



Effect of Counting Error Prevention Training on Operating Room Nurses' Counting Error Prevention Awareness and Perceptions of Patient Safety

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Abstract

Background: This study aimed to identify changes in counting error prevention awareness and patient safety perception through counting error prevention education to operating room nurses.

Methods: This was a one-group, pretest-posttest, quasi-experimental study. The participants were operating room nurses. A total of 46 nurses were recruited, and data was collected between October 1 and 31, 2022. Measures used for this study assessed counting error prevention awareness and patient safety perception. The data were analyzed using paired t-tests.

Results: The counting error prevention awareness of the participants increased significantly from 3.68 to 3.95 points before and after education, respectively ($t=-5.07$, $P<0.001$), while patient safety perception significantly increased from 3.95 to 4.20 points before and after training, respectively ($t=-2.68$, $P=0.010$).

Conclusions: Counting error prevention awareness and patient safety perception of operating room nurses prevent fatal damage to patients with surgeries and lower mortality. The results of this study suggest the necessity of various education methods to reduce medical accidents among surgical patients and to raise patient safety perception for operating room nurses.

Keywords: Nurses, Operating rooms, Operating room nursing, Patient safety, Surgery

INTRODUCTION

The operating room (OR) is a high-risk environment within a healthcare organization with a high incidence of errors resulting in serious injury or death to patients [1]. Furthermore, various interdisciplinary surgeries are performed in the OR, and surgical nursing care is provided here. Therefore, accurate communi-

cation with interdisciplinary team members and an understanding of equipment and supplies are required; high risk of patient safety incidents exists when these skills are lacking [2].

In the OR, verifying the type and number of items used during surgery is called “counting” and is one of the most important tasks to protect the patient from retained gauze, sutures, and surgical instruments in their body. It is also important for

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infection control, supply management, and the safety of medical personnel involved in surgery [3,4]. According to previous studies in Korea, “counting” ranked highest and second highest in the safety domain in the studies by Jang [5] and Kim and Kim [6], respectively, in terms of the importance of nursing interventions perceived by nurses working in the OR. As such, nurses in the OR consider counting to be one of the most important patient safety interventions. Nursing scholars and nurses in the field have been developing guidelines to reduce counting errors and suggesting ways to develop duty of care in the field, but counting errors still occur. Studies on OR miscounting errors have mainly addressed miscounting errors in the realm of safety management or conducted studies on factors related to miscounting errors [3,4,7], and studies on miscounting error prevention education are lacking. The standard guidelines for counting errors currently used in Korea are presented by the Korean Association of Operating Room Nurses, which is based on the standard guidelines of the American Association of Perioperative Registered Nurses and modified for Korea [8].

The importance of patient safety in the OR increases yearly, and according to a previous study, surgery-related areas recorded the highest report rate (36.9%) of medical disputes due to medical accidents in 2017 [9]. Patients undergoing surgery are unable to defend themselves due to anesthesia, and communication is difficult. Patient safety is consequently entirely the domain of the medical staff performing the surgery [2,9].

Given the importance of patient safety in the OR, the World Health Organization (WHO) has recommended the use of safety checklists, such as the WHO Surgical Safety Checklist [10], in hospitals to reduce the incidence of death and complications in surgical patients. Various outcomes have been reported, such as enhanced communication between healthcare providers, improved mobility, reduced surgical complications, and reduced readmission rates [2]. Other patient safety education programs have also been implemented, and several linear studies of nurses have reported that on-the-job training on basic skills and medication knowledge was effective in improving nurses’ job confidence and medication knowledge. Furthermore, Kim et al. [11] reported positive effects on safety perception, sense of safety control, and acceptance of responsibility through patient safety-related nursing error prevention education using case studies.

The effectiveness of nurse education for patient safety has been proven by several studies. However, studies that have conducted patient safety education for OR nurses do not currently

exist in Korea, and no study has measured the extent of patient safety awareness of OR nurses through counting error prevention education. Patient safety issues often arise in the OR, and these issues are related to the lives of surgical patients and complications. As such, the perception of patient safety by OR nurses is crucial, and measures to improve this perception of patient safety are needed [12].

Therefore, this study aimed to provide prevention education to OR nurses to determine the extent of prevention awareness and patient safety awareness before and after education and to provide a basis for developing an educational program for patient safety management of OR nurses.

METHODS

Study design

This study was a quasi-experimental study using a single-group pre-post design to determine the effectiveness of counting error prevention education by comparing changes in pre- and post-counting error prevention awareness and patient safety perceptions among OR nurses.

Participants

The participants of this study are nurses working in the OR of Gachon University Hospital located in Incheon City. The selection criteria for the participants were nurses with more than 3 months of work experience who had completed their initial training and were participating as disinfection or circulating nurses in the OR. Nurses working at this research organization during the study period and nurses with less than 3 months of work experience were excluded. The number of participants was calculated using the G*power 3.1.9.4 program based on a prior study by Kim et al. [13]. The power (0.8), significance level (0.05), and effect size (0.5) were calculated, and the initial sample size was 27. Considering a dropout rate of 20%, a total of 34 participants were selected. Ultimately, the analysis included all 46 participants who volunteered to attend training at a single study site.

Procedures: education to prevent counting errors

The educational materials for the prevention of counting errors used in this study were developed by seven medical staff working in the OR (three head nurses and four nurses with over 10 years of clinical experience in the OR) and one professor of nursing, who modified and supplemented the previously used

educational materials for OR nurses by referring to the 2013 article “Development of a guideline to prevent errors of surgical counts in the operating room at a university hospital” by Park and Jang [4].

The educational content consisted of the purpose of OR counting, OR counting guidelines (sponge counting guidelines, sharps counting guidelines, instrument counting guidelines, OR specimen counting guidelines, and guidelines for counting discrepancies), and OR counting records (surgical nursing record sheet guidelines, computerized surgical nursing record guidelines).

To enhance the content validity of the educational program, it was validated by six experts (two nurses with more than 10 years of experience in the OR, two nurses with more than 5 but less than 10 years of experience, one surgeon, and one nurse dedicated to OR education). As a result of the validation, the content validity of the education program was >0.8 for each component, and the training was conducted without further modifications.

The existing counting-error prevention education provided new nurses in the OR with approximately 10 minutes of education time and a surgical nursing guideline with a brief explanation during a 1 month-long curriculum. The counting-error prevention education developed in this study used a lecture-style education and presented counting-error cases to allow participants to discuss the problem. The education program comprised 40 minutes of lecture and 20 minutes of case-based discussions, focusing on specific examples of counting errors that can occur before, during, and following surgery. The sessions were conducted in person by the researcher, and due to the challenges posed by the nature of nurses' shift work, the training was divided into three sessions.

Measurements

General characteristics

The demographic characteristics investigated in this survey included sex, age, education level, total years of experience, years in the OR, position, work type, experience counting errors, and need for counting error education.

Cause of counting errors

We asked subjects what they thought were the causes of counting errors. After a preliminary survey of nurses working in the OR, we were able to collect the following items: ‘time constraints,’ ‘pressure from the doctor,’ ‘insufficient knowledge,’

‘burden to make mistakes,’ and ‘excessive work,’ which we presented to the participants.

Awareness of counting error prevention

A tool developed by Park and Jang [4] and modified and supplemented by Lee [14] was used to measure the awareness of preventing counting errors. The tool consisted of 29, 94, and 13 questions before, during, and after surgery, respectively, totaling 136 questions in three subsections. The tool used a 4-point Likert scale ranging from 0 for “not at all important” to 4 for “very important,” and the distribution of scores ranged from a minimum of 0 to a maximum of 544, with higher scores indicating greater awareness of preventing counting errors. The reliability of the tool was not published when it was developed, thus the exact reliability could not be confirmed. The Cronbach α was 0.99 in this study.

Patient safety perception

The patient safety perception measurement tool was the Hospital Survey on Patient Safety developed by the Agency for Health Research and Quality [15], a healthcare management organization in the United States, translated by Kim et al. [16], and modified by Park et al. [17]. The instrument consisted of 25 questions with five subscales: hospital environment (four questions), departmental work environment (eleven questions), communication and procedures (five questions), immediate supervisor/manager attitude (four questions), and departmental patient safety (one question). The tool used a 5-point Likert scale ranging from 1 (“not at all”) to 5 (“very much so”), and the distribution of scores ranged from 25 to 125, with higher scores indicating higher levels of patient safety awareness. The reliability of the tool at the time of development was Cronbach $\alpha=0.82$, and the reliability in this study was Cronbach $\alpha=0.94$.

Data collection

The data collection period of this study was from October 1 to October 31, 2022. The pre-questionnaire was distributed in an envelope after completing the voluntary participation agreement, and the questionnaire was returned in the envelope after completion. The post-training questionnaire was also distributed in an envelope, which was returned in a sealed envelope after being filled out.

Data analysis

The collected data were analyzed using the IBM SPSS/WIN 25.0

(IBM Corp.) program, and the specific analysis methods are as follows.

- 1) The general characteristics of the participants were analyzed using means, standard deviations, frequencies, and percentages.
- 2) The scores of the participants counting error prevention awareness and patient safety awareness were analyzed using the mean and standard deviation.
- 3) The paired t-test was used to compare the difference between pre- and post-education awareness and patient safety awareness.

Ethical considerations

The study was conducted after ethical review approval (No. GBIRB2021-480) from the research ethics committee of Gachon University Hospital located in Incheon City. Participants were informed of the relevance, purpose, benefits, and risks of the study; their autonomy to discontinue the study; the time required for training and questionnaire completion; and confidentiality of information. Participants were asked for their consent to participate in the study, and those who completed the questionnaire were provided with a token.

All participant information used in this study was anonymized with alphabetic and numeric characters. To enhance participant privacy, collected data were stored only on the personal computer of the principal investigator and encrypted so that only the principal investigator could access it. The data from this study were used only for the study and will be stored for 3 years after the completion of the study report before being destroyed to protect personal information.

RESULTS

General characteristics

The general characteristics of the participants are shown in [Table 1](#). The average age of the participants was 26.93 years, and most were female (91.3%). In terms of education, 43 (93.5%) were 4-year graduates, and 30 (65.2%) were nurses with less than 3 years of overall clinical experience. Regarding OR experience, 33 (71.7%) had less than 3 years; generalist nurses were the most common with 42 (91.3%). Most nurses—42 (91.3%)—worked shifts, and 25 (54.3%) had experience with counting errors. When asked about the need for miscount training, 30 (65.2%) responded that it was very necessary and 16 (34.8%) responded that it was necessary.

Causes of counting errors according to the participants

Table 2 shows the causes of counting errors according to the participants. Among the causes of counting errors, 20 participants (43.5%) indicated “time constraints,” followed by “pressure from the doctor (nine participants, 19.6%),” “insufficient knowledge (seven participants, 15.2%),” “burden to make mistakes (five participants, 10.9%),” and “excessive work (five par-

Table 1. General characteristics of participant (n=46)

Characteristic	Value
Age (yr)	26.93±5.74
Sex	
Female	42 (91.3)
Male	4 (8.7)
Level of education	
College	3 (6.5)
BSN	43 (93.5)
Total career (yr)	
<3	30 (65.2)
3–5	8 (17.4)
6–9	3 (6.5)
>9	5 (10.9)
Experience of operation room (yr)	
<3	33 (71.7)
3–5	6 (13.0)
6–9	3 (6.5)
>9	4 (8.7)
Position	
Staff nurse	42 (91.3)
Charge nurse	4 (8.7)
Duty type	
Rotation duty	42 (91.3)
Mid duty	4 (8.7)
Experience of counting error	
Yes	25 (54.3)
No	21 (45.7)
Need for counting error education	
Very necessary	30 (65.2)
Necessary	16 (34.8)

Values are presented as mean±standard deviation or number (%). The sum of the percentages does not equal 100% because of rounding.
BSN, bachelor of science in nursing.

Table 2. The cause of counting error in operating room nurses opinion (n=46)

Category	Value
Time shortage	20 (43.5)
Burden to make mistakes	5 (10.9)
By the pressure of the doctor	9 (19.6)
Insufficient of knowledge	7 (15.2)
Excessive work	5 (10.9)

Values are presented as number (%). The sum of the percentages does not equal 100% because of rounding.

ticipants, 10.9%).”

Awareness of counting errors prevention and perception of patient safety before and after education

The pre- and post-training awareness and patient safety perceptions of the participants are shown in Table 3. The total score of the participants’ awareness of preventing counting errors before and after the training significantly increased from 500.76 ± 51.56 (mean 3.68 ± 0.38) before the training to 537.11 ± 16.13 (mean 3.95 ± 0.12) after the training ($t = -5.07$, $P < 0.001$). Considering the differences in the subscale of awareness of preventing counting errors, the preoperative item increased significantly from 106.07 ± 11.52 (rating mean 3.66 ± 0.40) before education to 114.15 ± 3.58 (rating mean 3.94 ± 0.12) after training ($t = -5.02$, $P < 0.001$), and the intraoperative items increased significantly from 345.20 ± 37.74 (mean 3.67 ± 1.30) before training to 371.00 ± 11.03 (mean 3.95 ± 0.12) after training ($t = -4.95$, $P < 0.001$). The postoperative item significantly increased from 49.50 ± 5.38 (mean 3.81 ± 0.41) pre-training to 51.96 ± 2.30 (mean 4.00 ± 0.18) post-training ($t = -2.80$, $P = 0.007$).

Participants’ perception of patient safety increased significantly from 98.80 ± 13.58 (mean 3.95 ± 0.54) before the training to 104.91 ± 14.36 (mean 4.20 ± 0.57) after the training ($t = -2.68$, $P = 0.010$).

DISCUSSION

Counting errors in the OR still occur, albeit less frequently than in the past, and are a medical error that can adversely affect patient outcomes. However, the exact incidence and cases of medical errors, including counting errors, are not shared due to hospital evaluation, patient safety concerns, and blame on individuals [18], and effective education on counting errors remains lacking. Therefore, to reduce the incidence of these errors and increase awareness of patient safety, this study was conducted to develop an education program on the prevention of counting errors and to determine its effectiveness after applying it to OR

nurses.

The results of this study showed a significant increase in the participants’ awareness of counting error prevention before and after training and a significant increase in each subdomain. Patient safety awareness also increased significantly from pre- to post-training. Based on these findings, this study indicates that the education of OR nurses on counting error prevention is beneficial for positive changes in awareness of counting error prevention and patient safety perceptions.

Given that the error prevention education used in this study was developed and applied by the developers, referring to the guidelines for error prevention in the OR by Park and Jang [4], direct comparison is difficult due to the lack of previous studies. That said, this study shall be compared to previous studies on error prevention activities for OR nurses and studies that measured patient safety awareness among nurses.

The participants’ awareness of counting error prevention was 3.68 ± 0.38 before training, which was somewhat lower than the mean of 3.89 ± 0.20 in a study by Lee [14] that measured the awareness of counting error prevention among OR nurses. This difference may be due to the difference in clinical experience since only 28.2% of the nurses in the previous study had less than 3 years of experience, compared to 65.2% in this study. As such, education on counting error prevention should be specialized by years of experience, and education should be focused on those with less than 3 years of experience.

The participants’ awareness of preventing counting errors increased significantly from 3.68 ± 0.38 points before the training to 3.95 ± 0.12 points after the training. Although accurate comparisons are difficult to make due to the lack of studies in Korea verifying the effectiveness of preventing counting errors, this study likely proved the effectiveness of preventing counting errors. Miscalculation is a medical error that causes fatal complications and deaths in surgical patients, thus subsequent studies should be conducted to verify the effectiveness of improving awareness of miscalculation prevention through education, as well as the reduction in the actual incidence of miscalculation

Table 3. Differences of counting error prevention awareness, patient safety perception before and after education (n=46)

Variable	Pre-education	Post-education	t (P)
Counting error prevention awareness	500.76 ± 51.56 (3.68 ± 0.38)	537.11 ± 16.13 (3.95 ± 0.12)	-5.07 (<0.001)
Preoperation	106.07 ± 11.52 (3.66 ± 0.40)	114.15 ± 3.58 (3.94 ± 0.12)	-5.02 (<0.001)
Intraoperation	345.20 ± 37.74 (3.67 ± 1.30)	371.00 ± 11.03 (3.95 ± 0.12)	-4.95 (<0.001)
Postoperation	49.50 ± 5.38 (3.81 ± 0.41)	51.96 ± 2.30 (4.00 ± 0.18)	-2.80 (0.007)
Patient safety perception	98.80 ± 13.58 (3.95 ± 0.54)	104.91 ± 14.36 (4.20 ± 0.57)	-2.68 (0.010)

Values are presented as mean $\pm$ standard deviation of total score (mean score).

through various education programs [4].

Furthermore, since this study was conducted only in one medical center and the education was delivered in a lecture format by the researcher, the effectiveness of education for the prevention of counting errors must be verified through various educational formats using simulations and multicenter studies in the future.

When looking at the difference in scores by subsection of the awareness of counting error prevention by training, the preoperative item had the largest difference in score. This suggests that there was a lack of training on the steps to verify the counting of pre-operative items and pre-operative preparation in general. As such, education must be provided to OR nurses focusing on preoperative nursing care, counting, and overall surgical preparation, and further studies should be conducted to verify the effectiveness of education in preventing preoperative counting errors.

The biggest problem with OR counting errors is the complications associated with retained foreign bodies in the body cavity. According to previous studies, it takes an average of 2.2 years for a foreign body to be detected after surgery, and the main complications are intestinal adhesions, abscesses, and fistula formation, and the mortality rate associated with foreign body retention is reported to be 11% to 35% [19,20]. Based on these previous studies, changes in the awareness of counting error prevention among OR nurses are directly related to patient safety issues, which are also linked to patient prognosis and survival. Therefore, although many hospitals in Korea conduct training, various societies and organizations, including the Hospital Surgical Nurses Association, should strive to improve the knowledge and awareness of OR nurses on counting error prevention through improved guidelines and regular education on counting error prevention.

In this study, we investigated the patient safety awareness of the participants, and the mean patient safety awareness before the training was 3.95 ± 0.54 . This was higher than the score of 3.33 ± 0.39 in the study by Park et al. [17] on OR nurses, and higher than the score of 3.42 ± 0.30 in the study by Kim and Kim [21] on general hospital nurses. Comparing the results of the present study with the two previous studies, educational levels differed, although the clinical experience was similar; 69.5% of the nurses in Park et al.'s study [17] were 3-year graduates, and 61.2% in Kim and Kim's study [21] were 3-year graduates, compared to 6.5% in this study. However, given that the educational level of the participants in the previous study was reported as

3.23 ± 0.22 by Im and Park [22], where 36.1% were 4-year graduates and 63.9% had a master's degree or higher, distinguishing between 3 and 4 years of education is complicated. Further research is needed to identify factors that affect patient safety perceptions by controlling these variables.

The patient safety awareness of the participants increased significantly from 3.95 ± 0.54 before training to 4.20 ± 0.57 after training, indicating that patient safety awareness was improved by the prevention of counting errors. Considering that previous studies have reported that counting and counting error prevention are crucial for patient safety [9,23,24], the counting error prevention education conducted in this study may have improved the patient safety awareness of OR nurses.

Previous studies that measured patient safety awareness by providing nurses with medication education for patient safety and education on nursing error cases have shown that various topics can positively change nurses' patient safety awareness [11,13]. However, education on the topic of patient safety awareness is lacking. As such, further research on developing such a curriculum and verifying its effectiveness is required.

In a systematic review of patient safety-related educational programs to improve patient safety awareness on nursing students, Seo et al. [25] recommended that patient safety education should include content on adverse events, safety risks, coping, communication, safety culture, teamwork and cooperation, clinical safety, safety systems or informatics, and other knowledge related to patient safety. Various educational methods—such as lectures, simulations, problem-based learning, small group lectures, group discussions, and watching video cases—were also recommended. A previous study that developed a practical education program on patient safety for surgical nurses reported that education in six practical areas, including medication knowledge, suctioning, drainage tube management, oxygen administration, etc., contributed to enhancing awareness of patient safety [13]. There was no research conducted on educating OR nurses about patient safety in Korea. However, in other countries, there was an emphasis on improving patient safety through enhancing teamwork with surgeons [26]. In another previous study, education on four different areas, including safe surgical techniques, industrial safety, safety management theory, and medical information security, was conducted using various methods such as lectures, case-based learning, and group discussions. This study reported that a duration of 4 to 8 hours of education was considered appropriate [27]. Based on these previous studies, developing a systematic education

program for patient safety targeting OR nurses, considering various topics, educational delivery methods, and appropriate timing, is recommended.

This study asked the OR nurses who participated in the study about the causes of counting errors in their opinion, and the most common cause was “Time shortage” (43.5%), followed by “Due to pressure from the doctor” (19.6%) and “Insufficient of knowledge” (15.2%). These results indicate that time to perform pre-operative, intra-operative, and post-operative counts is insufficient compared to the recent increase in the number of surgeries. Medical centers should consider Providing ample time for surgeries and ensuring that counts are performed efficiently to ensure patient safety and prevent coding errors. Furthermore, in a previous study by Kwon et al. [28] that compared physicians’ and nurses’ perceptions of miscalculation and patient safety, the nurses’ perception of miscalculation was significantly higher than the physicians’ perception of miscalculation. This result suggests that perceptions of miscalculations can be enhanced through communication and cooperation between nurses and physicians.

Given that this study was conducted in a single medical institution using convenience sampling, the results of the study cannot be generalized. Furthermore, since the method of education involved lecturing by the researchers, it was difficult to assess and evaluate the participants’ understanding of the educational contents and its practical applicability in real-world settings. Additionally, since the education was provided in one session that was about 60 minutes long, it was difficult to gauge the appropriateness of the duration of the education. Therefore, verifying the effectiveness of error-prevention education with more than one session using various educational methods, including repeated sessions, simulations, practical training, and multi-institutional research, rather than a single institution for future follow-up studies is imperative. Because this was a single-group study without a control group, observing differences in the effect of education between groups. Therefore, future follow-up studies should consider establishing control groups to explore ways to assess the effectiveness of education objectively. Additionally, although this study focused solely on education regarding error prevention among OR nurses, future research should consider developing education programs for error prevention, as well as enhancing patient safety awareness. Such an approach could have a positive impact on patient safety and outcomes.

Finally, the results of this study showed that both the level of awareness of prevention of counting errors and patient safety

awareness were significantly improved before and after the prevention education. The causes of counting errors were investigated, and the main causes were discussed. However, there are several limitations that impact the generalizability of the study findings. Firstly, limitations due to the single-arm pre-post study design are present. Therefore, an randomized controlled trial study design should be considered for further evaluation of effectiveness. Secondly, this study did not measure the long-term effects of a single training session. Therefore, measuring the long-term effects of various training methods is crucial.

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AUTHOR CONTRIBUTIONS

Dr. Hana KO had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Dr. Hana KO reviewed this manuscript and agreed to individual contributions.

Conceptualization: all authors. Data curation: MKH, MJL, KAL, YOK, and JAJ. Formal analysis: MJJ and HK. Investigation: MKH, MJL, KAL, YOK, and JAJ. Methodology: MJJ and HK. Software: MJJ. Validation: MJJ and HK. Writing—original draft: MJJ and HK. Writing—review & editing: all authors.

CONFLICTS OF INTEREST

No existing or potential conflict of interest relevant to this article was reported.

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DATA AVAILABILITY

The data presented in this study are available upon reasonable

request from the corresponding author.

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