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Application of FOCUS-PDCA cycle in enhancing the standardization of emergency collaboration among thoracic surgery nurses

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To explore the effectiveness of the FOCUS-PDCA (Find, Organize, Clarify, Understand, Select, Plan, Do, Check, Act) management cycle in improving the standardization of emergency collaboration among thoracic surgery nurses. Forty nurses from two thoracic surgery wards at Zhejiang Cancer Hospital were selected as study subjects. The FOCUS-PDCA cycle was implemented to conduct mixed-mode emergency training, and the standardization scores of nursing operations, job competency self-assessment, and emergency collaboration before and after implementation were compared. After the implementation of FOCUS-PDCA, the assessment scores of nursing operations such as defibrillation, cardiopulmonary resuscitation, suction, tracheal intubation cooperation, and the use of nasal high-flow humidification therapy devices, as well as self-assessment scores of job competency and emergency collaboration standardization, were higher than those before the implementation ($p < 0.05$). The implementation of FOCUS-PDCA helps improve the standardization of emergency collaboration among thoracic surgery nurses. It should be appropriately carried out according to the department's situation to promote continuous improvement in nursing quality and emergency response levels.

Keywords FOCUS-PDCA cycle, Thoracic surgery, Emergency collaboration standardization, Nursing management

Abbreviations

FOCUS-PDCA	Find, organize, clarify, understand, select, plan, do, check, act
PDCA	Plan, do, check, act
NSCLC	Non-small cell lung cancer
HFNC	High-flow nasal cannula oxygen therapy
AVG	Adventure game
ICC	Intraclass correlation coefficient
ICU	Intensive care unit
CPR	Cardiopulmonary resuscitation

Lung cancer is one of the cancers with the highest incidence and mortality rates, with non-small cell lung cancer (NSCLC) accounting for 80–85% of lung cancer cases. Surgery is the preferred treatment for NSCLC[1,2]. The perioperative period of lung cancer involves a high risk of life-threatening complications such as acute pulmonary embolism, postoperative massive bleeding, acute respiratory failure, and pneumothorax[3,4]. Studies have shown that the complication rate after thoracoscopic lung surgery ranges from 33.3 to 38%, with severe complications occurring in 7.1–8.4% of cases, and the mortality rate due to complications is between 0.4 and 0.8%[5]. Nurses are often the first to detect changes in a patient's condition. Therefore, thoracic surgery nurses are required not only to have strong professional knowledge and operational skills but also to possess strong predictive and emergency response capabilities.

Clinical teaching is a crucial component of nursing education, playing a key role in the growth of clinical nurses, especially new nurses. However, due to issues such as the aging nursing workforce and low remuneration, there is a shortage of clinical teaching staff, which directly impacts the quality of clinical nursing education[6]. In the traditional clinical teaching training management system, the effectiveness and quality control of clinical

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teaching need improvement[7]. To address these issues, continuous quality improvement (CQI) models have been increasingly applied in nursing education and management.

The PDCA cycle was first proposed by American quality management expert Walter A. Shewhart in the 1930s and later popularized by Deming for corporate management, thus also known as the Deming cycle[8]. The FOCUS-PDCA (Find, Organize, Clarify, Understand, Select, Plan, Do, Check, Act) is an improved version of the PDCA cycle aimed at better understanding each process of the PDCA to achieve continuous quality improvement. Compared with traditional PDCA and other quality management models such as Six Sigma and Lean, FOCUS-PDCA places greater emphasis on problem identification, team collaboration, and structured process optimization, making it particularly suitable for dynamic and high-risk environments like emergency response training in thoracic surgery nursing.

FOCUS-PDCA consists of nine steps: F (Find)–identify the problem; O (Organize)–establish a continuous quality improvement team; C (Clarify)–streamline current processes and standards; U (Understand)–analyze the root causes of the problem; S (Select)–choose process improvement plans; and then use the PDCA model to achieve continuous quality improvement[9]. Since the 20th century, FOCUS-PDCA has been widely applied as a mature management model in critical patient management, hospital infection control, nursing management, personnel training, teaching management, and patient self-management, with significant results[10].

In recent years, FOCUS-PDCA has been successfully implemented in emergency nursing and surgical nursing education. Studies have demonstrated its effectiveness in improving emergency training outcomes among nurses. For example, Li et al.applied a simulation-based FOCUS-PDCA approach to enhance emergency response skills among junior emergency nurses, reporting significant improvements in pass rates for defibrillation, cardiopulmonary resuscitation (CPR), suctioning, and tracheal intubation cooperation[11]. Similarly, another study by Li et al.[12] applied FOCUS-PDCA in the prevention of incontinence-associated dermatitis (IAD) in an emergency ICU setting, significantly reducing IAD incidence and improving nurses' knowledge and preventive behaviors. Moreover, the FOCUS-PDCA framework has been used to optimize the management of medical equipment in emergency departments, leading to increased efficiency and user satisfaction.

In surgical nursing education, FOCUS-PDCA has demonstrated notable advantages over traditional training approaches. Zhang et al.[13] introduced a modular layered training model based on FOCUS-PDCA in hospital nursing management, achieving improvements in nurses' examination scores, nursing quality indicators, and research output. Additionally, Yang and Huang[14] successfully applied this model in operating room nursing education, showing significant improvements in theoretical knowledge, practical skills, and adherence to standardized procedures among surgical nurses.

Despite its established benefits in emergency care and surgical nursing education, there have been few reports on the impact of the FOCUS-PDCA model on emergency training outcomes for thoracic surgery nurses. Given the high-risk nature of perioperative complications in thoracic surgery, improving emergency response capabilities through structured training is critical. Compared with traditional teaching methods that often rely on passive learning and inconsistent assessment, FOCUS-PDCA offers a systematic, iterative, and team-based approach to skill enhancement, ensuring that emergency protocols are continuously refined based on real-world feedback and performance evaluation.

This study applies FOCUS-PDCA to the emergency training of thoracic surgery nurses, exploring its impact on the assessment scores of nursing operations such as defibrillation, cardiopulmonary resuscitation, suction, tracheal intubation cooperation, and the use of nasal high-flow humidification therapy devices, as well as nurses' self-assessment scores of job competency and the standardization of emergency collaboration.By addressing these aspects, this study aims to provide empirical evidence supporting the use of FOCUS-PDCA in enhancing the preparedness of thoracic surgery nurses in managing perioperative emergencies.

Methods

General information

Forty clinical nurses from two thoracic surgery wards at Zhejiang Cancer Hospital were selected as the study subjects. Among them, there were 3 males and 37 females, with ages ranging from 23 to 45 years. The work experience of the nurses ranged from 1 to 27 years. The group consisted of 3 nurses, 25 nurse practitioners, and 12 nurse-in-charge, all of whom had a bachelor's degree. There were no personnel changes during the study period. All procedures performed in the study were in accordance with the Declaration of Helsinki. This study was conducted as part of a routine quality improvement initiative and approved by the Zhejiang Cancer Hospital Ethics Committee. All participants provided written informed consent.

Research methods

Using the FOCUS-PDCA method to train and manage thoracic surgery nurses' operational skills and simulation drills (designed based on acute pulmonary embolism in this study), the process includes the following nine parts:

Finding problems (F) In recent years, the number of patients in our thoracic surgery department has been continuously increasing, leading to a higher risk of critical complications in the ward. We recognize the need to improve the standardization of emergency assistance by thoracic surgery nurses to meet the actual clinical situation and requirements.

Organizing (O) A continuous quality improvement team was established from the two thoracic surgery wards to clarify responsibilities. The team comprised 11 members: 2 head nurses, 4 team leaders, 4 key nurses, and 1 deputy chief physician of thoracic surgery. A specialized nurse and a team leader managed the project overall, formulating plans and supervising implementation. The head nurse acted as a coordinator, overseeing and providing guidance. The deputy chief physician offered theoretical knowledge related to thoracic surgery. Other

team leaders and key nurses were responsible for implementing the plans, ensuring adherence to the quality improvement process, achieving expected goals, and collecting relevant data.

Clarifying (C) Based on the identified continuous quality improvement project, the team decided to conduct a baseline survey on emergency-related operations and nurses' job competency and the standardization of emergency collaboration among nurses before implementing FOCUS-PDCA. Emergency operations included defibrillation, cardiopulmonary resuscitation, suction, tracheal intubation cooperation, and the use of high-flow nasal cannula oxygen therapy (HFNC). The assessment criteria were based on the hospital nursing department's standards, with random evaluations and records by clinical teaching instructors. The standardization of emergency collaboration among nurses was scored using a self-designed evaluation form, with scores recorded by doctors, head nurses, and team leaders. The standardization of emergency collaboration among nurses was scored using a self-designed evaluation form, developed through literature review, expert consultation, and group discussions to ensure content validity. The form included 27 items across eight dimensions, covering condition observation and judgment, reporting of condition changes, emergency handling measures, preparation of emergency items, use of emergency instruments, execution of verbal medical orders, use of emergency drugs, and documentation of emergency nursing records (see Table S1 for specific entries in the scale). Each item was scored on a Likert 5-point scale, with higher scores indicating better adherence to standardized emergency collaboration practices.To ensure inter-rater reliability, scores were independently assigned by doctors, head nurses, and team leaders, who underwent unified training on the evaluation criteria before scoring. Inter-rater reliability was assessed using the intraclass correlation coefficient(ICC), demonstrating a high level of agreement (ICC = 0.812), indicating strong consistency among evaluators.

Understanding (U) Using a fishbone diagram, the team analyzed the low standardization of emergency collaboration among thoracic surgery nurses from six aspects: personnel, equipment, materials, methods, environment, and measurement (Fig. 1). Through brainstorming and literature review, combined with clinical practice, the primary causes were identified using the "5-3-1" scoring method, and real causes were verified through two emergency drills each quarter.

Selecting improvement measures (S) Based on the reasons identified ("unstandardized emergency drill scripts," "lack of standardized operational videos," and "need for improved teaching methods"), the team brainstormed improvement measures. Using the "5-3-1" principle for scoring and the 80/20 rule, the comprehensive improvement plan included perfecting drill scripts, shooting drill videos, and using mixed teaching methods for training.

Planning (P) The overall project plan was charted using a Gantt chart. The team reviewed literature and comprehensive Grade-A tertiary hospital drill scripts, then discussed and refined the "acute pulmonary embolism" emergency drill script. After perfecting the script, a drill video was produced. Based on actual problems encountered during drills, theoretical and operational training was provided. An AVG game on "acute pulmonary embolism" was created using the "Waking" engine. Teaching methods were improved from traditional clinical teaching to a combination of offline, online, and video game-based mixed teaching. A countermeasure implementation plan was devised using the 5W1H method, with the project leader supervising and checking each step's specific method and division of responsibilities discussed in team meetings.

Doing (D):

1. Perfecting the "acute pulmonary embolism" drill script

   (1) Analyze the shortcomings of the current drill scripts, including incomplete content, unclear role division, and insufficient dialogue details.
   (2) Integrate information from papers and web pages about nursing emergency drills.

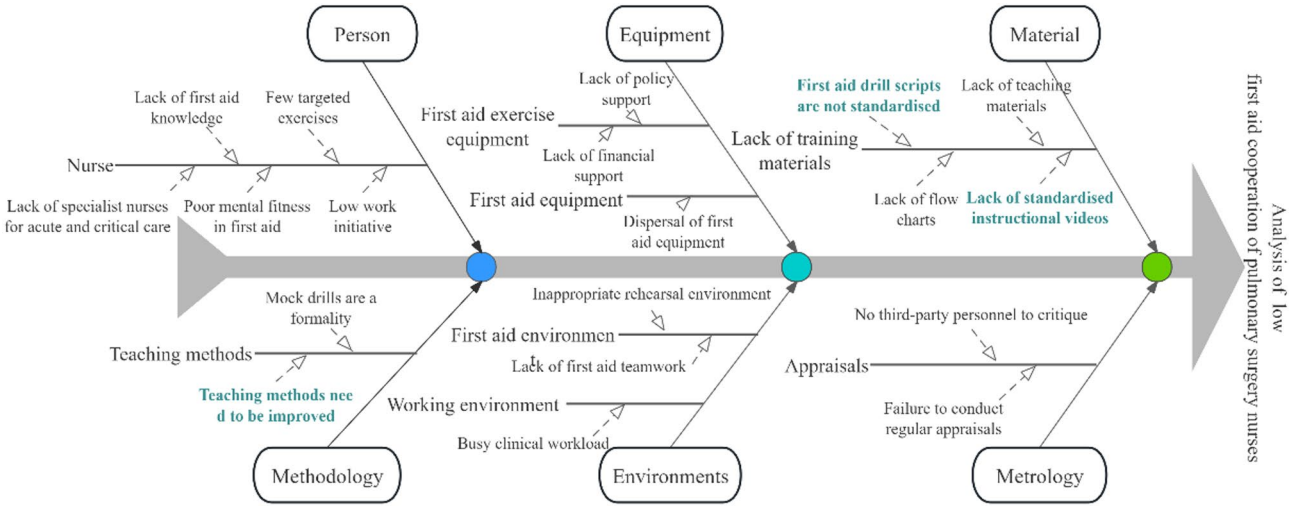

Fig. 1. Fishbone diagram of low first aid cooperation of pulmonary surgery nurses.

(3) Consult with thoracic surgery, respiratory medicine, and oncology departments of comprehensive Grade-A tertiary hospitals, and modify the current script based on their acute pulmonary embolism drill scripts after team discussion.
(4) Actively communicate online and offline about the script; main departmental leaders discuss offline and post the revised script in the team DingTalk group for feedback.
(5) Consult internal and external experts to finalize the revised script, including header and footer with hospital name and motto, drill project name, time, and location, drill background (patient history, treatment, and nursing), role setting, role division (including positioning requirements for 1–4 person rescues and placement of rescue drugs and instruments), script content (including scenes, locations, dialogues, actions, and assessment points), effect evaluation (including personnel availability, performance, material availability, coordination, and results evaluation), existing problems, cause analysis, improvement measures, and relevant attachments.

2. Shooting the drill video based on the perfected script.
3. Creating an AVG game: Utilizing the Waking engine to create an educational game on "acute pulmonary embolism" based on the improved script and the Chinese expert consensus on the diagnosis and treatment of acute pulmonary embolism (2015)[15].
4. Problem-oriented teaching based on issues encountered in previous drills: The clinical teaching instructors enhance training on defibrillation and tracheal intubation cooperation, frequently watch drill videos to familiarize themselves with the rescue process and use the educational game during leisure time to learn theoretical knowledge about pulmonary embolism.

Checking (C): Comparing nurses' operational assessment scores, job competency scores, and emergency collaboration standardization scores before and after the project implementation to determine if the project met its expected goals and if existing problems improved.

Acting (A):

(1) Standardizing the criteria for evaluating the standardization of emergency collaboration and job competency of thoracic surgery nurses.
(2) Establishing emergency nursing workflows for thoracic surgery.
(3) Creating a thoracic surgery rescue station positioning diagram.

A schematic diagram of the PDCA cycle was drawn for this study and is shown in Fig. S1.

Observation indicators

Nurses' operational assessment scores The operational assessment scores were evaluated using the clinical nurse operation assessment form formulated by the hospital nursing department. The total score was 100 points, with a score of 80 or above considered passing. Higher scores indicated more standardized nursing operations. The content validity of this assessment was ensured through expert review, involving senior nursing professionals who evaluated the comprehensiveness and relevance of the items in the assessment form. Criterion validity was assessed by analyzing the correlation between operational assessment scores and nurses' clinical performance records, demonstrating a significant positive correlation.

Nurses' job competency scores The job competency scores were assessed using a simplified and adapted version of the thoracic surgery nurse job competency scale, based on the core competencies of trauma nurses developed by Wang et al.[16]. This scale includes 21 items across four dimensions: specialized knowledge, professional ability, personal traits, and personal motivation (see Table S2 for specific entries in the scale). Each item was self-rated using a Likert 10-point scale, with a total score ranging from 21 to 210 points. Higher scores indicated stronger job competency. The Cronbach's alpha coefficient for this scale was 0.969, indicating good reliability.Content validity was established through expert panel evaluation, ensuring that the items adequately reflected the core competencies of thoracic surgery nurses. Criterion validity was examined by correlating job competency scores with performance evaluations and professional development metrics, yielding statistically significant positive associations.

Nurses' emergency collaboration standardization scores The emergency collaboration standardization scores were evaluated using a self-designed thoracic surgery nurse emergency collaboration standardization scoring form, developed through literature review, group discussion, and expert consultation. This form includes 27 items across eight dimensions: condition observation and judgment, reporting of condition changes, emergency handling measures, preparation of emergency items, use of emergency instruments, execution of verbal medical orders, use of emergency drugs, and writing of emergency nursing records(see Table S1 for specific entries in the scale). Each item was rated by others using a Likert 5-point scale, with a total score ranging from 27 to 135 points. Higher scores indicated better standardization of emergency collaboration. The Cronbach's alpha coefficient for this scale was 0.981, indicating good reliability.Content validity was supported by expert consultation, ensuring that the scale comprehensively covered all key aspects of emergency collaboration in thoracic surgery nursing. Criterion validity was evaluated by analyzing the correlation between emergency collaboration standardization scores and clinical emergency response outcomes, showing a significant positive relationship.

Statistical methods

Data analysis was performed using SPSS25.0 software. Data entry was independently verified by two individuals after being recorded by team members to ensure accuracy.Categorical data were described using counts and percentages (cases[%]). Measurement data were tested for normality using the Shapiro-Wilk test. Normally

distributed data were presented as mean ± standard deviation. For data that did not follow a normal distribution, medians and interquartile ranges were reported.Paired sample t-tests were used to compare nurses' operational assessment scores and job competency self-assessment scores before and after project implementation, provided that normality assumptions were met. If normality was violated, the Wilcoxon signed-rank test was applied as a non-parametric alternative.Independent sample t-tests were used to compare the emergency collaboration standardization scores of nurses participating in emergency drills. If the normality assumption was not satisfied, the Mann-Whitney U test was used instead.A p-value of less than 0.05 was considered statistically significant.

Results

Comparison of nurses' performance in operation assessment before and after FOCUS-PDCA implementation

After the implementation of FOCUS-PDCA pulmonary surgery nurses and according to the different groups of work experience (less than 3 years, 3–5 years, 6–10 years, more than 10 years) and title (nurse, nurse practitioner, nurse in charge) defibrillation, cardiopulmonary resuscitation, sputum suctioning, endotracheal intubation with the use of the HFNC and other nursing operation assessment results were higher than the implementation of the former (of which the nurse group of the use of the HFNC $p = 0.55$, the rest $p < 0.05$), as shown in Table 1.

Compar ison of nurses' job competency self-assessment scores before and after FOCUS-PDCA implementation

The results of the self-ratings of job competence including speciality knowledge, professional competence, personal attributes and personal motivation of the pulmonary surgery nurses after the implementation of FOCUS-PDCA and in different subgroups according to the number of years of exp erience (less than 3 years, 3 to 5 years, 6 to 10 years, more than 10 years) and job title (nurse, nurse practitioner, nurse in charge) are shown in Table 2 in comparison with the results of the pre-implementation period.

Comparison of nurses' emergency collaboration standardization scores before and after FOCUS-PDCA implementation

The emergency collaboration standardization scores of thoracic surgery nurses, including dimensions such as condition change observation, condition change reporting, emergency handling measures, emergency item preparation, use of emergency instruments, execution of verbal medical orders, use of emergency drugs, and writing of emergency nursing records, were all higher after the implementation of FOCUS-PDCA compared to before the implementation ($p < 0.05$), as shown in Table 3.

In order to accurately analyse the effectiveness of the training and control for potential confounders, analysis of covariance (ANCOVA) was used to conduct the study. Nurses' scores on the standardisation of first aid coordination before and after training were set as the dependent variable, and years of working experience and job title were included as covariates in the analysis system. Statistical results showed that years of working experience as a covariate did not have a significant effect on the pre- and post-training scores ($F = 1.275$, $p = 0.262$), while job title as a covariate had a significant effect on the pre- and post-training scores ($F = 8.469$, $p = 0.005$). After effectively controlling for confounders, nurses' pre- and post-training scores showed significant differences ($F = 60.368$, $p < 0.01$). The results indicate that after controlling for key confounders, it is still possible to clearly observe that training has a significant enhancing effect on nurses‘ first aid cooperation normative scores, highlighting the positive effectiveness of training in enhancing nurses' professionalism.

Discussion

This study demonstrated that the implementation of the FOCUS-PDCA cycle significantly improved emergency operational performance, work competence, and standardisation of emergency collaboration among thoracic surgery nurses. After the intervention, nurses' operational scores significantly improved in all operational procedures assessed, including defibrillation, cardiopulmonary resuscitation (from 75.38 ± 8.41 to 90.25 ± 3.36, $p < 0.01$), suctioning, endotracheal intubation co-ordination, and the use of high-flow nasal catheters. Job competency scores also improved significantly across all dimensions, particularly in the areas of expertise, professional competence and personal attributes, with total competency scores improving from 152.68 ± 22.69 to 173.75 ± 16.66 ($p < 0.01$). In addition, the standardisation of first aid co-ordination was significantly enhanced, with the overall score improving from 95.70 ± 12.86 to 116.08 ± 14.93 ($p < 0.01$), which reflected greater competence in observation of the condition, first aid measures, use of equipment, and communication. However, some of the findings also suggested that the difference was not statistically significant ($p > 0.05$). Specifically, for certain subgroups, such as nurses with less than three years of experience and nurses with lower professional ranks, the improvement in the use of HFNC, professional knowledge, professional competence, and personal cumulative traits did not reach statistically significant levels. This suggests that although FOCUS-PDCA was generally effective, new nurses may need additional training sessions, longer learning cycles, or the use of other educational strategies to achieve similar skill gains. These findings are consistent with previous research, which has shown that PDCA-based interventions can enhance nursing skills and standardise emergency response processes[17,18]. Similar studies conducted in intensive care unit (ICU) and acute care settings reported improved team communication, shorter response times, and increased adherence to codes of practice following PDCA-based training[11,19].Our approach incorporates multiple emergency response processes into a structured, iterative framework that promotes greater competence than traditional methods[20].

Increased proficiency in emergency skills ensures that interventions are delivered accurately and in a timely manner, leading to improved patient outcomes. For example, higher levels of performance in CPR operations are strongly associated with improved patient survival and reduced complications[21]. Standardisation of first

Items	Subgroup (*n*)	Pre-project	After project	t	*p*
Use of HFNC	Ungrouped (40)	67.98 ± 8.94	89.73 ± 4.01	19.721	< 0.001
	Less than 3 years (9)	60.33 ± 9.99	85.44 ± 2.30	7.330	< 0.001
	3 to 5 years (10)	64.33 ± 7.75	87.70 ± 2.42	9.97	< 0.001
	6 to 10 years (9)	71.44 ± 5.96	91.00 ± 1.41	10.98	< 0.001
	More than 10 years (12)	73.83 ± 5.59	94.17 ± 1.70	16.86	< 0.001
	Nurses (3)	55.00 ± 13.75	86.00 ± 3.00	4.106	**0.055**
	Nurse practitioners(25)	66.24 ± 7.32	87.96 ± 2.95	16.473	< 0.001
	Nurse-in-charge(12)	74.83 ± 5.32	94.33 ± 1.56	16.044	< 0.001
Cardiopulmonary resuscitation	Ungrouped (40)	75.38 ± 8.41	90.25 ± 3.36	14.248	< 0.001
	Less than 3 years (9)	67.44 ± 7.92	86.56 ± 1.33	6.934	< 0.001
	3 to 5 years (10)	70.90 ± 5.92	88.80 ± 2.10	9.392	< 0.001
	6 to 10 years (9)	79.78 ± 4.84	90.67 ± 2.00	8.335	< 0.001
	More than 10 years (12)	81.75 ± 5.45	93.92 ± 2.07	9.431	< 0.001
	Nurses (3)	68.67 ± 7.02	85.67 ± 1.53	4.715	0.042
	Nurse practitioners(25)	72.88 ± 7.75	88.92 ± 2.16	11.263	< 0.001
	Nurse-in-charge(12)	82.25 ± 5.74	94.17 ± 1.70	8.609	< 0.001
Suction	Ungrouped (40)	72.65 ± 5.71	89.08 ± 2.69	21.675	< 0.001
	Less than 3 years (9)	67.89 ± 4.60	86.22 ± 1.64	11.660	< 0.001
	3 to 5 years (10)	69.80 ± 5.59	88.30 ± 1.34	10.297	< 0.001
	6 to 10 years (9)	75.33 ± 5.20	88.89 ± 2.03	7.859	< 0.001
	More than 10 years (12)	76.58 ± 2.15	92.00 ± 1.65	24.823	< 0.001
	Nurses (3)	64.67 ± 6.81	86.33 ± 1.53	6.226	0.025
	Nurse practitioners(25)	71.76 ± 5.55	87.96 ± 1.88	15.285	< 0.001
	Nurse-in-charge(12)	76.50 ± 2.20	92.08 ± 1.68	23.732	< 0.001
Use of defibrillator	Ungrouped (40)	72.65 ± 8.35	89.90 ± 3.59	16.043	< 0.001
	Less than 3 years (9)	67.11 ± 6.77	86.11 ± 1.97	8.848	< 0.001
	3 to 5 years (10)	67.40 ± 7.18	88.50 ± 2.07	8.804	< 0.001
	6 to 10 years (9)	75.78 ± 7.82	90.33 ± 1.80	6.581	< 0.001
	More than 10 years (12)	78.83 ± 5.20	93.58 ± 2.91	10.016	< 0.001
	Nurses (3)	62.00 ± 8.72	86.33 ± 2.89	5.718	0.029
	Nurse practitioners(25)	70.36 ± 6.96	84.44 ± 2.27	13.427	< 0.001
	Nurse-in-charge(12)	80.08 ± 4.94	93.83 ± 2.79	9.241	< 0.001
Endotracheal intubation co-ordination	Ungrouped (40)	72.65 ± 6.34	88.80 ± 3.44	19.807	< 0.001
	Less than 3 years (9)	67.89 ± 6.17	86.00 ± 1.00	8.772	< 0.001
	3 to 5 years (10)	70.40 ± 4.07	86.40 ± 1.78	12.000	< 0.001
	6 to 10 years (9)	74.78 ± 6.87	89.11 ± 2.32	6.446	< 0.001
	More than 10 years (12)	76.50 ± 4.89	92.67 ± 2.61	15.183	<0.001
	Nurses (3)	67.00 ± 5.57	86.67 ± 1.16	6.185	0.025
	Nurse practitioners(25)	70.92 ± 5.57	87.16 ± 2.21	14.559	< 0.001
	Nurse-in-charge(12)	77.67 ± 5.12	92.75 ± 2.60	12.956	<0.001

Table 1. Comparison of nurses' performance in operational assessment before and after project implementation (n, $\bar{x} \pm s$) To make the non-significant results stand out more clearly, we have bolded the p-values greater than 0.05.

aid co-ordination is evidenced by improved team coordination scores, which clarifies the division of roles and speeds up emergency response, reducing errors and minimising adverse events for patients. Improved work competence also translated into greater self-confidence and more efficient decision-making by nurses, ultimately creating a safer clinical environment and reducing burnout. These findings highlight the need for a structured, continuous quality improvement model in clinical nursing education.

The structured and iterative nature of FOCUS-PDCA was a key factor in improving performance[22]. By identifying deficiencies, implementing targeted training, and refining strategies based on feedback, nurses were able to develop stronger emergency response skills. Simulation-based exercises and structured review sessions provided hands-on opportunities to strengthen clinical decision-making and motor skills. In addition, the emphasis on teamwork and communication improved role allocation and workflow efficiency in emergencies, leading to a more coordinated and effective response. These mechanisms are consistent with the existing literature supporting the use of PDCA-based quality improvement interventions in medical training[17–19]. Ensuring that these improvements are sustained over time remains a priority. Studies have shown that without

dimension (math.)	Subgroup (*n*)	Pre-project	After project	t	*p*
Specialist knowledge	Ungrouped (40)	33.55 ± 6.16	40.00 ± 3.85	6.015	< 0.001
	Less than 3 years (9)	33.33 ± 7.04	38.56 ± 1.59	2.076	**0.072**
	3 to 5 years (10)	33.70 ± 6.75	37.40 ± 2.88	1.644	**0.135**
	6 to 10 years (9)	31.33 ± 5.22	39.78 ± 2.86	4.722	0.001
	More than 10 years (12)	35.25 ± 5.75	43.42 ± 4.17	4.232	0.001
	Nurses (3)	34.33 ± 8.96	39.67 ± 0.58	1.000	**0.423**
	Nurse practitioners(25)	32.72 ± 6.07	38.28 ± 2.61	4.219	< 0.001
	Nurse-in-charge(12)	35.08 ± 5.85	43.67 ± 4.03	4.397	0.001
Professional capacity	Ungrouped (40)	34.73 ± 5.94	40.35 ± 4.09	5.615	< 0.001
	Less than 3 years (9)	32.22 ± 4.44	39.22 ± 1.48	4.725	0.001
	3 to 5 years (10)	34.90 ± 7.13	37.20 ± 2.57	0.949	**0.367**
	6 to 10 years (9)	31.89 ± 5.28	39.89 ± 3.30	3.539	0.008
	More than 10 years (12)	38.58 ± 4.56	44.17 ± 4.28	3.516	0.005
	Nurses (3)	32.00 ± 4.00	39.33 ± 1.16	3.051	**0.093**
	Nurse practitioners(25)	33.24 ± 5.95	38.28 ± 2.73	3.668	0.001
	Nurse-in-charge(12)	38.50 ± 4.70	44.92 ± 3.18	3.818	0.003
Personal characteristic	Ungrouped (40)	62.03 ± 10.60	69.00 ± 7.11	4.938	< 0.001
	Less than 3 years (9)	56.78 ± 10.95	62.56 ± 2.01	1.410	**0.196**
	3 to 5 years (10)	58.60 ± 13.08	66.30 ± 4.90	2.639	0.027
	6 to 10 years (9)	59.78 ± 4.44	68.78 ± 7.53	3.274	0.011
	More than 10 years (12)	70.50 ± 6.42	76.25 ± 4.16	2.896	0.015
	Nurses (3)	55.33 ± 4.16	64.00 ± 0.00	3.606	**0.069**
	Nurse practitioners(25)	59.04 ± 10.52	65.80 ± 5.66	3.384	0.002
	Nurse-in-charge(12)	69.92 ± 7.32	76.92 ± 3.26	3.098	0.010
Personal motivation	Ungrouped (40)	22.38 ± 3.72	24.40 ± 3.13	2.938	< 0.001
	Less than 3 years (9)	22.56 ± 3.36	22.78 ± 1.92	0.154	**0.881**
	3 to 5 years (10)	21.50 ± 5.50	23.20 ± 2.25	1.118	**0.293**
	6 to 10 years (9)	22.11 ± 1.90	24.22 ± 3.31	1.820	**0.106**
	More than 10 years (12)	23.17 ± 3.46	26.75 ± 3.22	2.733	0.019
	Nurses (3)	23.67 ± 0.58	23.67 ± 0.58	-	–
	Nurse practitioners(25)	21.76 ± 4.06	23.08 ± 2.41	1.568	**0.130**
	Nurse-in-charge(12)	23.33 ± 3.28	27.33 ± 2.90	2.942	0.013
Total points	Ungrouped (40)	152.68 ± 22.69	173.75 ± 16.66	5.938	<0.001
	Less than 3 years (9)	144.89 ± 20.91	163.11 ± 5.35	2.246	**0.055**
	3 to 5 years (10)	148.70 ± 30.69	164.10 ± 10.80	1.852	**0.097**
	6 to 10 years (9)	145.11 ± 11.39	172.67 ± 15.17	4.370	0.002
	More than 10 years (12)	167.50 ± 17.12	190.58 ± 14.61	3.748	0.003
	Nurses (3)	145.33 ± 15.01	166.67 ± 2.31	2.268	**0.151**
	Nurse practitioners(25)	146.76 ± 22.91	165.44 ± 11.06	4.016	0.001
	Nurse-in-charge(12)	166.83 ± 18.08	192.83 ± 12.19	3.955	0.002

Table 2. Comparison of nurses' job competency scores before and after project implementation (n, $\bar{x}\pm s$) To make the non-significant results stand out more clearly, we have bolded the p-values greater than 0.05.

Groups	Person-times	Observational judgement of disease	Reporting of changes in condition	First aid measures	Preparation of first aid items	Use of first aid equipment	Execution of oral prescription	Use of first aid medicines	First aid nursing writing	First aid co-ordination normative
Pre-project	44	10.95 ± 2.09	6.71 ± 1.26	17.47 ± 2.50	6.93 ± 1.14	17.22 ± 2.60	16.04 ± 2.86	9.91 ± 1.99	10.45 ± 1.26	95.70 ± 12.86
After project	52	13.11 ± 1.59	8.32 ± 1.41	21.25 ± 3.04	8.82 ± 1.23	21.15 ± 2.93	18.17 ± 2.10	12.44 ± 1.91	12.79 ± 2.03	116.08 ± 14.93
t		-5.742	-5.879	-6.561	-7.742	-6.876	-4.191	-6.333	-6.607	-7.092
P		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Table 3. Comparison of nurses' normative scores for first aid co-operation before and after implementation (n, $\bar{x}\pm s$)

reinforcement, emergency response skills, particularly resuscitation skills, decline over a period of months[23]. To sustain the progress made, our department plans to incorporate regular retraining, ongoing assessment, and further integration of PDCA into our daily routines. Institutional support, including the incorporation of emergency response protocols into nursing guidelines, is essential to maintain a high level of competence over time. Regular audits and scenario-based assessments can further ensure that skills remain proficient and that standardised responses continue beyond the study period.

Study limitations and future research

Although this study highlights the benefits of FOCUS-PDCA, some limitations should be noted. Firstly, the sample size was relatively small and the study was conducted in a single centre. Second, this study used a pre-posttest design with no parallel control group. Although the improvements were large and statistically significant, potential confounders or biases that may have arisen over time cannot be completely ruled out. For example, nurses may have been influenced to some extent by learning effects or by other concurrent training initiatives unrelated to the programme. We attempted to minimise these effects by focusing the intervention on specific components, but due to the lack of a randomised control, we must be cautious in attributing all enhancements to FOCUS-PDCA. In addition, raters were aware that a quality improvement project was underway, which could have introduced observer bias. We attempted to mitigate this effect by using objective criteria for skill assessment, but some subjective effects may still be present. Another limitation is that our follow-up assessments were conducted shortly after the intervention; therefore, we do not know how well these skills were maintained in the long run. Long-term follow-up was not conducted in this study to determine if ability scores remained high. Finally, although we measured process outcomes, we did not directly measure patient-centred outcomes during the study period.

A focus of future research is to longitudinally assess the skills of these nurses–for example, re-testing the same indicators of competence at 6 and 12 months post-intervention to see if these improvements are maintained, or if retraining is needed. Inclusion of a control group in future studies strengthens causal inferences by considering trends over time or testing effects. In addition, it is recommended that the study be extended to multiple centres. A multi-centre trial or collaborative project could verify whether FOCUS-PDCA produces similar benefits in different clinical settings. Future studies could also explore modifications to the intervention: for example, what is the optimal frequency of simulation exercises, or does a specific PDCA cycle length result in optimal skill retention? Finally, studies should attempt to more directly link improvements in nurse performance to patient outcomes. It would be meaningful to track metrics such as patient survival in emergencies, time to intervention, or incidence of adverse events before and after implementation of FOCUS-PDCA. In conclusion, although our study supports the effectiveness of FOCUS-PDCA in improving nursing performance, further research is needed to replicate these findings, confirm their durability, and continue to improve the quality of emergency care in nursing practice.

Conclusion

This study demonstrated that FOCUS-PDCA is an effective framework for improving nurses' competence in emergency care. By integrating structured training, iterative feedback, and standardised collaboration, it significantly improved nurses' proficiency, work capacity, and teamwork in emergency procedures. These findings support the broader application of continuous quality improvement models in clinical nursing education to optimise emergency preparedness and patient care outcomes.

Data availability

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

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References

1. Bray, F. et al. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J. Clin.* **74**, 229–263. https://doi.org/10.3322/caac.21834 (2024).
2. Shen, H. et al. Minimally invasive surgery versus thoracotomy for resectable stage II and III non-small-cell lung cancers: A systematic review and meta-analysis. *Eur. J. Cardiothorac. Surg.* **59**, 940–950. https://doi.org/10.1093/ejcts/ezaa437 (2021).
3. Liang, X., Zhao, L., Yang, J. & Yin, S. Q. Exploration of the connection between severe perioperative complications and preoperative basic diseases of surgical patients with non-small cell lung cancer. *Zhonghua Zhong Liu Za Zhi.* **42**, 937–942. https://doi.org/10.3760/cma.j.cn112152-20200207-00074 (2020).
4. Toste, P. A. & Revels, S. L. Management of complications following lung resection. *Surg. Clin. North. Am.* **101**, 911–923. https://doi.org/10.1016/j.suc.2021.06.013 (2021).
5. Bédat, B. et al. Comparison of postoperative complications between segmentectomy and lobectomy by video-assisted thoracic surgery: A multicenter study. *J. Cardiothorac. Surg.* **14**, 189. https://doi.org/10.1186/s13019-019-1021-9 (2019).
6. Phillips, K. F., Mathew, L., Aktan, N. & Sandanapitchai, P. The effectiveness of shared clinical teaching in nursing. *Int. J. Nurs. Sci.* **6**, 211–215. https://doi.org/10.1016/j.ijnss.2019.03.002 (2019).
7. Hu, K., Ma, R. J., Ma, C., Zheng, Q. K. & Sun, Z. G. Comparison of the BOPPPS model and traditional instructional approaches in thoracic surgery education. *BMC Med. Educ.* **22**, 447. https://doi.org/10.1186/s12909-022-03526-0 (2022).
8. Chen, J. et al. Application of the PDCA cycle for managing hyperglycemia in critically ill patients. *Diabetes Ther.* https://doi.org/10.1007/s13300-022-01334-9 (2022).
9. Jin, Y. et al. Effect of FOCUS-PDCA procedure on improving self-care ability of patients undergoing colostomy for rectal câncer. *Rev. Esc Enferm USP* **55**, e03729. https://doi.org/10.1590/s1980-220x2020012503729 (2021).

10. Niu, Y., Zhang, L. & Sun, X. Efficacy of seamless care management under FOCUS-PDCA for patients with acute cerebral infarction complicated with dysphagia and its influence on nutritional status and neurological functions. *Altern. Ther. Health Med.* **30**, 251–257 (2024).
11. Li, Q., Zhao, Z. & Wang, S. Analysis on the improving the passing rate of basic operation skills of junior nurses in emergency department based on simulated FOCUS-PDCA method. *J. Bengbu Med. Coll.*,48, 399–401+405. https://doi.org/10.13898/j.cnki.issn.1000-2200.2023.03.029 (2023).
12. Li, S., Liu, W., Yang, J., Mo, J. & Wiu, L. Effectiveness of FOCUS-PDCA mode in prevention and treatment of incontinence-associated dermatitis in emergency intensive care unit. *Mod. Clin. Nurs.* **23**, 29–36 (2024).
13. Zhagn, L., Yu Y., Yang, J., Li, Z. & Lu, H. Application of FOCUS-PDCA modular hierarchical training mode in nursing management. *Anhui Med.* **43**, 438–442 (2022).
14. Yang, L. & Huang, Q. Application of the FOCUS-PDCA modular tiered training model to nursing management in the operating theatre. *Int. J. Nurs.* **43**, 2453–2456. https://doi.org/10.3760/cma.j.cn221370-20230325-00574 (2024).
15. [Chinese expert consensus on the diagnosis and management of acute pulmonary embolism (2015)]. *Zhonghua Xin Xue Guan Bing Za Zhi* **44**, 197–211. https://doi.org/10.3760/cma.j.issn.0253-3758.2016.03.005 (2016).
16. Wang, L. et al. Development and psychometric evaluation of the trauma nurse core competency scale. *Front. Public Health* **10**, 959176. https://doi.org/10.3389/fpubh.2022.959176 (2022).
17. Koota, E., Kääriäinen, M., Kyngäs, H., Lääperi, M. & Melender, H. L. Effectiveness of evidence-based practice (EBP) education on emergency nurses' EBP attitudes, knowledge, self-efficacy, skills, and behavior: A randomized controlled trial. *Worldviews Evid. Based Nurs.* **18**, 23–32. https://doi.org/10.1111/wvn.12485 (2021).
18. Intelligence & Neuroscience, C. Retracted Effect Analysis of Midwife Education and Training with PDCA Model. *Comput. Intell. Neurosci.* **2023**, 9801473. https://doi.org/10.1155/2023/9801473 (2023).
19. Wang, Y. et al. Construction and application of a training program for ICU nurses to manage artificial airway gasbags to prevent ventilator-associated pneumonia. *J. Multidiscip Healthc.* **16**, 3737–3748. https://doi.org/10.2147/jmdh.S438316 (2023).
20. Abuzied, Y., Alshammary, S. A., Alhalahlah, T. & Somduth, S. Using FOCUS-PDSA quality improvement methodology model in healthcare: Process and outcomes. *Glob J. Qual. Saf. Healthc.* **6**, 70–72. https://doi.org/10.36401/jqsh-22-19 (2023).
21. Kaplow, R. et al. Impact of CPR quality and adherence to advanced cardiac life support guidelines on patient outcomes in in-hospital cardiac arrest. *AACN Adv. Crit. Care* **31**, 401–409. https://doi.org/10.4037/aacnacc2020297 (2020).
22. Chen, Y., Zheng, J., Wu, D., Zhang, Y. & Lin, Y. Application of the PDCA cycle for standardized nursing management in a COVID-19 intensive care unit. *Ann. Palliat. Med.* **9**, 1198–1205. https://doi.org/10.21037/apm-20-1084 (2020).
23. Kim, Y. J. et al. Retention of cardiopulmonary resuscitation skills after hands-only training versus conventional training in novices: A randomized controlled trial. *Clin. Exp. Emerg. Med.* **4**, 88–93. https://doi.org/10.15441/ceem.16.175 (2017).

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Ting Fang, and Hui Xu conceived the project.Yiting Luo and Anlong Wang performed the statistical analysis and wrote the manuscript. All authors contributed to the article and approved the submitted version. All authors read and approved the final manuscript.

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Declarations

Competing interests
The authors declare no competing interests.

Ethics approval and consent to participate
All procedures performed in the study were in accordance with the Declaration of Helsinki and approved by the Zhejiang Cancer Hospital Ethics Committee. All participants provided written informed consent.

Consent for publication
Not applicable.

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