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Application of Flipped Classroom Combined with Scenario Simulation in Non-Technical Skills Training for Operating Room Nurses in Emergency Response

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Abstract: To investigate the effect of flipped classroom combined with scenario simulation on non-technical skills (NTS) training for operating room nurses in crisis management. Fifty-three operating room nurses received NTS training in crisis management through flipped classroom combined with scenario simulation. SimBaby was used to run simulation scenarios, and the TeamTAG scale was used to facilitate guided reflection. All participants (100%) were satisfied with the 17 items of the scenario simulation teaching design. After training, participants' familiarity with NTS concepts increased from (2.53±1.07) to (3.98±0.46) points, with a statistically significant difference (P<0.001). The score of grouped emergency drills increased from (82.30±9.82) to (89.81±6.30) points, and the mean TEAM score increased from 33 to 39.9 points. This teaching program can effectively enhance training engagement and improve the NTS of operating room nurses in crisis management, thereby strengthening their comprehensive emergency response capabilities.

Keywords: Flipped Classroom; Scenario Simulation; Operating Room Nurses; Non-Technical Skills (NTS)

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1. Introduction

Non-technical skills (NTS) refer to the cognitive, social, and personal resource skills that complement technical skills and contribute to safe and efficient task performance [1]. In 2003, Flin et al. proposed a medical NTS framework encompassing six skill categories: decision-making, situation awareness, cooperation, communication, leadership, and personal resources [2]. This framework has been broadly adopted in NTS training—also termed crisis resource management (CRM)—and in outcome evaluation across healthcare settings. Technical skills are essential yet insufficient on their own to guarantee patient safety[3]. Available evidence suggests that NTS-related issues arise considerably more often than technical errors in trauma care. The NTS of surgical teams have a direct bearing on the safety and quality of surgical patient care [4]. Among contributing factors to surgical adverse events, communication breakdowns account for 43% of errors[5]. For operating room nurses, surgical and anesthetic assistance relies not only on technical competence but also, to a large degree, on decision-making, situation awareness, communication, and other non-technical skills [6, 7].

Scenario simulation is presently the predominant approach for NTS training-a teaching method that substitutes real clinical settings with high-fidelity simulated patients and clinical scenarios, thereby helping learners transfer knowledge to clinical practice and improving clinical performance[8]. Scenario simulation focuses primarily on cultivating knowledge application,

whereas the flipped classroom serves as an effective instructional approach for building foundational knowledge and skills beforehand. The flipped classroom inverts the conventional teaching sequence and represents a blended learning model that combines online learning with face-to-face instruction [9]. It can effectively boost learners' interest and motivation, enhance learning efficiency, and strengthen their analytical and teamwork capabilities [10].

However, a systematic review published in 2025 noted that simulation-based crisis management training in the operating room has predominantly targeted medical personnel, with limited evidence regarding nurses' participation and outcomes[11]. A 2026 scoping review further revealed that although educational interventions - particularly simulation-based training and blended courses can effectively enhance the competencies of operating room nurses, assessment of non-technical skills remains inconsistent, and organizational-level strategies have yet to be explored[12]. Concurrently, a CiteSpace-based knowledge mapping analysis in China showed that while research hotspots in emergency response training for junior nurses have encompassed the operating room nurse population, dedicated studies on NTS training remain scarce, and a cohesive core research workforce has yet to emerge [13]. Against this background, the present study employed flipped classroom combined with scenario simulation to train junior operating room nurses in emergency NTS and to evaluate its effectiveness.

2. Participants

A convenience sampling method was used to recruit 53 operating room nurses at N0-N2 levels between July 2025 and December 2025. Inclusion criteria: registered nurses currently employed at N0-N2 levels in the operating room. Exclusion criteria: ① those rotating to other departments during the study period; ② those resigning during the study period; ③ those taking leave of ≥1 month during the study period.

3. Methods

3.1 Teaching Process

3.1.1 Preparations before the course

Prior to the training, participants completed a theoretical assessment of emergency knowledge and rated their familiarity with the concept of non-technical skills using a 5-point Likert scale ranging from "very unfamiliar" to "very familiar", with scores of 1–5.

3.1.2 Educational intervention

A flipped classroom combined with scenario simulation was used to deliver non-technical skills training to junior operating room nurses. Based on the teaching objectives and common emergency scenarios in our department, two resuscitation scenarios were developed: intraoperative sudden cardiac arrest in a neonate and intraoperative sudden hemorrhagic shock in a parturient. The 53 nurses were divided into two batches for training. Within each batch, participants were assigned to 4–5 groups of 5–6 members according to the teaching tasks.

3.1.3 Course design

The teaching process consisted of four stages. Stage 1: Self-directed learning. Self-directed learning materials were provided according to the teaching objectives. Stage 2: Didactic session on NTS theory. The concept of NTS was introduced, and relevant content was presented and illustrated using the Scrub Nurse Non-Technical Skills Scale [14] as a framework; groups then participated in a competitive exercise to identify examples of non-technical skills in daily practice. Stage 3: Case-based nursing cooperation. Participants delivered case reports using the SBAR handover format, analyzed key points and critical concerns in intraoperative nursing cooperation, and presented their findings as a group. Stage 4: Simulated emergency scenario assessment. SimBaby simulation software was used to run the cases, with participants completing scenario simulations in teams. After each drill, guided reflection(debriefing) was conducted based on the GAS model and the TeamTAG rating scale, covering six domains: anticipating and planning ahead, dynamically setting priorities, calling for help early, demonstrating leadership and followership, communicating effectively, and reassessing repeatedly. After the course, participants completed a scenario simulation satisfaction evaluation form and the Non-Technical Skills Awareness Questionnaire.

3.2 Outcome Measures

3.2.1 Research instruments

(1) A demographic data form, including name, sex, age, and years of work experience.

(2) A self-designed theoretical examination of emergency knowledge, with a maximum score of 100 points. The examination was reviewed and revised by three nursing experts in the operating room.

(3) Simulation design evaluation: The Jeffries Simulation Design Scale (SDS) was used. This instrument comprises five dimensions with a total of 20 items. The overall Cronbach's α coefficient was 0.948, and the Cronbach's α coefficients for the five dimensions ranged from 0.798 to 0.832[15]. A 5-point Likert scale was employed, with each item scored from 1 to 5.

(4) A self-designed emergency drill scoring rubric.

(5) The Team Emergency Assessment Measure (TEAM) has been widely validated in both real clinical resuscitation and simulation-based education settings[16]. TEAM consists of 12 items across three domains: leadership, teamwork, and task management. Items 1–11 are scored on a 5-point Likert scale (0–4 per item), and item 12 provides a global rating of non-technical skills (1–10). Scoring may use the sum of items 1–11, the global rating, or a combination of both. The Cronbach's α coefficient is 0.94[16]. In this study, the sum of items 1–11 was used for scoring.

3.2.2 Measurement methods

The training program lasted six months, with one themed scenario session conducted each quarter. The 53 participants completed the training in two batches. A single-group pre-post design was employed. Before the emergency skills workshop, participants' familiarity with non-technical skills was assessed. At each training session, emergency drill scores and TEAM scores were evaluated on site for each group. After the training, participants' familiarity with non-technical skills and training satisfaction were assessed.

3.2.3 Statistical analysis

All data were analyzed and described using SPSS 23.0. Categorical data were expressed as frequencies, and continuous data were presented as mean ± standard deviation. Paired-sample t-tests were performed, and the rank-sum test was used for data that did not conform to a normal distribution. A P-value < 0.05 was considered statistically significant.

4. Results

4.1 Participant Characteristics

A total of 55 operating room nurses at N0–N2 levels were initially enrolled; one nurse was excluded for rotating to another department and one for taking leave, leaving 53 nurses who completed the training. Among them, 6 were male (11.3%) and 47 were female (88.7%). The mean age was 26.38 ± 1.3 years. Six nurses (11.3%) were at the N0 level, 22 (41.5%) at the N1 level, and 25 (47.2%) at the N2 level.

4.2 Nurses' Evaluation of the Emergency NTS Training Design

Of the 53 nurses who participated in the emergency NTS training, 51 completed the Jeffries Simulation Design Scale, yielding a response rate of 96.23%. Among the 20 items, 17 achieved a 100% agreement rate. The remaining three items had agreement rates as follows: "sufficient information and guidance were provided before the course, and I was encouraged to participate" (90.20%); "timely support and assistance were available during the simulation" (94.12%); and "the simulation replicated a realistic environment" (96.08%).

4.3 Comparison of Familiarity with NTS Concepts before and after the Intervention

Scores of participants' familiarity with NTS concepts before and after the emergency NTS training are shown in Table 1.

Table 1 Familiarity with NTS concepts before and after the training

	Pre-training	Post-training
Familiarity	2.53±1.07	3.98±0.46
Z value	-5.16	
P value	<0.001	

4.4 Emergency Drill Scores before and afte r the Intervention

Before the training, four emergency drills on topics consistent with the training themes were organized for N0–N2 level

nurses over the year, with a total of 15 participants: 4 at the N0 level, 5 at the N1 level, and 6 at the N2 level. The proportions of participants at each level before and after the emergency skills training are shown in Table 2; no statistically significant difference in the level distribution was found between the two groups. A comparison of emergency drill scores before and after the training is presented in Table 3.

Table 2 Comparison of the level composition of participants before and after the training

	N0	N1	N2
Pre-training	5	7	8
Post-training	7	21	25
χ^2 value	1.474		
P value	0.478		

Table 3 Comparison of emergency drill scores before and after the training

	Pre-training	Post-training
emergency drill scores	82.30±9.82	89.81±6.30
Z value	-3.242	
P value	0.001	

4.5 Comparison of TEAM Scores

The mean TEAM score was 33 before the training, 35 after the first quarterly training session, and 39.90 after the second quarterly training session.

5. Disccusion

5.1 Mechanisms Underlying NTS Improvement through Flipped Classroom Combined with Scenario Simulation

The present findings showed that participants‘ familiarity with NTS concepts increased significantly after training (2.53 ± 1.07 vs. 3.98 ± 0.46, P < 0.001), emergency drill scores rose to 89.81 ± 6.30 (Δ +7.51), and TEAM scores increased from 33 to 39.9 (Δ +6.9). These results suggest a possible synergistic effect between the flipped classroom and scenario simulation: the flipped classroom reinforced participants' understanding of NTS theory through pre-class knowledge construction, while scenario simulation facilitated knowledge transfer through high-fidelity scenarios [9,17]. In the neonatal cardiac arrest scenario run on SimBaby, for instance, participants had to dynamically adjust priorities (e.g., coordinating early calls for help with circulatory support), which is precisely one of the core objectives of emergency NTS training. A recent meta-analysis of 65 studies confirmed that simulation practice combined with debriefing/feedback is among the most effective intervention types for improving NTS (SMD: 1.80, 95% CI: 1.18–2.41), further supporting the critical role of debriefing in NTS training [18]. Hassan and Elsaman (2023), in a randomized controlled trial, demonstrated that simulation-based flipped classroom significantly improved nursing students‘ acquisition of cardiopulmonary resuscitation skills and simulation experience satisfaction (P < 0.05) [19], providing evidence for the application of flipped classroom in emergency skills training; however, its applicability to the operating room nurse population requires further investigation.

5.2 Association between High Satisfaction and Teaching Design

All 17 teaching design objectives achieved a 100% satisfaction rate, exceeding the results typically reported for the Jeffries Simulation Design Scale in general simulation-based teaching (usually 85%–95%) [15]. This may be attributable to two factors: first, the competitive group discussions in the flipped classroom (e.g., the "everyday NTS examples competition") enhanced learning engagement; second, guided reflection using TeamTAG provided structured directions for improvement (e.g., refining the "effective communication" item to the SBAR handover format) [20]. A meta-analysis of 18 nursing education studies showed that flipped learning significantly improved learning satisfaction (Hedges' g = 0.79) and clinical competence (g = 0.53) [21,22], which is consistent with the high satisfaction reported by participants in this study. In addition, TeamTAG, as a cognitive aid, is designed to structure the debriefing process and ensure that CRM principles are systematically discussed [23],

which aligns with the design of the guided reflection in this study. However, existing research has not yet demonstrated that TeamTAG significantly improves the quality of teamwork itself; its role appears to lie more in focusing discussion and managing time . The effectiveness of the guided reflection in this study still requires further investigation.

5.3 Clinical Significance of Improved Emergency Drill Scores

Emergency drill scores increased from 82.30 ± 9.82 to 89.81 ± 6.30 (P = 0.001), with no statistically significant difference across nurse levels (P = 0.478), indicating that the method is applicable to nurses of varying seniority. This finding is conceptually consistent with the key non-technical skill dimensions identified by Mitchell et al. [7] for scrub nurses (situation awareness, communication, and teamwork). In addition, the improvement in scores may be related to repeated practice of standardized resuscitation workflows during scenario simulation (e.g., team role allocation in the hemorrhagic shock scenario), and such workflows have been shown to reduce errors caused by communication breakdowns (43%) [5, 24].

The systematic review and meta-analysis by Sánchez-Marco et al. (2023) further supports the broad effectiveness of simulation-based training in improving NTS among emergency and critical care personnel. This meta-analysis of 38 studies showed that simulation-based interventions significantly improved both overall non-technical skills (d+ = -0.642, 95% CI: -0.849, -0.434) and team non-technical skills (d+ = -0.606, 95% CI: -0.949, -0.262) [25].

5.4 Limitations and Future Directions

This study did not evaluate the long-term impact of NTS improvement on clinical outcomes (e.g., resuscitation success rates). Future research could incorporate the fourth level of the Kirkpatrick model (results evaluation) to conduct follow-up studies [26]. In addition, the sample was drawn from a single center with a relatively low proportion of male nurses (11.3%), which may limit the generalizability of the findings; larger sample sizes and multi-center data are needed for validation. Existing systematic reviews have also noted that evaluations of simulation-based crisis management training in the operating room have focused predominantly on the reaction and learning levels, with limited evidence at the levels of behavior change and long-term outcomes, suggesting that future studies should strengthen longitudinal designs to verify the sustainability of NTS improvement through flipped classroom combined with high-fidelity simulation.

In summary, junior nurses have relatively weak emergency skills. Repeated practice and error-based reflection before clinical practice, through which experience is internalized, enable them to respond rapidly and correctly in real clinical settings and improve resuscitation efficiency. Flipped classroom combined with scenario simulation can effectively improve participants‘ non-technical skills and is worthy of broader application.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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