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Effect of Patient Safety Training Program of Nurses in Operating Room

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Purpose: This study developed an in-service training program for patient safety and aimed to evaluate the impact of the program on nurses in the operating room (OR). **Methods:** A pretest-posttest self-controlled survey was conducted on OR nurses from May 6 to June 14, 2020. An in-service training program for patient safety was developed on the basis of the knowledge-attitude-practice (KAP) theory through various teaching methods. The levels of safety attitude, cognition, and attitudes toward the adverse event reporting of nurses were compared to evaluate the effect of the program. Nurses who attended the training were surveyed one week before the training (pretest) and two weeks after the training (posttest). **Results:** A total of 84 nurses participated in the study. After the training, the scores of safety attitude, cognition, and attitudes toward adverse event reporting of nurses showed a significant increase relative to the scores before the training ($p < .001$). The effects of safety training on the total score and the dimensions of safety attitude, cognition, and attitudes toward nurses' adverse event reporting were above the moderate level. **Conclusion:** The proposed patient safety training program based on KAP theory improves the safety attitude of OR nurses. Further studies are required to develop an interprofessional patient safety training program. In addition to strength training, hospital managers need to focus on the aspects of workflow, management system, department culture, and other means to promote safety culture.

Key words: Patient Safety; Operating Rooms; Nurses; Inservice Training

INTRODUCTION

According to the Global Patient Safety Action Plan 2021~2030 of the World Health Organization (WHO), "Patient safety is a framework of organized activities that creates cultures, procedures, behaviours, technologies and environments in health care that consistently and sustainably lower risks, reduce the occurrence of avoidable harm, make error less likely and reduce its impact when it does occur" [1]. In recent decades, patient safety has been under intensive focus globally and has become a global public health concern. The data from the WHO [1] show that in high-income countries, 1 in 10 patients experience adverse events during hospital treatment while in low- and middle-income countries, there are 134 million adverse events per annum due to unsafe hospital care, resulting in approximately 2.6 million deaths. Rochefort et al. [2] and Nilsson et al. [3] reported that 30% to 58% of adverse events are preventable and that 20% to 25% of these preventable adverse events result in permanent disability or death. Unsafe healthcare also leads to economic losses. Slawomirski and Klazinga [4] estimated the social cost of patient injuries to be US$ 1~2 trillion per year.

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Among in-patient adverse events, those ascribed to surgical treatment are the most common. Surgery, which is designed to treat diseases and remove excess matter, is an invasive procedure that poses safety risks to patients. The reasons for this include the complex composition of the surgical team, complex surgical procedures, use of high-risk drugs during surgery, high surgical turnover rate, and time pressure for rapid surgical procedures during emergencies [5]. Potential patient safety incidents in operating rooms (ORs) include residual foreign body accidents after surgery, wrong-site surgery, surgical site infections, falls, and electrosurgical injuries [6,7]. Hempel et al. [8] found 0.09 events related to wrong-site surgery and 1.32 events related to retained surgical items per 10,000 surgeries in the United States from 2004 to 2014. The most frequently reported adverse event reported in the Joint Commission International Alarm Event Database in 2015 was residual foreign body accidents after surgeries, the occurrence of which had been increasing year on year [9]. Although the number of patient safety incidents in surgeries is much smaller than the number of surgeries performed, the harm caused to patients, their families, healthcare staff, and the healthcare system can be devastating [10].

Although surgery-related adverse events are usually considered to be associated with the skills of surgeons, the complexity of surgical procedures, and patient conditions, these events are now known to be associated with many other factors, such as healthcare system design, teamwork, and organizational safety culture [11]. Safety culture refers to the values, attitudes, and beliefs of the members of an organization toward the life and safety of their staff or the general public; minimizes the harm to patients during medical services; and is an overall model of the attitude, ability, behavior, and value of a group, individual, and institution [12]. Furthermore, safety culture is considered a key factor in shaping the safety cognition, attitude, and belief of clinical medical staff. Meanwhile, the safety attitude of medical staff and their cognition and attitude toward adverse events also reflect the safety culture of medical institutions [13].

According to the Association of Perioperative Registered Nurses (AORN), OR nurses are registered nurses who work in hospital surgical departments, day surgery units, ambulatory surgery centers, and in-clinics or physician offices that perform invasive procedures; they also include scrub nurses and circulating nurses. OR nurses are different from nurses in other hospital units as they provide healthcare and assist in invasive procedures that directly involve critically ill patients and their work poses greater potential risk to patient safety. Building a safety culture in an OR requires fostering teamwork. Surgeons play a leading role in the OR; however, the role of OR nurses should not be ignored. OR nurses are responsible for coordination in the OR, observing changes in the patient's vital signs and collaborating with the surgeon and anesthesiologist. OR nurses' communication and coordination skills are directly associated with the success of surgery [5]. Hierarchies exist in the OR, with the surgeon generally having great freedom of expression and with OR nurses lacking opportunities to offer suggestions or make requests. As a result of poor communication, breakdowns in multidisciplinary teamwork in the OR are reported as one of the most common factors that contribute to the occurrence of wrong site surgeries and other surgical adverse events [14].

Birkmeyer et al. [15] showed that a low level of safety culture is associated with a high incidence of surgical adverse events. However, Rocha et al. [16] reported that OR nurses have a relatively poor overall perception of patient safety. Pimentel et al. [17] also reported that OR nurses have a lower level of understanding of safety culture than anesthesiologists and surgeons. The Patient Safety 2030 Report [18] by the National Institute for Health and Care Research shows that more training in safe patient care should be provided for healthcare professionals over the next 15 years to raise their awareness of this issue and thereby improve patient safety. Indubitably, nurses play a positive role in improving patient safety, but it should also be recognized that most nurses do not receive appropriate patient safety training. Hence, it is important to understand the types of patient safety education for nurses [19,20]. As reported in several studies [21-24], patient safety training positively improves the safety attitude of surgeons and OR nurses, changes doctors' cognition and attitude toward patients falls, and im-

proves nurses' awareness of blood transfusion safety. Therefore, personal safety cognition, attitudes, and beliefs could be altered through education and training, which can in turn improve the safety culture of the whole organization. Considering that the establishment of safety culture requires the establishment of correct safety cognition, attitudes, beliefs, and values, we carried out patient safety training based on the knowledge-attitude-practice (KAP) theory for OR nurses through face-to-face lectures, case-based teaching, group discussions, scene simulation training, and online teaching. KAP theory revolves around health-related behavior change, arguing that healthcare knowledge and information are the basis for establishing health beliefs and forming a positive attitude toward change in health-related behavior while belief and attitude are internal motivations for behavior change [25]. Previous studies [26-28] have shown that KAP theory-based training for nurses with a focus on hospital-acquired infections and patients' physical restraints has achieved good effects. In the current study, we hypothesized that a safety training program based on this theory enhances the patient safety awareness of OR nurses, strengthens safety beliefs, and promotes a strong sense of safety among nurses at work, thereby encouraging them to engage in rigorous nursing behavior.

Therefore, this study developed a surgical patient safety training program on the basis of KAP theory and employed a combination of various teaching methods. It aimed to evaluate the effect of the proposed program on improving the safety attitude, cognition, and attitude toward adverse event reporting of OR nurses.

METHODS

1. Study design

This work was designed as a before-and-after study involving the same participants. The self-controlled design is characterized by small sample sizes, convenient implementation, low time consumption, and high efficiency. Nurses who attended the training were surveyed one week before the training (pretest) and two weeks after the training (posttest).

2. Setting and participants

This study was conducted at a specialized hospital for women and children in Chengdu, Sichuan, China, from May 6 to June 14, 2020. The hospital has 34 open ORs in the inpatient department. The participants were OR nurses who met the inclusion criteria. The inclusion criteria of the subjects were as follows: registered nurses those who had been engaged in nursing work in the OR for more than 1 year, those who had not received systematic safety training in the OR, and voluntary participants. The exclusion criteria were as follows: those who were on vacation during the study period and those who went out for further study. The rejection criteria were as follows: those who withdrew from the research prior to survey completion or those who did not complete the questionnaire. The sample size was determined by a power analysis as outlined by Cohen [29]; effect size is typically expressed as Cohen's d, and Cohen described a small effect size = 0.2, medium effect size = 0.5, and large effect size = 0.8. We referred to relevant studies [28-30] and decided to use a medium effect size to calculate the sample size. G*Power 3.1 software [31] was used to calculate the sample size. The power $(1-\beta)$ was set at 0.95, with $\alpha > .05$, effect size = 0.5, two-tailed t-test, and two dependent means (matched pairs). Therefore, at least 54 participants were required.

3. Ethics statement

This study was approved by the Ethics Committee of the West China Second University Hospital (approval number: 2020154). The participants were informed of the research objectives and their rights. They were informed that participation was voluntary and that they could withdraw from the study at any time without penalties. Their anonymity and confidentiality were ensured, and they were assured that their personal details and the research results would only be used in this study and would not be shared with any third party. They provided written informed consent prior to the commencement of the study, and two nurses (PZ and JL) and one staff member from the medical affairs department of the safety training management group were responsible for

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obtaining the participants' informed consent.

4. Intervention

1) Safety training program setup

First, a safety training management group was set up with two surgeons, one anesthesiologist, two head nurses, and five nurses at certified nurse level 3 (CN3), which is a Chinese nursing hierarchy with five levels from low to high (i.e., CN0 to CN4); CN3 refers to a nurse who has an intermediate professional title and has more than 10 years of work experience. One staff member from the hospital's legal affairs department and two staff members from the hospital's medical affairs department also participated. In total, the safety training management group comprised 13 individuals. The team members clearly defined the responsibilities at all levels and strengthened the control of the entire training. Their ages ranged from 29 to 48 years. In terms of educational attainment, seven had undergraduate qualifications, two had master's degrees, and three had doctoral degrees. The design of the training curriculum was based on the results of a safety culture survey among OR nurses in Chengdu, Sichuan, China [32]; AORN guidelines for perioperative practice [33]; WHO guidelines for safe surgery [34]; and the researchers' clinical experience. After the educational protocol was developed, three OR nursing experts were invited to review and critically examine the contents. On the basis of their suggestions and comments, the final outline of the program was set up to include six training topics. Four topics, namely, safe operation techniques, occupational safety, safety management theory, and medical information security, were created to improve nurses' safety knowledge. The other two topics, namely, medical laws and classification and reporting of medical adverse events, were created to enhance nurses' attitudes and beliefs regarding safety. Amiri et al. [35] and Habahbeh and Alkhalaileh [22] reported that 4 to 8 hours of training in patient safety are appropriate for hospital staff. Therefore, we set up a 6-hour training program for the six topics, each of which was explored for 1 hour. We provided the training for the OR nurses during the Thursday and Friday morning meetings to avoid conflicts with the nurses' work schedules. The training program lasted for three weeks, with two sessions per week and 1 hour per session. To enforce safety behaviors among the nurses, quality control nurses inspected the following factors: patient identification, nurse-patient communication, surgical position, counting of surgical instruments and materials, surgical safety checking, and nurses' reporting of adverse medical events. A monthly safety and quality control conference was held within the department to summarize, analyze, and discuss safety and quality control issues.

2) Implementation of safety training

The training was conducted via face-to-face lectures, case-based teaching, group discussions, and online teaching during morning meetings every Thursday and Friday for 3 weeks. The members of the safety training management team implemented safety training, and the trainers received professional training in teaching methods. Face-to-face lectures were conducted for all six topics. For the three topics, namely, safe operation techniques, medical laws, and classification and reporting of medical adverse events, we prepared case study videos on topics such as medical ethics, surgical time-out, patient identification, surgical count, and surgical specimen management (Supplementary Figure 1–3), which showed correct versus incorrect handling methods for certain patient safety events. The nurses were asked to conduct group discussions and debriefings according to the video content. For the topic of occupational safety, we conducted scene simulation training, after which the trainer assessed the scenario simulation process. All course materials and videos were uploaded to the "WeChat Learning Platform" (Supplementary Figure 4) for further viewing. After the training sessions, the nurses were required to answer relevant questions using the platform. The details of the content and implementation of the safety training program are presented in Table 1.

5. Data collection tools

1) General information questionnaire for OR nurses

The self-designed "general information questionnaire for OR nurses" was used. The contents included items pertaining to age, gender, work experience (in years), highest edu-

Table 1. Content and Implementation of the Safety Training Program

Topic	Week (session)	Curriculum	Teaching methods	Duration (min)
Medical laws and ethics	1 (1)	Medical laws	Face-to-face lecture Case-based teaching Group discussion Online teaching	30
	1 (1)	Medical ethics	Face-to-face lecture Case-based teaching Group discussion Online teaching	30
Medical information security	1 (2)	Nursing documentation in electronic medical record system	Face-to-face lecture Group discussion Online teaching	30
Occupational safety	1 (2)	Occupational protection measures for different infectious diseases	Face-to-face lecture Online teaching	30
	2 (1)	Emergency and disaster handling	Scene simulation training Online teaching	60
Safety management theory	2 (2)	Safety theory (Iceberg Theory, Swiss Cheese Model, etc.)	Face-to-face lecture Online teaching	30
	2 (2)	Nurse-patient communication	Face-to-face lecture Online teaching	30
Safe operation techniques	3 (1)	Surgical specimen management	Case-based teaching Group discussion Online teaching	20
	3 (1)	Surgical count	Case-based teaching Group discussion Online teaching	20
	3 (1)	Handover and transfer of critical patients	Case-based teaching Group discussion Online teaching	20
	3 (2)	Patient identification, surgical safety checklist (surgical time-out)	Case-based teaching Group discussion Online teaching	30
Classification and reporting of medical adverse events	3 (2)	Classification and reporting of medical adverse events	Face-to-face lecture Case-based teaching Group discussion Online teaching	30

cation level, professional title, marital status, current shift schedule (e.g., night shift), length of overtime work per week, and whether adverse nursing events had been reported in the past year.

2) Chinese version of the Safety Attitudes Questionnaire (C-SAQ)

This study utilized the C-SAQ translated and revised by Xia [36] according to the general version of SAQ [37] in 2009 and evaluated its reliability and validity. The questionnaire was approved by the developers of the original and Chinese versions.

The Cronbach's α coefficient of each dimension was .72~.85, and the overall Cronbach's α was .88, indicating that the scale had good internal validity, test-retest reliability, split-half reliability, and adequate reliability and stability. The revised scale consisted of six dimensions and 31 items: teamwork (items 1~6), safety climate (items 7~13), management perception (items 14~17), job satisfaction (items 18~22), working conditions (items 23~27), and stress rec-

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ognition (items 28~31). A 5-point Likert scale was adopted (1 = totally disagree, 2 = somewhat disagree, 3 = not sure, 4 = somewhat agree, 5 = very much agree). Among them, items 6, 13, 28, 29, 30, and 31 were negative entries that were scored in reverse (1 = very much agree, 5 = totally disagree), and each entry was assigned a score of 1~5 points. The total score on the scale was 31~155 points. The higher the score, the higher the safety attitude.

3) Revised questionnaires of cognitive and attitudes toward adverse event reporting

Lian [38] of Nanjing University of Traditional Chinese Medicine introduced and translated the Reporting of Clinical Adverse Events Scale [39], forming the revised questionnaire on the cognition and attitudes toward adverse event reporting that was more suitable for the Chinese context. The questionnaire was approved by the developers of the original and Chinese versions. The Cronbach's α coefficient, test-retest reliability, and content validity of the questionnaire were .85, .62, and .80, respectively, indicating satisfactory reliability and validity. The questionnaire consisted of 28 items, including 14 positive and 14 negative items, which were divided into five dimensions: management expectation, punishment environment, department culture, execution intention, and report cognition. A 5-point Likert scale was adopted (proficiency = 5 points, familiarity = 4 points, understanding = 3 points, clarity = 2 points, not knowing = 1 point; very much agree = 5 points, agree = 4 points, neutral = 3 points, disagree = 2 points, very disagree = 1 point); the negative items were scored in reverse. The sum of the items was the total score of the scale, which was 28~140 points. The higher the score, the better the cognition of adverse event reporting, the more positive the attitude, and the more positive the executive intention.

6. Data collection procedure

After informing the head nurse of the purpose and procedure of the study, the OR nurses who met the inclusion criteria were recruited with the assistance of the head nurse, and two nurses of the safety training management group reviewed the inclusion and exclusion criteria for the study participants. Four researchers from the safety training management group were responsible for collecting the data for the study. Each OR nurse was instructed to randomly select a number from a card enclosed in an opaque envelope. Only the training management team members and the nurses themselves knew this number. Each nurse was required to complete the questionnaire with the correct reference number. This number was used for questionnaire matching before and after the training sessions. the nurses were asked to complete the questionnaire within 30 minutes. Prior to the training, the content and related materials were kept strictly confidential. One week before the training, all participants were gathered during a morning meeting, and the questionnaires were distributed to them once they had provided their informed consent. The completed questionnaires were returned at the meetings. After the 2-week training on patient safety, the same questionnaires were distributed to the participants at a morning meeting and were returned during the meeting. The participants were not allowed to converse while filling out the questionnaires. After the completed questionnaires were collected, the training management team members matched the questionnaires filled in before and after the training according to the reference numbers.

7. Statistical methods

All the data were entered in Microsoft Office Excel 2016 and statistically analyzed using SPSS version 18.0 (SPSS Inc., Chicago, IL, USA). The general characteristics were statistically described by frequency, composition ratio, and mean ± standard deviation. The Kolmogorov-Smirnov test was performed to determine the normality of the study variables, and the difference between two pairs of data was normally distributed ($p > .05$). A paired sample t-test was conducted to compare the scores on safety attitude, adverse event reporting cognition, and attitude of nurses before and after training. $p < .05$ indicated that the difference was statistically significant.

RESULTS

1. General data of OR nurses

A total of 99 nurses were enrolled in this study. Among them, 7 nurses did not meet the inclusion criteria, 2 nurses declined to participate in the study, 2 nurses did not complete the questionnaire, and 4 nurses did not complete all courses of the training. In total, 84 nurses participated in the study (Figure 1). The average age of the participants was 32.3 ± 7.6 years, and 98.8% of them were women with an average work experience of 9.98 ± 8.76 years. Approximately 72.6% of the participants had a bachelor's degree, 69.1% had primary professional titles, 77.4% were married, and 54.8% worked on night shift schedules. The average overtime work duration was 2.68 ± 0.88 hours per week. Approximately 33.3% of the staff reported adverse nursing events in the past year (Table 2).

2. Score of C-SAQ scale for OR nurses

The results of this study showed that before training, the total score for the safety attitude of the OR nurses was 127.26 ± 11.40 points, with the minimum and maximum total scores being 93 and 146 points, respectively. After training, the total score for the safety attitude of the OR nurses was 132.32 ± 9.20 points, with the minimum and maximum total scores being 106 and 147 points, respectively. Statistical analysis showed significant differences in the total score of safety attitude and each dimension score of the OR nurses before and after the patient safety training ($p < .001$), with the scores being higher after training than before training. The training program exerted a strong impact on the total score of the C–SAQ, teamwork, safe climate, and working conditions of OR nurses (Cohen's $d > 0.8$); and a moderate effect on management perception, job satisfaction, and stress recognition ($0.5 < \text{Cohen's } d < 0.8$) (Table 3).

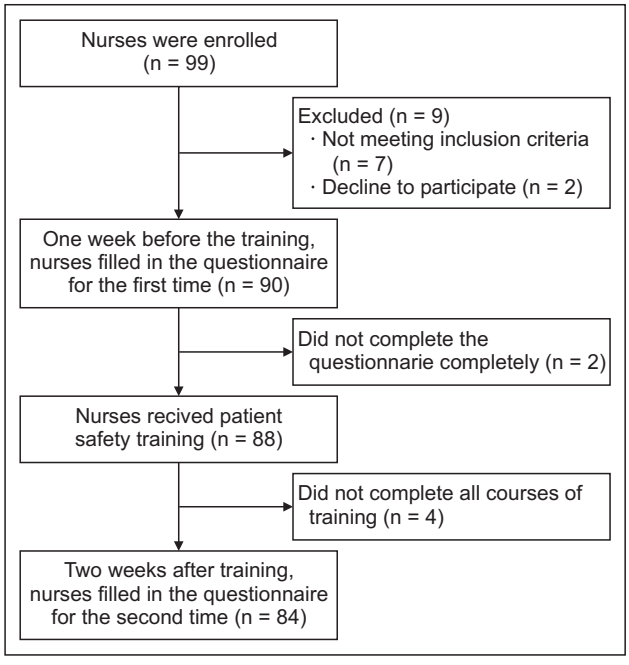

Figure 1. Flow diagram of the study.

3. Score of revised questionnaires of cognitive and attitudes toward adverse event reporting

In terms of cognition and attitude toward adverse event reporting, the total score of the OR nurses before training was 85.62 ± 7.43 points, with the minimum and maximum being 61 and 104 points, respectively. After training, the to–

Table 2. General Data of Operating Room Nurses (N = 84)

Variables	M ± SD or n (%)
Age (yr)	32.3 ± 7.6
Gender	
Women	83 (98.8)
Men	1 (1.2)
Duration of work (yr)	9.98 ± 8.76
Education levels	
Junior college	23 (27.4)
Bachelor	61 (72.6)
Professional title	
Primary title	58 (69.0)
Middle title	25 (29.8)
High title	1 (1.2)
Marriage status	
Married	65 (77.4)
Unmarried	19 (22.6)
Whether night shift at present	
Yes	46 (54.8)
No	38 (45.2)
Duration of overtime per week (h)	2.68 ± 0.88
Whether reported nursing adverse events	
Yes	28 (33.3)
No	56 (66.7)

M = Mean; SD = Standard deviation.

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Table 3. Score of C-SAQ for Operating Room Nurses Before and After Training (*N* = 84)

Scale dimension	Before training (M ± SD)	After training (M ± SD)	Paired difference		Effect value Cohen's d	t	*p*-value
			M ± SD	SEM			
Teamwork	24.10 ± 2.67	25.18 ± 2.22	− 1.08 ± 1.03	0.11	1.05	− 9.62	< .001
Safe climate	28.61 ± 3.01	29.79 ± 2.61	− 1.18 ± 1.31	0.14	0.90	− 8.25	< .001
Management perception	17.57 ± 2.39	18.38 ± 1.77	− 0.81 ± 1.08	0.12	0.75	− 0.86	< .001
Job satisfaction	21.14 ± 3.56	21.62 ± 3.31	− 0.48 ± 0.80	0.09	0.60	− 5.46	< .001
Working conditions	19.62 ± 3.04	20.70 ± 2.58	− 1.08 ± 1.13	0.12	0.96	− 8.77	< .001
Stress recognition	16.23 ± 3.56	16.65 ± 3.13	− 0.43 ± 0.70	0.08	0.61	− 5.62	< .001
Total score	127.26 ± 11.40	132.32 ± 9.20	− 5.06 ± 3.37	0.37	1.50	− 13.77	< .001

C-SAQ = Chinese version of the Safety Attitudes Questionnaire; M = Mean; SD = Standard deviation; SEM = Standard error of the mean.

Table 4. Score of the Revised Questionnaires of Cognitive and Attitudes towards the Adverse Events Report for Operating Room Nurses Before and After Training (*N* = 84)

Scale dimension	Before training (M ± SD)	After training (M ± SD)	Paired difference		Effect value Cohen's d	t	*p*-value
			M ± SD	SEM			
Management expectation	27.08 ± 3.36	28.17 ± 3.17	− 1.08 ± 1.09	0.12	0.99	− 9.12	< .001
Punishment environment	10.63 ± 3.69	11.35 ± 3.69	− 0.71 ± 0.80	0.09	0.89	− 8.18	< .001
Department culture	18.80 ± 2.95	19.40 ± 2.97	− 0.61 ± 0.89	0.10	0.69	− 6.24	< .001
Execution intention	10.12 ± 3.15	11.58 ± 3.21	− 1.46 ± 1.14	0.12	1.28	− 11.83	< .001
Reporting cognition	18.99 ± 3.52	20.24 ± 2.81	− 1.25 ± 1.32	0.14	0.95	− 8.71	< .001
Total score	85.62 ± 7.43	90.74 ± 6.93	− 5.12 ± 2.87	0.31	1.78	− 16.33	< .001

M = Mean; SD = Standard deviation; SEM = Standard error of the mean.

tal score of cognition and attitude toward adverse event reporting of the OR nurses was 90.74 ± 6.93 points, with the minimum and maximum being 72 and 108 points, respectively. Before and after the implementation of patient safety training, significant differences were noted in the total scores of cognition and attitudes toward adverse event reporting and the scores of each dimension among OR nurses ($p < .001$); the total scores were higher after training than before training. Thus, the training program had a strong effect on the total score, management expectation, punishment environment, execution intention, and cognition of adverse event reporting by OR nurses (Cohen's $d > 0.8$) but had a moderate effect on the department's cultural dimension ($0.5 <$ Cohen's $d < 0.8$) (Table 4).

DISCUSSION

The results of this study demonstrated that after the implementation of the patient safety training program using various teaching methods on the basis of KAP theory, the total scores and dimensions of the C-SAQ and the revised questionnaires of the cognitive and attitudes toward adverse event reporting of OR nurses were significantly higher than those before training, similar to the results of previous studies [21,22,40]. Our study shows that the proposed surgical patient safety training program based on KAP theory and delivered using a variety of teaching methods has positive effects on patient safety culture among OR nurses. Another study [21] conducted a one-day safety culture training for 90 surgeons and found that at 3 months after the training, the surgeons' safety attitudes had changed significantly. The US Veterans Health Administration [40] created a safe operational environment by forming an interdisciplinary team to implement a medical team training program. Habahbeh and Alkhalaileh [22] conducted a 4 h safety education study on 66 OR nurses and reported the improved safety culture

levels of the OR nurses.

In recent years, some patient safety intervention programs have emerged, and they focus on unsafe factors in medical techniques and processes. However, particularly in hospitals throughout China, safety promotion activities within an organizational culture have not been fully implemented and internalized, and there remains a large knowledge gap among healthcare staff in terms of their attitudes toward and cognition of patient safety. Habahbeh and Alkhalaileh [22] speculated that in view of the complexity and high risk of nursing work in the OR, OR nurses need to strengthen their safety awareness through group discussions, situational drills, and other forms. Biglan and Embry [41] demonstrated that the repetition and strengthening of individual behavior leads to cultural changes in group values, attitudes, abilities, and behavior. Therefore, in addition to developing OR nurses' professional skills to meet patient safety needs, continuing education is crucial. Continuing education can reduce the problems caused by the gaps in education levels and help nurses bring their professional knowledge and attitude up to standard [42]. Thus, implementing patient safety education for individuals can alter individual cognition, attitudes, and values that would improve organizational safety culture. Therefore, the comprehensive model training of nurses based on the framework of KAP theory can constantly improve and update OR nurses' knowledge and change their cognition. In addition, the training would help managers fully mobilize nurses' enthusiasm to participate in safety management by prompting them to identify potential safety hazards, report patient safety incidents caused by nonhuman factors, and ultimately promote the formation of a safety culture atmosphere based on a collective upholding of safety management standards and mutual trust. In addition, our training program disseminates knowledge via a combination of online and offline learning, thereby enabling nurses to integrate emotion, knowledge, skills, and attitudes via knowledge sharing, acting, and discussing and ultimately realize the rapid transformation of knowledge into practical ability.

It is worth noting that our training program had a less positive effect on the nurses' management perception, stress recognition, and job satisfaction in comparison with the other aspects of safety attitude (0.5<Cohen's d<0.8); this result is similar to the those of Ameryoun et al. [21]. In a survey [43] on the safety attitude of nurses in the OR, the score of the cognitive dimension of stress was low, which might be due to tedious nursing work and complex surgery in the OR. This requires cooperation between surgeons and anesthetists, resulting in heavy workload, long overtime hours, and a complex working environment. The results of Park and Kim [44] showed that healthcare providers lack the ability to manage stress effectively or have limited ability to cope with stress. In addition, the social status of Chinese nurses is not high, resulting in greater pressure from all aspects related to work. Thus, in a high-pressure working environment, nurses are likely to make mistakes and experience negative emotions, resulting in low job satisfaction [45]. Our study showed that it is difficult to effectively ameliorate OR nurses' work stress and improve their job satisfaction simply through patient safety training. Hospital managers should humanize the workplace and improve nurses' job satisfaction via various means, such as creating a flexible scheduling system for alleviating workload; providing guarantees in terms of salary, vacations, and welfare; reappraising the value of nursing work; and improving hospital facilities. At the same time, teamwork is essential in ORs. It is necessary to provide interprofessional patient safety training for the entire surgical team, which could help overcome communication barriers among nurses, surgeons, and anesthesiologists and thereby increase nurse engagement.

In this study, nurses' perception regarding adverse events had little effect on department culture (0.5<Cohen's d<0.8). A key point in improving patient safety is the accurate monitoring of adverse events. However, when facing adverse events, nurses may fail to timely handle and report adverse events due to a lack of relevant knowledge, insufficient communication, or fear of being reprimanded by superiors [10,46]. Kohn et al. [47] proposed that healthcare staff must be informed of the definition and classification of adverse events, types of reports and reporting system procedures, and the benefits of reporting in order to improve their cognition of adverse events. It is advisable to provide more training on adverse events to improve nurses' cognition, develop correct

attitudes, and promote adverse event reporting. Our study confirms that building a department culture involving an active reporting of adverse events in the OR cannot rely solely on nurse training programs. Lozito et al. [10] proposed that obstacles to reporting adverse events include poor communication, fear of punishment and legal sanctions, lack of knowledge of the reporting process, and lack of attention from superiors. If organizations can communicate sincerely in the face of adverse events, ensure smooth reporting channels, take nonpunitive responses to errors, actively organize learning, and improve continuously, the occurrence of the underreporting of adverse events can be reduced. Several studies have confirmed [48,49] that the deep-rooted punitive consciousness and responsibility system are major factors affecting nurses' initiative to report adverse events and that the blame culture not only affects the active reporting of adverse events but also exerts other negative effects. It is important to cultivate an organizational culture that enables nurses to identify and explain their mistakes and the causes, thereby preventing recurrence [50]. Thus, it was suggested that managers should examine safety issues from a systematic and overall point of view, improve the system, clarify the related declaration regulations and processes on adverse events, and optimize the reporting process or links to make the operation scientific, reasonable, and convenient. These parameters need to be based on a nonpenalty system, confidentiality mechanism, and appropriate incentive mechanism. In addition, diversified and multiple reporting channels should be established such that the information construction of safety management is accelerated to promote timely feedback. In addition, it is advisable to provide interprofessional patient safety training to hospital managers, surgeons, and anesthesiologists to establish the appropriate team communication channels.

Some important limitations of this study should be acknowledged. First, this study was conducted only in a single hospital in Sichuan, China, and a quasi-experimental design was used. Therefore, the sample size was small in this non-randomized controlled trial, which limits the generalizability of the results. Second, the training content of this study has not been strictly evaluated by experts; hence, there may be some deficiencies in the setting of training content. Finally, the indicator of the effect evaluation in this study was only the results of the subjective questionnaire filled out by the participants, and it did not include the objective results related to nurses' behavior. Therefore, there were many uncontrollable factors in the results. In the future, the patient safety training on OR nurses can be carried out through more rigorous curriculum and study settings, and the effect of the training program can be evaluated through objective indicators.

CONCLUSION

The results of this study proved that the proposed patient safety training program based on KAP theory improves the cognition, attitudes, and beliefs related to the safety culture of OR nurses. This approach is expected to improve the safety and quality of nursing care for patients in ORs. Furthermore, carrying out a safety culture training project in an OR could increase the objective nursing process or outcome indicators for the evaluation of the training effect. The program could also facilitate the exploration of the training intervention methods, duration, and other related issues. It is suggested to carry out interprofessional patient safety training. However, to improve nurses' job satisfaction, reduce work pressure, and support their active reporting of adverse events, in addition to strength training, hospital managers need to focus on the aspects of workflow, management systems, department culture, and other means to promote a positive and healthy OR safety culture.

CONFLICTS OF INTEREST

The authors declared no conflict of interest.

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DATA SHARING STATEMENT

Please contact the corresponding author for data availability.

SUPPLEMENTARY DATA

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