interview findings, and guided by the "structure-process-outcome" model, an initial draft for the PACU endotracheal intubation and extubation nursing quality evaluation index system was developed. This draft encompasses 3 structure indicators (11 items), 4 process indicators (15 items), and 1 outcome indicators (6 items).

The implementation process of Delphi method

Determine the inquiry expert group

The selection of experts strictly follows the principles of representativeness and authority. Relevant anesthesia medical and nursing experts with years of management or professional experience are selected from public hospitals in China, and can provide detailed opinions and suggestions for this research. The inclusion criteria for experts are as follows: (1) Research areas include anesthesia nursing, anesthesiology, and nursing management; (2) Bachelor's degree or above; (3) Intermediate or above professional title; (4) Work in the professional field for 10 years or more; (5) Voluntarily participate in this study and ensure continuous participation during the study period.

Determine expert consultation and questionnaires

The research team members sorted, classified, and analyzed the relevant indicators formed through the evidence-based process, and discussed and analyzed representative indicators that are beneficial for improving the quality of endotracheal tube removal care in the PACU. Based on the current situation of comprehensive hospital management of patients undergoing tracheal tube removal after general anesthesia and nursing management measures in the PACU, determine the first round of expert consultation and questionnaire. The consultation and questionnaires consists of three parts: (1) Introduction Section: including research background, purpose, implementation steps of Delphi method, and instructions for filling out the

consultation questionnaire. (2) Main body: including the inquiry item table. The scoring method uses the Likert 5-point rating system to evaluate the importance of items, with scores ranging from the most important (5 points) to the least important (1 point). At the end of each scoring item, there is an open opinion column for experts to provide relevant opinions and suggestions based on their experience. Expert Basic Information Survey Form and Expert Familiarity and Judgment Basis Self Evaluation Form for the Research Question. (3) The basic information survey of experts includes age, education level, professional title, length of service, major, and so on [18]. There are four self-evaluation items based on the survey form, which can be selected from three levels: large, medium, and small.

Distribution and collection of questionnaires for expert consultations

Both rounds of the Delphi process were conducted in the workplace. The subjects in this study were experts selected based on their expertise and experience in the relevant field. They were approached via email, which included an

introduction to the study, the purpose of the Delphi process, and a request for their participation. If necessary, telephone assistance was provided to guide them through the questionnaire and address any questions or concerns.

Each round of the Delphi process had a time limit of 2-3 weeks for experts to complete and return the questionnaires. The first round began in November 2023, and subsequent rounds were scheduled based on the completion of the previous round and the time required for data analysis and questionnaire revision.

The questionnaires were distributed and collected electronically via email. This method ensured efficiency and allowed for easy tracking of responses. After the questionnaires were collected, the research team summarized and analyzed the results within 2 weeks. Based on the analysis, internal discussions were held to revise the questionnaire for the next round. The revised results were then fed back to the experts to maintain transparency and ensure the effectiveness of the process.

Statistical analysis

After collecting and organizing the inquiry questionnaire, it is necessary for two people to conduct a preliminary inspection. If any omissions or unclear understanding are found, they should contact experts in a timely manner to clarify the content before conducting statistical analysis. The data in the expert inquiry questionnaire survey feedback results were entered into Excel and analyzed using SPSS 23.0 statistical software. The structural composition of experts is usually represented by frequency, composition ratio, mean, standard deviation, and so on. The questionnaire response rate can reflect the level of enthusiasm of experts; The questionnaire recovery rate can reflect the degree of enthusiasm of experts; the degree of concentration, authority and coordination of expert opinions are measured using the mean $\pm$ standard deviation, authority coefficient (Cr), coefficient of variation (CV) and Kendall's harmony coefficient (W) respectively. and its significance test to reflect the explanation.

Results

Basic information of experts

This study involved semi-structured interviews with 11 experts, comprising 4 anesthesiologists, 4 PACU nurses, and 3 nursing manager from the anesthesiology department. These experts were selected from five tertiary hospitals across China. For further details, please see Table 1.

Table 1 General Information About the Experts of Semi-structured Interviews.

Participants	Code	Sex	Years of experience
anesthesiologist	D1	F	14
anesthesiologist	D2	F	12
anesthesiologist	D3	M	10
anesthesiologist	D4	M	11
PACU nurses	N1	F	8
PACU nurses	N2	F	9
PACU nurses	N3	F	10
PACU nurses	N4	F	10
Nursing manager	N5	M	6
Nursing manager	N6	M	6
Nursing manager	N7	F	5

This study invited a total of 22 clinical healthcare professionals or managers for 2 rounds of consultation. These experts come from 20 tertiary public hospitals in six provinces and cities, including Shanghai, Chongqing, Jiangsu, Henan, Anhui, and Guangxi. Two rounds of inquiry with experts aged between 33-55, with a working experience of 15.78 ± 5.93 (10-31); Expert education: 4 with master's degree or above, 18 with bachelor's degree; Expert titles: 1 senior professional title, 5 deputy senior professional titles, and 16 intermediate professional titles (Table 2).

Table 2 Basic information of experts.

Project	Classification	Number of people (example)	Composition ratio (%)
Professional field	Nursing Management	8	36.4
	clinical nursing	12	54.5
	Clinical Medicine	2	9.1
Work experience (years)	10~20	17	77.3
	20~30	4	18.2
	>30	1	4.5
education	Doctor of Philosophy	1	4.5
	master	3	13.6
	undergraduate	18	81.8
title	Advanced level	1	4.5
	Deputy Senior	5	22.7
	intermediate	16	72.7
Age (years)	<40	15	68.2
	40~49	6	27.3
	50~59	1	4.5

Expert enthusiasm level

The response rate of survey questionnaires serves as a key visual indicator, with its percentage positively correlated to the importance that experts attach to the research. It is generally accepted that when the positive coefficient reaches 50.0%, the collected questionnaire data can be considered suitable for analysis. A positive coefficient of 70.0% or higher indicates a high level of enthusiasm among experts regarding their participation. In the first round of this study, 24 questionnaires were distributed, and 22 were collected, resulting in an effective response rate of 92.0%. In the second round, all 22 distributed questionnaires were collected, achieving an effective response rate of 100.0%. Both rounds of expert inquiry questionnaires exhibited response rates exceeding 70.0%, demonstrating a strong level of enthusiasm and engagement from the experts.

The degree of expert authority

The degree of authority is expressed by authority coefficient (Cr), which is evaluated by the educational level of the expert and the basis for judgment (Ca) and the degree of the expert's familiarity with the indicators (Cs). The range of Cr values is between 0-1. Generally, if the Cr of all consulting experts is ≥ 0.7 , it indicates that the experts have sufficient confidence in the content of the inquiry field and the results are reliable[6]. The calculation of Ca is based on the expert's assignment judgment in the feedback inquiry form, and the self selected results are compared with the corresponding scores of each item to calculate the arithmetic mean of the total self-evaluation scores of all experts. The calculation of Cs is based on the expert's self selected familiarity with the inquiry content in the feedback inquiry form, and the corresponding score for each item is calculated as the arithmetic mean of the total self-evaluation scores of all experts. The results obtained showed that Ca was 0.90 (first round) and 0.94 (second round), and Cs was 0.94 (first round) and 0.95 (second round), respectively. Based on the above results, the authoritative coefficients for the two rounds were 0.92 (first round) and 0.95 (second round), both greater than 0.80, indicating that the selected

experts are familiar with the management and nursing of endotracheal tube removal after anesthesia recovery, have a high degree of confidence in this field, and the credibility of the inquiry is high.

Degree of coordination of expert opinions

The degree of coordination of expert opinions indicates the consistency of expert judgments on indicators, and is mainly represented by Kendall's harmony coefficient. The value of Kendall's *W* ranges from 0 to 1. The larger the value, the higher the coordination of expert opinions and the more unified the expert opinions are. The Kendall's *W* significance test is used to verify the consistency of the reliability of the correspondence expert opinions. The smaller the *P* value, the higher the credibility, and the higher the consistency reliability of the expert opinion. The coefficient of variation (*CV*) of the first round of expert correspondence was 0 to 0.19, and Kendall's *W* was 0.13(*P*<.001); the *CV* of the second round of expert correspondence was 0 to 0.26, and Kendall's *W* was 0.15 (*P*<.001), the experts in this study asked Kendall's *W* value as shown in Table 3.

Table 3 Degree of coordination of expert opinions.

Round by round	Kendall's <i>W</i>	χ^2	<i>P</i>
First round	0.13	114.19	<0.001
Second round	0.15	167.99	<0.001

Kendall'W: Kendall's coefficient of concordance. X^2 : chi-square test. *P*: Wilcoxon test, Significance was set a *P*< 0.001.

Index screening and modification results

Analysis of the first round of results

This research team used a double-blind method to enter, process and analyze data, and finally checked them. Furthermore, after the first round of the Delphi method consultation, 54.5% of the experts provided suggestions, with proposed revisions as follows: (1) Add "Ventilator use" as a secondary indicator to the process indicators; add "Occurrence of adverse events" as a secondary indicator to the outcome indicators, and change "Incidence of airway-related complications" to "Occurrence of Complications".(2) In the structural indicators, the tertiary indicator "The department is equipped with emergency intubation equipment" was revised to "The department is equipped with emergency intubation equipment and difficult airway vehicles"; "the department has endotracheal tube extubation procedures and system" was changed to "the department has endotracheal tube extubation procedures and specifications"; "The department has a tracheal tube extubation operation standard" was deleted; "The department has an emergency plan for unplanned extubation" was added; "The ratio of PACU nurses to PACU beds" was revised to "The ratio of PACU nurses to PACU beds is not less than 0.5:1"; and "PACU has fixed full-time anesthesiologists" was changed to "PACU has full-time anesthesiologists".(3)In the process indicators, the tertiary Indicator "Medical staff in the department are aware of high-risk factors before tracheal extubation" was revised to "Nurses in the department are aware of high-risk factors before tracheal extubation.""Nurses should prepare antagonists according to the doctor's orders" was revised to "Nurses should prepare antagonists, sedatives and other related drugs according to the doctor's orders", "Nurses should know the indications and contraindications for the use of antagonists" was changed to "Nurses are aware of the indications and contraindications of relevant drugs", "Nurses should use antagonists correctly according to the doctor's orders" was changed to "Nurses should use related drugs correctly according to the doctor's orders", "Nurses should evaluate the efficacy and adverse reactions of antagonists in a timely manner" was changed to "Nurses should evaluate the efficacy and adverse reactions of drug use in a timely manner", and "Nurses

should master the selection of ventilator modes and the adjustment of parameters" and Nurses should master the indications for weaning" were added. " and "Nurses should promptly aspirate sputum in the airway before and after extubation" were changed to "Nurses should promptly clear respiratory secretions before and after extubation", "Nurses should closely monitor changes in patients' vital signs during extubation" was changed to "Nurses closely monitor the patient's vital signs during the entire extubation process","Nurses should promptly observe the patient's breathing, consciousness, and other conditions after extubation" was revised to "The nurse should promptly observe the patient's consciousness after extubation".(4)In the outcome indicators, the tertiary indicator "the incidence of secondary intubation after extubation" was revised to a tertiary indicator under "occurrence of adverse events"; five additional tertiary indicators were added, namely "the incidence of abnormal blood pressure after extubation", "the incidence of abnormal heart rate after extubation", "the incidence of unplanned extubation", "the incidence of tooth damage during extubation", and "the incidence of delayed PACU transfer after anesthesia".

Analysis of the Second Round Results

After integrating the results of the previous round of inquiries, the research team discussed and formed the second round of inquiry questionnaires, and invited experts to re-evaluate the newly formed indicator items at all levels and give further opinions and suggestions. The experts for the second round of inquiries must be experts who participated in the first round of inquiries and gave replies. The questionnaires are still distributed by email. The indicator items are repeatedly confirmed and evaluated by experts to determine the criteria for terminating the inquiry. Items with a mean importance value of ≥ 3.5 and a coefficient of variation (CV) < 0.25 are retained

[19,20]. After the second round of inquiries, the experts of each indicator item had no objection to deletion or modification and passed unanimously. Finally, a "structure-process-result" indicator system was formed, including 3 primary indicators, 10 secondary indicators, and 38 tertiary indicators .

Establish the weight of the nursing quality evaluation indicator system for extubation of endotracheal tube in the PACU unit based on the hierarchical analysis method

The judgment matrix was constructed using the Saaty scale, which was established based on the differences in the mean comparisons of importance scores from the second round of expert consultations. Specifically, if the difference in the mean importance score was between 0.75 and 1.0, the Saaty scale was assigned a value of 5. Conversely, if the difference was between -0.50 and -0.25, the scale was assigned a value of 1/3[21-22]. The weight of each indicator at each level was sequentially calculated using yahhp10.3 software, and each matrix underwent a consistency test. The resulting weights of the indicators and the consistency test outcomes are presented in Table 4 and Table 5.

Table 4 Primary and Secondary Indicators of the Structure-Process-Outcome Framework

Primary and Secondary Indicators	Importance Assignment(M±SD)	CV	Weight	Combination weight
1 Structural indicators	5.00±0.00	0.00	0.33	—
1.1 Facilities and equipment	5.00±0.00	0.00	0.33	0.11
1.2 Policies and procedures	5.00±0.00	0.00	0.33	0.11
1.3 Human resources	5.00±0.00	0.00	0.33	0.11
2 Process indicators	5.00±0.00	0.00	0.33	—
2.1 Pre-extubation assessment	5.00±0.00	0.00	0.20	0.07
2.2 Drug use	5.00±0.00	0.00	0.20	0.07
2.3 Ventilator use	5.00±0.00	0.00	0.20	0.07
2.4 Master the indications for extubation	5.00±0.00	0.00	0.20	0.07
2.5 Tracheal tube extubation procedure	5.00±0.00	0.00	0.20	0.07
3 Outcome indicators	5.00±0.00	0.00	0.33	—
3.1 The occurrence of complications	5.00±0.00	0.00	0.50	0.17
3.2 The occurrence of adverse events	5.00±0.00	0.00	0.50	0.17

Table 5 Tertiary Indicators of the Structure-Process-Outcome Framework

Tertiary Indicators	Importance Assignment(M±SD)	CV	Weight	Combination weight
1.1.1 The department has PACU	4.50±0.94	0.21	0.11	0.01
1.1.2 The department has training materials related to tracheal extubation	4.68±0.63	0.14	0.15	0.02
1.1.3 The department is equipped with complete suction equipment	4.95±0.21	0.04	0.37	0.04
1.1.4 The department is equipped with emergency intubation equipment and difficult airway vehicle	4.95±0.21	0.04	0.37	0.04
1.2.1 The department has endotracheal tube extubation procedures and specifications	4.73±0.62	0.13	0.14	0.02
1.2.2 The department has an emergency plan for unplanned extubation	4.82±0.39	0.08	0.23	0.03
1.2.3 The department has operating procedures for suctioning sputum	4.86±0.34	0.07	0.40	0.04
1.2.4 The department has observation and treatment standards and procedures for complications related to extubation	4.82±0.39	0.08	0.23	0.03
1.3.1 PACU has full-time anesthesia nurse	4.73±0.62	0.13	0.43	0.05
1.3.2 The ratio of PACU nurses to PACU beds is no less than 0.5:1	4.27±1.05	0.25	0.14	0.02
1.3.3 PACU has full-time anesthesiologist	4.73±0.45	0.10	0.43	0.05
2.1.1 Nurses in the department understand the high-risk factors before tracheal extubation	4.64±0.71	0.15	0.20	0.01
2.1.2 Nurses in the department are aware of high-risk factors before tracheal extubation.	4.68±0.70	0.15	0.40	0.03
Table 5 continued				
2.1.3 Nurses should promptly inform anesthesiologists of high-risk factors	4.68±0.70	0.15	0.40	0.03
2.2.1 Nurses should prepare antagonists, sedatives and other related drugs according to the doctor's orders	4.64±0.48	0.10	0.19	0.01
2.2.2 Nurses are aware of the indications and contraindications of relevant drugs	4.59±0.72	0.16	0.12	0.01
2.2.3 Nurses should use related drugs correctly according to the doctor's orders	4.91±0.29	0.06	0.50	0.03
2.2.4 Nurses should evaluate the efficacy and adverse reactions of drug use in a timely manner	4.64±0.57	0.12	0.19	0.01
2.3.1 Nurses should master the selection of ventilator modes and the adjustment of parameters	4.59±0.72	0.16	0.33	0.02
2.3.2 Nurses should master the indications for weaning	4.64±0.57	0.12	0.67	0.04

2.4.1 Nurses know and master the patient extubation standards	4.95±0.21	0.04	0.67	0.44
2.4.2 Nurses can correctly assess patients' extubation indications	4.91±0.29	0.06	0.33	0.22
2.5.1 Nurses must remove the endotracheal tube according to the doctor's instructions and must not remove the tube without authorization	4.95±0.21	0.04	0.11	0.01
2.5.2 Nurses should promptly clean respiratory secretions before and after extubation	5.00±0.00	0.00	0.20	0.01
2.5.3 The nurse should promptly aspirate the gas in the cuff before extubation	4.82±0.65	0.14	0.20	0.01
2.5.4 Nurses closely monitor the patient's vital signs during the entire extubation process	5.00±0.00	0.00	0.20	0.01
2.5.5 The nurse should promptly observe the patient's consciousness after extubation	5.00±0.00	0.00	0.09	0.01
2.5.6 The nurse promptly gave the patient oxygen after extubation and observed the patient's blood oxygen saturation	5.00±0.00	0.00	0.20	0.01
3.1.1 The incidence of postextubation laryngospasm	4.91±0.42	0.09	0.31	0.05
3.1.2 The incidence of postextubation hypoxemia	4.86±0.34	0.07	0.19	0.03
3.1.3 The incidence of hoarseness after extubation	4.86±0.46	0.10	0.19	0.03
3.1.4 The incidence of postextubation sore throat	4.68±0.63	0.14	0.14	0.02
3.1.5 The incidence of abnormal blood pressure after extubation	4.64±0.64	0.14	0.09	0.01
3.1.6 The incidence of abnormal heart rate after extubation	4.64±0.64	0.14	0.09	0.01
3.2.1 The incidence of unplanned extubation	4.86±0.34	0.07	0.42	0.07
3.2.2 The incidence of secondary intubation after extubation	4.82±0.49	0.10	0.29	0.05
3.2.3 The incidence of tooth damage during extubation	4.77±0.42	0.09	0.18	0.03
3.2.4 The incidence of delayed PACU transfer after anesthesia	4.55±0.94	0.21	0.11	0.02

Discussion

Necessity and scientific analysis of indicator construction

General anesthesia is one of the most important and commonly used methods for surgical patients worldwide. Relevant data indicate that over two-thirds of surgical patients in the United States receive general anesthesia[23], with more than half of these cases involving endotracheal intubation. Consequently, the extubation of the endotracheal tube following general anesthesia has become a critical aspect of the perioperative period. The nursing quality evaluation indicator system for endotracheal tube extubation in the PACU developed in this study is grounded in global literature evidence. The initial draft of this evaluation system was created using a three-dimensional framework that encompasses structure, process, and outcome indicators. The structure-process-outcome quality model serves as the

theoretical foundation for constructing these quality evaluation indicators, illustrating how structure and process indicators influence outcomes[24]. As a result, this indicator evaluation system aligns well with clinical practice. Additionally, this study employed a Delphi expert consultation to refine the draft. The Delphi method is a well-established structured communication technique used internationally. Consensus was achieved through multiple rounds of questionnaires administered to an expert group[25]. The experts, all affiliated with various general hospitals in China, contributed to the further revision of the indicator system's content. Therefore, the indicator system developed in this study demonstrates strong scientific rigor.

Content analysis of the evaluation index system for nursing quality of endotracheal tube removal in the PACU

This study developed a "structure-process-outcome" Indicator system, consisting of 3 primary indicators, 10 secondary indicators, and 38 tertiary indicators. These indicators were finalized through two rounds of the Delphi method, involving 22 experts from various regions of China. The response rates for the two rounds of expert questionnaires were 92.0% and 100.0%, respectively, with expert authority coefficients of 0.92 and 0.95, demonstrating high levels of enthusiasm and expertise among the participants[26]. The results indicated that the 3 primary indicators, 10 secondary indicators were all rated with full marks, reflecting strong consensus and recognition of their importance by the experts. After two rounds of consultations, the experts displayed a high degree of agreement on the relevance of these indicators.

The structural indicators comprise 3 secondary indicators and 11 tertiary indicators, encompassing aspects related to facilities and equipment, policies and procedures, and human resources. Among these, the tertiary indicators under "Facilities and Equipment"—"The department is equipped with complete suction equipment" and "The department is equipped with emergency intubation equipment and difficult airway vehicle"—are assigned the highest importance scores and weights. This underscores the prevalence of suction procedures in the PACU and their critical role in maintaining the patency of patients' upper airways. The presence of emergency intubation equipment and difficult airway vehicle is deemed essential for managing sudden airway obstructions and safeguarding patient safety. Within the "Policies and Procedures" category, the tertiary indicator "The department has operating procedures for suctioning sputum" receives the highest importance score and weight. This emphasizes the necessity for PACU nurses to master the most common operational methods, reflecting a key focus area in PACU nurse training programs. Within the "Human Resources" category, the two tertiary indicators—"PACU has full-time anesthesia nurses" and "PACU has full-time anesthesiologist"—were assigned notably high importance scores and weights. This reflects the consensus among experts that human factors play a pivotal role in ensuring patient safety within the PACU. A shortage of human resources could lead to an increased workload for medical staff, potentially undermining the quality of care provided.

The process indicators encompass 5 secondary indicators and 17 tertiary indicators, covering aspects such as pre-extubation assessment, drug use, master the indications for extubation, and tracheal tube extubation procedure. Among these, the two tertiary indicators under "Pre-Extubation Assessment"—"Nurses in the department are aware of high-risk factors before tracheal extubation." and "Nurses should promptly inform anesthesiologists of high-risk factors"—were assigned the highest importance scores and weights. This highlights the critical role of nurses in evaluating risk factors prior to tracheal tube extubation and relaying this information to the physician, which is a decisive step in determining the patient's extubation strategy. Within the "Drug use" category, the tertiary indicator "Nurses should use related drugs correctly according to the doctor's orders" received the highest importance score and weight. In the PACU, patients may be prescribed a variety of drugs, including neuromuscular reversal agents, vasoactive drugs, sedatives, and analgesics, tailored to their individual needs. It is essential for nurses to be well-versed in the proper administration techniques and routes of these drugs to prevent adverse reactions resulting from medication errors.

The secondary indicator "Ventilator Use" was added following the first round of expert consultation and includes two tertiary indicators: "Nurses should master the selection of ventilator modes and the adjustment of parameters" and "Nurses should master the indications for weaning" This addition was made because, during the PACU recovery phase, ventilators serve as critical respiratory support devices. Compared to anesthesia machines, ventilators may be more conducive to facilitating patients' respiratory recovery. Therefore, it is essential for nurses to master the methods for adjusting various ventilator parameters. Additionally, ventilator weaning is a crucial step prior to tracheal extubation, and a patient's ability to be successfully weaned from the ventilator is a strong predictor of their readiness for extubation. As a result, this indicator was assigned the highest importance score and weight. The "Master the indications for extubation" category also includes two tertiary indicators: "Nurses know and master the patient extubation standards" and "Nurses can correctly assess patients' extubation indications." Among these, the indicator "Nurses know and master the patient extubation standards" was assigned the highest importance score and weight. The successful removal of a tracheal tube depends on factors such as the patient's level of consciousness, recovery from neuromuscular blockade, and tidal volume, all of which are critical monitoring parameters in the PACU. This indicator directly evaluates the patient's readiness for a smooth and safe extubation process. The "Tracheal tube extubation procedure" category comprises six tertiary indicators, four of which received the highest possible importance scores. These indicators cover aspects such as airway suctioning, vital signs, level of consciousness, and oxygen saturation, all of which serve as critical criteria for assessing patient safety post-extubation. Additionally, the tertiary indicator "Nurses must remove the endotracheal tube according to the doctor's instructions and must not remove the tube without authorization" was also assigned relatively high importance scores and weights. This is primarily due to the current legal and professional standards in China, where physicians hold the ultimate decision-making authority, akin to prescribing privileges, while nurses do not yet possess such rights. Consequently, nurses are required to perform tracheal extubation strictly under the guidance of physician orders.

The outcome indicators comprise two secondary indicators and ten tertiary indicators, focusing on complications and adverse events. The secondary indicator "The occurrence of complications" includes six tertiary indicators, covering common post-extubation complications such as laryngospasm, hypoxemia, hoarseness, sore throat, abnormal blood pressure, and abnormal heart rate. Among these, "The incidence of postextubation laryngospasm" was assigned the highest importance score and weight. This is likely due to the fact that laryngospasm is considered a critical emergency, as delayed intervention can rapidly lead to airway obstruction, posing significant risks to patient safety. Consequently, it is prioritized as the first complication to be ruled out following extubation. The secondary indicator "Occurrence of adverse events" encompasses four tertiary indicators, with "The incidence of unplanned extubation" being assigned the highest importance score and weight. This underscores its significance as a critical and long-standing quality control metric in nursing practice[27]. Relevant studies indicate that the incidence of unplanned extubation in China ranges from 4.5% to 22.1%[28], notably higher than the global range of 3.0% to 16.0%[29]. This disparity highlights the need for targeted interventions to address this issue and improve patient safety outcomes. Unplanned extubation can lead to serious complications, such as dyspnea, airway injury, and the need for reintubation. Therefore, reducing the incidence of unplanned extubation in the PACU has become a critical focus for improving patient safety outcomes.

In summary, this study emphasizes the importance of nurse expertise in the extubation process and highlights the prevention of unplanned extubation as a key outcome measure for ensuring patient safety in the PACU.

Analysis of the Scope of Application of Indicator Construction

The evaluation indicator system for the quality of nursing care during endotracheal tube removal in the post-anesthesia recovery room, as proposed in this study, is primarily designed to assess the effectiveness and standardization of airway management in this critical setting. Its scope of application extends beyond just evaluating

patient outcomes following endotracheal intubation. This system also serves as a tool for assessing the quality of care provided by anesthesia nurses, thus playing a key role in promoting the professional development of these nurses and enhancing the overall management capabilities of the anesthesia department.

By using this indicator system, healthcare facilities can ensure that both patient care and staff performance are held to high standards, contributing to better patient outcomes and the ongoing professional growth of the nursing team. The indicator system thus holds significant value in advancing specialized nursing practice in PACU.

Limitations

This study has some limitations. The expert panel was drawn from specific regions of China, which may introduce regional biases in the selection process, limiting the generalizability of the findings. Additionally, the number of experts involved in the Delphi consultations was relatively small, which could affect the diversity of perspectives. Another limitation is that the proposed evaluation indicator system for the quality of nursing care during endotracheal tube removal in the PACU has not yet been tested in clinical practice. As a result, further multi-center studies are needed to validate its effectiveness and applicability in real-world clinical settings.

Conclusions

Endotracheal tube extubation represents one of the most critical tasks for nurses caring for patients in the PACU. As such, the indicator system established in this study plays a pivotal role in advancing anesthesia nursing specialty practices and ensuring perioperative airway safety for patients. This is particularly significant for hospitals, regions, and countries that have recently introduced anesthesia nursing programs or established PACUs. The study provides a multifaceted framework for quality management, enabling comprehensive monitoring of endotracheal tube care quality during the PACU and promoting continuous improvement.

For perioperative nursing quality supervisors and policymakers, the indicators and practical outcomes derived from this research serve as a robust tool to evaluate gaps in staffing, equipment, and environmental conditions within clinical departments. By leveraging these indicators, they can identify and address shortcomings in nursing practices, thereby minimizing airway-related complications among patients in the PACU. This approach not only enhances the overall proficiency of nursing staff but also significantly contributes to patient safety. Moving forward, the findings of this study will be further utilized to develop targeted nursing interventions aimed at optimizing the quality of endotracheal tube extubation during the PACU, ultimately supporting improved patient recovery and outcomes.

Abbreviations

PACU Postanesthesia Care Unit

JBI Joanna Briggs Institute

ASA American Society of Anesthesiologists

CINAHL Cumulative Index to Nursing and Allied Health Literature

NICE National Institute for Health and Clinical Excellence

NGC National Guideline Clearing House

CBM China Biomedical Abstracts Database

CNKI China National Knowledge Infrastructure

CV The coefficient of variation

Declarations

Acknowledgements

Not applicable.

Authors' contributions

YTW helped handle this manuscript, designed the study, and wrote the manuscript. YJW helped in analyzing the data, supervising the study, and critically revising the manuscript. YY helped in collecting the data, analyzing the data, and conducting the study. All authors read and approved the final manuscript.

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Data availability

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

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Affiliated Hospital of Jiangsu University (Approval No. KY20210702-7) . All methods were performed in accordance with the relevant guidelines and regulations. Informed consent was obtained from all subjects.

Clinical trial number

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Figures

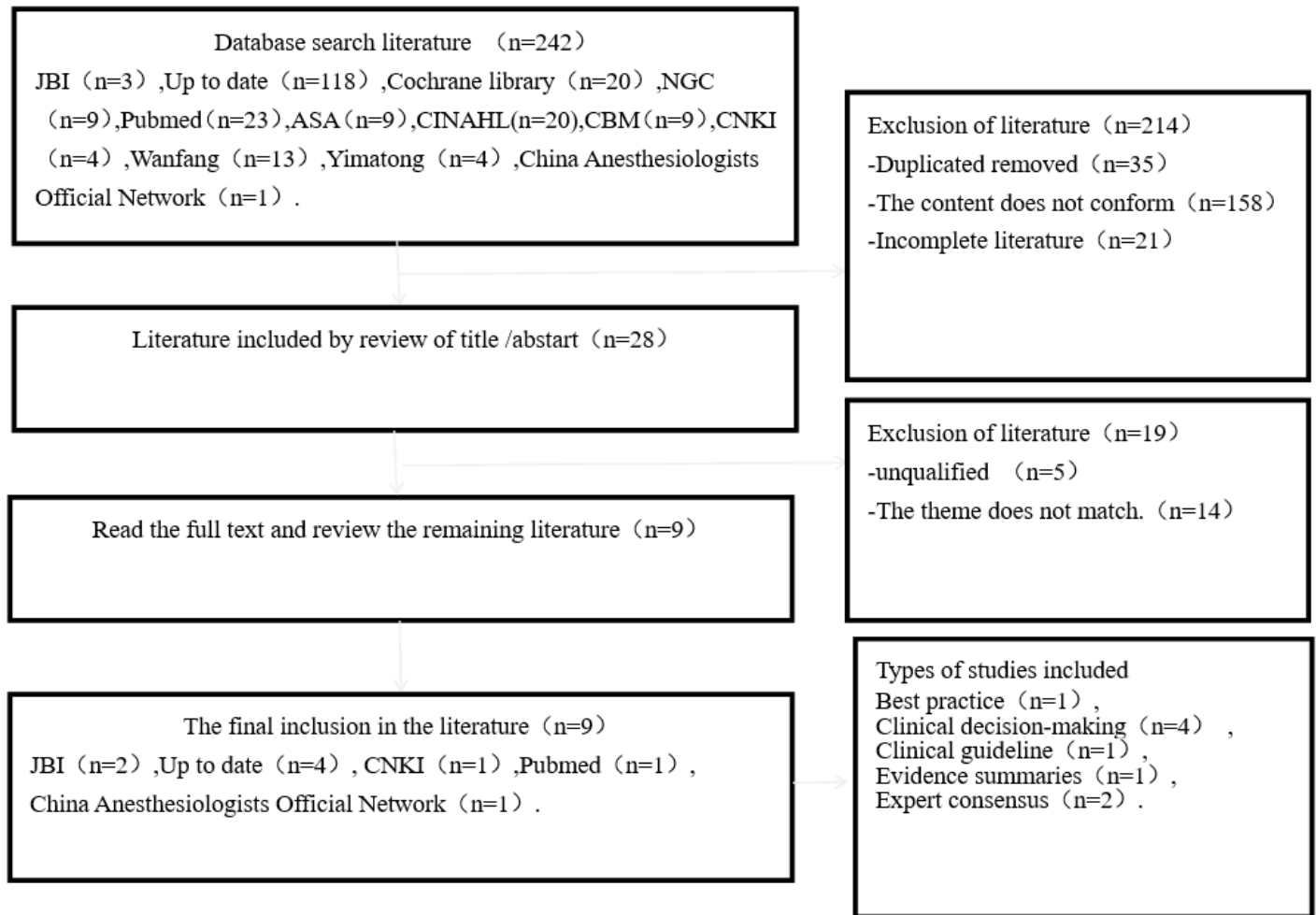


Figure 1

Flow chart of the study selection process. Abbreviations: JBI, Joanna Briggs

Institute; NGC, National Guideline Clearing House; ASA, American Society of Anesthesiologists; CINAHL, Cumulative Index to Nursing and Allied Health Literature; CBM, China Biomedical Abstracts Database; CNKI, China National Knowledge Infrastructure.