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Research Paper

Effects of the small private online course combined with simulation-based training in a patient safety education program among nursing students: A quasi-experimental study

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ABSTRACT

Objective: This study aimed to explore the effects of the small private online course (SPOC) combined with simulation-based training in a patient safety education program among nursing students in China. **Methods:** A quasi-experimental design was conducted. A total of 219 nursing students from four parallel classes were selected from the nursing department of a health vocational college in Zhengzhou, China, from November 2020 to June 2021 and allocated to the intervention group ($n = 113$) and control group ($n = 106$). Based on SPOC, nursing students in the intervention group implemented simulation teaching in small groups, with three class hours each time, a total of two times, divided into three stages: pre-class preparation, teaching implementation, and after-class reflection. The control group received theoretical patient safety education through SPOC, implemented on the DingDing platform for two class hours each time, four times. All participants were invited to complete a demographic questionnaire and the Chinese version of Patient Safety Competency Self-Evaluation (PSCSE) before and after the intervention.

Results: A total of 103 and 102 students from the intervention and control groups completed the study. The total scores of PSCSE in the post-test of the intervention group (176.24 ± 13.73 vs. 144.64 ± 13.75) and the control group (160.87 ± 14.88 vs. 142.57 ± 15.66) were higher than those in the pre-test ($P < 0.01$), and the total scores of PSCSE of the intervention group were higher than those of the control group (176.24 ± 13.73 vs. 160.87 ± 14.88 , $P < 0.01$). After intervention, the scores of PSCSE in all dimensions were increased in the intervention group ($P < 0.01$); in the control group, the scores of patient safety competency in most dimensions were increased ($P < 0.01$), except for the dimensions of reporting and response to error and communication related to error ($P > 0.05$). Except for the dimensions of knowledge and attitude of error reporting and disclosing ($P > 0.05$), the scores of other dimensions in the intervention group were higher than those in the control group ($P < 0.01$).

Conclusion: The patient safety education program using the SPOC combined with simulation-based training can effectively improve the patient safety competency of nursing students in terms of attitude, skills, and knowledge.

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What is known?

- Patient safety education programs should be provided to nursing students.
- Studies showed considerable variations in the methods and outcomes of patient safety education conducted.

What is new?

- The small private online course (SPOC) can be used for theoretical teaching to expand the breadth and depth of patient safety education.
- The SPOC, combined with simulation-based training, is an effective strategy for implementing patient-centered care and improving patient safety competency among nursing students.

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1. Introduction

Patient safety is a fundamental principle of health care worldwide and involves the prevention of unnecessary errors and adverse harm to patients [1]. Unexpected and unwanted events could occur in any setting where health care is delivered. Many patients are harmed during healthcare, resulting in permanent injury, increased length of stay in healthcare facilities, and even death [2]. High incidence rates of medical errors cause considerable harm to patients and impose a heavy financial burden on the healthcare system [3]. As the largest group of healthcare workforce, nurses provide direct patient care 24 h a day in hospitals and are thus in the best position to improve patient safety. The delivery of safe nursing practices is expected and emphasized, given the increasing use of new technologies and the rapid changes in the healthcare system [4].

The need for ensuring patient safety has been increasingly recognized, and the importance of nursing education and how it affects patient safety competencies among nursing students have been emphasized [5–8]. As a system property, patient safety education plays a key role in minimizing patient harm [8]. Clinical nursing students and younger nurses have a high incidence of committing adverse events because of a lack of familiarity with the clinical environment, communication skills, and nursing operations skills [9–13]. As the reserve force for clinical nursing, students will be the main implementers of safe nursing in the future and thus should be educated early on patient safety [3,8,14].

As the importance of patient safety in hospitals is increasingly emphasized, the nursing education system begins to emphasize patient safety in nursing colleges worldwide. The WHO developed a patient safety curriculum guide containing 11 components in 2011 [15]. However, given the differences in the medical system and cultural background, most patient safety education programs are mainly designed based on their countries' education guidelines, training guidelines, and competency frameworks [4]. Patient safety competency is defined as the ability of healthcare professionals to reduce the risk of unnecessary harm associated with healthcare to an acceptable minimum; it focuses on the healthcare system perspective rather than the completion of a specific job and emphasizes safety culture, teamwork, communication, safety risk management, adverse event identification, and reporting evidence-based nursing practice [16]. In China, patient safety competency includes the following six aspects: patient-centered care, safety risk management, evidence-based nursing practice, clinical practice, patient safety culture, and continuous quality [16]. Considering that nursing students have yet to obtain professional qualification certification, nursing education experts in China pointed out that the safety competency framework suitable for nursing students should be different from those for nurses and divided into three levels: knowledge, skills, and attitude [17].

In China, patient safety was integrated into the Fundamental Nursing course as an independent chapter in 2012. The teaching content is limited to the basic concepts of patient safety, medication safety, infection prevention, and control and is considered by experts as needing more systematic design [4]. Studies reported significant differences in the delivery of patient safety education to students concerning course design, contents, and the stage when it was introduced to the curriculum, evaluation processes, and outcomes [18–21]. Online courses, which have unlimited learning time and place, are used for nursing teaching worldwide, especially after the outbreak of COVID-19 [22–26]. Johns Hopkins University provides patient safety education courses for medical staff in over 100 countries through the massive open online course (MOOC) platform, in which participants achieve significant improvements in clinical practice and communication skills. However, MOOCs

have a low participation rate of only 8% [22]. Small private online courses (SPOCs) were first proposed by Professor Armando Fox at the University of California Berkeley in 2013 to improve learners' participation rates by organically combining high-quality MOOC resources with face-to-face teaching [27]. SPOCs make up for the lack of interaction and low student completion rate in MOOCs; they also help improve the quality of teaching and the most concerned type of online curriculum in the "post-MOOC period" [26]. It has been used in oncology, psychology, and other medical-related courses and has achieved good results [28,29].

Simulation-based training is a teaching method to design high-simulation patients and clinical scenarios to replace real patients to conduct clinical medicine teaching practice [30]. It is widely used in the fields of medical education, such as anesthesia, surgery, emergency, and nursing, and has been proven significant in improving students' clinical practice abilities, such as critical thinking and communication skills, especially in the area of patient safety [27–34]. Simulation-based training allows students to recognize unsafe conditions in complex clinical environments and implement safe nursing behavior through safety-related clinical scenarios. Besides, simulation-based training is also used to improve learning from adverse incidents to prevent recurring mistakes [30].

Delivering safe nursing in complex, pressurized, and fast-moving environments is one of the greatest challenges faced by health care today [2]. Given the limited content of patient safety education in the existing course, the depth and breadth of patient safety education content must be expanded, and effective teaching methods explored. Scholars have recognized that online patient safety education could improve nursing students' knowledge of, attitude toward, and skills in patient safety and the need to develop a method to combine online education with various learning activities [6]. Simulation-based training conducted in teamwork can help uncover latent errors in a medical system and improve patient safety [31]. This study aimed to examine the effects of a patient safety education program using an SPOC combined with simulation-based training on patient safety competency among nursing students in China.

2. Method

2.1. Study design and participants

A quasi-experimental study was conducted. This study was conducted in the nursing department of a health vocational college from November 2020 to June 2021 in Zhengzhou, China. The college has a three-year nursing program. There were 219 nursing students from four classes in grade two. The inclusion criteria were as follows: a) willingness to participate and b) non-participation in the other teaching intervention studies. We excluded students who did not complete the program as planned. Sample size was calculated using the formula $n_1 = n_2 = 2 * [(\mu_\alpha + \mu_\beta) / (\delta / \sigma)]^2$ [35]. A two-sided test was adopted, with $\alpha = 0.05$, $\beta = 0.10$, $\mu_\alpha = 1.96$, and $\mu_\beta = 1.28$ was obtained by checking the table. According to the scores of the two groups after implementing the teaching intervention in similar studies [5], σ was 19.125, and δ was 19.73. The result showed that 20 valid samples were needed for the two groups. All four classes were included in the study, exceeding the required sample size and enabling effective statistical analysis and teaching management.

The students were separated into two groups: the odd-numbered classes were assigned to the intervention group, while the even-numbered classes were assigned to the control group. Two classes in the intervention-control groups had 54 and 52 students, respectively, and the two control intervention group classes had 58 and 55 students. The two groups were similar in age, gender, and academic performance.

2.2. Procedure

2.2.1. Creation of a teaching team

We set up a teaching team of eight people, including college teachers, clinical nursing teaching teachers, nurse managers, and nursing education experts. The college teachers participating in the teaching have a master’s degree, more than three years of clinical nursing work experience, and more than eight years of nursing education experience. Both groups used the same teaching team to ensure that the students received comprehensive theoretical teaching of patient safety education.

2.2.2. Construction the program of patient safety education

2.2.2.1. Construction of the teaching content. The patient safety education program was implemented relying on the course of Fundamental Nursing, in which patient safety is included, but the content is limited. The teaching group set patient safety education as eight themes according to the WHO patient safety framework [15] and the Chinese safety competency framework [16], including a summary of patient safety (theme 1), adverse events (theme 2), risk management (theme 3), evidence-based nursing and information literacy (theme 4), effective communication (theme 5), teamwork (theme 6), clinical practice (theme 7), and patient-centered care (theme 8).

In the college’s three-year nursing program, the Fundamental of Nursing course covered parts of themes 1, 7, and 8 of patient safety education mentioned above. Other themes were not included in the course, such as teamwork, and adverse events, which could be supplemented in the form of SPOCs. The teaching group designed the teaching content for SPOC and teaching resources for simulation-based training. The content for SPOC included themes 1–6 of patient safety education, which were not included in the Fundamental of Nursing course (Table 1). Themes 7 and 8 could be reinforced by implementing simulation-based training in which teaching resources, such as the simulation evaluation form, clinical cases, and nursing medical records, were needed. The simulation evaluation form is used for teachers and peer students to evaluate the performance of the students of the simulation group in simulation-based training, in which patient safety awareness, teamwork, communication skills, and clinical obstacle response

were included. Two representative clinical cases conforming to the clinical characteristics were compiled, each involving four nursing operations and having the risk of three to four adverse events that are easily induced in multiple links of nursing (Table 1). The nursing medical record was designed to implement patient safety throughout the whole process of nursing procedures. It included nursing safety risk assessment tools, which required students to conduct risk assessments of patients and implement care measures according to the assessment results.

2.2.2.2. Construction of the teaching approach. Theoretical education in the form of SPOC was provided to both the intervention and control groups. To explore the more effective form of patient safety education, the intervention group received additional simulation-based training in combination with SPOC. The participating students attended classes in strict groups to avoid cross-contamination. Online SPOC and offline simulation-based training required teamwork to complete the discussion, pre-class preparation, and homework to promote student communication and collaboration.

2.2.3. The intervention group

Given that the content and teaching methods of SPOC are consistent with the control group, only simulation-based training is introduced in this part. Each class was divided into two practical training classes (≤30 students), by which the offline simulation-based training was implemented. Each practical training class were divided into five student teams: two simulated nursing care process of Case 1, and the other teams simulated Case 2. According to the process, the training was divided into three stages: pre-class preparation, class implementation, and post-class reflection.

2.2.3.1. Pre-class preparation. Four students were recruited as standardized patients. The teacher distributed situational cases and nursing medical records one week before the class and trained the standardized patients. Students completed the study together before class through discussion, simulation-based practice, and writing nursing medical records. Students practiced through role-playing, and teachers gave guidance and feedback before the class. Teachers set 2–3 barriers for each case and trained

Table 1
The patient safety education program.

| Group | Teaching methods | Themes | Contents and activities | Class hour |
|---|-----------------------------|-----------|--|------------|
| The intervention group and control groups | Small private online course | Theme 1 | Lecture: summary of patient safety Introduction of nursing adverse events (concept, level, type, and reporting method) | 2 |
| | | Theme 2 | Discussion: Types of adverse events of clinical nursing students The role of nurses in patient safety | |
| | | Theme 3 | Lecture: Predict, identify, and manage patient safety risks Cause and analysis methods of adverse events Case study and discussion: Root cause analysis of a medication error case | 2 |
| | | Theme 4 | Lecture: Evidence-based nursing and information literacy Online operation demonstration: Retrieving the placement time interval of the indwelling catheter in the database Homework: Select a clinically common adverse event and summarize progress in group preventive measures | 2 |
| | | Theme 5,6 | Lecture: Effective communication and teamwork Group presentation: Strengthen effective communication and team cooperation among medical staff | 2 |
| The intervention group | Simulation-based training | Theme 2-8 | Case 1: Nursing care of a respiratory infection patient with COPD who was admitted to the hospital with a wheelchair (Types of adverse events: communications barriers, infection, medication errors, and falling out of bed) Topic: Response to a medication error in case 1. Case 2: Basic nursing care for a hemiplegic woman after stork (Types of adverse events: pressure sores, infection, catheter displacement, falling out of bed) | 3 |

standardized patients to simulate the corresponding clinical manifestations, such as dyspnea after infusion. The remaining students were unaware of the type of barrier.

2.2.3.2. Implementation in class teaching. Simulation-based training was conducted in groups to simulate the nursing process of patients in clinical, in which standardized patients was involved. During a training session, a team of students simulated nursing care for a standardized patient while the others observed. Taking Case 1 (Table 1) as an example, a standardized patient assumed the role of a respiratory infection patient with COPD who was admitted to the hospital with a wheelchair. Nursing care for this case included operating a wheelchair for patient transport, assessing vital signs, administering oxygen inhalation, and intravenous infusion. Each student in the simulation team was required to perform at least one nursing task. However, physical assessment and communication with a standardized patient were also part of the tasks performed. Most nursing tasks were performed on a nursing operation manikin, except for physical assessment and communication on a standardized patient. The teacher would add challenges to the tasks. For instance, the medical orders provided to each team differed slightly, such as the dose of antibiotics given. During the simulation, the standardized patient simulated the operation abnormalities according to the instructions given by the teacher before the performance began. In Case 1, the standardized patient reported experiencing dyspnea or poor solution dripping during intravenous fluids. Students' comprehensive ability would be assessed based on their correspondence to abnormal situations. The teacher distributed the simulation evaluation form to observation groups who observed and recorded problems in performance. After completing all simulation groups, the teacher organized discussions and gave feedback on the performance of each group, including self-evaluation, peer evaluation, and standardized patient evaluation, which can help nursing students understand their shortcomings and correct them in the future.

According to the common problems reported by the students in the simulation teaching, the teachers carried out targeted training. In Case 1, more than half of the students had medication errors during intravenous fluids, mainly drug dosage errors, wrong drug names, and infusion speed errors. Most of the students did not find mistakes committed by them, but those were pointed out by the teacher or the rest of the students in the discussion. After learning about the errors occurred, almost all the students showed nervousness and concern, indicating a lack of adequate response to medication errors in the operation. Therefore, the teacher arranged a topic to deal with medication errors and help students practice communication and reporting adverse events.

2.2.3.3. Post-class reflection. After class, teachers and students reflected on and summarized the implementation of simulation-based training. The students that completed the simulation reflected on the learning process and the simulation performance and revised the nursing medical records. The students that as observers summarized and reflected on what they learned in this lesson. The teachers reflected on the teaching process to provide measures and the basis for patient safety education in the future.

2.2.4. The control group

This group carried out patient safety education only through SPOCs. Several student teams were formed in each class based on their preferences, with 5-6 members in each team. The teaching content consists of six themes, divided into four times according to their logical relationship. The teacher used the DingDing platform to distribute the PPT and discussion outline to guide the students in completing their pre-class self-study and cooperative learning.

SPOCs were implemented on the DingDing platform by class for 90 min each time. In addition to lectures, case studies, discussions, and demonstrations emphasized the interaction between teachers and students. Students completed homework or group discussions after class and submitted them on the platform.

2.3. Ethical considerations

This study conformed to the Declaration of Helsinki and was approved by the Academic Affairs Office at the participating college. Consent was obtained from the participants before the study to protect their rights in research participation. The students voluntarily participated in the program and could withdraw at any time.

2.4. Data collection

The intervention and control groups completed surveys in November 2020 (before the start of the study) and in July 2021 (after the end of the study). Web-based questionnaires were set up and sent to the participants through WeChat. The participants completed the questionnaires and submitted them anonymously on mobile clients.

Demographic data included age, gender, and class. The Patient Safety Competency Self-Evaluation (PSCSE) was developed to measure the patient safety competencies of nursing students in Korea [36]. PSCSE was chosen to measure the level of patient safety competency because of its high reliability, moderate number of items, and comprehensive content [5,6,37]. Considering the differences in culture and healthcare system, we introduced the scale and conducted reliability and validity tests after obtaining consent from the author of the scale. The Chinese version of PSCSE contains 40 items, which are divided into seven dimensions: knowledge, skills of reporting and response to error, communication skills related to errors, skills of resource utilization and evidence-based practice, skills of safe nursing practice, attitude of safe nursing responsibility, and attitude of error reporting and disclosing. This scale was tested in a pilot study, which revealed acceptable internal consistency (Cronbach's α coefficient of PSCSE was 0.948 and ranged from 0.870 to 0.916 for dimensions) and content validity (0.98) estimates [38]. Participants responded to each item on a five-point scale, ranging from 1 (very inconsistent) to 5 (very consistent), with high scores indicating high competency regarding patient safety.

2.5. Data analysis

Data were analyzed with descriptive and inferential statistics by using SPSS 17.0 statistical software (version 17.0, IBM) and presented by frequency, percentage, mean, and standard deviation. The independent *t*-test was used to compare the pre- and post-test results between the two groups. Paired *t*-test was conducted to examine the effects of the intervention within control and intervention groups.

3. Results

3.1. Characteristics of students

Two hundred five nursing students participated in the study (103 students in the intervention group and 102 in the control group). Fourteen students did not complete the program because of illness or suspension. The loss-visit rates were 8.85% and 3.77%, respectively, within the acceptable range. The mean ages were 19.65 ± 0.75 years for the control group and 19.78 ± 0.77 years for the intervention group ($t = -1.222$, $P = 0.223$), and the proportion

of women in the intervention and control groups was 87.4% and 89.2%, respectively ($\chi^2 = 0.829, P = 0.424$). All students received patient safety education in the regular teaching system, including communication in the Introduction to Nursing course and an overview of patient safety in the Fundamental Nursing course. The general characteristics and experience in patient safety education were not significantly different between the intervention and control groups (Table 2).

3.2. Difference in patient safety competency within groups and between groups

The total scores of patient safety competency in the post-test of the intervention group (176.24 ± 13.73 vs. 144.64 ± 13.75) and the control group (160.87 ± 14.88 vs. 142.57 ± 15.66) were higher than those in the pre-test ($P < 0.01$). After the intervention, the intervention group's total scores of patient safety competency (176.24 ± 13.73 vs. 160.87 ± 14.88) were higher than those of the control group. Table 2 shows that the scores of patient safety competency in all dimensions in the intervention group increased after completing the patient safety course ($P < 0.01$). In the control group, the scores of patient safety competency increased in most dimensions after receiving theoretical education in the form of SPOC ($P < 0.01$), except for the reporting and response to error ($t = -1.91, P = 0.058$) and communication-related to error ($t = -1.75, P = 0.083$).

Table 2 also shows that students in the intervention group had higher scores in the dimensions of skills and attitudes of safe nursing responsibility than those in the control group after the intervention ($P < 0.01$). No significant differences were found in the dimensions of knowledge ($t = 1.62, P = 0.108$) and attitude of error reporting and disclosing ($t = 1.29, P = 0.197$).

4. Discussion

This study examines the patient safety competency of junior college nursing students who completed a patient safety program using SPOC and simulation-based training. The levels of patient safety knowledge, attitude toward safe nursing responsibility, attitude of error reporting and disclosing skills of resource utilization and evidence-based practice, and skills of safe nursing practice increased in the control group after theoretical education. All the seven dimensions of patient safety competency involving knowledge, skills, and attitudes increased after completing the patient safety program in the intervention group. Patient safety knowledge of the post-test was higher than the pre-test in both groups. However, no significant difference was observed between the two groups in the post-test. This finding indicates that improving patient safety knowledge mainly depends on systematic and comprehensive theoretical education. After having a comprehensive understanding of patient safety, the attitude of nursing students toward patient safety was improved. This result is inconsistent with the report of local research [21,39] due to differences in content and teaching methods in the theoretical approach. This study used discussion, case study, demonstration, group presentation, and lecture. Teaching factors, such as teaching mode and patient safety knowledge level, are important because they affect the nursing adverse events by nursing students during clinical practice [40].

SPOC is an effective strategy to teach patient safety; it includes lectures, group presentations, discussions, demonstrations, and case studies and can be used to supplement existing theoretical teaching to expand the depth and breadth of patient safety education. With resource utilization and evidence-based practice as an example, teachers can demonstrate how to retrieve the literature in

Table 2 Comparison of patient safety competency among two groups (n = 205).

| Variables | | The intervention group (n = 103) | The control group (n = 102) | t | P |
|--|-----------|----------------------------------|-----------------------------|--------|---------|
| Knowledge | Pre-test | 19.32 ± 3.71 | 19.05 ± 3.84 | 0.51 | 0.608 |
| | Post-test | 23.52 ± 3.96 | 22.74 ± 2.96 | 1.62 | 0.108 |
| | t | -8.69 | -8.47 | | |
| | P | < 0.001 | < 0.001 | | |
| Reporting and response to error | Pre-test | 8.95 ± 2.15 | 8.99 ± 2.26 | - 0.13 | 0.900 |
| | Post-test | 12.01 ± 2.16 | 9.04 ± 2.25 | 9.65 | < 0.001 |
| | t | -11.53 | -1.91 | | |
| | P | < 0.001 | 0.058 | | |
| Communication related to error | Pre-test | 10.72 ± 1.94 | 10.53 ± 2.21 | 0.65 | 0.516 |
| | Post-test | 13.08 ± 1.88 | 10.56 ± 2.21 | 8.80 | < 0.001 |
| | t | -11.33 | -1.75 | | |
| | P | < 0.001 | 0.083 | | |
| Resource utilization and evidence-based practice | Pre-test | 17.35 ± 2.91 | 16.80 ± 3.35 | 1.25 | 0.215 |
| | Post-test | 22.30 ± 2.88 | 19.61 ± 2.40 | 7.26 | < 0.001 |
| | t | -16.01 | -8.17 | | |
| | P | < 0.001 | < 0.001 | | |
| Safe nursing practice | Pre-test | 36.53 ± 5.03 | 35.92 ± 5.76 | 0.81 | 0.418 |
| | Post-test | 43.45 ± 3.86 | 40.68 ± 5.46 | 4.48 | < 0.001 |
| | t | -15.65 | -8.10 | | |
| | P | < 0.001 | < 0.001 | | |
| Attitude of safe nursing responsibility | Pre-test | 39.46 ± 6.03 | 39.19 ± 5.84 | 0.33 | 0.745 |
| | Post-test | 47.47 ± 4.01 | 44.42 ± 5.99 | 4.28 | < 0.001 |
| | t | -14.10 | -8.47 | | |
| | P | < 0.001 | < 0.001 | | |
| Attitude of error reporting and disclosing | Pre-test | 12.31 ± 2.58 | 12.09 ± 2.43 | 0.64 | 0.526 |
| | Post-test | 14.42 ± 3.74 | 13.83 ± 2.62 | 1.29 | 0.197 |
| | t | -5.17 | -5.03 | | |
| | P | < 0.001 | < 0.001 | | |
| Total scores | Pre-test | 144.64 ± 13.75 | 142.57 ± 15.66 | 1.01 | 0.315 |
| | Post-test | 176.24 ± 13.73 | 160.87 ± 14.88 | 7.69 | < 0.001 |
| | t | -39.82 | -20.36 | | |
| | P | < 0.001 | < 0.001 | | |

Note: Data are Mean ± SD.

the database through SPOC and evaluate its quality according to the principle of quality evaluation to draw preliminary conclusions. Teachers also assigned nursing students to retrieve and summarize preventive measures for adverse events in groups. In addition to improving the ability of the students to use information, the homework helped students understand nurses' responsibilities in promoting patient safety. Historically, patient safety education has not been fully included in nursing education and is difficult to incorporate into current curricula fully [41].

The levels of the attitude of safe nursing responsibility, the skills of reporting and response to error, skills of communication-related to the error, resource utilization and evidence-based practice, and skills of safe nursing practice were significantly higher in the intervention group than those in the control group after the test. Simulation-based training effectively implements patient-centered care and improves patient safety competency, providing a relatively real environment for nursing students to implement continuous care and provide a safe environment that allows students to discover and deal with adverse events [23]. Safe nursing practice skills, such as sterile and isolation techniques and medication policies for safe care, are included in the Fundamental Nursing course. Students in the intervention group had better safe nursing skills as they were exposed to problems in learning, although simulation-based training was reinforced through feedback. Nursing medical records guided the students to use risk assessment tools to assess patient safety risks and develop nursing measures for patient-centered care. On this basis, students were guided to make clinical decisions by consulting teaching books, the Internet, and databases and selecting the best practice plan to further strengthen the information utilization ability. Division of labor learning in groups helps students understand the importance of teamwork. Group practice improved the level of communication and team collaboration between medical staff. Nontechnical skills, regarded as the cause of 70%–80% of adverse events, such as situational awareness and communication, are important to improve patient safety [42].

Students who receive simulation-based training have a deeper understanding of the role of nurses in patient safety. The reporting, communication, and response to adverse events, regarded as difficult in improving patient safety education, can be strengthened through special topics after simulation. Students practiced the operation model in school and did not encounter the actual situation of adverse events, leading to insufficient communication and response to adverse events. In this study, most students did not find mistakes by themselves, and the mistakes were only pointed out by the teacher or the rest of the students in the discussion. Students showed concern and fear of failure after knowing they made mistakes, which would diminish their performance confidence and hinder a successful transition [43,44]. Learning from experienced mistakes is more effective for learners and conducive to strengthening the check principle of medication treatment to promote the implementation of safe nursing practice by nursing students. Moreover, it eliminated bad emotions, such as student anxiety, and helped to improve their ability to cope with errors in the future. Teachers need to respond with a positive and tolerant attitude toward the mistakes made by students and guide students to learn how to prevent and deal with adverse events from their mistakes.

However, the post-test attitude of error reporting and disclosing had no significant difference between the two groups. The problem was complicated when involving attitude on reporting adverse events, especially those caused by others. Adverse event reporting was also affected by various factors, such as safety culture in the hospital [43,45,46]. The quality of healthcare and patient safety can be enhanced when healthcare managers dedicate adequate support and resources to ensure teamwork, effective communication, and a

blame-free culture [47]. Students who witnessed adverse events also considered carefully the potential negative consequences of reporting for themselves and their colleagues. Students recognized the professional obligation to raise concerns if they witnessed an adverse event; however, intrinsic and extrinsic factors influenced their willingness to do so [43].

This study's limitations are that the teaching program was only conducted in one medical school and was limited to junior college students. Future research should expand the study participants to undergraduate nursing students and conduct multicenter trials.

5. Conclusion

The patient safety competency of students after the intervention improved from that before the intervention in both groups and the intervention group had a higher level of safety competency. These findings indicated that the patient safety program using SPOC combined with simulation-based training could improve the patient safety competency of junior college nursing students. Systematic and comprehensive patient safety education should be integrated into the existing curriculum system. Teaching methods, such as simulation-based training, should be used to improve patient safety competency and promote safe nursing practice.

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Data availability statement

The datasets generated during and/or analyzed during the current study are not publicly available due to we have carried out the follow-up research on this basis and the projects has not yet been completed. But the datasets are available from the corresponding author upon reasonable request.

CRedit authorship contribution statement

Hui Li: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - original draft, Writing - review & editing, Project administration. **Wenzhong Zhao:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing - review & editing, Supervision, Project administration. **Bo Li:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - original draft, Writing - review & editing, Project administration. **Yanhong Li:** Conceptualization, Methodology, Validation, Formal analysis, Resources, Writing - review & editing.

Declaration of competing interest

The authors have declared no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijnss.2023.09.014>.

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