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Development and effect of hybrid simulation program for nursing students: focusing on a case of pediatric cardiac catheterization in Korea: quasi-experimental study

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Purpose: Hybrid simulation has emerged to increase the practicality of simulation training by combining simulators and standardized patient (SP) that implement realistic clinical environments at a high level. This study aimed to develop a hybrid simulation program focused on case of pediatric cardiac catheterization and to evaluate its effectiveness. **Methods:** The hybrid simulation program was developed according to the Analyze, Design, Develop, Implement, and Evaluate (ADDIE) model. And deep learning-based analysis program was used to analyze non-verbal communication with SP and applied it for debriefing sessions. To verify the effect of the program, a quasi-experimental study using a random assignment design was conducted. In total, 48 nursing students (n=24 in the experimental group; n=24 in the control group) participated in the study. **Results:** Knowledge ($F=3.53$, $p=.038$), confidence in clinical performance ($F=9.73$, $p<.001$), and communication self-efficacy ($F=5.20$, $p=.007$) showed a significant difference in both groups and interaction between time points, and the communication ability of the experimental group increased significantly ($t=3.32$, $p=.003$). **Conclusion:** Hybrid simulation program developed in this study has been proven effective, it can be implemented in child nursing education. Future research should focus on developing and incorporating various hybrid simulation programs using SP into the nursing curriculum and evaluating their effectiveness.

Keywords: Communication; Heart defects, congenital; High fidelity simulation training; Pediatric nursing; Students, nursing

INTRODUCTION

Nursing education aims to prepare professional nurses with the competency to provide nursing care through theoretical and practical courses [1]. In particular, nursing practicums are vital for developing critical thinking and clinical skills as they enable nursing students to effectively apply their theoretical knowledge to real clinical settings [2]. However, owing to an increasing emphasis on patient rights and safety along with a shortage of hospitals offering diverse clinical experiences, nursing students find it challenging to apply their theoretical knowledge to limited clinical-practice settings [3]. Simulation nursing education has been introduced to address this challenge. In South Korea, the Korean Accreditation Board of Nursing Education has recognized simulation education as a clinical practice [1]. Simulation practice refers to the provision of nursing care and debriefing the process using a simulator or standardized patient (SP) for scenarios that may occur in clinical settings [1]. High-fidelity patient simulators (HPS) are advanced models that realistically replicate clinical situations. In simulation education, HPS allows nursing students to enhance their clinical skills by integrating theoretical knowledge and performing nursing techniques directly in realistic scenarios [4]. An SP is an individual trained to simulate a real patient's history, personality, psychological reactions, and physical examination results [5]. Simulation practice using SPs is employed to enhance communication skills because it involves direct interactions with patients or family members in scenarios that closely mimic real-life situations [6]. Recently, hybrid simulation training, which incorporates simulators with various fidelities and SP, has emerged. This approach reflects the realism and practicality of simulation training by combining an HPS with an SP to create scenarios that closely mimic actual clinical environments. This method offers nursing students practical experiences that are often challenging to obtain in traditional clinical practice [7]. Previous studies have shown that hybrid simulation education, which involves creating and communicating with SP in realistic environments, significantly increases nursing students' confidence in their clinical performance and enhances their learning satisfaction [8,9].

In the field of child nursing education, nursing students have fewer opportunities to encounter pediatric cases and often do not experience a variety of nursing interventions that focus primarily on observation or simple tasks. Therefore, simulation education using pediatric cases is crucial for providing students with the necessary practical experience and skills [10]. Simulation programs for various pediatric nursing scenarios have been developed to evaluate their impact on clinical performance, problem-solving abilities, critical thinking tendencies, self-efficacy, and communication skills [2]. In particular, in pediatric wards, nurses primarily interact with children and their parents, who are the main caregivers. Therefore, skills to effectively communicate with children and their parents are crucial for pediatric nurses [11]. Therefore, hybrid simulation practice is recommended for integrating pediatric nursing knowledge, which is often difficult to acquire in clinical settings, enhancing clinical performance, and developing essential communication skills.

Nursing care for pediatric cardiac catheterization is a critical area of child nursing education. Special attention is required before and after the procedures to ensure children's safety and minimize complications [12]. However, encountering clinical cases during educational courses is challenging for nursing students. Additionally, parents, who are primary caregivers, play a crucial role in their children's recovery. Therefore, nurses must educate and support parents before and after procedural care to foster cooperative and trusting relationships. Effective communication skills are essential for nurses to achieve this goal. Communication involves both verbal and nonverbal elements. If nursing students lack strong communication skills, they may also struggle with nonverbal communication, such as the one that uses facial expressions or body language [5]. In fact, in uncertain situations, patients tend to trust nonverbal cues from health professionals more than verbal messages [13]. Therefore, developing nursing students' nonverbal communication skills in addition to their verbal skills is crucial. Recently, educational methods utilizing deep-learning-based facial expression analysis have been introduced to enhance communication skills. This approach suggests the potential of objective nonverbal communication analysis in educational programs [14]. When nursing students communicate with patients during simulation practice, their facial expressions and body posture are objectively analyzed through a computer program. The debriefing process using this objective analysis can provide nursing students with reflective learning opportunities.

Therefore, this study aimed to develop a hybrid simulation program with a focus on pediatric cardiac catheterization and assess its effects on nursing students' knowledge, clinical-performance confidence, communication self-efficacy, and communication ability. The research hypotheses are as follows:

Hypothesis 1: The experimental group that participated in the hybrid simulation program will have a difference in knowledge scores over time compared to the control group.

Hypothesis 2: The experimental group that participated in the hybrid simulation program will have a difference in clinical performance confidence scores according to time compared with the control group.

Hypothesis 3: The experimental group that participated in the hybrid simulation program will have a difference in communication self-efficacy scores according to time compared with the control group.

Hypothesis 4: Communication ability of the experimental group participating in the hybrid simulation program will improve.

METHODS

Ethical statements: This study was approved by the Institutional Review Board (IRB) of Kangwon National University (IRB No. 2022-05-003-001). Informed consent was obtained from all participants.

1. Study Design

This quasi-experimental study performed random allocation to develop a hybrid simulation program focusing on pediatric cardiac catheterization and confirm its effectiveness. This study followed the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) reporting guidelines [15].

2. Participants

The participants of this study included nursing students of the third and fourth grades of the Department of Nursing at K University in C City, South Korea, who had completed more than a semester of theory courses in child nursing. The participants had experience in clinical and simulation practice but lacked experience in simulation practice using SPs. They understood the purpose of the study and voluntarily agreed to participate. The number of participants for the independent t test and one-sided test was calculated using G*power 3.1.9.2 program. It was found that when the significance level (α) = . 05, power (1-β) = .80, and effect size (d) = .80 [16], a minimum of 42 participants were required—21 per group. Overall, 52 people were recruited, with a dropout rate of 10%, and 48 people who met the criteria for the target selection were finally selected. Using a random number generator, 24 participants were assigned to experimental and control groups. There were no dropouts; therefore, all participants were included in the final analysis (Figure 1).

3. Measurements

1) Knowledge

The researcher developed 20 questions based on the learning materials from theory classes. The developed tool was tested for content validity of the evaluation items by two child-nursing professors, two pediatric-cardiology nurses with more than 10 years of work experience, and one tool-development expert. The scale-level content validity index was determined to be 0.94. Each question had four choices, with one point scored for a correct answer and zero for an incorrect answer, for a total of 20 points. Higher scores indicated

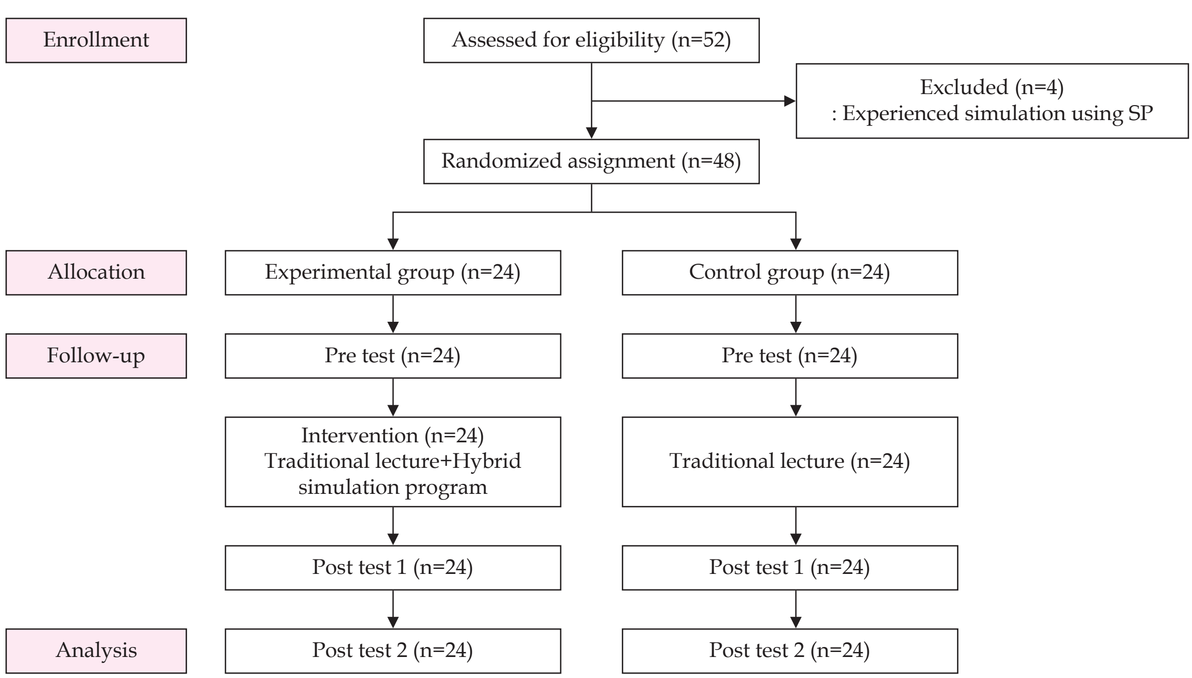

Figure 1. Flow diagram of participant allocation, follow-up, and analysis. SP, standardized patient.

the participants' enhanced knowledge.

2) Clinical performance confidence

This study used a clinical performance measurement tool developed by Lee at al. [17] and modified by Park [18]. It is rated on a 5-point Likert scale, ranging from "very well" to "very poorly," with higher scores indicating greater confidence in clinical performance abilities. Cronbach's α was .94 in Park's study [18] and .95 in this study.

3) Communication self-efficacy

The Korean version of the Communication Self-Efficacy Measurement Tool (KSE-12) was used for nursing students [19]. It uses a 10-point scale, ranging from 1 ("very uncertain") to 10 ("very confident,") with higher scores indicating greater communication self-efficacy. At the time of development, Cronbach's α was .95 for SE-12 and .98 for KSE-12; in this study, Cronbach's α was .95.

4) Program satisfaction

To measure program satisfaction, the researcher modified the educational satisfaction tool developed by Kim [20] by supplementing it with items. It is a 5-point Likert scale ranging from 5 for ("very much so") to 1 for ("not at all.") The higher the score, the greater the level of satisfaction with the educational program. At the time of development, Cronbach's α was . 93; in this study, it was .83.

5) Communication ability

The Korean version of the revised and supplemented communication ability assessment tool (K-HCAT) [21] was used to evaluate communication ability in a simulated situation. The tool uses a 5-point Likert scale ranging from 1 ("not at all") to 5 ("very much,") with higher scores indicating better communication abilities. The tools available for evaluation by instructors and SP were K-HCAT's evaluator. Cronbach's α of .73–.84 and SP Cronbach's α of .78. Intra-class correlation (ICC) between instructors with experience in simulating child nursing and SP evaluators was 0.78 in the first session and 0.75 in the second. In this study, Cronbach's α was .88 by the first session instructor, .83 for SP, .84 by the second session instructor, and.82 by SP, respectively.

4. Procedure

1) Development of hybrid simulation program

To develop the hybrid simulation program, an Analyze, Design, Develop, Implement, and Evaluate (ADDIE) model was applied. First, the researchers conducted an online survey of 21 third-year nursing students to identify the need to experience a simulation education program to provide nursing care for patients with congenital heart disease and to learn how to communicate with patients. Additionally, the laboratory environment for the simulation was analyzed. Second, the learning objectives and educational content were based on the learning objectives of the Korean Academy of Child Health Nursing and the learning outcomes of the Korean Accreditation Board of Nursing Education [1].

To design the hybrid simulation, the following learning goal for direct nursing intervention was established: to be able to assess the patient assessment and provide appropriate nursing intervention before and after pediatric catheterization to children with atrial septal defect. The educational content using HPS was created accordingly. We also established the learning goal for communication with parents as being able to carry out therapeutic communication with the parents of patients, and we used an SP for the role of parents to construct educational content for actual communication.

Third, the simulation program included nursing cases before and after pediatric cardiac catheterization. Pre-pediatric cardiac catheterization nursing involves preparing patients just before moving them to the procedure room and providing supportive care to children and mothers who are anxious because of delays in the procedure. Post-pediatric cardiac catheterization nursing includes post-procedure medication, diet, and posture maintenance for children who arrive at the ward in a sedated state, education of mothers who are anxious about the child's condition, and maintaining an open airway. The participants were divided into two groups and played the role of nurses while driving the scenario, and the instructor coordinated and monitored the simulation process, The program was designed to help the participants reflect on the simulation through debriefing after the simulation driving was completed. A deep-learning-based facial expression and motion analysis program was used to analyze and debrief learners' verbal and non-verbal communication [14]. This pilot computer program was developed in 2022 by our research team and engineers specializing in artificial intelligence. It can analyze facial expressions (neutral, happiness, sadness, surprise, fear, disgust, anger) and movements (eye contact, light touch, distance, tilted upper body) using video file of nursing students communicating with patients [14]. In this study, the program's analysis of nursing students' interactions with mother was used as an auxiliary tool to help students objectively reflect on their non-verbal communication during debriefing. The overall content of the simulation program was designed using the National League for Nursing/Jeffries Simulation Framework as the conceptual framework [22]. Expert reviews were conducted to validate the program's content. The team of expert reviewers included a professor of child nursing with simulation teaching experience and two nurses who had worked in pediatric cardiology for more than 10 years. The final program was developed after applying the pilot program to six fourth-grade nursing students with experience in simulation classes using SPs and checking the overall scenario flow, operating time, movement, appropriateness of child patient voice recordings, and angle of video cameras for non-verbal communication analysis programs.

2) Pre test

Data were collected from July 27 to October 19, 2022. After announcing recruitment through social networking sites, the participants were recruited on a first-come-first-served basis. A preliminary survey was conducted on the general characteristics, knowledge, clinical-performance confidence, and communication self-efficacy of those who signed the consent form to participate in the study. Participants were randomized into experimental and control groups.

3) Intervention

After online lectures, the experimental group participated in a hybrid simulation program, which consisted of ten sessions, including nursing care, before and after cardiac catheterization. One group of six nursing students and two nursing students played nurses' roles during the course of the study. Each group discussed the scenario and practiced nursing skills (90 minutes), followed by simulation running for the first nurse role (30–45 minutes), intermediate debriefing and group discussion (30 minutes), simulation running for the second nurse role (30–45 minutes), and team debriefing (30 minutes) for a total of 450 minutes (Table 1). The researcher developed online lecture content, program guidelines, reflection diaries, and scenario scripts. In the clinical setting, the lower limb purse was changed and a physical reaction high-fidelity child simulator was used. The SP were performed by a pretrained professional actor. The control group participated only in online lectures on pediatric catheterization. Data from the control group were first collected at different time intervals so that the treatment of the experimental group did not spread to the control group.

4) Post test

The first post-test evaluation of knowledge, clinical-performance confidence, communication self-efficacy, program satisfaction, and communication ability was performed in the experimental group immediately after the end of the program. In the control group, knowledge, clinical performance confidence, and communication self-efficacy were surveyed in the third week after the lecture, which was the same time point as the experimental group, and there were no dropouts. For the second post-test evaluation, the experimental and control groups were surveyed for knowledge, clinical performance confidence, and communication self-efficacy 3 weeks after the first post-test.

5. Data Analysis

Data were analyzed using the IBM SPSS Statistics ver. 26.0 (IBM Corp.). The general characteristics of the participants were analyzed using real numbers, percentages, means, and standard deviations. The general characteristics of the experimental and control groups and the homogeneity test for research variables were analyzed using the chi-square test, Fisher's exact test, and independent t test. Repeated-measures ANOVA confirmed the effectiveness of the program and the sphericity assumption, referring to Wilks' lambda value if sphericity was not satisfied. Knowledge, clinical performance confidence, and communication self-efficacy at each time point were analyzed using independent t tests. The reliability of the measurement tool was obtained through Cronbach's α and the reliability between evaluators through ICC.

RESULTS

1. General Characteristics of the Participants and Homogeneity of Study Variables

Among the general characteristics, there were no significant differences between the two groups in terms of age, sex,

Table 1. Hybrid Simulation Program for Nursing Students Focusing on a Case of Pediatric Cardiac Catheterization

Parts	Process	Contents	Time
1: Care of before catheterization	1: Pre simulation activity	• Review of child condition and nursing care before cardiac catheterization • Practice of nursing skills • Group formation and setting roles of two nurses (2 person/group)	90 min
	2: First simulation running & facial expression recording	• Assessment of child condition (using HPS) • Preparation for cardiac catheterization (using HPS) • Communication and support with mother (with SP)	30 min
	3: Short debriefing	• Group debriefing about nursing intervention	30 min
	4: Second simulation running	• Repeat first simulation running contents • Switch the role of nurses within group	30 min
	5: Post simulation activity	• Team debriefing about Part 1 simulation practice (3 group/team) • Debriefing and discussion with SP • Feedback and discussion for non-verbal communication using analysis of participants' facial expression during practice	30 min
2: Care of after catheterization	1: Pre simulation activity	• Review of child condition and nursing care of after cardiac catheterization • Practice of nursing skills	90 min
	2: First simulation running & pose recording	• Assessment and intervention for airway maintenance and blood circulation in sedation (using HPS) • Education and support mother (with SP)	45 min
	3: Short debriefing	• Group debriefing about nursing intervention	30 min
	4: Second simulation running	• Repeat first simulation running contents • Switch the role of nurses within group	45 min
	5: Post simulation activity	• Team debriefing about Part 2 simulation practice (3 group/team) • Debriefing and discussion with SP • Feedback and discussion for non-verbal communication using analysis of participants' pose during practice	30 min

HPS, high-fidelity patient simulators; SP, standardized patient.

academic performance, satisfaction with major, satisfaction with clinical practice, nursing education related to congenital heart disease, or communication education for children and parents. However, interpersonal relationships differed significantly between the two groups ($p = .017$). All study variables were confirmed to be normally distributed using the Shapiro–Wilk test. There were no statistically significant differences between the two groups in knowledge, clinical performance ability, or communication self-efficacy. Therefore, the two groups were confirmed to be homogeneous (Table 2).

2. Effects of Hybrid Simulation Program for Nursing Students

For repeated-measures analysis of variance, interpersonal relationships that demonstrated significant differences among general characteristics were treated as covariates, and the estimated marginal mean values and standard errors were confirmed.

For Hypothesis 1 the interaction between time and groups was significant ($F = 3.53$, $p = .038$). Compared with the control group, the experimental group had a significantly higher change in knowledge after the intervention ($t = 2.23$, $p = .031$) and 3 weeks after the intervention ($t = 2.14$, $p = .038$). Therefore, Hypothesis 1 is supported (Table 3).

For Hypothesis 2 the interaction between time and groups was significant ($F = 9.73$, $p < .001$). Compared with the control group, the experimental group had a significantly higher change in confidence in clinical competence after the intervention ($t = 3.78$, $p < .001$) and 3 weeks after the intervention ($t = 3.81$, $p < .001$). Therefore, Hypothesis 2 is supported (Table 3).

For Hypothesis 3 the interaction between time and group was significant ($F = 5.20$, $p = .007$). Compared with the control

Table 2. General Characteristics of Study participants and Homogeneity of Study Variables between Two Groups (*N*=48)

Characteristics	Categories or Range	Exp. (n=24) n (%) or M±SD	Cont. (n=24) n (%) or M±SD	χ² / t (*p*)
Age (y)		21.13±1.15	21.42±1.25	0.84 (.405)
Sex	Female	21 (87.5)	21 (87.5)	0.00 (.667[a])
	Male	3 (12.5)	3 (12.5)	
Academic performance	>4.0	10 (41.7)	6 (25.0)	1.79 (.080[a])
	3.5–3.9	11 (45.8)	8 (33.3)	
	3.0–3.4	2 (8.3)	10 (41.7)	
	<3.0	1 (4.2)	0 (0)	
Satisfaction with major	Very satisfied	11 (45.8)	5 (20.8)	1.26 (.216[a])
	Satisfied	8 (33.3)	12 (50.0)	
	Neutral	4 (16.7)	7 (29.2)	
	Dissatisfied	1 (4.2)	0 (0)	
Satisfaction with clinical practice	Very satisfied	6 (25.0)	6 (25.0)	0.65 (.521[a])
	Satisfied	15 (62.5)	12 (50.0)	
	Neutral	3 (12.5)	6 (25.0)	
	Dissatisfied	0 (0)	0 (0)	
Interpersonal relation	Good	19 (79.2)	11 (45.8)	2.48 (.017)
	Neutral	5 (20.8)	13 (54.2)	
	Bad	0 (0)	0 (0)	
CHD family history or past history	Yes	0 (0)	0 (0)	-
	No	24 (100.0)	24 (100.0)	
Nursing education experience related to congenital heart disease	Yes	2 (8.3)	4 (16.7)	0.76 (.666[a])
	No	22 (91.7)	20 (83.3)	
Communication education experience for children and parents	Yes	6 (25.0)	2 (8.3)	2.40 (.245[a])
	No	18 (75.0)	22 (91.7)	
Knowledge	0–20	13.46±2.17	13.08±2.13	0.61 (.548)
Clinical performance confidence	15–75	53.71±8.91	56.33±11.19	0.90 (.373)
Communication self-efficacy	12–120	83.17±13.55	87.92±14.30	1.18 (.244)

[a]Fisher's exact test; CHD, congenital heart disease; Cont., control group; Exp., experimental group; M, mean.

Table 3. Results of Repeated Measured ANOVA for Study Variables between the Experimental and Control Groups (*N*=48)

Variables	Time	Exp. (n=24)	Cont. (n=24)	Sources	F or t (*p*)
		M±SE or M±SD			
Knowledge	Pre	13.35±0.45	13.19±0.45	Time	7.49 (.009)
	Post 1	16.12±0.48	13.84±0.48	Group	0.11 (.989)
	Post 2	16.07±0.67	13.51±0.67	T×G	3.53 (.038)
	Post 1-Pre	2.58±2.72	0.83±2.73		2.23 (.031)
	Post 2-Pre	2.54±3.36	0.50±3.26		2.14 (.038)
Clinical performance confidence	Pre	53.34±2.15	56.70±2.15	Time	0.34 (.563)
	Post 1	62.38±1.56	58.21±1.56	Group	4.99 (.009)
	Post 2	64.41±1.68	60.01±1.68	T×G	9.73 (<.001)
	Post 1-Pre	9.42±7.10	2.13±6.23		3.78 (<.001)
	Post 2-Pre	10.79±6.74	3.58±6.38		3.81 (<.001)
Communication self-efficacy	Pre	82.08±2.90	89.01±2.90	Time	0.10 (.751)
	Post 1	91.74±2.85	91.84±2.85	Group	4.96 (.009)
	Post 2	96.50±3.13	93.21±3.13	T×G	5.20 (.007)
	Post 1-Pre	10.75±10.67	1.75±10.43		2.96 (.005)
	Post 2-Pre	14.21±11.03	4.42±12.65		2.86 (.006)

Cont., control group; Exp., experimental group; M, mean; Post 1, immediately after the program; Post 2, three weeks after the program; Pre, before intervention; SD, standard deviation; SE, standard error; T×G, time×group.

Table 4. Changes in Communication Ability of the Experimental Group during Participation in the Program (*N*=48)

Variable	Part 1 simulation	Part 2 simulation	t (*p*)
	M±SD	M±SD	
Communication ability	55.06±4.52	57.83±4.61	3.32 (.003)

M, mean.

group, the experimental group had a significantly higher change in communication self-efficacy after the intervention (t=2.96, *p*=.005) and 3 weeks after the intervention (t=2.86, *p*=.006). Therefore, Hypothesis 3 is supported (Table 3).

For Hypothesis 4 communication ability increased significantly after the program compared to the situation before it (t=3.32, *p*=.003). Therefore, Hypothesis 4 is supported (Table 4).

DISCUSSION

This study developed a hybrid simulation program focusing on pediatric cardiac catheterization and assessed its effectiveness. The discussion is divided into two parts: the development of the program and its effectiveness.

First, simulation programs must include scenarios that consider nursing students' educational needs and learning levels. These scenarios provide nursing students with a variety of experiences and opportunities to fully demonstrate their capabilities [23]. A clinical environment and situation similar to those in a real clinical setting should be created to allow nursing students to fully immerse themselves in a simulation program. In this study, the educational needs of nursing students were assessed before the program was developed. We created simulation scenarios by modifying real cases based on the nursing manual for pediatric cardiac catheterization used in hospitals. The learning objectives of simulations reflected the characteristics of the hybrid simulation program. This enabled the assessment and intervention in changing patient conditions using HPS and communication and interaction with SP who played the role of mothers. Before pediatric catheterization, participants were encouraged to easily assess the child's condition and mother's anxiety and provide supportive nursing care. Participants were guided to perform nursing skills in a simulation, which allowed them to directly experience nursing interventions for pediatric cardiac catheterization. In another session, after pediatric catheterization, the simulation scenario was more advanced and was designed to allow nursing students to independently solve problems with the child's condition, provide education for the mother, and provide emotionally supportive nursing care, thereby increasing communication opportunities through interactions with the SP. When nursing students perform assigned roles within the team, the learning effect may diminish if roles are not properly allocated because of the nature of simulation classes [24]. Therefore, in each scenario in our program, nurses' roles were divided into nursing skills, education, and supportive care. The simulation was repeated with role changes, allowing students to experience all the roles. Since nurses in pediatric wards experience more stress than those in other wards when they communicate with patients and caregivers, sufficient communication training and practice with pediatric patients or their caregivers is essential [25]. Simulations showed that increased confidence in this hybrid program improved communication self-efficacy. This study provided opportunities for communication with the SP by repeating simulation practices in the same situation. To ensure that nursing students remain focused on and engaged in the simulation, the actions of the SP must be realistic [26]. Therefore, professional actors with experience in SP roles, specifically as mothers, were recruited for this study, and an objective analysis of non-verbal communication focusing on the faces and poses of nursing students was conducted [14]. During debriefing, individual feedback was provided to the participants to encourage them to reflect on verbal and non-verbal communication. The hybrid simulation program developed in this study focused on communication with parents, which is crucial in child nursing. It involves analyzing nursing problems and providing appropriate direct nursing care through scenarios based on real clinical cases. Additionally, it includes analysis and reflection on both the verbal and non-verbal elements of communication.

The next aspect is the program's effectiveness. First, the knowledge scores of the experimental group varied over time compared to those of the control group, showing a pattern of maintaining a high level. It was reaffirmed that knowledge gained through simulation practice is retained longer than that acquired through theoretical education [22]. This outcome is thought to result from the internalization of theoretical knowledge through simulation practice, which directly involves educating patients and parents. Since the simulation practice is not merely meant for acquiring knowledge, but for applying and integrating it, clearly defining learning goals is essential. When evaluating the effects of simulation, the focus should be on assessing how knowledge is used and applied rather than simply measuring the knowledge itself. Second, the clinical performance confidence scores of the experimental group varied over time compared to those of the control group, showing a pattern of maintaining a high level. A direct comparison is challenging because of the lack of previous studies measuring confidence in clinical performance. However, previous studies measuring clinical performance have shown an increase in clinical performance [5,27]. However, a study using SP and HPS did not show an increase in clinical performance, indicating the need for further research on the effects of simulations [28]. As this study did not include instructors' clinical performance evaluations, future research should involve comparative studies on actual clinical performance capabilities by simultaneously conducting instructors' and students' self-evaluations. Additionally, the students participated more actively in the second session than in the first session. This increased engagement is, perhaps, because the participants provided the necessary nursing care to the child and mother, leading to simulation based on their own judgment and thoughts. A simulation scenario running method that provides an open practice environment for students to proactively judge and cope with open learning opportunities to try various interventions is suggested. Third, self-efficacy scores for communication ability in the experimental group varied over time compared with the control group, showing a pattern of maintaining a high level. Communication self-efficacy is the confidence in nurses' ability to effectively communicate with patients while providing nursing care [18]. This is improved by repeated simulation practice training in situations similar to SPs and clinical sites rather than in practice using simple models [29]. In this study, the use of SP allowed participants to experience communication similar to real-world scenarios. Communication self-efficacy improved as the participants reflected on both verbal and non-verbal communication through intermediate and team debriefings. Finally, the experimental group showed improved communication skills compared to their levels before participating in the program. This is similar to previous studies showing that communication ability can increase as communication self-efficacy increased [30]. Communication skills are an important nursing competency; communication-related courses are often limited to theoretical classes, but communication requires both theoretical learning and practical application training. The results suggest that hybrid simulation practice is an effective educational method for integrating theoretical nursing knowledge, improving communication skills, and providing practice and training opportunities in nursing care.

One limitation of this study is that it is difficult to generalize the results because the research was conducted with nursing students from one university. In addition, this effect may have been exaggerated because the participants were volunteers, who were more likely to be actively engaged in the simulation program. There is no absolute standard for acceptable inter-rater reliability when evaluating communication skills, but a value of 0.8 or higher is recommended [31]. The inter-rater reliability results of this study show that a better understanding of the evaluation items and measurement methods is needed before starting the simulation.

This study confirmed the effectiveness of a hybrid simulation program that combines the HPS and SP with a focus on pediatric cardiac catheterization, which is difficult to encounter in clinical practice. The program developed in this study can be used as an educational module to develop practical competencies in pediatric nursing interventions and to train communication with parents.

CONCLUSION

This developed a hybrid simulation program focusing on pediatric cardiac catheterization and confirmed its effectiveness. The results showed that the program effectively improved nursing students' knowledge and abilities in clinical performance, confidence, communication self-efficacy, and communication ability. This program can be used as an educational intervention in pediatric nursing education and practice to enhance nursing competencies, including communication with children and their parents. Future research should focus on developing and incorporating various hybrid simulation programs using SP into the nursing curriculum and evaluating their effectiveness. Further studies are needed to assess competencies of nursing students participating in these programs in clinical practice settings.

ARTICLE INFORMATION

Authors' contribution

Conceptualization: all authors; Data collection and Formal analysis: Eunju Jin; Writing-original draft: Eunju Jin; Writing-review and editing: Hyunju Kang; Final approval of published version: all authors.

Conflict of interest

Hyunju Kang has been an editor of *Child Health Nursing Research* since 2024. She was not involved in the review process of this article. No existing or potential conflict of interest relevant to this article was reported.

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Data availability

Please contact the corresponding author for data availability.

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